FINAL FEASIBILITY STUDY REPORT

FORMER TEMCO UNIFORMS SITE
WEST HAVERSTRAW, NEW YORK
SITE NO. 344054

Prepared for:

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

New York State Department of Environmental Conservation
Division of Environmental Remediation
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FEBRUARY 2018

CERTIFICATION STATEMENT

FORMER TEMCO UNIFORMS SITE
FEASIBILITY STUDY REPORT
WEST HAVERSTRAW, NEW YORK

I, Thomas Drachenberg, am currently a registered professional engineer licensed by the State of New York, I had primary direct responsibility for implementation of the remedial program activities, and I certify that the Remedial Action Work Plan was implemented and that all construction activities were completed in substantial conformance with the Department-approved Remedial Action Work Plan.

I certify that the data submitted to the Department with this Final Engineering Report demonstrates that the remediation requirements set forth in the Remedial Action Work Plan and in all applicable statutes and regulations have been or will be achieved in accordance with the time frames, if any, established for the remedy.

I certify that all use restrictions, Institutional Controls, Engineering Controls, and/or any operation and maintenance requirements applicable to the Site are contained in an environmental easement created and recorded pursuant ECL 71-3605 and that all affected local governments, as defined in ECL 71-3603, have been notified that such easement has been recorded.

I certify that a Site Management Plan has been submitted for the continual and proper operation, maintenance, and monitoring of all Engineering Controls employed at the Site, including the proper maintenance of all remaining monitoring wells, and that such plan has been approved by the Department.

I certify that all documents generated in support of this report have been submitted in accordance with the DER's electronic submission protocols and have been accepted by the Department.

I certify that all data generated in support of this report have been submitted in accordance with the Department's electronic data deliverable and have been accepted by the Department.

I certify that all information and statements in this certification form are true. I understand that a false statement made herein is punishable as a Class "A" misdemeanor, pursuant to Section 210.45 of the Penal Law. I, Thomas Drachenberg, of Parsons, am certifying as Owner's Designated Site Representative for the site.

086020	2/22/18	Thomas [signature]
NYS Professional Engineer #	Date	Signature

STATE OF NEW YORK · THOMAS C. DRACHENBERG · LICENSED PROFESSIONAL ENGINEER · 086020

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ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms Per Liter
µg/m³	Micrograms Per Meter Cube
1,2-DCE	Dichloroethylene
COC	Contaminant of Concern
CPOI	Chemical Parameters of Interest
DNAPL	Dense Non-Aqueous Phase Liquids
EISB	Enhanced In Situ Bioremediation
EVO	Emulsified Vegetable Oil
FS	Feasibility Study
HPT	Hydraulic Profiling Tool
HRC	Hydrogen Release Compound
ISCO	*In-Situ* Chemical Oxidation
ISCR	*In-Situ* Chemical Reduction
mg/kg	Milligrams/Kilogram
MIP	Membrane Interference Probe
MNA	Monitored Natural Attenuation
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
PCE	Tetrachloroethene
RAO	Remedial Action Objective
RI	Remedial Investigation
ROD	Record of Decision
ROI	Radius of Influence
SCG	Standards, Criteria and Guidance
SCO	Soil Cleanup Objectives
Site	Former Temco Uniforms Site
SSD	Sub-Slab Depressurization System
SV	Soil Vapor
SVE	Soil Vapor Extraction
SVI	Soil Vapor Intrusion
TCE	Trichloroethene
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
VC	Vinyl Chloride
VOCs	Volatile Organic Compounds
ZVI	Zero Valent Iron

EXECUTIVE SUMMARY

BACKGROUND

- The Former Temco Uniforms Site is an in-active dry cleaner located in West Haverstraw, New York, at which there were historical releases of dry cleaning related products.
- The Remedial Investigation (RI) Report was completed in January 2017, and awaiting approval by the New York State Department of Environmental Conservation (NYSDEC).
- This Feasibility Study (FS) Report presents remedial action objectives, screens potentially applicable remedial technologies, and contemplates an evaluation of remedial action alternatives for the Temco Site. The FS report has been prepared in accordance with NYSDEC's DER-10, Technical Guidance for Site Investigation and Remediation.

SITE DESCRIPTION

- The 2.6-acre site is located in a primarily residential setting, and features an industrial zoned 32,000 sf single story building with perimeter fence.
- Building has been vacant since 2002 and is in an advanced state of disrepair
- A railroad track extends along the south-southwest side of the site
- Soils consist of brown fine to coarse silty sand, fine gravel, and cobbles. Glacial till/silt and bedrock lie beneath site soils (depth to bedrock is approximately 90').
- No water supply wells have been identified on site (nearest water supply well is 1.5 miles to the west of the site).
- No wetlands exist on or adjacent to the site.
- Site is currently overgrown with brush and vegetation.

NATURE, EXTENT, AND SOURCES OF CPOIs

- Chemical Parameters of Interest (CPOIs) were not found in subsurface soils at concentrations exceeding relevant standards or guidance values.
- Chemical Parameters of Interest (CPOIs) were detected in surface soils in exceedance of relevant standards and guidance values. Polynuclear aromatic hydrocarbon (PAH) compound indendo(1,2,3-c,d)pyrene was detected at location SS-04 at a concentration of 0.53 milligrams/kilogram (mg/kg), in exceedance of its associated Soil Cleanup Objectives (SCO) (0.5 mg/kg). No chlorinated compounds were detected at any of the sample locations around and/or in close proximity to the onsite building.
- Groundwater quality analytical results from the site show contamination from Tetrachloroethene (PCE) at concentrations above Class GA SGVs. The Class GA Standard for PCE is 5 micrograms per liter (µg/L). Based on the 2016 sampling event, of which 14 wells were sampled, 10 were observed to have PCE concentration greater than class GA groundwater standards. The highest PCE concentrations were observed in site groundwater samples from three locations at more than 20 times the Class GA Standard.
- Under the supervision of Parsons, indoor air and sub-slab vapor samples were collected at 6 properties in the vicinity of the Temco site. PCE concentrations were found in exceedance of New York State Department of Health (NYSDOH) guidance at multiple locations.

REMEDIAL ACTION OBJECTIVES (RAOS)

- Prevent ingestion of groundwater with contaminant levels exceeding drinking water standards

- Prevent contact with, or inhalation of volatiles, from contaminated groundwater
- Restore groundwater aquifer to pre-disposal / pre-release conditions, to the extent practicable
- Prevent the discharge of contaminants to surface water
- Remove the source of ground or surface water contamination
- Mitigate impacts to public health resulting from existing, or the potential for vapor intrusion into buildings

GROUNDWATER REMEDIAL ACTION ALTERNATIVES EVALUATED

GW-1 – No action

GW-2 – Enhanced *In situ* bioremediation

GW-3 – *In situ* chemical oxidation

GW-4 – Soil removal

SOIL VAPOR REMEDIAL ACTION ALTERNATIVES EVALUATED

SV-1 – No action

SV-2 – Monitoring

SV-3 – Mitigation

RECOMMENDED REMEDIAL ACTION ALTERNATIVE

- Alternative GW-2 – Enhanced *In Situ* bioremediation. Alternative 2 would be protective of human health and the environment and meet site Standards, Criteria and Guidance (SCGs). Enhanced bioremediation would provide permanent soil treatment of multiple CPOIs. A pilot test may be conducted to confirm treatment effectiveness and design the remedy.
- In conjunction with Alternative GW-2, Alternative SV-3, installation of active Soil Vapor Intrusion (SVI) mitigation systems within impacted homes, is recommended. This alternative would be implemented following additional assessment of homes within the vicinity of the site.

SECTION 1 INTRODUCTION

1.1 BACKGROUND

This FS Report documents the evaluation of remedial alternatives to address risks identified during the Remedial Investigation conducted at the Temco Site (Site), located at 29 Samsondale Avenue, in the village of West Haverstraw, Rockland County, New York (Figure 1.1).

The purpose of the FS is to identify and screen potentially applicable technologies to address contamination found at the Site, to develop and compare remedial alternatives capable of remediating site contamination to New York State Standards, and to recommend an alternative for design and implementation. This FS Report has been prepared in accordance with 6NYCRR Part 375, and DER-10, Technical Guidance for Site Investigation and Remediation (NYSDEC, 6NYCRR Part 375, Environmental Remediation Programs, Subparts 375-1 to 375-4 & 375-6. December 2006 and NYSDEC, DER-10, Technical Guidance for Site Investigation and Remediation. May 2010).

This report is organized into five sections as follows:

- Section 1 summarizes site information including site history; physical and ecological characteristics; nature and extent of impacts; risk assessment results; and key findings of the RI that pertain to the FS.
- Section 2 identifies regulatory and other applicable requirements, proposed remedial action objectives, preliminary remedial goals, and affected areas and volumes.
- Section 3 identifies and screens potential remedial technologies that address the affected media at the site.
- Section 4 presents and evaluates remedial alternatives in accordance with evaluation criteria that apply to the Temco site.
- Section 5 summarizes the alternative recommended for the site.

Following this FS, NYSDEC will prepare a Proposed Plan for the Temco site that will present the agency's recommended remedy and the basis for its selection. Following a public comment period for the Proposed Plan, NYSDEC will issue a Record of Decision that will specify the remedy to be designed and implemented.

1.2 SITE DESCRIPTION

The Former Temco Uniforms Site (the site) is a 2.6-acre parcel located in the village of West Haverstraw, Rockland County, New York, approximately 25 miles north-northwest of New York City and west of the Hudson River. The site includes an abandoned 32,000 square foot, one-story building and a perimeter fence. The site is located near the edge of the village, adjacent to a residential area. A railroad track extends along the south-southwest side of the site. The site has remained unused since the building became vacant in 2002 and is mostly overgrown with vegetation.

The site is situated at a ground surface elevation of approximately 79 to 85 feet above mean sea level with an approximate 6-foot drop in elevation generally from the northwest to the southeast across the site. This pitch follows the general area topography toward Minisceongo Creek, located approximately 0.5 miles south-southeast of the site, and the Hudson River further downstream.

Groundwater near the Site is not used as a potable water source due to the area being served by public water.

1.3 SITE CHARACTERISTICS

1.3.1 CLIMATE

The climate in the Rockland County area is "humid continental climate", according to the Koppen climate classification system. Air temperatures in the region are generally moderated by the proximity to the coast. Winters are cold with a mean average January temperature of 20ºF with moderate snowfall. The weather limits the construction season to between March and November in most years. Precipitation is relatively evenly distributed throughout the year, averaging roughly 48.85 inches of precipitation per year.

1.3.2 LAND USE

The former Temco site is bordered to the northeast by Samsondale Ave, to the west by Old Mill Rd, to the east by active train tracks and to the south by a row of residential properties. The Temco site is approximately 4,500 feet west of the Hudson river and approximately 1,000 feet north of the Minisceongo Creek.

1.3.3 GEOLOGY AND SOILS

Figures 1.2, 1.3 and 1.4 show plan view and cross sections from soil borings completed at the Site during the RI. Based on the RI and previous investigations at, and in the vicinity of, the Site, the subsurface can be characterized from the ground surface to depth as follows:

- Fill Material - Fill material consisting of fine to coarse sand, and fine to coarse gravel as well as some cobbles. Fill materials range in thickness from approximately 5 to 12 feet.
- Silty Sand Layer Unit –A silty sand unit consisting of coarse, medium and fine sands and silts, mixed with some sporadic coarse to medium gravel. Where found, this unit ranged in thickness from <1 to 25 feet.
- Gravely Sand Unit – A gravely sand unit consisting of moist, dense medium to fine sand and medium to fine gravel. Where encountered, this unit thickness ranges from approximately <1 to 15 feet.
- Sand unit – This unit underlies the fill material, Silty sand, and gravely sand units. This unit consists of medium dense to loose, brown medium to fine sand. This unit was encountered at all boring locations and ranged in thickness from 10 to 60 feet.
- Till unit – This unit underlies the sand unit and was encountered at one location. The till consists of dense poorly graded sands and gravels. The till was encountered approximately 80 feet below existing ground surface and is assumed to be a confining layer, which would need to be confirmed during design.

Groundwater levels measured on five different occasions during this investigation from May 2012 to August 2016 indicated fluctuating directions of groundwater movement. On May 23, 2012, measurements suggested groundwater movement was to the southwest. On November 13 through 15, 2012, measurements suggested groundwater movement was to the east-northeast. On January 14, 2013, measurements suggested groundwater movement was to the south-southeast. On December 3, 2015, and August 29, 2016 measurements suggested groundwater movement was to the east. Varying directions of groundwater movement may be slowing the pace at which groundwater is migrating away from the site or source area.

Minisceongo Creek flows southeast discharging into the Hudson River approximately 0.5 miles east of the site. Precipitation at the Site that does not infiltrate the soils would naturally follow the site topography towards the residential structures to the south of the site and ultimately towards Minisceongo Creek.

1.4 SOURCES OF CHEMICAL PARAMETERS OF INTEREST

The chlorinated VOCs detected at the Temco site, are primarily PCE which is attributed in the RI to dry cleaning operations. Other VOC compounds were also detected in indoor air and subsurface vapor samples. These compounds are common in household products and their presence was not considered a result of dry cleaning operations.

1.5 NATURE AND EXTENT OF SITE IMPACTS

This section summarizes the Nature and Extent of Site Impacts specific to the Remedial Investigation conducted between 2012 and 2016.

1.5.1 SOIL VAPOR INTRUSION INVESTIGATION RESULTS

Based on the 2012 and 2013 soil vapor intrusion analytical results for PCE concentrations in sub-slab air and the New York State Department of Health (NYSDOH) guidance matrix (NYSDOH, 2005), mitigation was recommended for Property 1, Property 2, Property 4 and Property 6. Two other properties showed PCE results below NYSDOH guidance matrix concentrations for which mitigation is recommended. NYSDOH has since successfully installed soil vapor mitigation systems at Properties 2 and 4. Several unsuccessful attempts were made to contact owners of Properties 1 and 11 for the purpose of offering to install soil vapor mitigation.

NYSDOH guidance recommends installation of a mitigation system when sub-slab concentrations are in excess of 100 micrograms per cubic meter. NYSDOH also assess indoor air concentrations when considering whether a mitigation system is warranted.

1.5.2 SURFACE SOIL INVESTIGATION RESULTS

Analytical results for surface soils show a single compound exceeding SCOs for unrestricted use at one sample location, of the six locations sampled. Polynuclear aromatic hydrocarbon (PAH) compound indendo(1,2,3-c,d)pyrene was detected at location SS-04 at a concentration of 0.53 mg/kg, in exceedance of its associated SCO (0.5 mg/kg). No chlorinated compounds were detected at any of the sample locations around and/or in close proximity to the onsite building.

1.5.3 SUBSURFACE SOIL INVESTIGATION RESULTS

Analytical results for subsurface soils collected within the footprint of the onsite building show no exceedances of VOCs in soils above SCOs for unrestricted use. It should be noted that sub-surface soils collected prior to the 2012 Remedial Investigation sampling detected VOCs in the vicinity of the cleaner within the building, but when this area was sampled 2012 no detections were observed.

1.5.4 GROUNDWATER INVESTIGATION RESULTS

Groundwater quality analytical results from the site show contamination from PCE at concentrations above Class GA SGVs. The Class GA Standard for PCE is 5 micrograms per liter (µg/L). Based on the 2016 sampling event of which 14 wells were sampled, 10 were observed to have PCE concentration greater than class GA groundwater standards.

The highest PCE concentrations were observed in site groundwater samples from three locations at more than 20 times the Class GA Standard. The highest PCE concentrations measured in groundwater are outlined below:

Groundwater samples collected from MW-8S, located near the northeast corner of the former dry cleaning building, resulted in the highest PCE concentrations detected during each sampling round. The sample from MW-8S collected in May 2012 reported a PCE concentration of 280 µg/L. The sample from MW-8S collected in November 2012 was the highest of any PCE detection onsite at a concentration of 350 µg/L. Finally, the sample from MW-8S collected in 2016 reported a PCE concentration of 200 µg/L.

Groundwater samples collected from MW-3, also located near the northeast corner of the former dry cleaning building, resulted in the second highest PCE concentrations detected during each sampling round, excluding the 2016 sampling event when a blockage prevented sampling of this location. The sample from MW-3 collected in May 2012 reported a PCE concentration of 220 µg/L. The sample from MW-3 collected in November 2012 was the second highest of any PCE detection onsite at a concentration of 300 µg/L.

Groundwater sample location MW-5, located near MW-3 and MW-8S, is the third location which resulted in PCE concentrations detected more than 20 times its Class GA Standard value. A PCE concentration of 140 µg/L was observed in the sample collected from MW-5 in 2016.

Chloroform was also detected in site groundwater above its Class GA SGV during all sampling rounds. Elevated chloroform concentrations were observed at three locations in May 2012, five locations in November 2012, and only 2 locations in 2016.

1.6 TRANSPORT AND FATE

PCE is the predominant VOC detected in groundwater at the site. Although chloroform was detected in many of the groundwater samples chloroform is not commonly attributed to the dry cleaning operations. Concentrations of PCE in site groundwater are relatively low indicating that it unlikely that dense non-aqueous phase liquids (DNAPL) exists at the site. The mainly stable PCE concentrations between 2008 and 2016 at MW-8S, and further south at MW-10S and MW-10D, suggests potential ongoing source of PCE to groundwater. The higher concentrations of PCE observed in shallow monitoring wells (screens beginning near the water table) within and near the northeast corner of the building where PCE was historically detected in shallow soil (mainly beneath the existing slab) is consistent with this area being the primary source (surface and/or subsurface) of PCE to groundwater. The sandy nature of the surface and subsurface soils likely reduce the extent of abiotic PCE retardation processes including sorption to organic matter and diffusion into fine grained soil intervals. The lack of measurable quantities of Dichloroethylene (1,2-DCE) and Vinyl Chloride (VC) at any concentration, and the high concentrations of dissolved oxygen in groundwater, indicate that natural PCE biodegradation is likely not occurring through reductive dehalogenation, at least not at measurable levels.

1.7 CONCEPTUAL SITE MODEL

The conceptual model for the Temco Site is based on the following key RI findings:

- RI Subsurface soils at the Site contain no VOCs that exceed unrestricted use SCOs.
- Groundwater contains PCE concentrations that exceed New York State Class GA quality standards. PCE was detected at a maximum concentration of 8,631 μg/L in 1997, most recently when the well was re-sampled, PCE was detected at 300 μg/L in 2012.
- Sub-slab vapor samples show that PCE concentrations in the air correlate to the concentrations found in groundwater.
- The ecological value of the Temco site is negligible. The property does not have any significant habitat because of pavement, building size, and a history of commercial use.

SECTION 2 IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES

2.1 INTRODUCTION

This section identifies remedial action objectives (RAOs) used to evaluate remedial action alternatives and select an appropriate remedy for the Temco site.

The development of RAOs requires the identification of standards, criteria, and guidance (SCG), consisting of applicable and promulgated federal and state statutes and regulations for the applicable media. Applicable media of concern, chemical parameters of interest (CPOIs), and exposure pathways must also be identified. The SCGs are evaluated with the media of concern, CPOIs, and exposure pathways to form RAOs.

2.2 SCGS

“Standards and criteria” are cleanup standards and other substantive environmental requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, contaminant, remedial action, location, or other considerations.

“Guidelines” are non-promulgated criterial, advisories, and/or guidance that are not legal requirements and do not have the same status as “standards and criteria”; however, remedial alternatives should consider guidance documents that may be applicable to the project.

The establishment of SCGs during the Feasibility Study provides a benchmark against with remedial alternatives developed can be measured and compared.

The SCGs for groundwater were obtained from 6 NYCRR 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations, and NYSDEC TOGS 1.1.1, “Ambient Water Quality Standards and Guidance Values”, dated June 1998. Groundwater analytical results for the Temco site are compared to Class GA groundwater standards and guidance values. These standards and guidance values would be applicable for the execution of any remedial action taken at the Temco site.

The SCGs for soil vapor were obtained from the Guidance for Evaluating Soil Vapor Intrusion in the State of New York, dated October 2006 (NYSDOH, 2006). Sub-slab vapor concentrations and indoor air concentrations are compared to NYSDOH guidance for recommended actions. This guidance would be applicable for the execution of any remedial action taken at the Temco site.

Any remedial program developed for implementation at the Temco site will be in accordance with 6 NYCRR Part 375, and DER-10 “Technical Guidance for Site Investigation and Remediation”, and in accordance with local Regulations and Ordinances.

2.3 MEDIA AND CONTAMINANT OF CONCERN (COC)

2.3.1 MEDIA OF CONCERN

The RI report for this site identified groundwater and soil vapor as media of concern. In the vicinity of the Site, groundwater is approximately 25 feet BGS. Groundwater wells showing impacts from the CPOI are screened between 25 feet and 60 feet bgs, and are primarily screened within a sand unit. Based on the assessment of impacts measured in vicinity wells and geological strata, movement of CPOIs in groundwater appears to take place horizontally rather than downward. Based on RI results, PCE was not detected in soils (surface and subsurface) in exceedance of 6 NYCRR Part 375 Unrestricted Criteria. PCE exceedances in soil was detected in pre-RI sampling and then this area was further sampled in the RI and PCE impacts were not observed. For the purposes of this FS, soils are not considered a media of concern.

2.3.2 CONTAMINANT OF CONCERN

CPOIs are identified for the Temco site based on screening site data against NYSDEC Class GA Ambient Water Quality Standards and NYSDOH *Guidance for Evaluating Soil Vapor Intrusion in the State of New York* (NYSDOH, 2006). CPOIs are selected so that chemicals present at levels of concern are considered in the evaluation of alternatives.

Table 2.1 summarize instances when the site parameter (PCE) was detected for Temco site groundwater exceed numeric SCGs.

The evaluation of the potential for soil vapor intrusion resulting from the presence of site related groundwater contamination was evaluated by the sampling of sub-slab soil vapor under structures, and indoor air inside structures. This sampling was conducted as part of the RI completed for the Temco site. Based on these sampling results, PCE is considered the primary COC which will drive remediation of soil vapor in alternatives considered in this FS.

2.3.3 PATHWAYS OF CONCERN

Based on the results of the RI, pathways of concern associated with risks to human health exists through site groundwater and soil vapor. Pathways for groundwater include exposure to impacted groundwater through future potential construction (excavation) activities. The groundwater ingestion pathway is not complete, because groundwater is not, has not, and is not planned to be used for human consumption. However, exceedances of groundwater quality standards are noted in accordance with NYSDEC requirements regardless of the anticipated extent of future contact. Pathways for soil vapor exists for residents and workers occupying buildings within the extent of PCE-impacted groundwater.

2.4 REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) are medium-specific objectives for the protection of public health and the environment. The following RAOs have been established for the Temco site, and are based on the evaluation of SCGs, the nature and extent of CPOIs, including their transport and fate, and exposure pathways.

<u>Groundwater</u>

RAOs for Public Health Protection

- Prevent ingestion of groundwater with contaminant levels exceeding drinking water standards.
- Prevent contact with, or inhalation of volatiles, from contaminated groundwater.

RAOs for Environmental Protection

- Restore groundwater aquifer to pre-disposal/pre-release conditions, to the extent practicable.
- Prevent the discharge of contaminants to surface water.
- Remove the source of ground or surface water contamination.

<u>Soil Vapor</u>

RAOs for Public Health Protection

- Mitigate impacts to public health resulting from existing, or the potential for soil vapor intrusion into buildings at a site.

2.5 ESTIMATED SOIL REMEDIATION AREAS, VOLUMES AND CHEMICAL MASS

Based on data collected during the RI, impacted areas and volumes corresponding to exceedances of Class GA groundwater standards have been estimated. For the purposes of this analysis, estimates are based on exceedances of the COCs identified (PCE) in Section 2.3 above. Calculations are summarized in Table 2.2.

The estimated area of exceedance was drawn from Figure 10 of the RI Report (Parsons, 2017). Within these areas, isopleths corresponding to concentration increments were drawn using 2016 groundwater concentrations from wells within each area, as presented on Figures 2.1. The area of each of the isopleth was tabulated, to calculate an area-weighted mass of contaminant. For this calculation, average elevations for the water table and underlying till layer (assumed to be consistent within each area) were used to calculate impacted volumes of groundwater. Contaminant mass estimate was then calculated on an area-weighted basis using the concentration isopleth values, and the quantity of groundwater contained therein. As presented in Table 2.2, the total area exceeding standards for PCE was approximately 1.3 acres (56,116 square feet), which encompasses a groundwater volume of approximately 8.8 million gallons. The estimated mass of PCE within the area that exceeds the Class GA groundwater standard is approximately 33.4 pounds.

Areas and volumes presented represent the limits of known PCE impacts. Further investigation would be required to complete the delineation of the PCE plume. As such, areas and volumes presented in this FS are likely under estimated to the full expanse of impacted groundwater.

SECTION 3 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

3.1 INTRODUCTION

This section identifies and screens control methods and remedial technologies potentially capable of achieving the RAOs identified in Section 2. These control methods and remedial technologies (collectively referred to as *technologies* in the remainder of this report) are identified based on a variety of technical sources, current and anticipated future site use, and site physical and chemical data. The most appropriate technologies are retained for use in developing remedial alternatives.

Conventional as well as innovative technologies are presented in this section. Innovative technologies are defined as those with limited full-scale experience and/or performance and cost data.

3.2 SOURCES FOR IDENTIFYING POTENTIALLY APPLICABLE TECHNOLOGIES

Information used in the identification and screening of potentially applicable technologies was gathered from a variety of sources, including the experience of Parsons. In addition, the following literature sources and databases were reviewed:

- United States Environmental Protection Agency (USEPA) Reach-It Program (http://www.epa.gov/tio/reachit.html).
- USEPA CLU-IN Technology Innovation Office (http://clu-in.org/techfocus/ default.focus).
- Federal Remediation Technologies Roundtable web site (http://www.frtr.gov).
- Army Corps of Engineers Guidance Documents and Technical Notes website (http://www.wes.army.mil/ed/dots/doer).
- Hazardous Substance Research Center South and Southwest (HSRC, 2002) web site.
- USEPA Superfund Innovative Technologies Evaluation Program (http://www.epa.gov/ORD/SITE/).
- USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies* (USEPA, 1988).
- United States Department of Energy (USDOE) Environmental Restoration Program (http://www.em.doe.gov/).
- USDOE Technical Information Exchange (http://www.em.doe.gov/tie/).
- NYSDOH Guidance for Evaluating Soil Vapor Intrusion in the State of New York (http://www.health.ny.gov/environmental/investigations/soil_gas/svi_guidance/docs/svig_final2006_complete.pdf)

Many of these web sites include portals that allow access to additional databases.

3.3 GENERAL RESPONSE ACTIONS

General response actions are broad categories of media-specific actions that, by themselves or in combination with other general response actions, will satisfy the RAOs. General response actions that are potentially applicable at the Temco Site related to groundwater are:

- No action
- Institutional controls
- Containment
- Removal
- Treatment

General response actions that are potentially applicable at Temco Site related to soil vapor are:

- No action
- Monitoring
- Sub slab depressurization systems

3.4 DEVELOPMENT AND SCREENING OF TECHNOLOGIES

Each general response action can be implemented using one or more remedial technologies. Potentially applicable technologies associated with the general response actions listed above are identified and screened in this section of the FS.

NYSDEC DER-10 / Technical Guidance for Site Investigation and Remediation specifies that individual technologies should be preliminarily screened on ability to meet media-specific objectives, short-term and long-term effectiveness, and implementability. In this feasibility study, the screening of technologies is presented as follows:

Effectiveness: This criteria includes an assessment of the ability of technologies to meet media-specific objectives, and an assessment of short-term and long-term effectiveness.

Implementability: This criteria includes an assessment of technical feasibility, availability of the technologies, and the administrative feasibility of implementing a control method or technology (USEPA, 1988 and NYSDEC, 1990). If a method or technology requires equipment, specialists, or facilities that are unavailable within a reasonable time, it would be eliminated from further consideration.

The screening of technologies, including the technical justification for retaining or not retaining each technology, is presented in Table 3.1 for groundwater and Table 3.2 for soil vapor, and are discussed in Sections 3.5 and 3.6 below.

3.5 GROUNDWATER

3.5.1 NO ACTION

Under "No Action," no new remedial action or further action of any type would be implemented. The no action alternative reflects site conditions as described in the RI report. The no-action alternative would be appropriate if the site posed no current or future threat to human health or the environment, or if a previous response had eliminated the need for further remedial response. Generally, where institutional controls or remediation is required to control risks, the no-action remedy is inappropriate. Nonetheless, no action is retained in any FS as a general response action to serve as a baseline for comparison with other technologies.

3.5.2 INSTITUTIONAL CONTROLS

Institutional controls are widely recognized as suitable for use at sites affected with chemicals (USEPA, 2004). Most institutional controls are administrative or legal methods implemented by the owner or governing entities to discourage human exposures to site-related residuals. Institutional controls typically supplement active response actions by reducing effects to human health. By themselves, institutional controls may not always effectively reduce effects on the environment or comply with remediation requirements, but they can be effective to supplement active response methods or technologies as part of a total remediation solution.

The cost to implement institutional controls can vary widely because of site-specific circumstances, and they are often economical methods for reducing the potential for human exposure to affected media. Institutional controls that are potentially applicable to the Temco site are government controls and property use or access controls.

3.5.2.1 Government Controls

Government controls include federal, state, and local government limits on site use. They can include requirements to control site use or site modifications and are implemented through zoning codes, property easements, or permits for building or excavation. These controls can be implemented at the discretion of the governing agency with jurisdiction over the site. They can be implemented by agency action or as court injunctions filed with a court of law. Government controls are retained for further evaluation.

3.5.2.2 Property Controls

Property controls consist of covenants in deeds (environmental easements) for individual properties. They can limit, for example, future site use, restrict use of surface soil or groundwater, prohibit well drilling, and define precautions needed for intrusive activities onsite. Such environmental easements can be an effective and low-cost method for preventing human exposure to affected media. Environmental easements are retained for further evaluation.

3.5.3 CONTAINMENT TECHNOLOGIES

3.5.3.1 Subsurface Barrier Wall

A barrier wall is made of a low-permeability material. It can be installed to keep chemically affected groundwater from migrating from a site. One important factor in the success of a barrier wall for groundwater containment is the presence of a continuous low-permeability geologic unit that the wall can be keyed into. Otherwise, downward movement of groundwater beneath the wall can negate the effectiveness of the wall in limiting horizontal groundwater movement. A till unit exists beneath the Temco site at a depth of approximately 80 feet below ground surface, which could potentially serve as a key-in layer for a subsurface barrier wall. The till was only encountered in one boring to this depth and the permeability of this material is uncertain, although till is usually a relatively dense low-permeability material. Additional geotechnical analysis of the till unit would be needed to verify its suitability for this approach. Another concern of a barrier wall is this environment is the variability of the groundwater flow direction.

Types of subsurface barrier wall technologies would include a slurry trench barrier wall, sheet pile barrier wall, geomembrane barrier wall, deep-soil mixing, compacted clay, conventional and jet grouting, and colloidal silica injection.

However, considering site constraints including the presence of urban infrastructure (e.g., houses, buildings, roads, railways, underground utilities), depth the wall would need to be constructed to below grade and variability in groundwater flow, this technology would not be considered implementable or effective. Therefore, the barrier wall technology is not retained for further evaluation.

3.5.3.2 Groundwater Collection and Treatment

Groundwater collection and treatment can reverse the direction of groundwater flow toward a well or trench and into a site or point of collection. Extraction trenches and extraction wells are reliable and effective conventional methods for containing groundwater. Trenches are generally preferred if groundwater impacts extend along an elongated flow path and are less than 20 to 25 feet deep. Wells are generally preferred if the groundwater to be collected is in multiple distinct areas, if the area is broad laterally in both dimensions, if the groundwater is within sandy, relatively permeable soils, or if the need to extract groundwater is short term. Extraction wells are typically vertical wells, but horizontal wells have also been used to collect shallow groundwater.

Remedial action objectives and subsurface conditions determine the number and location of extraction trenches or wells. A groundwater flow model is often used to provide a basis for optimizing numbers and locations of collection trenches or wells. This technology can be applied in conjunction with capping and a barrier wall to achieve more rapid hydraulic steady-state conditions than containment alone.

Although groundwater collection can effectively achieve containment, groundwater collection generally is not effective for remediating groundwater to meet water quality standards. This is because of the time-dependent decrease in rate of desorption of residuals from soil, and the existence of immobile residuals that can be trapped in low-permeability zones (Doty and Travis, 1991) like those which exist onsite (silty clay and gray clay units). Past performance and modeling studies show that pumping groundwater is effective only for plume containment and some residual mass reduction. Based on these considerations, groundwater collection would not be an effective technology, and is not retained for further evaluation in this FS.

3.5.4 REMOVAL TECHNOLOGIES

3.5.4.1 Soil Excavation

Soil excavation using conventional equipment such as backhoes and bulldozers is typically employed for shallow soil excavation. Targeted removal of shallow (above the groundwater table) "hot spots" or source material can be highly effective when used to supplement other technologies, and increase remedy success rates. Based on data collected during the RI, shallow soils meeting the DER 10 definition of "source area" were not found. However, should further investigation conducted prior to remedy implementation (i.e., pre-design investigation) reveal the presence of such material, excavation could be considered.

Deeper excavations require the use of long-reach excavators or equipment such as clamshells. Either shoring of the excavation sides or sloping of the sidewalls away from an excavation is often needed to maintain safe working conditions and to avoid collapse. Both shoring and side slopes can add significant effort and cost to an excavation. In addition, excavation in the vicinity of occupied buildings and residences increase the level of complexity involved with completion of a deep excavation event.

Soil excavation significantly below the water table can require water management efforts and dewatering and/or solidification of excavated soils. Related construction difficulties and cost factors include space requirements, increased processing time, and measures to prevent releases of contaminants during soil handling. As such, soil excavation is not typically cost-effective for addressing groundwater contamination of PCE. However, it would be considered both effective and potentially implementable. As such, soil excavation is retained for further evaluation.

3.5.4.2 Soil Vapor Extraction with Air Sparging

Soil vapor extraction (SVE) is a source removal option for unsaturated soil above the water table. VOCs can be removed from the subsurface by applying a vacuum through vertical or horizontal wells. The vacuum pulls the impacted vapor to the ground surface for treatment.

Soil vapor extraction is often used in conjunction with air sparging. Air sparging involves the active application of air into the groundwater within the impacted area. The introduction of the air transfers VOCs from groundwater and saturated soil to the unsaturated zone of soil above the water table. As air sparging pushes VOCs up from the saturated zone to the unsaturated zone, vapor extraction can remove the VOCs in the unsaturated zone. The effectiveness of air sparging could be enhanced with the addition of ozone, which can degrade COCs in place; however, spatial limitations would still apply.

Several factors for the Temco site would inhibit the effectiveness of air sparging. The introduction of oxygen though the air sparging process would essentially eliminate any biodegradation of the chlorinated solvent plume that may be occurring, which requires anaerobic conditions. Additionally, air sparging to depths of greater than 80 ft below existing grade through over 50 ft water has challenges. This would render this technology as likely to be less effective than treatment technologies, some of which can be designed to both proactively destroy the chlorinated solvent plume, and foster bioremediation conditions. The flow of air introduced by the sparging process through the saturated zone may be difficult to accurately predict. Given impacts to downgradient homes due to SVI, this could have the potential to exacerbate soil vapor impacts, requiring a more widespread SVE system. Given the relatively large thickness (in excess of 50 ft), and depth of treatment interval (> 75 ft bgs) associated with the Temco site, this could lead to undesired consequences, potentially limiting the effectiveness of the technology. As such, SVE with air sparging is not retained for further analysis.

3.5.5 TREATMENT TECHNOLOGIES

Many different types of groundwater treatment technologies could be implemented. *In situ* groundwater treatment technologies include natural attenuation, bio-remediation, and chemical oxidation. If treatment is applied *in situ*, techniques are needed to transmit needed compounds or medium to the subsurface so treatment can take place. Groundwater can also be treated *ex situ*. However, as described above, collection of groundwater for *ex situ* treatment would not be an effective remedy, and is not considered further in this FS. The different types of *in situ* groundwater treatment processes are discussed in this subsection.

3.5.5.1 Monitored Natural Attenuation

Monitored natural attenuation (MNA) typically consists of long-term monitoring of a system or plume, which relies on natural processes to break the contaminants down into harmless bi-products. The MNA of chlorinated ethenes can be a viable stand-alone remedy if the site conditions provide a natural capacity for plume attenuation sufficient to prevent unacceptable risk to human health and the environment or exceedance of groundwater criteria at regulatory points of compliance. In cases where the natural attenuation rates are not adequate, MNA can be combined with other remedies directed at reducing the source and migration of chlorinated ethenes until MNA is a viable stand-alone remedy.

The natural attenuation capacity is dependent on degradation, adsorption, volatilization, and dispersion that are dependent on site-specific conditions. The degree of natural chlorinated ethene biodegradation is an important factor influencing the extent of chlorinated ethenes attenuation. PCE is biodegradable only under anoxic conditions through reductive dechlorination. During this process, chlorine atoms are sequentially removed resulting in trichloroethene (TCE), 1,2-DCE and VC intermediates, and finally ethene which is an innocuous gaseous end-product. The extent of complete biodegradation versus partial degradation to intermediates varies between sites. Under reducing conditions, abiotic degradation catalyzed by reduced iron and sulfide minerals can contribute to the attenuation of chlorinated ethenes. While PCE is not biodegradable under aerobic conditions, lesser chlorinated ethenes including TCE, 1,2-DCE, and especially VC, are subject to biodegradation under aerobic conditions. Complete chlorinated ethene biodegradation can occur through the biodegradation of PCE and TCE under anoxic conditions followed by 1,2-DCE and VC biodegradation under aerobic conditions, if redox conditions allow for both, such as along a diverse plume flow path.

Results summarized in the 2017 RI indicate negligible or no naturally occurring PCE biodegradation at the site (Parsons, 2017). PCE biodegradation intermediates were not detected in 2016 with the exception of trace levels of TCE (< 1.2 µg/L) at three monitoring wells. High concentrations of dissolved oxygen (6.5 mg/L average) were detected at all monitoring wells except MW-11 (0.8 mg/L) which is screened significantly deeper (70-80 feet below ground surface.) than other monitoring wells at the site. The predominantly sandy surface and saturated soils are conducive to the vertical infiltration of oxygenated precipitation and likely contain insufficient concentrations of total organic carbon needed to support oxygen depletion through aerobic microbial respiration.

Figure 1.5 provides PCE concentrations detected in monitoring wells during the 1997, 2008, 2012, and 2016 sampling events. Although additional monitoring is required to establish PCE concentration trends for several monitoring wells at the site, the following observations suggest decreasing PCE at some wells, and mainly stable PCE concentrations at others:

- The highest PCE concentrations measured at the site were detected in 1997 at MW-3 (8,831 µg/L), MW-4 (4,355 µg/L), and MW-7 (890 µg/L) located near the northeastern corner of the building. PCE concentrations at MW-3 decreased by greater than 10X between the 1997 and 2008 sampling events.
- PCE decreased after 1997 to non-detect concentrations at MW-1 located near the southwestern building corner.
- Overall stable PCE concentrations between 2008 and 2016 have been observed at MW-8S, MW-10S and MW-10D.

The higher concentrations of PCE observed in shallow monitoring wells (10 feet screens beginning at the water table) within and surrounding the northeast corner of the building where PCE was detected in shallow soil is consistent with this area being the primary source (surface and/or subsurface) of PCE to groundwater. The mainly stable PCE concentrations between 2008 and 2016 at MW-8S, and further south at MW-10S and MW-10D, suggests an ongoing source of PCE to groundwater.

Given the above indications, natural attenuation is unlikely to result in substantial decreases in groundwater PCE concentrations within a reasonable time frame. As such, it would not be considered an effective stand-alone technology, but is retained as a potential supplemental technology to combine with more proactive remedial approaches.

3.5.5.2 Enhanced In-Situ Bioremediation (EISB) and In-Situ Chemical Reduction (ISCR)

In general, bioremediation is a common remediation approach for chlorinated ethene plumes in groundwater at similar sites within New York State. Enhanced *in situ* bioremediation (EISB) and *in situ* chemical reduction (ISCR) are discussed jointly in this section because both biodegradation and abiotic chemical reduction reactions are typically initiated during EISB and ISCR implementation. EISB is accomplished by introducing organic substrate(s) to stimulate anaerobic microbial reductive dechlorination. During this process, chlorine atoms are sequentially removed resulting in 1,2-DCE and VC intermediates, and finally ethene which is an innocuous gaseous end-product.

ISCR involves introducing zero valent iron (ZVI) available in a variety of particle sizes dissolved in various carrier solutions. ZVI catalyzes the abiotic degradation of chlorinated ethenes to acetylene, which is a short lived non-chlorinated biodegradable intermediate. The ZVI carrier solutions are biodegradable and serve as substrate to fuel microbial reductive dehalogenation. For example, emulsified vegetable oil can be used as a ZVI carrier.

EISB and ISCR enhance the degradation of adsorbed COCs, COC present in low permeability soil, and DNAPL (ITRC, 2007). Therefore EISB and/or ISCR can be applied to degrade COCs in soil and groundwater within source areas. Example formats for source area treatment include:

- Closely spaced injections throughout the source area
- Injections into the upgradient portion of the source area with downgradient expansion of the treatment area through the advective transport of organic substrate(s).
- Permeable reactive barriers

Commonly used injectable organic substrates include emulsified vegetable oil (EVO), hydrogen release compound (HRC), whey, sodium lactate, and combinations thereof.

Based on site conditions, and previous project experience, a combination of EVO and whey would be expected to be the most effective substrate for this project. These materials are readily available, are cost-effective, and have a proven record of treating chlorinated ethene plumes similar to that found at the site. Implementation of EISB remedy using EVO and whey has been retained for further evaluation.

There are potential drawbacks with EISB and ISCR that should be considered. The potential for daughter product formation and migration beyond an EISB and/or ISCR treatment zone exists. This can be minimized or eliminated through one or more of several means including the use of bioaugmentation cultures, combining EISB and ISCR, creating a treatment zone of adequate width along the flow path to provide enough time for complete COC degradation, and allowing natural biodegradation downgradient of the treatment zone to degrade the intermediates. The oxidizing groundwater conditions at the site should enhance the biodegradation of potential intermediates downgradient of the EISB treatment zone.

One additional potential concern with EISB that has been documented, is the potential generation of methane as a result of the natural degradation of introduced sources of organic carbon. The migration of methane represents a risk for methane accumulation under building slabs located downgradient of EISB application areas. Several conditions at the site limit the potential for methane accumulation under off-site structures including the absence of buildings and residences in the immediate vicinity of the site, sandy soils that allow for dissipation of methane, and elevated dissolved oxygen concentrations which allow for microbial methane oxidation thereby limiting methane migration.

COC concentration rebound (an increase in groundwater concentrations from a post-remediation low) is less prevalent with EISB relative to in-situ chemical oxidation (ISCO) (ESTCP, 2008). Reductions in the source of COCs of about one order of magnitude or more often yield at least a one order of magnitude improvement in down-gradient groundwater quality. In instances of fast groundwater flow, low mass storage in plumes (i.e. less back diffusion from silts/clays), and/or active contaminant attenuation in plumes, a two to three order of magnitude down-gradient improvement in water quality may be observed generally over a period of several years.

Overall, EISB/ISCR would be an effective technology for mitigation of contaminants found at the site.
Therefore, EISB/ISCR based on an EVO and whey mixture is retained for further consideration.

3.5.5.3 Chemical Oxidation

In situ chemical oxidation (ISCO) involves the application of an oxidant into the subsurface to facilitate the oxidation of COCs to innocuous products such as carbon dioxide, water, and chloride. An understanding of the site's hydrogeology and contaminant distribution is necessary to design the ISCO approach in way that maximizes the contact between the chemical oxidant and contaminant. Effective chemical oxidants for chlorinated ethenes (including PCE, TCE, 1,2-DCE, and VC) include permanganate (K or Na permanganate) solution, activated persulfate solution, Fenton's reagent (hydrogen peroxide and iron) solution, and ozone gas. Persulfate ISCO requires the addition of a persulfate activation. Persulfate activators include caustic to raise the pH (i.e. base activated persulfate), chelated iron, heat, and naturally occurring minerals present within the injection area.

Notable differences, advantages, and drawbacks between the above oxidants include:

- The residence time for the oxidants in order of highest to lowest residence time is: permanganate > persulfate > Fentons reagent > ozone.
- Due to the short residence time of ozone, continuous or frequent pulsing is required.
- Permanganate is the only liquid oxidant that is injected as a sole constituent which can simplify the injection process.
- Permanganate solution and sodium persulfate are denser than water, which allows for more effective vertical transport within fractures or porous media where chlorinated ethenes are located.
- Off-gassing can occur during Fenton's reagent injection, leading to increased potential for surfacing and displacing COCs from the treatment area.
- Fentons reagent and sodium persulfate can break down into products post injection that can hinder the bioremediation process on a short term, but will not lead to long-term effects. Permanganate does not break down into products that would hinder the bioremediation process post-injection.

It is anticipated that the final selection of oxidant would be conducted as part of the remedial design process. Based on the considerations and site specific factors noted above, it is anticipated that permanganate or Fenton's reagent would likely be the most effective oxidant for the Temco site.

The design of the oxidant concentration and volume is dependent on the quantity of oxidant required to degrade the COC mass and to overcome that natural oxidant demand (mainly soil associated), the desired radius of influence, and persistence of the oxidant. The latter is less important for permanganate, which is long-lived but can be critical for oxidants including Fenton's reagent that have a short residence time. The aqueous oxidant solutions are prepared above grade and delivered into the subsurface.

ISCO using any chemical oxidant has the potential to increase the concentration of metals in groundwater. Typically, increases in metals concentrations are limited to the treatment zone due to metals attenuation within and downgradient of the treatment area. Multiple rounds of ISCO injections are often required depending primarily on the soil type and COC mass present. An increased number of injections should be anticipated to be required for the treatment of fine soil types and where DNAPL is present.

Overall, ISCO would be an effective technology for mitigation of contaminants found at the Temco site and is retained for further consideration. Therefore, ISCO based on either Fenton's Reagent or permanganate with oxidant delivery based on injection wells, are retained for further evaluation as an Alternative in Section 4. Actual selection of the oxidant would be determined during detailed design, if this technology was selected.

3.5.5.4 Distribution of In Situ Treatment Additives

Delivery of treatment additives (substrate, oxidants, etc.) is typically achieved through either horizontal or vertical injection points. Additionally, in some instances, the installation of an interceptor trench backfilled with treatment additive has been successfully implemented.

Horizontal injection wells installed perpendicular to groundwater flow can be effective for treating thin intervals. These wells are more costly to install than vertical wells on a unit-length basis, but can provide more effective coverage in some instances. Horizontal wells can provide a larger radius of influence, as it is a line source of treatment across an area, providing a larger well screen area than vertical wells. For the Temco site, the thickness of the saturated sand layer (approximately 50 feet), which would likely be the targeted treatment area, this would likely render horizontal wells as not the most cost-effective distribution method. On this basis, the use of horizontal wells to implement *in situ* treatment is not retained for further consideration.

Vertical injection points typically consist of semi-permanent injection wells, or a temporary Geoprobe® -driven injection point that can be raised and lowered during the injection. In many instances, a combination of both are used. Vertical injection relies on a radius-of-influence (ROI) around each point, which would be spaced accordingly to provide full coverage of the desired treatment area. For larger sites, or for sites where a smaller ROI might be expected, vertical injection points may be less cost effective than horizontal wells. However, for the Temco site, given its relative size, and anticipated ROI within the sand layer, vertical injection points may be cost effectively implemented. On this basis, use of vertical points, potentially consisting of both injection wells and injection points, to implement *in situ* treatment is retained for further consideration.

Installation of a trench for the purposes of delivering treatment additives to the desired treatment area is not likely feasible for the Temco site due to the depth the trench would need to be installed to (approximately 80 feet below existing ground surface). On this basis, the use of trenching to implement *in situ* treatment is not retained for further consideration.

3.6 SOIL VAPOR

As discussed in Section 1 above, analysis of samples collected from sub-slab soil vapor at several residences in the vicinity of the Temco site showed PCE concentrations above thresholds at which NYSDOH guidance recommends remedial measures be taken. These impacts to soil vapor are driven by impacted groundwater underlying the area. The technologies discussed in Section 3.5 are intended to address impacted groundwater, which will thereby address the primary factor causing soil vapor impacts. As some of the technologies evaluated will not result in an immediate elimination of impacts, technologies to address soil vapor contamination in the interim are evaluated herein.

To date, not all residences within the suspected impacted groundwater plume have been accessible to NYSDEC and NYSDOH to conduct vapor intrusion sampling. It is anticipated that future sampling will take place to assess these remaining residences. Those future results would ultimately drive required remedial measures. For the purposes of this FS, potential technologies that would be employed are considered herein.

3.6.1 NO ACTION

Under "No Action," no new remedial action or no further action of any type would be implemented. The no action alternative reflects site conditions as described in the RI report. The no-action alternative would be appropriate if the site posed no unacceptable current or future threat to human health or the environment, or if a previous response had eliminated the need for further remedial response. The results of sub-slab and indoor air samples would dictate whether no action would be protective and appropriate or not. No action is retained in any FS as a general response action to serve as a baseline for comparison with other approaches.

3.6.2 MONITORING

Routine monitoring can consist of periodic sampling of sub-slab vapor, basement air, lowest occupied living space air, and outdoor air, depending on location specific factors. This monitoring is designed to provide regular assessment of potentially impacted structures/buildings, to determine whether changing conditions warrant the implementation of, or modification, to an existing mitigation system. The results of sub-slab and indoor air samples would dictate whether a monitoring approach would be protective and appropriate or not. Monitoring of soil vapor is retained for further consideration.

3.6.3 MITIGATION

Active mitigation of impacted soil vapor generally consists of sealing subsurface vapor entry points where soil gas can enter a building or structure (e.g., foundation cracks, sump pumps, dirt floors etc.) and/or installing an active sub-slab depressurization system (SSD system). An SSD system uses a fan-powered vent and piping to draw vapors from beneath the structure's slab or foundation, and discharge to the atmosphere (NYSDOH, 2006). This system results in a decrease in the air pressure beneath the slab, which prevents soil vapor (including potential COCs) from entering the building or structure. In some instances, additional features are necessary to ensure the effectiveness of the system (e.g., application of a soil vapor retarder in the case of a dirt floor basement). When properly installed and maintained, SSD systems are effective in protecting human health, are readily implementable, and cost effective. The results of sub-slab and indoor air samples would dictate whether a mitigation system would be warranted. Active mitigation is retained for further consideration.

SECTION 4 DEVELOPMENT AND EVALUATION OF REMEDIAL ACTION ALTERNATIVES

4.1 INTRODUCTION

Based on the preliminary evaluation of the remedial technologies presented in Section 3, several technologies have been selected for development and further evaluation as a Remedial Alternative. Remedial alternatives evaluated within this Section for addressing the impacted groundwater at the Temco site include:

- Alternative GW-1 No action
- Alternative GW-2 Enhanced *In Situ* bioremediation / MNA
- Alternative GW-3 *In situ* chemical oxidation / MNA
- Alternative GW-4 Soil removal

In addition, remedial alternatives have been identified to address impacted soil vapor within the vicinity of the Temco site. These alternatives include:

- Alternative SV-1 No action
- Alternative SV-2 Long-term monitoring
- Alternative SV-3 Mitigation

A more detailed description of the remedial alternatives, and an evaluation pertaining to how the alternatives compare to the remedy selection factors set forth in NYSDEC DER-10, are presented below.

4.2 CRITERIA FOR EVALUATING REMEDIAL ACTION ALTERNATIVES

Each of the remedial action alternatives is assessed in this FS based on eight evaluation criteria set forth in 6 NYCRR 375-1.8(f). The final criteria (community acceptance) will be addressed after the FS is completed. USEPA and NYSDEC have provided guidance for evaluating these criteria in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*, (USEPA, 1988), and in DER-10 / Technical Guidance for Site Investigation and Remediation (NYSDEC, 2010). The nine evaluation criteria are:

Threshold Criteria

- Overall protection of human health and the environment
- Compliance with SCGs

Primary Balancing Criteria

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost effectiveness

- Land use

Modifying Criteria

- Community acceptance

A remedial action alternative must meet the two threshold criteria to be carried through the detailed analysis of alternatives. If the threshold criteria are met, the primary balancing criteria are evaluated to select an overall remedy among the alternatives. The modifying criteria (community acceptance), will be assessed during the development of the Record of Decision (ROD), based on the public's overall response to the alternatives described in the Proposed Plan and the FS.

A more detailed description of the threshold and primary balancing criteria are as follows:

Overall Protection of Human Health and the Environment

Overall protection of human health and the environment is the primary basis for developing the RAOs presented in Section 2; SCGs have been developed to meet these RAOs. Therefore, by evaluating the extent to which each of the potential alternatives would meet the SCG concentrations, the alternatives are evaluated on their ability to meet the threshold criteria of protection of human health and the environment. This criterion addresses whether or not a remedy provides adequate protection and describes how risks posed through each exposure pathway (based on a reasonable maximum exposure scenario) are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

Compliance with SCGs

SCG compliance is assessed by determining whether or not an alternative meets the federal and state SCGs identified for the Temco site. SCGs identified for this site were presented in Section 2.2 of this Feasibility Study.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of a remedial action are evaluated based on the following criteria:

- Permanence of the remedial alternative
- Magnitude of the human exposures, ecological receptors, and/or impacts to the environment remaining after remediation
- Adequacy and reliability of controls, if any, used to manage treatment residuals or untreated wastes that remain at the site following remediation.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This criterion is evaluated by measuring the effectiveness of material management technologies included as part of an overall remedial alternative. The evaluation of the reduction of toxicity, mobility, or volume through treatment involves consideration of the following:

- Type of containment and treatment
- Degree of expected reduction in toxicity, mobility, or volume
- Degree to which treatment would be irreversible
- Type and quantity of residuals that would be present following treatment.

Short-Term Effectiveness

Short-term effectiveness evaluates the effects of an alternative on human health and the environment during the construction or implementation phase of a remedial action. The following elements are considered while evaluating the short-term effectiveness of each alternative:

- Protection of the community during remedial construction
- Impacts on the environment
- Environmental impacts and impacts to site employees and remediation workers during remedial construction
- Elapsed time until remedial action objectives would be achieved.

Implementability

Implementability considers the technical and administrative feasibility of implementing an alternative and the availability of the services and materials required during its implementation. The following factors are examined as part of implementability to the extent each factor is relevant for a particular alternative:

- Ability to implement selected technologies under site conditions
- Reliability of technology
- Availability of necessary equipment, treatment materials, specialists, skilled operators, and provisions to ensure that any necessary additional resources are available.
- Extent and complexity of monitoring remediation effectiveness following implementation
- Activities needed to coordinate with and obtain consent from other offices and agencies to obtain necessary approvals and permits

Cost

Cost effectiveness as described in DER-10 is an evaluation of the overall cost effectiveness of all phases of a remedial alternative. Cost estimates are developed for each alternative which include initial capital costs, as well as long-term operation, monitoring and maintenance (OM&M) which may be applicable for a remedy. Long term costs in the cost estimate are normalized to develop a present worth for each alternative for comparison. Using these estimates, an assessment is made as to whether the cost is proportional to the overall effectiveness of the remedy. Cost estimates for Alternatives listed above are presented in Appendix A, and summarized for comparison purposes in Table 4.1 and 4.2

Land Use

Evaluation of land use assesses whether a remedial alternative is reasonable based on the current, intended, and reasonably anticipated future use of the site and its surroundings. This assessment considered factors such as:

- current use and historical / recent development patterns;
- zoning;
- brownfield redevelopment opportunities;
- any applicable comprehensive community master plans or land use plans;
- land use of surrounding / adjacent areas;
- public comments;
- environmental justice concerns;
- federal or state land-use designations;
- population growth patterns;

- accessibility of existing infrastructure;
- proximity to culturally significant resources;
- proximity to natural resources;
- impacts to off-site groundwater;
- proximity to floodplains;
- geography and geology; and
- current institutional controls applicable to the site.

Community Acceptance

In accordance with DER-10, community acceptance is evaluated as part of the final selection and approval of a remedy by NYSDEC. Comments submitted on the remedy during the public comment period are considered by NYSDEC for potential modifications to the remedy. As such, no evaluation of remedies for community acceptance is included in this FS Report.

4.3 DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES FOR GROUNDWATER

This section describes remedial alternatives that have been developed for the Temco Site to address impacted groundwater, based on the evaluation of technologies discussed in Section 3. Evaluation of these alternatives with respect to criteria outlined above, is provided in Section 4.4.

4.3.1 GW ALTERNATIVE 1 – NO ACTION

Under Alternative 1, no action would be taken to address site groundwater. Natural attenuation would continue in the site subsurface, but would not be quantified or monitored. This alternative is used as a baseline for comparison purposes.

4.3.2 GW ALTERNATIVE 2 – ENHANCED IN SITU BIOREMEDIATION & MNA

Alternative 2 includes the following technologies retained from the screening conducted in Section 3: institutional controls, enhanced *in situ* bioremediation (EISB) using an EVO and whey mixture, and MNA. Under this alternative, treatment of groundwater would be accomplished by introducing organic substrate(s) to stimulate anaerobic microbial reductive dechlorination, which would more rapidly reduce COC concentrations than the pace of naturally occurring processes. If elevated concentrations of PCE are detected in shallow unsaturated soil during a recommended pre-design investigation, this alternative may include excavating shallow soil impacted with PCE prior to bioremediation injections.

Prior to implementation, a pre-design investigation to refine the vertical and lateral distribution of PCE in groundwater and soil near the northeastern portion of the building would evaluate if PCE concentrations in shallow soil warrant excavation, and provide further definition of the targeted bioremediation treatment area and depth. For the purposes of this FS, this investigation is assumed to include eight membrane interface probe (MIP) borings from ground surface to the underlying till implemented with a Geoprobe® in the vicinity of the northeastern portion of the building. A hydraulic profiling tool (HPT) and conductance detector would be included with the MIP to identify intervals of lower conductivity. The MIP borings would be advanced until background detector readings are observed to a maximum depth of the till previously observed at approximately 50 feet below the water table (~ 85 ft. bls). A total depth of 70 feet bls. is assumed for the MIP borings. Shallow soil samples would be collected for VOC analysis adjacent to three of the MIP locations to confirm the MIP results and to quantify PCE concentrations in shallow soil.

Prior to implementation, a pre-design investigation to refine the vertical and lateral distribution of PCE in groundwater near the northeastern portion of the building would provide further definition of the targeted treatment area and depth. For the purposes of this FS, this investigation is assumed to include the use of a Geoprobe® with push ahead sampler to collect groundwater samples with depth at six locations. Groundwater samples would be collected at five feet intervals and screened in the field for total chlorinated solvents using the AQR Color-Tec® method. Drilling and sampling would continue until field measurements of total chlorinated solvents are below detection to a maximum depth of the till previously observed at approximately 50 feet below the water table (~ 85 ft. bls). Split samples would be sent to the laboratory for VOC analysis.

EVO and whey would be injected as the organic carbon sources into vertical injection wells targeting the source area. Ferrous sulfate would be included to stimulate microbial sulfate reduction and iron sulfide formation to generate more reducing conditions and for scavenging dissolved oxygen. A commercially available bioaugementation culture containing Dehalococcoides bacteria capable of complete PCE biodegradation to ethene would also be injected. For the purposes of this FS, it is assumed that bioremediation would be implemented in two phases, with results from the first phase used to optimize the design of the second phase, including if and where additional injection wells are needed for subsequent injections. Three injection events are anticipated to be required based on experience with EISB at sites with similar conditions.

Figure 4.1 presents a conceptual layout for the anticipated phase 1 injection locations (red circles), four new monitoring well locations, and potential phase 2 injection locations (blue circles). The number of phase 1 injection and monitoring wells, locations, and screened intervals would be finalized during detailed design based on results from the recommended pre-design investigation. Phase 1 injections would be implemented using a line of injection wells installed north of the northeastern corner of the building immediately upgradient of MW-3, MW-5, and MW-11. Locating the injection wells along the upgradient extent of the source area allows groundwater flow to transport organic carbon into the source area. The spacing between injection wells would be approximately 30 feet. The two injection locations adjacent to MW-3 and MW-5 would be comprised of two injection wells, one targeting the upper 15 feet of the saturated zone, and another targeting 15 to 30 feet below the water table. The remaining two injection locations include one injection well targeting the upper 15 feet of the saturated zone. The injection wells and new monitoring wells would be sampled for VOC analysis after installation.

Achieving a 15 foot ROI during the injections is not considered necessary for the EISB application due to the advection and dispersion of dissolved organic carbon from the points of injection. Based on an assumed effective porosity of 20%, and achieving a 12-foot ROI over the 15-foot injection intervals, an injection volume of approximately 10,000 gallons per injection well was calculated. This results in a total injection volume of approximately 60,000 gallons for the phase 1 injection and 100,000 gallons for each of the Phase 2 injections assuming injection into 10 wells as discussed above. Injections would likely be implemented by metering the substrate mixture into a water feed line and injecting into all injection wells simultaneously using a manifold. Based on an estimated injection rate of 2 gpm per well, it is estimated that approximately 6 days of injection would be required for the Phase 1 injection. Approximately 10 days of injection would be required for the Phase 2 injections.

Phase 1 groundwater monitoring would include a baseline (pre-injection) sampling event of all monitoring wells at the site (including three new monitoring wells) and two injection wells. Monitoring within the first year after the Phase 1 injections would include three sampling events of two injection wells; the four newly installed monitoring wells; MW-3; MW-5; MW-11; MW-9; MW-8S; MW-8D; MW-10S; MW-10D; and MW-15. Results from the Phase 1 injections would provide information needed to assess the need for additional injection events and injection wells (i.e. Phase 2). For the purposes of this FS, it is assumed that Phase 2 EISB activities would include:

- Installing two additional shallow injection wells with 15 foot screens beginning at the water table.
- Two yearly injection events using 10 injection wells including two of the Four monitoring wells installed to monitor the Phase 1 injections.
- Semi-annual sampling for two years.

Following completion of the injection activities, site groundwater monitoring wells within the chlorinated ethene plume would be sampled annually, to monitor COCs, until SCGs for groundwater were met. For the purposes of estimating costs in this FS, a monitoring period of 10 years to assess the effectiveness of the remedy is assumed.

4.3.3 GW ALTERNATIVE 3 – IN SITU CHEMICAL OXIDATION & MNA

Alternative 3 includes the following technologies retained from the screening conducted in Section 3: institutional controls, ISCO, and MNA. Under this alternative, treatment of groundwater would be accomplished by delivering oxidants to a targeted treatment area, which would more rapidly reduce COC concentrations than the pace of naturally occurring processes. As discussed in Section 3.5.5.3, for the purposes of this FS, this Remedial Alternative is developed based on the use of sodium permanganate or Fenton's reagent (hydrogen peroxide). Sodium permanganate will be identified as 3A, Fenton's reagent (hydrogen peroxide) as 3B.

Prior to implementation, a pre-design investigation of similar size and scope as described in Section 4.3.2 would be conducted. In addition, further evaluation (e.g., bench-scale testing) may be conducted to optimize the oxidant (type, concentration, volume) planned for injection, based on site contaminants and conditions, including the natural oxidant demand.

During the implementation of this alternative, oxidant will be injected into vertical injection wells within the targeted treatment area. For the purpose of evaluating this alternative, the targeted treatment area is presented on Figure 4.1 and the well construction would be the same as discussed in Section 4.3.2 above. This area encompasses monitoring wells, which have the two highest PCE concentrations seen onsite. Further assessment conducted during the design phase would determine the optimum locations for the treatment area and injection points. Contaminant levels exceeding SCGs have been observed outside of this target area (primarily downgradient), however, contaminant concentrations in these areas are relatively low, and below the point at which they can more efficiently and cost effectively be treated through MNA. MNA in these areas will be enhanced by the upgradient treatment and destruction of chlorinated compounds, which will subsequently reduce the migration of contaminants with groundwater.

Assuming an injection ROI of 10-15 feet (attainable in sand and gravel), it is anticipated that 8-10 injection locations would be required for the planned treatment area. Additional injection wells (approximately 4-5) may be necessary downgradient, depending on further delineation of the plume. Figure 4.1 presents a conceptual layout for the anticipated injection locations. The number of injection wells, locations, and screened intervals would be finalized during detailed design based on results from the recommended pre-design investigation.

For option 3A ISCO via sodium permanganate, based on the size of the treatment area presented in Figure 4.1, effective porosity of 20%, and natural oxidant demand, it is estimated that approximately 169,000 gallons of 10% sodium permanganate, or equivalent oxidant mass, would be required. Based on experience at similar sites, a 1-day injection pilot test (roughly 2,000 gallons of permanganate) may be considered prior to full-scale implementation, which would be used to gauge site conditions during an injection event and to refine plans for the full-scale events. Following completion of the pilot study, and interpretation of the data, the first full-scale injection event would be conducted. It is assumed that approximately half of the total estimated necessary volume would be injected during this event, which would be anticipated to take 2-3 weeks to complete.

For option 3B ISCO via Fenton's reagent (hydrogen peroxide), based on the size of the treatment area presented in Figure 4.1, effective porosity of 20%, and natural oxidant demand, it is estimated that approximately 80,000 gallons of 17.5% hydrogen peroxide, or equivalent oxidant mass, would be required. Based on experience at similar sites, a 1-day injection pilot test (roughly 2,000 gallons of hydrogen peroxide) may be considered prior to full-scale implementation, which would be used to gauge site conditions during an injection event and to refine plans for the full-scale events. Following completion of the pilot study, and interpretation of the data, the first full-scale injection event would be conducted. It is assumed that approximately half of the total estimated necessary volume would be injected during this event, which would be anticipated to take 1-2 weeks to complete.

The presence of underground utilities can be of concern for ISCO projects, as bedding material and/or utility lines can serve as preferential pathways for injections (as well as for contaminants). Additionally, some oxidants can adversely impact certain types of pipe. Permanganate typically has less potential for causing adverse impacts to utilities. The anticipated treatment zone shown in Figure 4.1 would likely be set a distance of 10-15 feet away from most underground utilities, which are typically routed under roadways. In addition, the injection depth intervals (likely ranging from 25 to 50 feet deep, corresponding to impacted groundwater discussed in Section 2.3.1) would add a degree of protection for underground utilities within the area, which are not typically buried as deep. Additional precautionary measures, such as installation of monitoring wells adjacent to sensitive utilities can be implemented, to provide that adverse impacts are not being caused by ISCO activities. Further consideration will be given during the design phase to assess potential impacts on utilities, and appropriate mitigation steps.

Sampling of existing monitoring wells would be conducted before implementing the first injection, and during two separate events following the first injection. Results from these samples would provide information needed to refine the design for the second injection event. For the purposes of this FS, it is assumed that one additional similarly-scaled injection event would be required, which would take place 1 year after the first injection. Following this injection, it is assumed the project would transition to an MNA phase.

Following completion of the injection activities, site groundwater monitoring wells within the chlorinated ethene plume would be sampled annually, to monitor COCs, until SCGs for groundwater were met. Assuming an estimated order of magnitude reduction in COCs following treatment, a period of approximately 10 years would be estimated until SCGs were fully met. Further assessment of this duration would be conducted during the design, and subsequent to the implementation of the remedy. For the purposes of estimating costs in this FS, a monitoring period of 10 years to assess the effectiveness of the remedy including natural attenuation after the injections is assumed.

4.3.4 GW ALTERNATIVE 4 – SOIL REMOVAL

Alternative 4 includes the following technology retained from the screening conducted in Section 3: soil removal. Under this alternative, soil impacted with chlorinated ethenes would be removed and disposed of off-site. As part of this remedy, impacted groundwater within the excavation would be collected, treated, and discharged. Soil concentrations were not found in exceedance of SCGs, therefore the limit of soil removal corresponds to the anticipated depth of groundwater impacts. Although soil removal is not typically a preferred method to address impacted groundwater, it would likely be considered effective and implementable (as discussed in Section 3), and is thereby considered in this FS for completeness as a full-removal alternative.

Soil removed for this alternative would correspond to the depth of the till layer, approximately 80 feet bgs, and further described below.

Removal would be conducted where groundwater concentrations of PCE were found in exceedance of SCGs (See Figure 4.1), and would encompass the known groundwater impacted by PCE. The depth of excavation would extend approximately 50 feet below the water table, and would encompass several homes, railroad track and a portion of the Temco building itself. Total volume of soil to be removed for this alternative would be approximately 165,000 cy assuming excavation 80 ft below existing grade. Based on the estimated removal volume, and activities associated with demolition of numerous structures, it is estimated that this Alternative would take approximately 2 years to complete. Actual construction duration could change, as design and construction planning would assess conditions and construction sequencing factors.

Areas and volumes presented represent the limits of known PCE impacts. Further investigation would be required to complete the delineation of the PCE plume. As such, areas and volumes presented in this FS are likely under estimated to the full expanse of impacted groundwater.

A construction laydown area would be necessary, including sufficient space for stockpiling of excavated material prior to trucking to the selected disposal site. Based on site analytical data, it has been assumed that excavated material would be disposed of as non-hazardous material. Additionally, since COCs have not been found in all surface soils, it may be possible to segregate clean soils overlying the sand and gravel layer, for reuse / backfill material.

Given the significantly deep excavation depths, appropriate precautionary measures would need to be taken to provide for the stability of the excavation, and adjacent structures may or may not be able to be left in place if detailed design showed excavation side sloping and set-backs were required. Construction water from the excavation work below the groundwater table would be collected, treated to discharge limits established by NYSDEC, and discharged in accordance with NPDES Permit requirements outlined in 6 NYCRR Part 375. Following the completion of excavation activities, the site would be backfilled with clean fill material, and restored to existing grade.

4.4 REMEDIAL ALTERNATIVE COST ESTIMATES

In accordance with DER-10, estimates have been developed for the remedial action costs that would be required for each development and implementation of the Alternatives listed in Section 4.4 above. For each Alternative, these estimates account for:

- All direct and indirect capital and engineering costs, including labor, materials, equipment, land purchase costs, etc.;
- Costs associated with Institutional Controls that may be required for a remedy, including associated legal, administrative, and capital costs;
- Long-term costs associated with remedy monitoring; and
- Remedial costs normalized to represent net present worth.

Cost estimates for Alternatives listed in Sections 4.3 are presented in Appendix A, and summarized for comparison purposes in Table 4.1. In estimating costs for each of the Remedial Alternatives under consideration, several assumptions were made, based on engineering judgment and practices. Assumptions for each alternative are documented on the associated estimate sheet in Appendix A.

4.5 EVALUATION OF REMEDIAL ALTERNATIVES FOR GROUNDWATER

Provided below, and summarized on Table 4.3, is an analysis of the remedial alternatives described in Section 4.3, with respect to each of the evaluation criteria presented in Section 4.2.

4.5.1 ALTERNATIVE #GW-1 – NO ACTION

4.5.1.1 Overall Protection of Human Health and the Environment (GW-1)

This Alternative would not be considered an effective means of achieving the RAOs for the Temco Site, and would not be protective of human health and the environment. Any naturally occurring degradation of the impacted groundwater plume would continue, and may eventually result in compliance with site SCGs. However, as presented in Section 3.5.5.1, the timeline for this degradation to occur may be significant. In addition, conditions contributing to impacts to soil vapor would be unmitigated. Under this alternative, there would be no institutional controls in place to prevent future exposure to impacted groundwater.

4.5.1.2 Compliance with SCGs (GW-1)

Since no action would be taken, any action-specific or location-specific SCGs would be met. Compliance with chemical-specific SCGs may eventually be met. However, this would be dictated by the pace of any naturally occurring biodegradation processes that may be in place, which are estimated to take in excess of 30 years to reach SCGs. Under this alternative, this process, and compliance with SCGs, would not be monitored.

4.5.1.3 Long-Term Effectiveness (GW-1)

This alternative would not provide significant long-term effectiveness, since the potential for transport and migration of contaminants would not be eliminated, and potential exposure routes would go unaddressed. Ongoing impacts of groundwater on soil vapor would go unmitigated.

4.5.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment (GW-1)

The toxicity and volume of site contaminants in groundwater would continue to be reduced slowly over time from on-going natural attenuation. Mobility of contaminants would not be reduced.

4.5.1.5 Short-Term Effectiveness (GW-1)

Implementation of this remedy would have no effect on the community as no action would occur. Current potential direct exposure to site groundwater is minimal; however, potential ongoing exposure to impacted soil vapor would not be mitigated.

4.5.1.6 Implementability (GW-1)

A *no action* alternative is implementable.

4.5.1.7 Cost (GW-1)

No capital or O&M costs are associated with this alternative.

4.5.1.8 Land Use (GW-1)

This alternative would allow for the present and anticipated future use of the Temco site and surrounding area.

4.5.2 ALTERNATIVE #GW-2 – ENHANCED IN SITU BIODEGRADATION / MNA

4.5.2.1 Overall Protection of Human Health and the Environment (GW-2)

This alternative would be an effective means of achieving the RAOs for the Temco site, and would be protective of human health and the environment. The introduction of the injected substrate into the subsurface would expedite and enhance the natural degradation processes that are already occurring. Ongoing natural degradation processes that may be in place downgradient would continue. A long-term monitoring program would gauge degradation trends until SCGs have been met, and institutional controls would be put into place to prevent future direct exposure to impacted groundwater.

4.5.2.2 Compliance with SCGs (GW-2)

Based on experience at numerous similar sites, and analysis of conditions at the Temco site, it is expected that chemical-specific SCGs would be met following treatment and a period of monitored biodegradation (estimated to be less than 10 years). Implementation in compliance with action-specific and location-specific SCGs would also be expected.

4.5.2.3 Long-Term Effectiveness (GW-2)

Following treatment and an MNA period, this alternative would provide long-term effectiveness, as contaminants present in and around the Temco site would be permanently eliminated. Potential exposure of contaminated groundwater is low, and the use of institutional controls would be implemented to further reduce potential exposures until SCGs are met. Impacts of contaminated groundwater on soil vapor would be mitigated and eliminated once SCGs are met.

4.5.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment (GW-2)

The toxicity, mobility, and volume of contamination would be reduced by the degradation process introduced into the subsurface by this alternative, and would continue during the MNA process until SCGs have been met.

4.5.2.5 Short-Term Effectiveness (GW-2)

It is anticipated that three injection events (one pilot event, and two full-scale events) would be required for this Alternative. A series of wells would be required to inject the media into the groundwater. These injection points would be installed on the Temco property, and would not impact public accessibility to roads, sidewalks, etc. Construction safety risk would need to be addressed through the development and implementation of a health and safety plan in accordance with Occupational Safety and Health Administration (OSHA) requirements. Injections would require careful planning and execution to limit methane that would be generated as a result of the biodegradation process. While this would not limit the effectiveness of the remedy, it may pose a concern if it accumulates; however, given the distance to structures and thickness of unsaturated soil this is not expected to be a concern. Additionally, this generation can be reduced through deliberate formulation of the substrate, and can be monitored during implementation, but cannot be fully eliminated.

Implementation of the MNA phase of the project would be unlikely to result in human exposures, adverse environmental impacts or nuisance conditions.

4.5.2.6 Implementability (GW-2)

This alternative would be implementable. Access agreements would be required for short term periods to install wells and inject the substrate, and in the long term access to monitoring wells for MNA. Experienced personnel, equipment, and materials needed for this alternative are readily available, due to the relative widespread use of this technology at other remediation sites. Monitoring activities associated with MNA are routine, and similar to sampling activities that have taken place at this site as part of the RI. Application of institutional controls would require legal counsel, and property owner consent, but are implementable.

4.5.2.7 Cost (GW-2)

Initial estimated capital cost of this alternative is $791,000. Total estimated present value cost for this alternative is $956,000. Table 4.1 summarizes costs estimated for each alternative. Appendix A provides the cost spreadsheets and other assumptions that form the basis for these cost estimates.

4.5.2.8 Land Use (GW-2)

This alternative would allow for the present, and anticipated future use of the Temco site and surrounding area.

4.5.3 ALTERNATIVE #GW-3 – ISCO / MNA

4.5.3.1 Overall Protection of Human Health and the Environment (GW-3)

This alternative would be an effective means of achieving the RAOs for the Temco site, and would be protective of human health and the environment. The introduction of the oxidants into the subsurface would destroy existing contaminants, leaving environmentally benign byproducts. Ongoing natural degradation processes that may be in place downgradient of the treatment area would continue. An MNA period would gauge degradation trends until SCGs have been met, and institutional controls would be put into place to prevent future direct exposure to impacted groundwater.

4.5.3.2 Compliance with SCGs (GW-3)

Based on experience at numerous similar sites, and analysis of conditions at the Temco site, it is expected that chemical-specific SCGs would be met following treatment and a period of MNA included in this alternative. Implementation in compliance with action-specific and location-specific SCGs would also be expected.

4.5.3.3 Long-Term Effectiveness (GW-3)

Following treatment and an MNA period, this alternative would provide long-term effectiveness, as contaminants present in and around the Temco site would be permanently eliminated. Potential exposure of contaminated groundwater is low, and the use of institutional controls would be implemented to further reduce potential exposures until SCGs are met. Impacts of contaminated groundwater on soil vapor would be mitigated and eliminated once SCGs are met.

4.5.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment (GW-3)

The toxicity, mobility, and volume of contamination would be reduced by the oxidation process introduced into the subsurface by this Alternative, and would continue during the MNA process until SCGs have been met.

4.5.3.5 Short-Term Effectiveness (GW-3)

It is anticipated that three injection events (one pilot event, and two full-scale events) would be required for this alternative. A series of injection points would be required to inject oxidants into the groundwater. It is anticipated that these injection points would be installed on the Temco property, and would not impact public accessibility to roads, sidewalks, etc. Construction safety risk would need to be addressed through the development and implementation of a health and safety plan in accordance with OSHA requirements. Injections would require careful planning and execution to limit off gasses or daylighting of the injected media, which could cause concern with the local community. Potential risks to underground utilities due to oxidants would need to be mitigated through the design process, and through additional steps taken during implementation.

4.5.3.6 Implementability (GW-3)

This alternative would be implementable. Access agreements would be required for short term periods for injection events, and in the long term access to monitoring wells for MNA. Experienced personnel, equipment, and materials needed for this alternative are readily available, due to the relative widespread use of this technology at other remediation sites. Monitoring activities associated with MNA are routine, and similar to sampling activities that have taken place at this site as part of the RI. Application of institutional controls would require legal counsel, and property owner consent, but are implementable.

4.5.3.7 Cost (GW-3)

Initial estimated capital cost for the sodium permanganate alternative is $2,561,000 and total estimated present value cost for this alternative is $2,698,000. Initial estimated capital cost for the Fenton’s reagent alternative is $1,213,000 and total estimated present value cost for this alternative is $1,349,000. Selection of the actual reagent would be determined during design, if this alternative is selected. Table 4.1 summarizes costs estimated for each alternative. Appendix A provides the cost spreadsheets and other assumptions that form the basis for these cost estimates.

4.5.3.8 Land Use (GW-3)

This alternative would allow for the present, and anticipated future use of the Temco site and surrounding area.

4.5.4 ALTERNATIVE #GW-4 – SOIL EXCAVATION

4.5.4.1 Overall Protection of Human Health and the Environment (GW-4)

Soil removal (excavation) would provide protection to human health and the environment through the removal of the soil from within the footprint of the impacted groundwater plume. Impacted groundwater would subsequently be collected and treated, eliminating potential further impacts to human health or the environment.

4.5.4.2 Compliance with SCGs (GW-4)

It is expected that chemical-specific SCGs would be met following excavation in this alternative. Implementation in compliance with action-specific and location-specific SCGs would be required by the remedial contractor, and would be detailed in the remedial design and remedial action work plan that would be prepared.

4.5.4.3 Long-Term Effectiveness (GW-4)

This alternative would provide long-term effectiveness, as contaminants present in and around the Temco site would be permanently removed, and disposed of within a permitted disposal facility.

4.5.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment (GW-4)

Toxicity and volume would be eliminated under this alternative as all impacted soil and groundwater would be removed and disposed of in a permitted disposal facility. Although some reductions would come through treatment through the treatment of collected groundwater, a majority of the reduction in toxicity, mobility, and volume would not be through treatment.

4.5.4.5 Short-Term Effectiveness (GW-4)

This alternative would involve the demolition of the Temco building, adjacent homes, a railway, as well as relocation of existing utilities to access the planned excavation area. Given the depth and anticipated footprint of this excavation, road closures may also be required to complete this alternative, which would require significant planning and coordination with numerous public entities. Public and construction worker health and safety would need to be addressed under this alternative by developing and implementing a health and safety plan in accordance with OSHA requirements.

Under this alternative, potential dust and volatile emissions, construction water, and excavated soil would need to be properly managed to minimize short-term risks associated with migration of constituents. In addition, excavation may need to include measures such as shoring to preserve the structural integrity of the building and properties outside the excavation.

Excavation is a rapid method for removing contaminant mass from a site. For this alternative, it is estimated that soil can be removed from the removal area within approximately three years.

4.5.4.6 Implementability (GW-4)

Excavation procedures and experienced personnel are available. Excavation and removal can be implemented, although it would be more difficult because additional safety efforts would be required with a deep excavation, air monitoring controls (as required) would be needed for a longer time period, and more construction water would need to be managed. In addition, care must be taken that the surrounding properties not in the removal area as well as the active train tracks to the east of the Temco property are not affected by soil removal. Excavation work would need to be kept a safe distance away from these structures. Based on soil characteristics and type and depth of the building foundations, shoring would need to be installed short term while soil is being excavated. The required distances away from the building and whether shoring would be required would be determined during remedial design.

4.5.4.7 Cost (GW-4)

Total estimated present value cost for this alternative is $56,000,000. Table 4.1 summarizes costs estimated for each alternative. Appendix A provides the cost spreadsheets and other assumptions that form the basis for these cost estimates.

Areas and volumes presented represent the limits of known PCE impacts. Further investigation would be required to complete the delineation of the PCE plume. As such, areas and volumes presented in this FS are likely under estimated to the full expanse of impacted groundwater.

4.5.4.8 Land Use (GW-4)

This alternative would lead to a significant impact on current land use, as all structures, roadways/railways, and utilities within the extent of the excavation area would need to be removed. Following excavation, the area would be backfilled to approximate existing grade and future land use would need to be determined, and developed.

4.6 COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES

A comparative analysis between the groundwater remedial alternatives is presented in the following sections, and is summarized in Table 4.4. In order for an alternative to be considered for selection, the first two threshold criteria must be met.

4.6.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative GW-1 would not be protective of human health and the environment, as impacted groundwater would remain in place, unmitigated. GW-2 and GW-3, would satisfy this criteria, as all would result in the elimination or destruction of the highest levels of contamination in groundwater. Lower levels of contamination downgradient of the targeted treatment/removal areas would continue to naturally attenuate. To address known exposure pathways, these alternatives would be supplemented by remedial action taken to address soil vapor, as described in Section 4.7 below. GW-4 would satisfy this criterion as known impacts would be removed.

4.6.2 COMPLIANCE WITH SCGS

Alternatives GW-2, GW-3, and GW-4 rely on active remedial approaches with GW-2 and GW-3 relying also on long-term monitoring to achieve SCGs. Treatment in alternatives GW-2 and GW-3 would rapidly address highest levels of contamination, and a period of MNA would be implemented to monitor conditions downgradient where treatment would be less effective. It is estimated compliance with SCGs at all monitoring wells would be achieved within 10 years under GW-2 and GW-3 and at the completion of construction under GW-4, estimated to be approximately 3 years.

4.6.3 LONG-TERM EFFECTIVENESS

The concentrations of contaminants in groundwater and the nature of the sand layer which contains the majority of the contaminant plume at the Temco site are such that *in situ* treatment (either enhanced anaerobic biodegradation or ISCO) would be expected to have comparable long-term effectiveness as soil excavation over an estimated 10 years. Alternatives GW-2 and GW-3 would both involve active remediation to the most heavily impacted area, and rely on MNA for less impacted areas downgradient. GW-4 would achieve this criterion at the end of excavation.

4.6.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

GW-2 and GW-3 would both result in a significant reduction of toxicity, mobility, and volume through treatment. GW-4 would result in a complete reduction of known impacted mobility; however that would not come via treatment, but by disposing of impacted material to a permitted disposal facility, and through treatment of collected groundwater.

4.6.5 SHORT-TERM EFFECTIVENESS

GW-2 and GW-3 would have significantly less impact on the community than option GW-4. GW-4 would have significant short-term impact on the community. This remedy would affect roadways, railways, utilities and homes during the process of removing the soil and groundwater below them within the footprint of the impacted plume. Both GW-2 (through potential for methane generation), and GW-3 (through potential impacts to underground utilities) have potential short-term effectiveness factors. Although the potential for both can be reduced through the design process.

In terms of short-term reductions on conditions contributing to impacts on soil vapor, alternative GW-4 would have the largest impact, as it would result in complete elimination of impacted groundwater and soil within the removal area. Alternative GW-3 would likely result in a slightly faster decline in groundwater concentrations as compared to GW-2, as the permanganate or Fenton's reagent would begin oxidizing COCs immediately upon injection. Alternative GW-2 would rely on the development of a biological culture following injections to reduce COC concentrations in groundwater, which would take a period of time longer than GW-3, and is expected to have the same effect after that period of time.

4.6.6 IMPLEMENTABILITY

Alternatives GW-2 and GW-3 are readily implementable. For the purposes of this FS, the construction footprint needed to implement GW-2 and GW-3 is assumed to be available space on the Temco property. Should conditions warrant expansion of injections beyond the Temco property, the nature of the activities and the equipment typically employed are relatively small, and would not likely lead to any impacts on the community.

GW-4 would be implementable; however, the significantly deep excavation and large footprint of removal would cause significant disruption to the area including demolition of homes, roadways, railroads, and utilities.

4.6.7 COST

Based on cost estimates developed for this FS, Alternative GW-2 is less costly than Alternatives GW-3 and GW-4. A cost summary is presented in Table 4.1. FS cost estimates are prepared to an accuracy of -30% / +50%. This range accounts for the potential for additional variables that may be identified during later stages of the remedial design, which may change the cost to implement a remedy. Alternative GW-4 would be considerably more expensive to implement, in comparison to GW-2 and GW-3.

4.6.8 LAND USE

Alternatives GW-2 and GW-3 both would allow for the present and anticipated future use of the site. Alternative GW-4 would impact present use of the site during implementation of the remedy, but would ultimately allow for anticipated future use of the site.

4.7 DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES FOR SOIL VAPOR

Based on NYSDOH guidance, remedy selection pertaining to addressing soil vapor contamination is driven by sampling results from individual structures or residences. Based on information collected to date, it is anticipated that additional characterization sampling of residential homes is needed, and will be conducted. Based on the sampling results, the appropriate response corresponding to the Alternatives below will be implemented. For the purposes of developing cost estimates, it is assumed that implementation of a remedial alternative will be required at ten additional residences in the vicinity of the Temco site. This assumption is arbitrary, the actual quantity of residences requiring consideration for remedial action will be based on the results of future sampling events.

4.7.1 ALTERNATIVE SV-1 - NO ACTION:

Under Alternative SV-1, no action would be taken to address site soil vapor. For this Alternative to be selected, future sampling results of subsurface vapor at a specific structure/residence would need to be below levels which NYSDEC and NYSDOH establish for monitoring or mitigation.

4.7.2 ALTERNATIVE SV-2 - LONG-TERM MONITORING:

Under Alternative SV-2, additional or long-term monitoring would be implemented at a structure/residence, intended to monitor presumably decreasing trends in subsurface vapor concentrations. For this Alternative to be effective, future sampling results of subsurface vapor at a specific structure/residence would need to be below or approaching levels which NYSDEC and NYSDOH establish for mitigation.

4.7.3 ALTERNATIVE SV-3 – MITIGATION:

Under Alternative SV-3, a mitigation system would be installed, which would draw impacted subsurface vapor from beneath the structure/residence, preventing infiltration into living space within the structure. For this alternative to be selected, future sampling results of subsurface vapor at a specific structure/residence would need to be at or above levels which NYSDEC and NYSDOH establish for mitigation. As part of this remediation, intermittent monitoring may be conducted in the future to assess the continued need for operation of the mitigation system.

4.8 COMPARATIVE ANALYSIS OF SOIL VAPOR ALTERNATIVES

As described in Section 4.6 above, implementation of a remedy to address soil vapor for a commercial or residential structure is primarily driven by indoor air and sub-slab samples collected at each location, which would be conducted in accordance with “Guidance for Evaluating Soil Vapor Intrusion in the State of New York (NYSDOH, 2006). Based on these factors, the potential exist where any of the three soil vapor remedies described above could be the minimum level of action needed to provide protection of human health and the environment, and to satisfy the remaining evaluation criteria. As such, a formal evaluation of alternatives is not conducted herein.

SECTION 5 RECOMMENDED REMEDIAL ACTION ALTERNATIVE

Based on the analysis of alternatives presented in Section 4, Parsons recommends implementing Alternative GW-2 (Enhanced *In Situ* Bioremediation) to remediate groundwater at the Temco site. This alternative would provide for a proactive and reduction of PCE in the area of the highest levels of PCE in groundwater. GW-2 also is expected to the be the least cost of the active remedies.

To implement Alternative GW-2, the subsurface would be prepared to receive EVO in liquid form. A pilot test would be conducted to confirm treatment effectiveness and design the remedy. During implementation, the EVO would be added during two rounds of injections over a 1 to 2-year period, followed by the monitoring of ongoing natural attenuation of the plume down gradient, until site remedial action objectives are met.

Based on results from other sites and an analysis the Temco site characteristics, enhanced bioremediation can meet the two threshold evaluation criteria of protecting human health and the environment at the site and complying with site SCGs. Enhanced bioremediation has been effectively implemented at other similar sites in New York sites. The estimated present value for Alternative GW-2 is $956,000.

As discussed, a PDI is recommended to provide additional data upon which the full-scale remediation would be designed. Although no shallow soil containing high levels of PCE was found during the RI, one surface soil sample location (SS-04) showed elevated levels of PAH. It is recommended that other remedial measures (e.g., limited source removal) be considered in the Proposed Plan, should “source” material be found during the PDI.

Implementation of enhanced bioremediation at the Temco site will reduce the source and concentration of PCE in the groundwater in the vicinity of the source, thereby reducing impacts to soil vapor, and potential for soil vapor intrusion, over time. To address impacts from soil vapor in the interim, assessment of impacted homes within the vicinity of the Temco site is recommended, with appropriate actions taken based on sampling result, and NYSDOH guidance. For the purposes of this FS, alternative SV-3 (mitigation) is included as a component of the recommended remedy. Actual remedial approach would be determined by NYSDEC and NYSDOH, on a house-by-house basis.

SECTION 6 REFERENCES

Army Corps of Engineers Guidance Documents and Technical Notes website (www.wes.army.mil/ed/dots/doer).

Doty and Travis, 1991.

Federal Remediation Technologies Roundtable web site (http://www.frtr.gov).

Hazardous Substance Research Center South and Southwest (HSRC, 2002) web site.

Interstate Technology & Regulatory Council (ITRC) Bioremediation of DNAPL's Team. 2007. In situ bioremediation of chlorinated ethane DNAPL source zones: case studies.

NYSDEC, 6NYCRR Part 375, Environmental Remediation Programs, Subparts 375-1 to 375-4 & 375-6. December 2006.

NYSDEC, DER-10, Technical Guidance for Site Investigation and Remediation. May 2010.

NYSDEC,1998. Division of Water Technical and Operational Guidance Series (1.1.1), Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations. June 1998.

NYSDOH, 2005. New York State Department of Health (NYSDOH), 2005. Guidance for Evaluating Soil Vapor Intrusion in New York State. Public Comment Draft February 2005.

NYSDOH, 2006. Guidance for Evaluating Soil Vapor Intrusion in the State of New York. October 2006.

Parsons 2017, Remedial Investigation Report for the Former Temco Uniforms Site. January 2017.

Parsons, 2010. Loading Rates and Impacts of Substrate Delivery for Enhanced Anaerobic Bioremediation. Environmental Security Technology Certification Program Project ER-0627.

Parsons, 2012. Work Scope for Former Temco Uniforms Site Remedial Investigation. Prepared for NYSDEC. March 2012.

Parsons. 2008. Technical Protocol for Enhanced Anaerobic Bioremediation Using Permeable Mulch Biowalls and Bioreactors. Air Force Center for Engineering and the Environmental Environmental Science Division.

Rickard, L. V. and D. W. Fisher, 1970. Geologic Map of New York, Finger Lakes Sheet, NYS Museum and Science Service Map and Chart Series No. 15. 1970.

Sale, T, C. Newell, H. Stroo, R. Hinchee, and P. Johnson. 2008. Frequently asked questions regarding management of chlorinated ethenes in soils and groundwater. ESTCP.

USDOE Environmental Restoration Program (http://www.em.doe.gov/).

USDOE Technical Information Exchange (http://www.em.doe.gov/tie/).

USEPA CLU-IN Technology Innovation Office (http://clu-in.org/).

USEPA Reach-It Program (http://www.epa.gov/tio/reachit.html).

USEPA Superfund Innovative Technologies Evaluation Program (http://www.epa.gov/ORD/SITE/).

USEPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. October 1988.

USEPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study.

USEPA, 2002. Groundwater Issue: Calculation and Use of First-Order Decay Constants for Monitored Natural Attenuation Studies. EPA/540/S-02/500. November 2002.

USEPA, 2004. Strategy to Ensure Institutional Control Implementation at Superfund Sites. OSWER No. 9355.0-106. September 2004.

USEPA, 2010. *United States Environmental Protection Agency Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review*, USEPA, January 2010.

TABLES

Table 2.1
Summary of Exceedances
Temco Site Final Feasibility Study
West Haverstraw, New York

DETECTED CHEMICALS (with at least one exceedance)	RATIO OF EXTENT OF EXCEEDANCES TO TOTAL NUMBER OF SAMPLES		
	NYS Class GA	Max. Detected to NYS Class GA Standard	Locations with Exceedances
Chloroform	4/19	17	MW-11, MW-15, MW-6, MW-7
Tetrachloroethylene (PCE)	15/19	4355	MW-6, MW-7, MW-4, MW-13, MW-2, MW-14, MW-16, MW-17, MW-10D, MW-10S, MW-15, MW-8D, MW-8S, MW-5, MW-3

(1) The Class GA concentration for thallium is a guidance value rather than a standard.

(2) Sumary Table using the analytical results of wells MW-6, MW-7, MW-2 from Jan 2008 sampling event, MW-13, MW-14, MW-16, MW-17, MW-10D, MW-10S, MW-15, MW-8D, MW-8S, MW-11, MW-5, from Aug/Sept 2016 sampling events, MW-4 from a 1997 sampling event and MW-3 from a Nov 2012 sampling event.

Table 2.2
Areas, Volumes and Mass of Contaminant Calculations
Temco Site Final Feasibility Study
West Haverstraw, New York

PCE					
Concentration Range (ug/L)	**Representative Concentration (ug/L)**	**Area (Sq ft)**	**Volume of soil (CF)**	**Volume of Impacted Groundwater (Gal*)**	**Mass of Contaminant (lbs)**
9-100	55	5,866	308,786	923,888	0.42
101-150	126	8,672	456,494	1,365,830	1.44
151-200	176	8,786	462,495	1,383,785	2.03
201-250	226	9,209	484,762	1,450,407	2.74
251-300	276	5,283	278,097	832,067	1.92
301-350	326	1,728	90,962	272,158	0.74
351-450	401	2,666	140,338	419,892	1.41
451-600	526	4,682	246,460	737,410	3.24
601-850	726	4,908	258,357	773,005	4.68
851-4351	2601	4,322	227,510	680,710	14.77
			Totals:	8,839,152	33.38

Area Impacted by 1 or More CPOI (sf)	Total Impacted Water Volume (Gal*)
56,122	8,839,152

*Assume 40% porosity

Note: Average water table depth of approximately 52.64' was calculated by averaging all water table depths for wells inside the effective plume area.

Table 3.1
Screening of Remedial Technologies for Groundwater
Temco Site Final Feasibility Study
West Haverstraw, New York

GENERAL RESPONSE ACTION	RESPONSE ACTION	TECHNOLOGY OR CONTROL METHOD	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	RETAINED OR NOT RETAINED FOR FURTHER EVALUATION
No Action	No action	No action	Not effective reduces site contaminants or reducing possible exposure	Readily implementable.	No cost	Retained, only for comparison to other alternatives
Institutional Controls	Access Controls	Government Controls	Would be effective at reducing possible exposure to contamination left in place	Difficult to implement on private properties and residences	low	Retained
		Property Controls	Would be effective at reducing possible exposure to contamination left in place	Difficult to implement on private properties and residences	low	Retained
Containment	Barrier Wall	Subsurface Barrier Wall	Would be effective to isolate contaminated groundwater to single area. Would not be effective to address potential off-site deep CVOCs sources including silts and clays.	Considering site constraints including the presence of urban infrastructure, and depth to a confining layer, this not considered implementable	Medium to High	Not retained
	Groundwater Collection	Groundwater Collection	Would only be effective were wells or trench could collect groundwater, therefore limited effectiveness throughout impacted area. Also technology would only collect and would not be effective on immobile residuals in the system.	Would required treating large volumes of water, thickness of the saturated zone is approximately 50 ft thick	Medium to High	Not retained
Removal	Soil Excavation	Mechanical Excavation	Potential hotspot excavation targeting the source can be reliable and effective. Will not address potential off-site CVOCs sources including silts and clays.	Likely not due to utilities and current commercial and private residences and Railroad track in the areas.	Medium to High	Retained
	Soil Vapor Extraction and Air Sparging	Soil Vapor Extraction and Air Sparging	Limited effectiveness, the introduction of oxygen though the air sparging process would essentially eliminate any biodegradation of the cholorinated solvent plume that may be occurring	implementable but would be challenges with the space the install sparging and vapor collection system, including the depths the system would be required to be installed to	medium	Not retained
Treatment	Monitored Natural Attenuation	Monitored Natural Attenuation	Limited effectiveness, based on conditions observed during the remedial investigations, natural biodegradation of the PCE does not appear to be occurring.	Readily implementable.	Low	Not Retained
	In-situ treatment	Enhanced Bioremediation	Highly effective, traditional technology implemented to mitigate chlorinated ethenes. Effectiveness can be impacted by nature of impacted media (sand/gravel vs. fine silt).	Implementable, if off-site injection are targeted, access agreements would be required.	Medium	Retained
	In-situ treatment	Chemical Oxidation	Highly effective, traditional technology implemented to mitigate chlorinated ethenes. Effectiveness can be impacted by nature of impacted media (sand/gravel vs. fine silt).	Implementable, if off-site injection are targeted, access agreements would be required.	Medium	Retained

Table 3.2
Screening of Remedial Technologies for Soil Vapor
Temco Site Final Feasibility Study
West Haverstraw, New York

GENERAL RESPONSE ACTION	RESPONSE ACTION	TECHNOLOGY OR CONTROL METHOD	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	RETAINED OR NOT RETAINED FOR FURTHER EVALUATION
No Action	No action	No action	Would be effective where future SV samples indicate no potential risk to human health	Readily implementable.	No cost	Retained
Monitoring	Monitoring	Future Soil Vapor / Indoor Air Sampling	Would be effective where future SV samples indicate no potential risk to human health, but additional monitoring is necessary to ensure concentrations do not increase	Readily implementable.	low	Retained
Removal	Vapor Removal	Subslab Depressurization System	Effective at eliminating potential infiltration of COC impacted soil vapor into indoor air	Readily implementable.	low	Retained

Table 4.1
Estimated Costs For Temco Groundwater Remedial Alternatives
Temco Draft Site Feasibility Study
West Haverstraw, New York

Alternative	**Technology**	**Capital Cost**	**Present Value of O&M Cost**	**Estimated Total Present Worth (1)**
GW-1	No action	$0	$0	$0
GW-2	Enhanced *In Situ* Bioremediation	$791,000	$165,000	$956,000
GW-3A	*In situ* Chemical Oxidation - Sodium Permanganate	$2,561,000	$137,000	$2,698,000
GW-3B	*In situ* Chemical Oxidation - Fenton's Reagent	$1,212,000	$137,000	$1,349,000
GW-4	Soil Removal - PCE Plume Extent	$55,759,000	$25,000	$55,784,000

Notes:

1.) Cost estimates are developed at a FS level for comparative evaluation of alternative, level of accuracy is +50% / -30%.
2.) See Appendix A for detailed cost estimates and related assumptions.

Table 4.2
Estimated Costs For Temco Soil Vapor Remedial Alternatives
Temco Draft Site Feasibility Study
West Haverstraw, New York

Alternative	Technology	Capital Cost	Present Value of O&M Cost	Present Worth [1]
SV-1	No action	0	0	$0
SV-2	Long Term Monitoring	$96,000	$50,000	$145,000
SV-3	Mitigation	$238,000	$0	$238,000

Notes:

1.) Cost estimates are developed at a FS level for comparative evaluation of alternative, level of accuracy is +50% / -30%.
2.) See Appendix A for detailed cost estimates and related assumptions.

Table 4.3

Evaluation of Remedial Action Alternatives
Temco Site Final Feasibility Study

West Haverstraw, New York

Evaluation Criteria\Alternative	**Alternative 1** **No Action**	**Alternative 2** **Enhanced *In Situ* Bioremediation**	**Alternative 3** ***In Situ* Chemical Oxidation**	**Alternative 4** **Soil Removal**
Description	• Under alternative 1, no action would be taken to address site groundwater. Natural attenuation would continue in the site subsurface, but would not be quantified or monitored.	• As with alternative 3, institutional controls will be developed • Enhanced in situ bioremediation using EVO and whey (1 pilot test and 2 full scale rounds estimated) • After the second round of injections, remedy would transition to MNA for a period of 10 years	• As with alternatives 2, institutional controls will be developed • ISCO (in situ chemical oxidation) (1 pilot test and 2 full scale rounds estimated), assumed reagents could be sodium permanganate or Fenton's reagent. • After the second round of injections, remedy would transition to MNA for a period of 10 years	• Soil impacted with chlorinated ethenes excavated and disposed of off site • Impacted ground water collected, treated and discharged • Site backfilled and restored to grade
Overall Protection of Human Health and the Environment	• Not protective of human health and the environment	• Effective means of achieving RAOs and is protective of human health and the environment • Long term monitoring program assesses degradation trends until SCGs have been achieved	• Effective means of achieving RAOs and is protective of human health and the environment • Long term monitoring program assesses degradation trends until SCGs have been achieved	• Would be protective of human health and the environment by elimination of known impacted material within the footprint of the PCE plume.
Compliance with SCGs	• Action & location specific SCGs would be met • Compliance with chemical-specific SCGs would be dictated by natural biodegradation processes (> 30 years). • Progress would not be monitored	• Chemical specific SCGs met following treatment rounds and a period of MNA (estimated to be < 10 years) • Implementation in compliance with action specific and location specific SCGs would be required of the remedial contractor	• Chemical specific SCGs met following treatment rounds and a period of MNA (estimated to be < 10 years) • Implementation in compliance with action specific and location specific SCGs would be required of the remedial contractor	• Chemical specific SCGs met following excavation. • Compliance with action specific and location specific SCGs would be required of the remedial contractor
Long-Term Effectiveness and Permanence	• Not effective long-term	• High long term effectiveness as impacts are permanently eliminated during treatment process • Use of institutional controls would mitigate potential exposures until SCGs are met	• High long term effectiveness as impacts are permanently eliminated during treatment process • Use of institutional controls would mitigate potential exposures until SCGs are met • Would provide flexibility in adaptive management during implementation should site conditions warrant alternative treatment methods	• High long term effectiveness as known impacts are permanently removed

Table 4.3

Evaluation of Remedial Action Alternatives
Temco Site Feasibility Study

West Haverstraw, New York

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Enhanced *In Situ* Bioremediation	Alternative 3 *In Situ* Chemical Oxidation	Alternative 4 Soil Removal
Reduction of Toxicity, Mobility, or Volume Through Treatment	• No reduction of toxicity, mobility or volume through treatment (no treatment) • Toxicity, mobility and volume of impacts slowly reduced over time by natural decomposition	• Will rapidly reduce toxicity, mobility and volume of contaminants within groundwater	• Will rapidly reduce toxicity, mobility and volume of contaminants within groundwater	• Reduction of toxicity and volume would be achieved in the immediate excavation footprint • Reductions would not be through treatment
Short-Term Effectiveness	• No actions taken would be effective in short term, no impacts to surrounding population • No short term benefit on impacted groundwater	• Low likelihood that short-term impacts to nearby population would result from implementation of this remedy • Three injection events required over a 2 year period anticipated • Implementation typically occupies very small footprint • Immediate reduction in impacts • Potential for methane generation and buildup would require consideration during the design	• Low likelihood that short-term impacts to nearby population would result from implementation of this remedy • Three injection events required over a 2 year period anticipated • Implementation typically occupies very small footprint • Immediate reduction in impacts • Low potential for impacts to underground utilities would require consideration during design	• Potential adverse impacts to local community (residents, sidewalk, road closures, etc) due to anticipated scale and extent of activities • Dust and volatile emissions possible, would need to be mitigated with best management practices, and comply with community air monitoring program. • Would require demolition of many existing structures and an active railway • Monitoring of adjacent properties may be required to monitor stability • Anticipated to be completed within two to three construction seasons
Implementability	• Readily implementable without constraint • May not be acceptable to regulatory agencies	• Alternative is implementable, experienced personnel, materials and equipment needed are readily available • Requires short term as well as long term access agreements • Requires legal counsel for application of institutional controls	• Alternative is implementable, experienced personnel, materials and equipment needed are readily available • Requires short term as well as long term access agreements • Requires legal counsel for application of institutional controls	• Alternative is implementable, although careful design and construction planning would be required to mitigate risks • Deep excavations bring safety concerns • Would likely involve the management of significant quantities of construction water
Estimated Cost	$0	Capital Costs: $791,000 O&M Cost Present Value: $165,000 Total Present Value Cost: $956,000	Variation in capital cost is based on using different reagents: Capital Costs: $1,213,000 to $2,561,000 O&M Cost Present Value: $137,000 Total Present Value Cost: $1,349,000 to $2,698,000	Capital Costs: $55,759,000 O&M Cost Present Value: $25,000 Total Present Value Cost: $55,784,000

Table 4.4

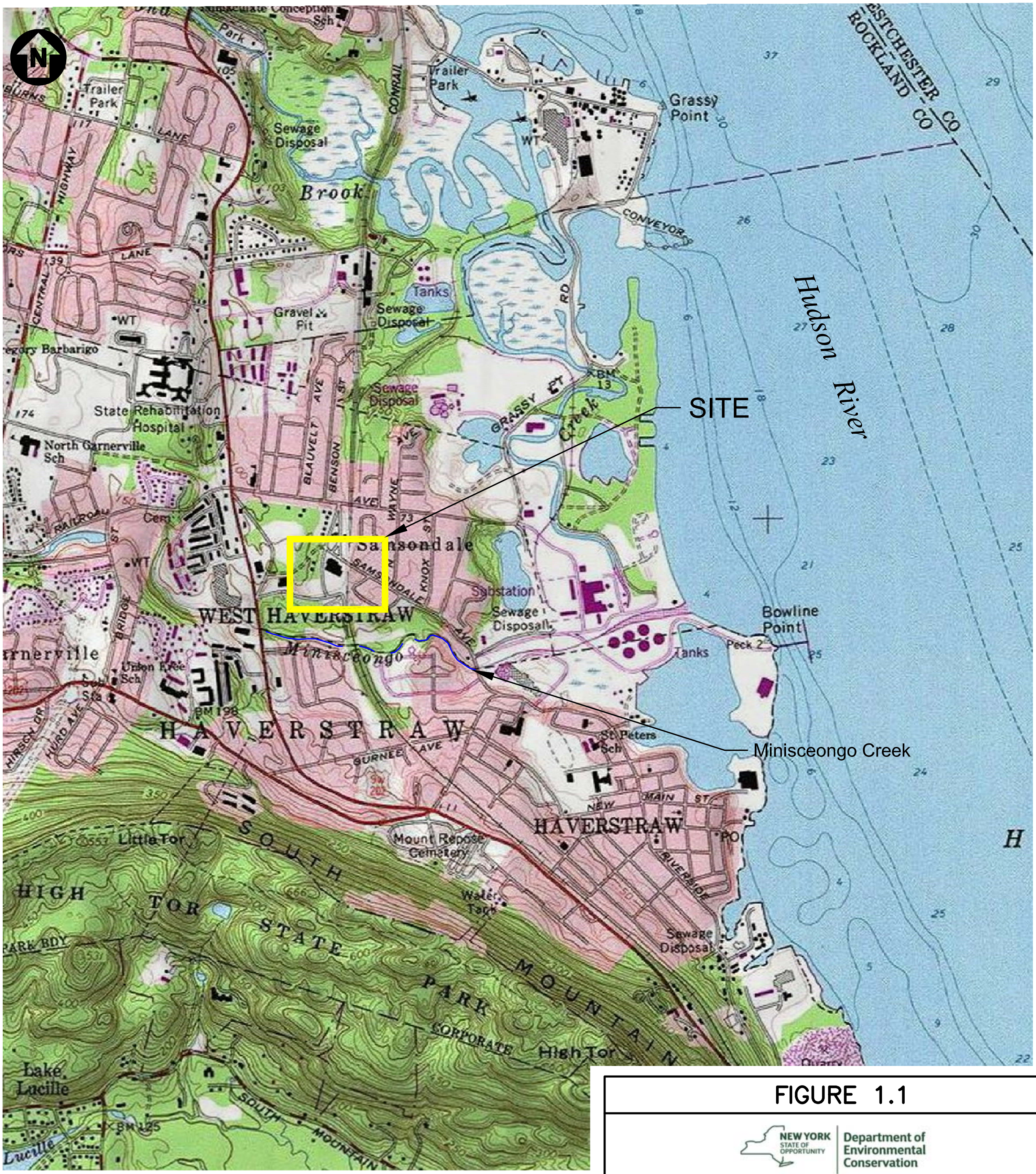
Comparative Analysis of Remedial Action Alternatives

Temco Site Draft Feasibility Study

West Haverstraw, New York

Evaluation Criteria\Alternative	**Alternative GW-1** **No Action**	**Alternative GW-2** **Enhanced *In Situ* Bioremediation / MNA**	**Alternative GW-3** ***In Situ* Chemical Oxidation / MNA**	**Alternative GW-4** **Soil Removal**
Overall Protection of Human Health and the Environment	Least protective alternative	Would provide overall protection of human health and the environment.	Would provide comparable level of protection of human health and the environment as GW-2	Would provide the greatest level of protection of human health and the environment as all known impacts would be removed
Compliance with SCGs	Duration needed to comply with chemical-specific SCGs would be slowest (> 30 years) Would provide greatest degree of compliance with location and action specific SCGs	Active remedial approach would result in faster achievement of chemical-based SCGs. Compliance with location and action specific SCGs would be expected	Achievement of chemical-based SCGs would be comparable to GW-2 Compliance with location and action specific SCGs would be expected	Achievement of chemical-based SCGs would be comparable to Alternative GW-2 and GW-3, just under GW-4 this would be achieved by the end of construction Compliance with location and action specific SCGs would require design and construction planning, but would be expected
Long-Term Effectiveness and Permanence	Offers least amount of long-term effectiveness and permanence	Offers high level of long-term effectiveness and permanence.	Comparable level of long-term effectiveness and permanence as Alternatives GW-2	Would be achieved by the end of construction
Reduction of Toxicity, Mobility, or Volume Through Treatment	No reduction in toxicity, mobility or volume	Would provide significant reduction of toxicity, mobility, and volume through treatment.	Would provide comparable levels of reduction to toxicity, mobility, and volume through treatment as Alternative GW-2	Would provide reduction of mobility, however, this would not come primarily through treatment
Short-Term Effectiveness	Most effective short-term	Would provide short-term effectiveness. Would have significantly less impact on the community compared to GW-4.	Likely provides slightly more short term effectiveness than Alternative GW-2, based on more rapid treatment of COCs. Would have significantly less impact on the community compared to GW-4.	Least effective short-term alternative among options that satisfy this criteria
Implementability	Easily implementable	Readily implementable	Comparable implementability as Alternative GW-2	Implementable, however not likely as readily as Alternatives GW-2 and GW-3 due to intrusive nature of work
Estimated Cost	Most cost effective option, but does not satisfy threshold criteria	Most cost effective option that satisfies threshold criteria	Comparable cost effectiveness as Alternative GW-2 (although potentially slightly more expensive) among options that satisfy threshold criteria	Least effective alternative among options that satisfy threshold criteria

FIGURES



LEGEND:

APPROXIMATE SITE BOUNDARY

NOT TO SCALE

FIGURE 1.1

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

FORMER TEMCO UNIFORMS SITE
WEST HAVERSTRAW, NY

SITE LOCATION MAP

PARSONS

301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\NYSDEC PROGRAM\447275 WA#1 FORMER TEMCO UNIFORMS SITE\10.0 TECHNICAL CATEGORIES\10.1 CAD - GIS\FIGURES\SLM.DWG
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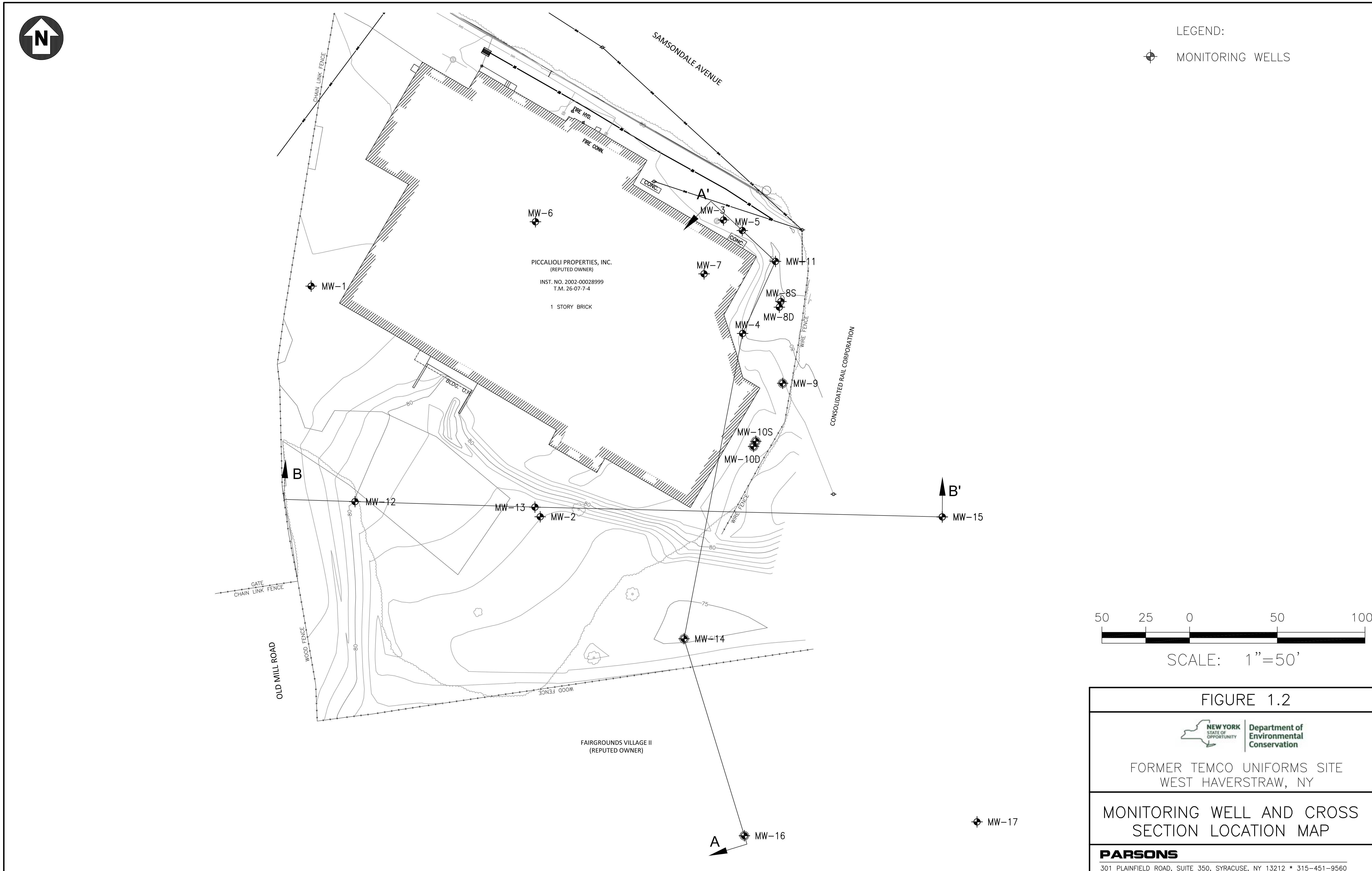

FIGURE 1.2

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

FORMER TEMCO UNIFORMS SITE
WEST HAVERSTRAW, NY

MONITORING WELL AND CROSS SECTION LOCATION MAP

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

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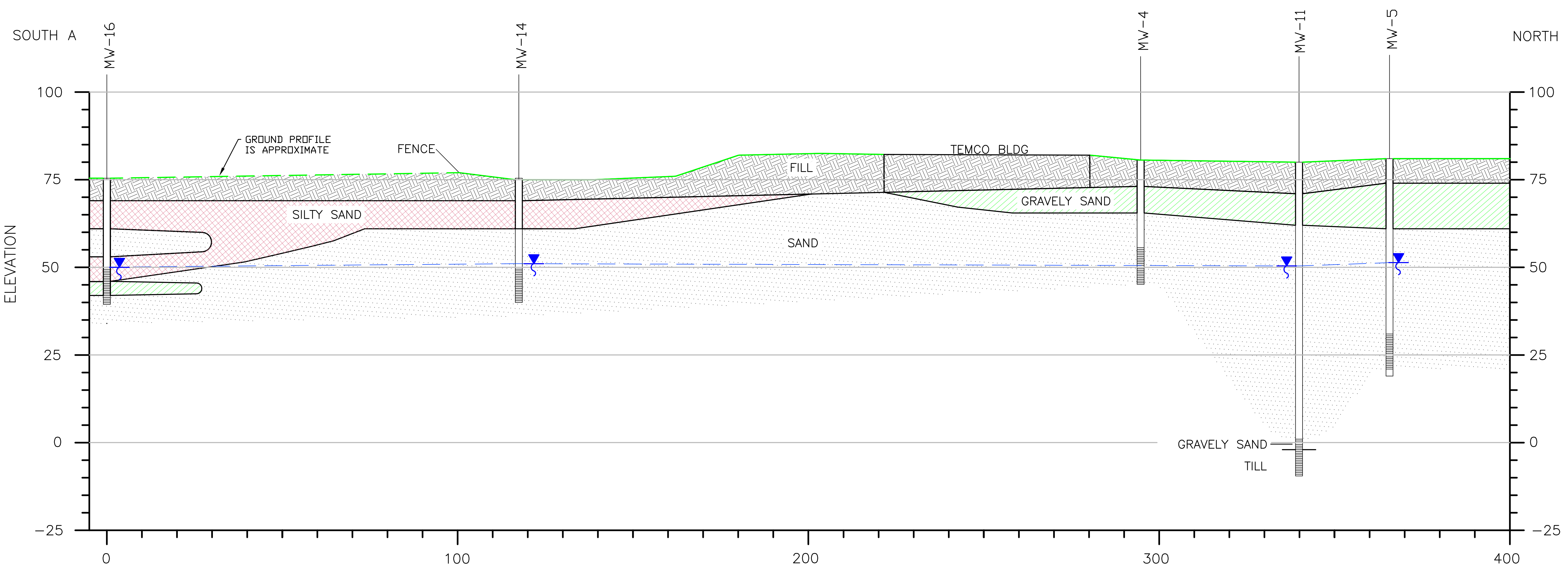

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SCALE: 1"=30'

NOTES:

- MW-4 LOCATION AND TOC POSITION IS APPROXIMATE

LEGEND:

TOP OF WATER TABLE (8/29/16 & 8/31/16)

WELL SCREEN

FIGURE 1.3

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

FORMER TEMCO UNIFORMS SITE
WEST HAVERSTRAW, NY

CROSS SECTION A–A'

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 • 315-451-9560

FILE NAME: P:\NYSDEC PROGRAM\447275 WA#1 FORMER TEMCO UNIFORMS SITE\10.0 TECHNICAL CATEGORIES\10.1 CAD - GIS\FIGURES\SECTION II\447275-SK012-GW CS.DWG
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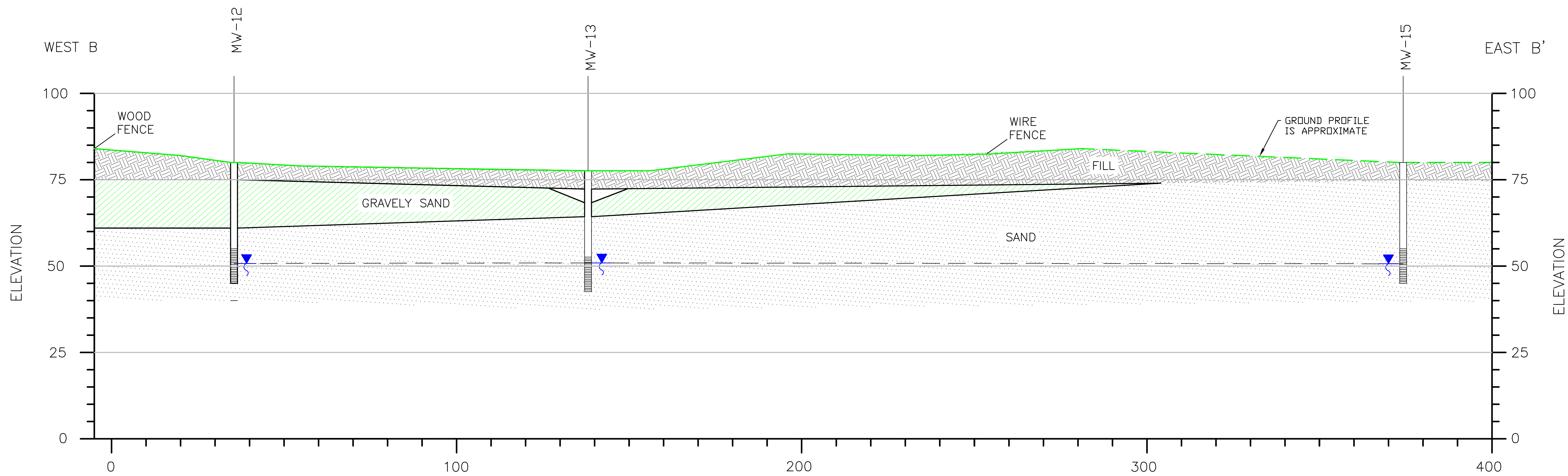

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SCALE: 1"=30'

LEGEND:

TOP OF WATER TABLE (8/29/16 & 8/31/16)

WELL SCREEN

FIGURE 1.4

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

FORMER TEMCO UNIFORMS SITE
WEST HAVERSTRAW, NY

CROSS SECTION B–B'

PARSONS

301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 • 315–451–9560

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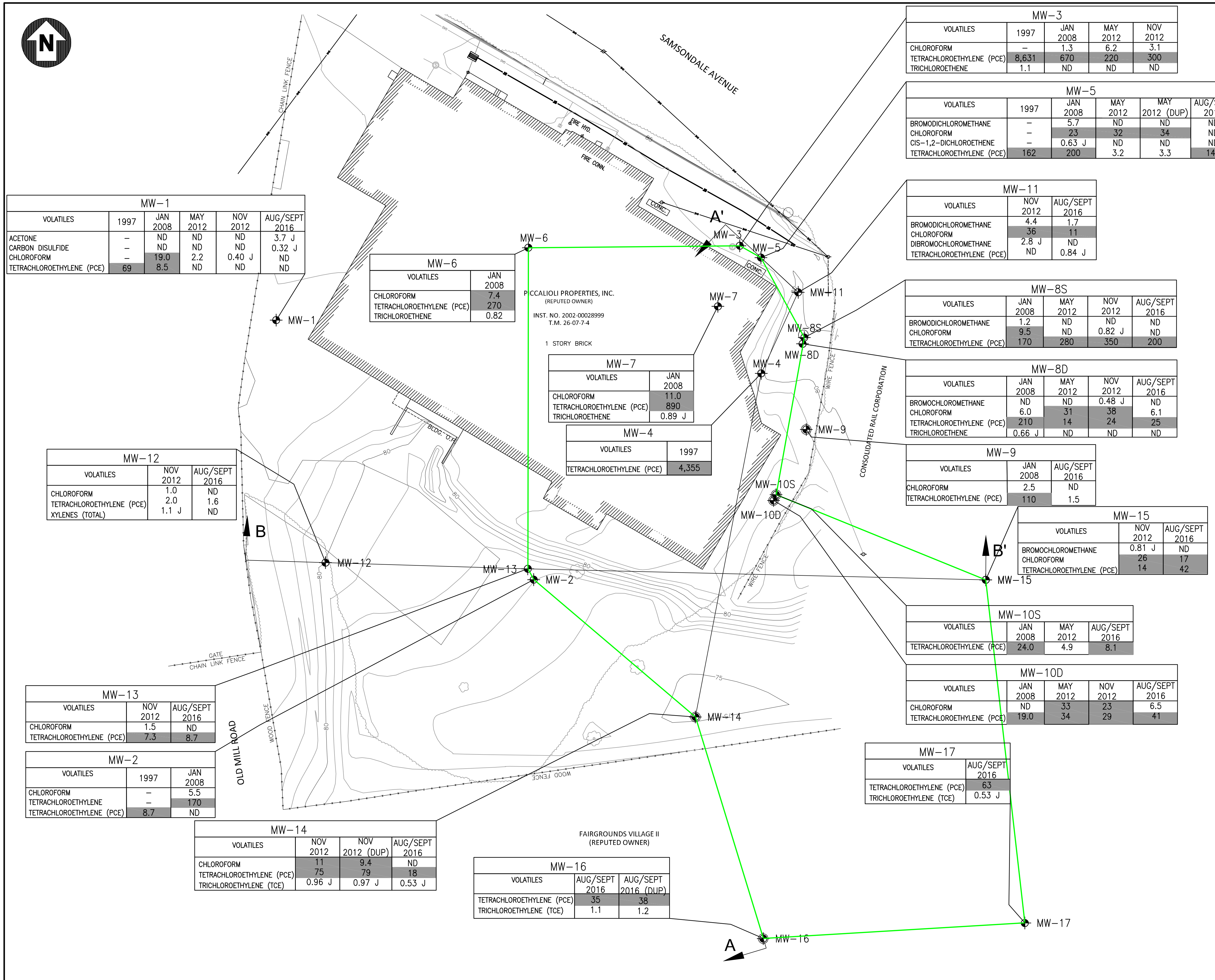


MW-1

VOLATILES	1997	JAN 2008	MAY 2012	NOV 2012	AUG/SEPT 2016
ACETONE	–	ND	ND	ND	3.7 J
CARBON DISULFIDE	–	ND	ND	ND	0.32 J
CHLOROFORM	–	19.0	2.2	0.40 J	ND
TETRACHLOROETHYLENE (PCE)	69	8.5	ND	ND	ND

MW-3

VOLATILES	1997	JAN 2008	MAY 2012	NOV 2012
CHLOROFORM	–	1.3	6.2	3.1
TETRACHLOROETHYLENE (PCE)	8,631	670	220	300
TRICHLOROETHENE	1.1	ND	ND	ND

MW-5

VOLATILES	1997	JAN 2008	MAY 2012	MAY 2012 (DUP)	AUG/SEPT 2016
BROMODICHLOROMETHANE	–	5.7	ND	ND	ND
CHLOROFORM	–	23	32	34	ND
CIS-1,2-DICHLOROETHENE	–	0.63 J	ND	ND	ND
TETRACHLOROETHYLENE (PCE)	162	200	3.2	3.3	140

MW-6

VOLATILES	JAN 2008
CHLOROFORM	7.4
TETRACHLOROETHYLENE (PCE)	270
TRICHLOROETHENE	0.82

MW-11

VOLATILES	NOV 2012	AUG/SEPT 2016
BROMODICHLOROMETHANE	4.4	1.7
CHLOROFORM	36	11
DIBROMOCHLOROMETHANE	2.8 J	ND
TETRACHLOROETHYLENE (PCE)	ND	0.84 J

MW-8S

VOLATILES	JAN 2008	MAY 2012	NOV 2012	AUG/SEPT 2016
BROMODICHLOROMETHANE	1.2	ND	ND	ND
CHLOROFORM	9.5	ND	0.82 J	ND
TETRACHLOROETHYLENE (PCE)	170	280	350	200

MW-7

VOLATILES	JAN 2008
CHLOROFORM	11.0
TETRACHLOROETHYLENE (PCE)	890
TRICHLOROETHENE	0.89 J

MW-8D

VOLATILES	JAN 2008	MAY 2012	NOV 2012	AUG/SEPT 2016
BROMOCHLOROMETHANE	ND	ND	0.48 J	ND
CHLOROFORM	6.0	31	38	6.1
TETRACHLOROETHYLENE (PCE)	210	14	24	25
TRICHLOROETHENE	0.66 J	ND	ND	ND

MW-4

VOLATILES	1997
TETRACHLOROETHYLENE (PCE)	4,355

MW-9

VOLATILES	JAN 2008	AUG/SEPT 2016
CHLOROFORM	2.5	ND
TETRACHLOROETHYLENE (PCE)	110	1.5

MW-12

VOLATILES	NOV 2012	AUG/SEPT 2016
CHLOROFORM	1.0	ND
TETRACHLOROETHYLENE (PCE)	2.0	1.6
XYLENES (TOTAL)	1.1 J	ND

MW-15

VOLATILES	NOV 2012	AUG/SEPT 2016
BROMOCHLOROMETHANE	0.81 J	ND
CHLOROFORM	26	17
TETRACHLOROETHYLENE (PCE)	14	42

MW-10S

VOLATILES	JAN 2008	MAY 2012	AUG/SEPT 2016
TETRACHLOROETHYLENE (PCE)	24.0	4.9	8.1

MW-13

VOLATILES	NOV 2012	AUG/SEPT 2016
CHLOROFORM	1.5	ND
TETRACHLOROETHYLENE (PCE)	7.3	8.7

MW-10D

VOLATILES	JAN 2008	MAY 2012	NOV 2012	AUG/SEPT 2016
CHLOROFORM	ND	33	23	6.5
TETRACHLOROETHYLENE (PCE)	19.0	34	29	41

MW-2

VOLATILES	1997	JAN 2008
CHLOROFORM	–	5.5
TETRACHLOROETHYLENE	–	170
TETRACHLOROETHYLENE (PCE)	8.7	ND

MW-17

VOLATILES	AUG/SEPT 2016
TETRACHLOROETHYLENE (PCE)	63
TRICHLOROETHYLENE (TCE)	0.53 J

MW-14

VOLATILES	NOV 2012	NOV 2012 (DUP)	AUG/SEPT 2016
CHLOROFORM	11	9.4	ND
TETRACHLOROETHYLENE (PCE)	75	79	18
TRICHLOROETHYLENE (TCE)	0.96 J	0.97 J	0.53 J

MW-16

VOLATILES	AUG/SEPT 2016	AUG/SEPT 2016 (DUP)
TETRACHLOROETHYLENE (PCE)	35	38
TRICHLOROETHYLENE (TCE)	1.1	1.2

LEGEND:

- MONITORING WELLS
- SHADED VALUES EXCEED SGVs (SEE NOTE 2)
- J – ESTIMATED VALUE
- J– – ESTIMATED VALUE, BIASED LOW
- ND – NOT DETECTED
- OBSERVED PCE EXTENTS

NOTES:

1. RESULTS REPORTED IN ug/L.
2. RESULTS BASED ON GROUNDWATER SGVs FROM NYSDEC CLASS GA AMBIENT WATER QUALITY STANDARDS AND GUIDANCE VALUES (TOGS 1998).
3. ONLY DETECTED COMPOUNDS ARE SHOWN.
4. LOCATIONS OF MW-4, MW-6 AND MW-7 ARE APPROXIMATE.
5. INFORMATION SHOWN ON THIS FIGURE REPRESENTS AVAILABLE VOC GROUNDWATER DATA COLLECTED DURING THE FOLLOWING SAMPLING EVENTS:
   - 1997 PHASE II INVESTIGATION CONDUCTED BY HRP ASSOCIATES
   - JANUARY 2008 REMEDIAL INVESTIGATION CONDUCTED BY EB CONSULTANTS
   - MAY 2012, NOV 2012, AND AUG/SEPT 2016 REMEDIAL INVESTIGATION CONDUCTED BY PARSONS

40 20 0 40 80

SCALE: 1"=40'

FIGURE 1.5

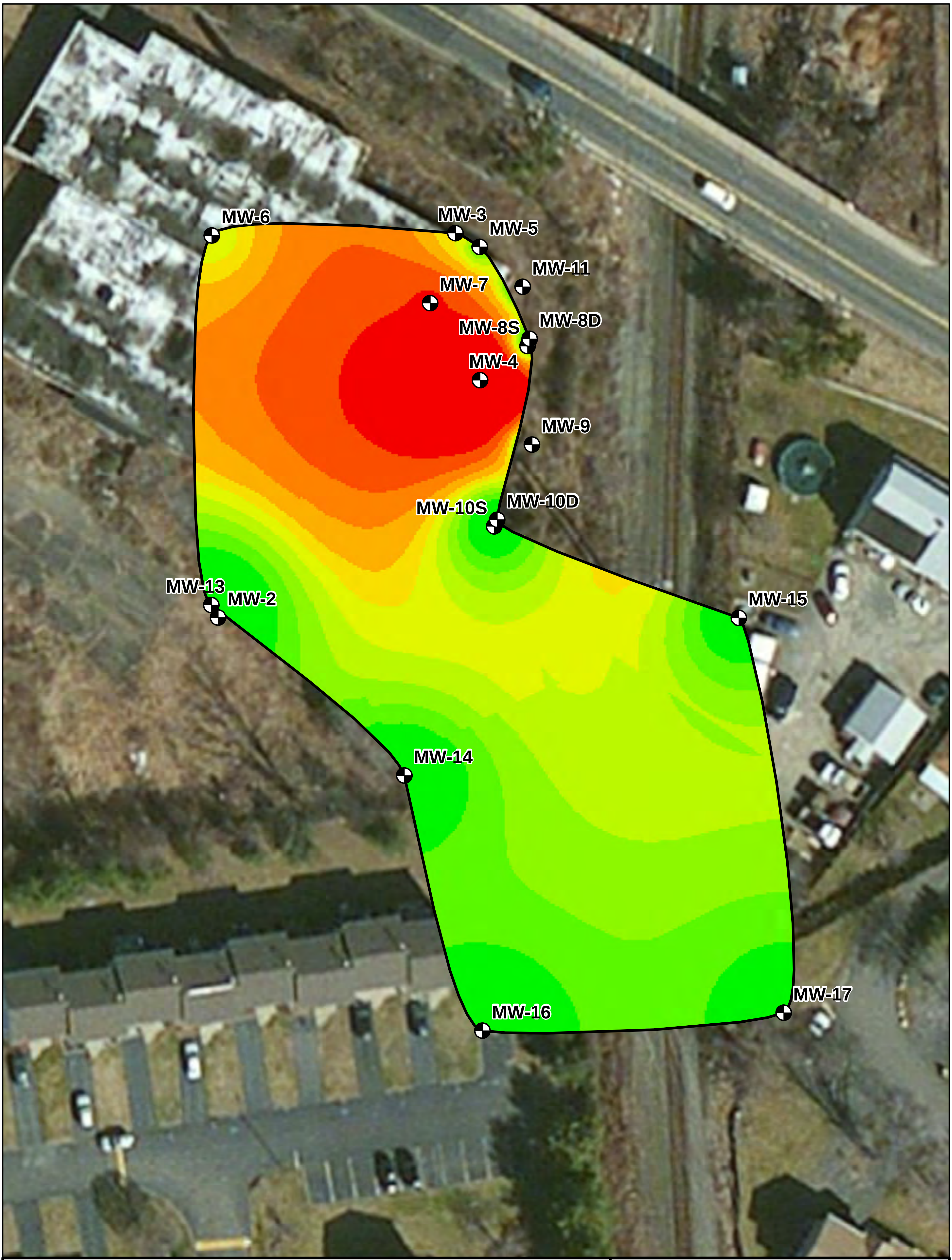
NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

FORMER TEMCO UNIFORMS SITE
WEST HAVERSTRAW, NY

COMPOUND PLUME MAP

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 • 315-451-9560

FILE NAME: P:\NYSDEC PROGRAM\447275 WA#1 FORMER TEMCO UNIFORMS SITE\10.0 TECHNICAL CATEGORIES\10.1 CAD – GIS\FIGURES\SECTION II\447275-SK013.DWG
PLOT DATE: 3/17/2017 11:33 AM PLOTTED BY: RUSSO, JILL



Concentration (ug/L)

9 - 100 (5,866 sq ft)	301 - 350 (1,728 sq ft)
101 - 150 (8,672 sq ft)	351 - 450 (2,666 sq ft)
151 - 200 (8,786 sq ft)	451 - 600 (4,682 sq ft)
201 - 250 (9,209 sq ft)	601 - 850 (4,908 sq ft)
251 - 300 (5,283 sq ft)	851 - 4,351 (4,322 sq ft)

40 20 0 40 80 Feet

N

FIGURE 2.1

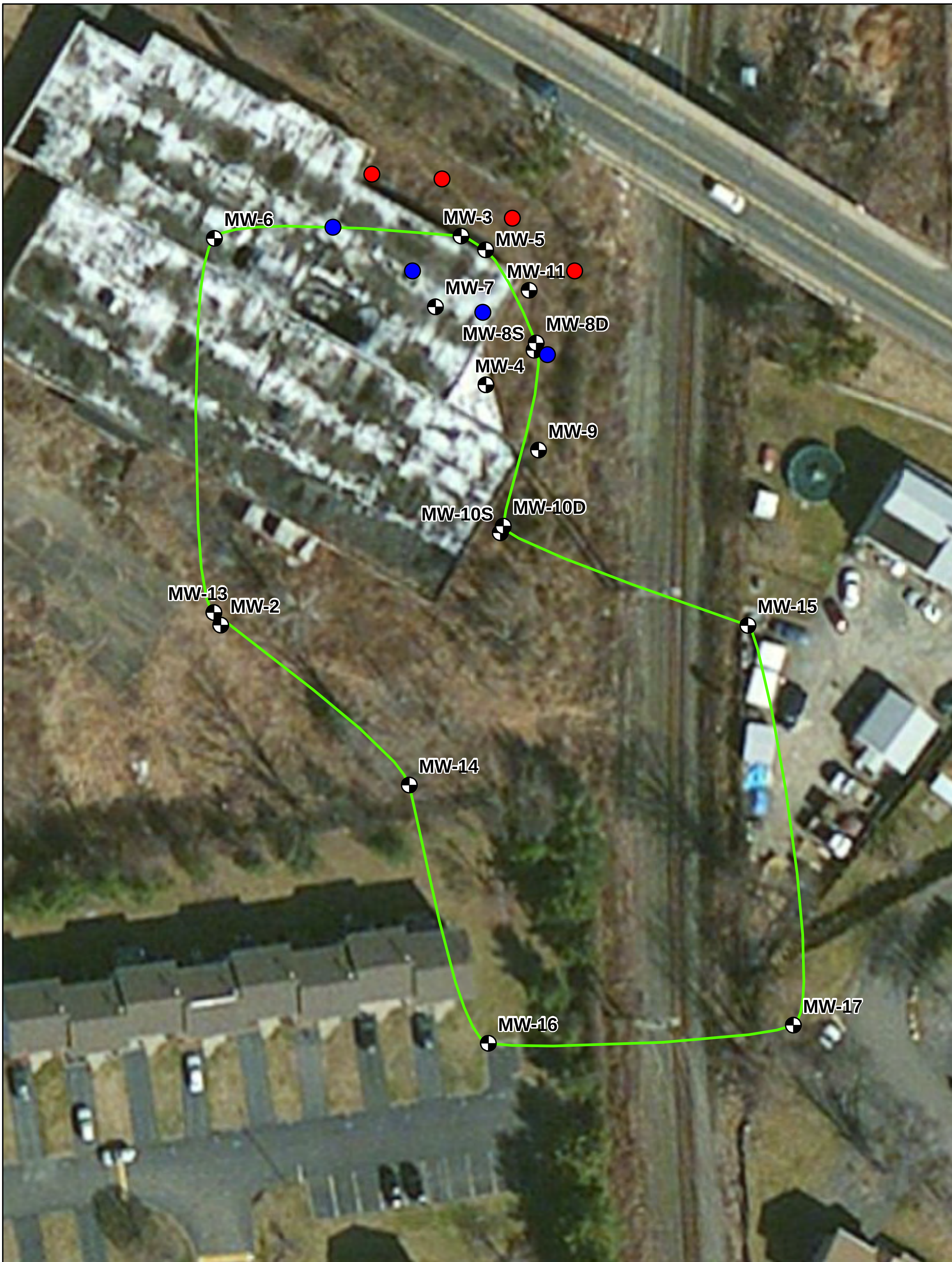
NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

Former Temco Uniforms Site

PCE Concentration Isopleth

PARSONS

301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560



Phase 1 Injection Well
Potential Phase 2 Injection Well
Monitoring Well Locations

40 20 0 40 80 Feet

FIGURE 4.1

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

Former Temco Uniforms Site

Injection Well Locations

PARSONS

301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

APPENDIX A

COST ESTIMATES FOR REMEDIAL ALTERNATIVES

TABLE A-1
TEMCO FEASIBILITY STUDY
Groundwater ALTERNATIVE 2 - EISB / MNA

NYSDEC Site: **Temco** Location: **West Haverstraw, New York** Phase: **Feasibility Study; +50%/-30% accuracy** Base Year: **2017** Date: **March 17, 2017**	Project title: **Alternative # 2 - EISB, assumes 5 years of annaul groundwater monitoring and a more robust project review every 5 yrs for a 10 year period.**

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
DIRECT CONSTRUCTION COSTS				
1.) Contractor Workplan Development	1	LS	$10,000	$10,000
2.) Required Submittals	1	LS	$10,000	$10,000
3.) Pre-design investigation	1	allowance	$50,000	$50,000
4.) Baseline Groundwater sampling and reporting	15	well	$1,500	$22,500
5.) Installation of injection wells	8	per well	$6,000	$48,000
6.) Mobilization (Injection - Round 1)	1	LS	$10,000	$10,000
7.) Purchase Whey (Injection Round 1)	3,000	lbs	$0.65	$1,950
8.) Purchase Emulsified Vegetable Oil (Injection Round 1)	11,880	lbs	$1.40	$16,632
9.) Daily injection crew and equipment (Injection Round 1)	10	days	$5,000	$50,000
10.) Post Round 1 groundwater sampling and reporting	15	wells	$1,500	$22,500
11.) Mobilization (Full Scale Injection - Round 2)	1	LS	$10,000	$10,000
12.) Purchase Whey (Full Scale Injection Round 2)	5,000	lbs	$0.65	$3,250
13.) Purchase Emulsified Vegetable Oil (Full Scale Injection Round 2)	19,800	lbs	$1.40	$27,720
14.) Daily injection crew and equipment (Full Scale Injection Round 2)	12	days	$5,000	$60,000
15.) Post Round 2 groundwater sampling and reporting	15	wells	$1,500.00	$22,500
16.) Mobilization (Full Scale Injection - Round 3)	1	LS	$10,000	$10,000
17.) Purchase Whey (Full Scale Injection Round 3)	5,000	lbs	$0.65	$3,250
18.) Purchase Emulsified Vegetable Oil (Full Scale Injection Round 3)	19,800	lbs	$1.40	$27,720
19.) Daily injection crew and equipment (Full Scale Injection Round 3)	12	days	$5,000	$60,000
20.) Post Round 3 groundwater sampling and reporting	15	wells	$1,500.00	$22,500
21.) Demobilization	1.00	LS	$10,000	$10,000
SUBTOTAL DIRECT CONSTRUCTION COSTS				**$498,522**
OTHER CAPITAL COSTS				
1. Indirect Construction Costs (% of direct construction costs)	1	Lot	17%	$84,749
2. Contingency (% of direct construction costs)	1	Lot	20%	$99,704
3. Engineering, Design & Construction Oversight (% of direct construction costs and contingency)	1	Lot	18%	$107,681
SUBTOTAL OTHER CAPITAL COSTS				**$292,134**
TOTAL CAPITAL COSTS				**$790,656**

TABLE A-1
TEMCO FEASIBILITY STUDY
Groundwater ALTERNATIVE 2 - EISB / MNA

ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS				
DESCRIPTION	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1. Project Management Administration, and Reporting	1	LS	$5,000	$5,000
2.Groundwater Monitoring	1	LS	$15,000	$15,000
3. Institutional Controls	1	LS	$2,500	$2,500
SUBTOTAL ANNUAL O&M COSTS				**$22,500**
4. Contingency (% of subtotal)	20%			$4,500
5. Technical Support/Troubleshooting (% of subtotal and contingency)	10%			$2,700
TOTAL ANNUAL O&M COSTS				**$29,700**

PERIODIC COSTS				
DESCRIPTION	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1. Project Review (once every 5 years)	1	LS	$35,000	$35,000
TOTAL PERIODIC COSTS				**$35,000**

PRESENT VALUE ANALYSIS					
COST TYPE	**YEAR**	**TOTAL COST**	**TOTAL COST PER YEAR**	**DISCOUNT FACTOR (7%)**	**PRESENT VALUE**
Capital Cost	0	$790,656	$790,656	1.000	$790,656
Annual OM&M Cost	1-5	$891,000	$29,700	4.100	$121,776
Periodic Cost	5	$35,000	$35,000	0.713	$24,955
Periodic Cost	10	$35,000	$35,000	0.508	$17,792
TOTAL PRESENT VALUE OF ALTERNATIVE					**$955,000**

Notes:
1. Period of analysis is equivalent to the estimated project duration.
2. Present value of alternative is rounded to the nearest $1,000.

PRESENT VALUE CALCULATION			**Annual Discount Factor =**		**7.0%**	
YEAR	**CAPITAL COSTS**	**ANNUAL O&M COSTS**	**PERIODIC COSTS**	**TOTAL COST**	**DISCOUNT FACTOR (7%)**	**PRESENT VALUE**
0	$790,656	$0	$0	$790,656	1.000	$790,656
1	$0	$29,700	$0	$29,700	0.935	$27,757
2	$0	$29,700	$0	$29,700	0.873	$25,941
3	$0	$29,700	$0	$29,700	0.816	$24,244
4	$0	$29,700	$0	$29,700	0.763	$22,658
5	$0	$29,700	$35,000	$64,700	0.713	$46,130
6	$0	$0	$0	$0	0.666	$0
7	$0	$0	$0	$0	0.623	$0
8	$0	$0	$0	$0	0.582	$0
9	$0	$0	$0	$0	0.544	$0
10	$0	$0	$35,000	$35,000	0.508	$17,792
TOTAL	**$790,656**	**$149,000**	**$70,000**	**$1,009,000**	**---**	**$956,000**

Notes and Assumptions:
1.) Cost estimates are developed at a FS level for comparative evaluation of alternative, level of accuracy is +50% / -30%.
2.) Estimate unit cost were developed using 2016 labor and material costs, and refined production rates based on Parsons experience and current industry standards.
3.) Present Worth analysis has been developed based on a 7% discount factor.

TABLE A-2
TEMCO FEASIBILITY STUDY
Groundwater ALTERNATIVE 3A - ISCO / MNA

NYSDEC	Project title:
Site: **Temco**	**Alternative # 3A - ISCO - with sodium permanganate, assumes 5 years of annaul groundwater monitoring and a more robust project review every 5 yrs for a 10 year period.**
Location: **West Haverstraw, New York**	
Phase: **Feasibility Study; +50%/-30% accuracy**	
Base Year: **2017**	
Date: **March 17, 2017**	

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
DIRECT CONSTRUCTION COSTS				
1.) Contractor Workplan Development	1	LS	$10,000	$10,000
2.) Required Submittals	1	LS	$10,000	$10,000
3.) Pre-design investigation	1	allowance	$50,000	$100,000
4.) Baseline Groundwater sampling and reporting	15	wells	$1,500	$22,500
5.) Installation of injection wells	8	per well	$6,000	$48,000
6.) Mobilization (Pilot Study)	1	LS	$5,000	$5,000
7.) Purchase Sodium Permanganate (Pilot Study)	2,000	gallon	$6.20	$12,400
8.) Daily injection crew and equipment (Pilot Study)	2	days	$7,500	$15,000
9.) Post Pilot study groundwater sampling and reporting	5	wells	$1,500	$7,500
10.) Mobilization (Full Scale Injection - Round 1)	1	LS	$10,000	$10,000
11.) Purchase Sodium Permanganate (Full Scale Injection Round 1)	85,000	gallon	$6.20	$527,000
12.) Daily injection crew and equipment (Full Scale Injection Round 1)	17	days	$7,500	$127,500
13.) Post Round 1 groundwater sampling and reporting	15	wells	$1,500	$22,500
14.) Mobilization (Full Scale Injection - Round 2)	1	LS	$10,000	$10,000
15.) Purchase Sodium Permanganate (Full Scale Injection Round 2)	85,000	gallon	$6.20	$527,000
16.) Daily injection crew and equipment (Full Scale Injection Round 2)	17	days	$7,500	$127,500
17.) Post Round 2 groundwater sampling and reporting	15	wells	$1,500.00	$22,500
18.) Demobilization	1.00	LS	$10,000	$10,000
SUBTOTAL DIRECT CONSTRUCTION COSTS				**$1,614,400**
OTHER CAPITAL COSTS				
1. Indirect Construction Costs (% of direct construction costs)	1	Lot	17%	$274,448
2. Contingency (% of direct construction costs)	1	Lot	20%	$322,880
3. Engineering, Design & Construction Oversight (% of direct construction costs and contingency)	1	Lot	18%	$348,710
SUBTOTAL OTHER CAPITAL COSTS				**$946,038**
TOTAL CAPITAL COSTS				**$2,560,438**

TABLE A-2
TEMCO FEASIBILITY STUDY
Groundwater ALTERNATIVE 3A - ISCO / MNA

ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS				
DESCRIPTION	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1. Project Management Administration, and Reporting	1	LS	$5,000	$5,000
2.Groundwater Monitoring	1	LS	$10,000	$10,000
3. Institutional Controls	1	LS	$2,500	$2,500
SUBTOTAL ANNUAL O&M COSTS				**$17,500**
4. Contingency (% of subtotal)	20%			$3,500
5. Technical Support/Troubleshooting (% of subtotal and contingency)	10%			$2,100
TOTAL ANNUAL O&M COSTS				**$23,100**

PERIODIC COSTS				
DESCRIPTION	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1. Project Review (once every 5 years)	1	LS	$35,000	$35,000
TOTAL PERIODIC COSTS				**$35,000**

PRESENT VALUE ANALYSIS					
COST TYPE	**YEAR**	**TOTAL COST**	**TOTAL COST PER YEAR**	**DISCOUNT FACTOR (7%)**	**PRESENT VALUE**
Capital Cost	0	$2,560,438	$2,560,438	1.000	$2,560,438
Annual OM&M Cost	1-5	$693,000	$23,100	4.100	$94,715
Periodic Cost	5	$35,000	$35,000	0.713	$24,955
Periodic Cost	10	$35,000	$35,000	0.508	$17,792
TOTAL PRESENT VALUE OF ALTERNATIVE					**$2,698,000**

Notes:

1. Period of analysis is equivalent to the estimated project duration.
2. Present value of alternative is rounded to the nearest $1,000.

PRESENT VALUE CALCULATION				**Annual Discount Factor =**	**7.0%**	
YEAR	**CAPITAL COSTS**	**ANNUAL O&M COSTS**	**PERIODIC COSTS**	**TOTAL COST**	**DISCOUNT FACTOR (7%)**	**PRESENT VALUE**
0	$2,560,438	$0	$0	$2,560,438	1.000	$2,560,438
1	$0	$23,100	$0	$23,100	0.935	$21,589
2	$0	$23,100	$0	$23,100	0.873	$20,176
3	$0	$23,100	$0	$23,100	0.816	$18,856
4	$0	$23,100	$0	$23,100	0.763	$17,623
5	$0	$23,100	$35,000	$58,100	0.713	$41,424
6	$0	$0	$0	$0	0.666	$0
7	$0	$0	$0	$0	0.623	$0
8	$0	$0	$0	$0	0.582	$0
9	$0	$0	$0	$0	0.544	$0
10	$0	$0	$35,000	$35,000	0.508	$17,792
TOTAL	**$2,560,438**	**$116,000**	**$70,000**	**$2,746,000**	**---**	**$2,698,000**

Notes and Assumptions:

1.) Cost estimates are developed at a FS level for comparative evaluation of alternative, level of accuracy is +50% / -30%.
2.) Estimate unit cost were developed using 2016 labor and material costs, and refined production rates based on Parsons experience and current industry standards.
3.) Present Worth analysis has been developed based on a 7% discount factor.

TABLE A-3
TEMCO FEASIBILITY STUDY
Groundwater ALTERNATIVE 3B - ISCO / MNA

NYSDEC Site: **Temco** Location: **West Haverstraw, New York** Phase: **Feasibility Study; +50%/-30% accuracy** Base Year: **2017** Date: **March 17, 2017**	Project title: **Alternative # 3B - ISCO - with Fenton's Reagent, assumes 5 years of annaul groundwater monitoring and a more robust project review every 5 yrs for a 10 year period.**

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
DIRECT CONSTRUCTION COSTS				
1.) Contractor Workplan Development	1	LS	$10,000	$10,000
2.) Required Submittals	1	LS	$10,000	$10,000
3.) Pre-design investigation	1	allowance	$50,000	$100,000
4.) Baseline Groundwater sampling and reporting	15	wells	$1,500	$22,500
5.) Installation of injection wells	8	per well	$6,000	$48,000
6.) Mobilization (Pilot Study)	1	LS	$5,000	$5,000
7.) Purchase Fenton's Reagent (Pilot Study)	2,000	gallon	$4.50	$9,000
8.) Daily injection crew and equipment (Pilot Study)	2	days	$6,500	$13,000
9.) Post Pilot study groundwater sampling and reporting	5	wells	$1,500	$7,500
10.) Mobilization (Full Scale Injection - Round 1)	1	LS	$10,000	$10,000
11.) Purchase Fenton's Reagent (Full Scale Injection Round 1)	40,000	gallon	$4.50	$180,000
12.) Daily injection crew and equipment (Full Scale Injection Round 1)	8	days	$6,500	$52,000
13.) Post Round 1 groundwater sampling and reporting	15	wells	$1,500	$22,500
14.) Mobilization (Full Scale Injection - Round 2)	1	LS	$10,000	$10,000
15.) Purchase Fenton's Reagent(Full Scale Injection Round 2)	40,000	gallon	$4.50	$180,000
16.) Daily injection crew and equipment (Full Scale Injection Round 2)	8	days	$6,500	$52,000
17.) Post Round 2 groundwater sampling and reporting	15	wells	$1,500.00	$22,500
18.) Demobilization	1.00	LS	$10,000	$10,000
SUBTOTAL DIRECT CONSTRUCTION COSTS				**$764,000**
OTHER CAPITAL COSTS				
1. Indirect Construction Costs (% of direct construction costs)	1	Lot	17%	$129,880
2. Contingency (% of direct construction costs)	1	Lot	20%	$152,800
3. Engineering, Design & Construction Oversight (% of direct construction costs and contingency)	1	Lot	18%	$165,024
SUBTOTAL OTHER CAPITAL COSTS				**$447,704**
TOTAL CAPITAL COSTS				**$1,211,704**

TABLE A-3
TEMCO FEASIBILITY STUDY
Groundwater ALTERNATIVE 3B - ISCO / MNA

ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS				
DESCRIPTION	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1. Project Management Administration, and Reporting	1	LS	$5,000	$5,000
2.Groundwater Monitoring	1	LS	$10,000	$10,000
3. Institutional Controls	1	LS	$2,500	$2,500
SUBTOTAL ANNUAL O&M COSTS				**$17,500**
4. Contingency (% of subtotal)	20%			$3,500
5. Technical Support/Troubleshooting (% of subtotal and contingency)	10%			$2,100
TOTAL ANNUAL O&M COSTS				**$23,100**

PERIODIC COSTS				
DESCRIPTION	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1. Project Review (once every 5 years)	1	LS	$35,000	$35,000
TOTAL PERIODIC COSTS				**$35,000**

PRESENT VALUE ANALYSIS					
COST TYPE	**YEAR**	**TOTAL COST**	**TOTAL COST PER YEAR**	**DISCOUNT FACTOR (7%)**	**PRESENT VALUE**
Capital Cost	0	$1,211,704	$1,211,704	1.000	$1,211,704
Annual OM&M Cost	1-5	$693,000	$23,100	4.100	$94,715
Periodic Cost	5	$35,000	$35,000	0.713	$24,955
Periodic Cost	10	$35,000	$35,000	0.508	$17,792
TOTAL PRESENT VALUE OF ALTERNATIVE					**$1,349,000**

Notes:
1. Period of analysis is equivalent to the estimated project duration.
2. Present value of alternative is rounded to the nearest $1,000.

PRESENT VALUE CALCULATION				Annual Discount Factor =	7.0%	
YEAR	**CAPITAL COSTS**	**ANNUAL O&M COSTS**	**PERIODIC COSTS**	**TOTAL COST**	**DISCOUNT FACTOR (7%)**	**PRESENT VALUE**
0	$1,211,704	$0	$0	$1,211,704	1.000	$1,211,704
1	$0	$23,100	$0	$23,100	0.935	$21,589
2	$0	$23,100	$0	$23,100	0.873	$20,176
3	$0	$23,100	$0	$23,100	0.816	$18,856
4	$0	$23,100	$0	$23,100	0.763	$17,623
5	$0	$23,100	$35,000	$58,100	0.713	$41,424
6	$0	$0	$0	$0	0.666	$0
7	$0	$0	$0	$0	0.623	$0
8	$0	$0	$0	$0	0.582	$0
9	$0	$0	$0	$0	0.544	$0
10	$0	$0	$35,000	$35,000	0.508	$17,792
TOTAL	**$1,211,704**	**$116,000**	**$70,000**	**$1,397,000**	**---**	**$1,350,000**

Notes and Assumptions:
1.) Cost estimates are developed at a FS level for comparative evaluation of alternative, level of accuracy is +50% / -30%.
2.) Estimate unit cost were developed using 2016 labor and material costs, and refined production rates based on Parsons experience and current industry standards.
3.) Present Worth analysis has been developed based on a 7% discount factor.

TABLE A-4
TEMCO FEASIBILITY STUDY
Groundwater ALTERNATIVE 4 - Soil Removal to PCE Exceedance Limit

NYSDEC Site: **Temco** Location: **West Haverstraw, New York** Phase: **Feasibility Study; +50%/-30% accuracy** Base Year: **2017** Date: **March 17, 2017**	Project title: **Alternative # 4 - Soil Targeted removal equal to the extent of the PCE Plume, 56,000 sf Area to 80 feet below existing grade. Estimate assumes a single project review, 5 years after the construction is completed.**

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
DIRECT CONSTRUCTION COSTS				
1.) Contractor Workplan Development	1	LS	$25,000	$25,000
2.) Required Submittals	1	LS	$10,000	$10,000
3.) Purchase Property (allowance per unit)	5	Allowance per Unit	$100,000	$500,000
4.) Demo Property (allowance per unit)	5	Allowance per Unit	$50,000	$250,000
5.) Mobilization	1	LS	$20,000	$20,000
6.) Utility Re-Location Allowance (railroad relocation not included)	1	Allowance	$250,000	$250,000
7.) Installation/removal of Excavation Support System (Deep Shoring)	20,000	SF	$50	$1,000,000
8.) Site Preparation and Construction of Dewatering/Stabilization Pad	1	Per Pad	$250,000	$250,000
9.) Remedial Excavation and Stockpile	165,000	CY	$25	$4,125,000
10.) Excavation Dewatering	30	MONTH	$75,000	$2,250,000
11.) Construction Water Treatment Plant Mob/Demob	2	LS	$150,000	$300,000
12.) Construction Water Treatment Operation	30	MONTH	$190,000	$5,700,000
13.) Dewatering Pad Operation	165,000	CY	$8	$1,320,000
14.) Purchase Backfill Material	178,200	TON	$18	$3,207,600
15.) Place and Compact Backfill Material	165,000	CY	$20	$3,300,000
16.) Material Solidification	82,500	CY	$15	$1,237,500
17.) Material Loadout	82,500	CY	$8	$660,000
18.) Off-Site Transportation and Disposal	178,200	TON	$60	$10,692,000
19.) Demobilization	1.00	LS	$10,000	$10,000
20.) Restoration	1.00	LS	$50,000	$50,000
SUBTOTAL DIRECT CONSTRUCTION COSTS				**$35,157,100**
OTHER CAPITAL COSTS				
1. Indirect Construction Costs (% of direct construction costs)	1	Lot	17%	$5,976,707
2. Contingency (% of direct construction costs)	1	Lot	20%	$7,031,420
3. Engineering, Design & Construction Oversight (% of direct construction costs and contingency)	1	Lot	18%	$7,593,934
SUBTOTAL OTHER CAPITAL COSTS				**$20,602,061**
TOTAL CAPITAL COSTS				**$55,759,161**

TABLE A-4
TEMCO FEASIBILITY STUDY
Groundwater ALTERNATIVE 4 - Soil Removal to PCE Exceedance Limit

ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS				
DESCRIPTION	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1. Project Management Administration, and Reporting	0	LS	$0	$0
2.Groundwater Monitoring	0	LS	$0	$0
3. Institutional Controls	0	LS	$0	$0
SUBTOTAL ANNUAL O&M COSTS				**$0**
4. Contingency (% of subtotal)	20%			$0
5. Technical Support/Troubleshooting (% of subtotal and contingency)	10%			$0
TOTAL ANNUAL O&M COSTS				**$0**

PERIODIC COSTS				
DESCRIPTION	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1. Project Review (once at 5 years)	1	LS	$35,000	$35,000
TOTAL PERIODIC COSTS				**$35,000**

PRESENT VALUE ANALYSIS					
COST TYPE	**YEAR**	**TOTAL COST**	**TOTAL COST PER YEAR**	**DISCOUNT FACTOR (7%)**	**PRESENT VALUE**
Capital Cost	0	$55,759,161	$55,759,161	1.000	$55,759,161
Periodic Cost	5	$35,000	$35,000	0.713	$24,955
TOTAL PRESENT VALUE OF ALTERNATIVE					**$55,784,000**

Notes:

1. Period of analysis is equivalent to the estimated project duration.
2. Present value of alternative is rounded to the nearest $1,000.

PRESENT VALUE CALCULATION			**Annual Discount Factor =**		**7.0%**	
YEAR	**CAPITAL COSTS**	**ANNUAL O&M COSTS**	**PERIODIC COSTS**	**TOTAL COST**	**DISCOUNT FACTOR (7%)**	**PRESENT VALUE**
0	$55,759,161	$0	$0	$55,759,161	1.000	$55,759,161
1	$0	$0	$0	$0	0.935	$0
2	$0	$0	$0	$0	0.873	$0
3	$0	$0	$0	$0	0.816	$0
4	$0	$0	$0	$0	0.763	$0
5	$0	$0	$35,000	$35,000	0.713	$24,955
TOTAL	**$55,759,161**	**$0**	**$35,000**	**$55,794,000**	**---**	**$55,784,000**

Notes and Assumptions:

1.) Cost estimates are developed at a FS level for comparative evaluation of alternative, level of accuracy is +50% / -30%.
2.) Estimate unit cost were developed using 2016 labor and material costs, and refined production rates based on Parsons experience and current industry standards.
3.) Present Worth analysis has been developed based on a 7% discount factor.
4.) Estimate assumes all removed materials will be non-hazardous and disposed for off-site for $60/tn.

5.) Estimate assumes excavation support can be supported by H-piles driven to 45 feet with timber lagging, this assumption would require detailed design and could cause revisions to this estimate.
6.) Water Treatment assumes an on-site water treatment plant that has the capacity to treatment up to 250 gpm.
7.) Water treatment system assume 24 hr per day operation.
8.) Estimate assumes 40% of the removed material will be suitable to re-use on-site as backfill.
9.) Estimate assumes half the removed material will require solidification.

10.) Purchasing properties and demolition of properties is shown as an allowance, this allowance would require evaluation during design and could cause revisions to this estimate.
11.) Utility re-location allowance is shown as a level of effort and judgement based on the scope of each removal alternative for comparative evaluation. Detailed utility location and re-location design would be required and could cause revisions to this estimate.

TABLE A-5
TEMCO FEASIBILITY STUDY
Soil Vapor ALTERNATIVE 2 - Long Term Monitoring

NYSDEC Site: **Temco** Location: **West Haverstraw, New York** Phase: **Feasibility Study; +50%/-30% accuracy** Base Year: **2017** Date: **March 17, 2017**	Project title: **Alternative # 2 - Long-term monitoring, assume 20 houses are assessed and 10 require additional monitoring at years 5 and 10.**

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
DIRECT CONSTRUCTION COSTS				
1.) Soil Vapor Monitoring	20	Per House	$4,000	$80,000
SUBTOTAL DIRECT CONSTRUCTION COSTS				**$80,000**
OTHER CAPITAL COSTS				
1. Indirect Construction Costs (% of direct construction costs)	1	Lot	0%	$0
2. Contingency (% of direct construction costs)	1	Lot	20%	$16,000
3. Engineering, Design & Construction Oversight (% of direct construction costs and contingency)	1	Lot	0%	$0
SUBTOTAL OTHER CAPITAL COSTS				**$16,000**
TOTAL CAPITAL COSTS				**$96,000**

TABLE A-5
TEMCO FEASIBILITY STUDY
Soil Vapor ALTERNATIVE 2 - Long Term Monitoring

ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS				
DESCRIPTION	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1. Project Management Administration, and Reporting	0	LS	$0	$0
2.Groundwater Monitoring	0	LS	$0	$0
3. Institutional Controls	0	LS	$0	$0
SUBTOTAL ANNUAL O&M COSTS				**$0**
4. Contingency (% of subtotal)	20%			$0
5. Technical Support/Troubleshooting (% of subtotal and contingency)	10%			$0
TOTAL ANNUAL O&M COSTS				**$0**

PERIODIC COSTS				
DESCRIPTION	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1. Soil Vapor Monitoring	10	Per House	$4,000	$40,000
TOTAL PERIODIC COSTS				**$40,000**

PRESENT VALUE ANALYSIS					
COST TYPE	**YEAR**	**TOTAL COST**	**TOTAL COST PER YEAR**	**DISCOUNT FACTOR (7%)**	**PRESENT VALUE**
Capital Cost	0	$96,000	$96,000	1.000	$96,000
Annual OM&M Cost	1-10	$0	$0	7.024	$0
Periodic Cost	5	$40,000	$40,000	0.713	$28,519
Periodic Cost	10	$40,000	$40,000	0.508	$20,334
TOTAL PRESENT VALUE OF ALTERNATIVE					**$146,000**

Notes:
1. Period of analysis is equivalent to the estimated project duration.
2. Present value of alternative is rounded to the nearest $1,000.

PRESENT VALUE CALCULATION			**Annual Discount Factor =**		**7.0%**	
YEAR	**CAPITAL COSTS**	**ANNUAL O&M COSTS**	**PERIODIC COSTS**	**TOTAL COST**	**DISCOUNT FACTOR (7%)**	**PRESENT VALUE**
0	$96,000	$0	$0	$96,000	1.000	$96,000
1	$0	$0	$0	$0	0.935	$0
2	$0	$0	$0	$0	0.873	$0
3	$0	$0	$0	$0	0.816	$0
4	$0	$0	$0	$0	0.763	$0
5	$0	$0	$40,000	$40,000	0.713	$28,519
6	$0	$0	$0	$0	0.666	$0
7	$0	$0	$0	$0	0.623	$0
8	$0	$0	$0	$0	0.582	$0
9	$0	$0	$0	$0	0.544	$0
10	$0	$0	$40,000	$40,000	0.508	$20,334
TOTAL	**$96,000**	**$0**	**$80,000**	**$176,000**	**---**	**$145,000**

Notes and Assumptions:
1.) Cost estimates are developed at a FS level for comparative evaluation of alternative, level of accuracy is +50% / -30%.
2.) Estimate unit cost were developed using 2017 labor and material costs, and refined production rates based on Parsons experience and current industry standards.
3.) Present Worth analysis has been developed based on a 7% discount factor.

TABLE A-6
BESTWAY CLEANERS FEASIBILITY STUDY
Soil Vapor ALTERNATIVE 3 - Mitigation

NYSDEC Site: **Temco** Location: **West Haverstraw, New York** Phase: **Feasibility Study; +50%/-30% accuracy** Base Year: **2017** Date: **March 17, 2017**	Project title: **Alternative # 3 - Mitigation, assumes assume 20 houses are assessed and 10 require a mitigation system.**

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
DIRECT CONSTRUCTION COSTS				
1.) Soil Vapor Monitoring	20	Per House	$4,000	$80,000
2.) Soil Vapor Mitigation System	10	Per House	$7,000	$70,000
SUBTOTAL DIRECT CONSTRUCTION COSTS				**$150,000**
OTHER CAPITAL COSTS				
1. Indirect Construction Costs (% of direct construction costs)	1	Lot	17%	$25,500
2. Contingency (% of direct construction costs)	1	Lot	20%	$30,000
3. Engineering, Design & Construction Oversight (% of direct construction costs and contingency)	1	Lot	18%	$32,400
SUBTOTAL OTHER CAPITAL COSTS				**$87,900**
TOTAL CAPITAL COSTS				**$237,900**

TABLE A-6
BESTWAY CLEANERS FEASIBILITY STUDY
Soil Vapor ALTERNATIVE 3 - Mitigation

ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS				
DESCRIPTION	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1. Project Management Administration, and Reporting	0	LS	$0	$0
2.Groundwater Monitoring	0	LS	$0	$0
3. Institutional Controls	0	LS	$0	$0
SUBTOTAL ANNUAL O&M COSTS				**$0**
4. Contingency (% of subtotal)	20%			$0
5. Technical Support/Troubleshooting (% of subtotal and contingency)	10%			$0
TOTAL ANNUAL O&M COSTS				**$0**

PERIODIC COSTS				
DESCRIPTION	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1	0	Unit	$0	$0
TOTAL PERIODIC COSTS				**$0**

PRESENT VALUE ANALYSIS					
COST TYPE	**YEAR**	**TOTAL COST**	**TOTAL COST PER YEAR**	**DISCOUNT FACTOR (7%)**	**PRESENT VALUE**
Capital Cost	0	$237,900	$237,900	1.000	$237,900
Annual OM&M Cost	1-10	$0	$0	7.024	$0
Periodic Cost	5	$0	$0	0.713	$0
Periodic Cost	10	$0	$0	0.508	$0
TOTAL PRESENT VALUE OF ALTERNATIVE					**$238,000**

Notes:

1. Period of analysis is equivalent to the estimated project duration.
2. Present value of alternative is rounded to the nearest $1,000.

PRESENT VALUE CALCULATION			**Annual Discount Factor =**		**7.0%**	
YEAR	**CAPITAL COSTS**	**ANNUAL O&M COSTS**	**PERIODIC COSTS**	**TOTAL COST**	**DISCOUNT FACTOR (7%)**	**PRESENT VALUE**
0	$237,900	$0	$0	$237,900	1.000	$237,900
1	$0	$0	$0	$0	0.935	$0
2	$0	$0	$0	$0	0.873	$0
3	$0	$0	$0	$0	0.816	$0
4	$0	$0	$0	$0	0.763	$0
5	$0	$0	$0	$0	0.713	$0
6	$0	$0	$0	$0	0.666	$0
7	$0	$0	$0	$0	0.623	$0
8	$0	$0	$0	$0	0.582	$0
9	$0	$0	$0	$0	0.544	$0
10	$0	$0	$0	$0	0.508	$0
TOTAL	**$237,900**	**$0**	**$0**	**$238,000**	**---**	**$238,000**

Notes and Assumptions:

1.) Cost estimates are developed at a FS level for comparative evaluation of alternative, level of accuracy is +50% / -30%.

2.) Estimate unit cost were developed using 2017 labor and material costs, and refined production rates based on Parsons experience and current industry standards.

3.) Present Worth analysis has been developed based on a 7% discount factor.