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November 18, 2013

Mr. Lucas Berresford
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NOV 19 2013

SITE ASSESSMENT,
REMEDICATION &
REVITALIZATION

Subject: Feasibility Study Work Plan
Joslyn Clark Controls, LLC. Facility
2013 West Meeting Street
Lancaster County, South Carolina

Dear Mr. Berresford:

On behalf of Joslyn Clark Controls, LLC, ERM NC, Inc. is pleased to present two hard copies and one electronic copy of the Feasibility Study Work Plan for the above referenced site.

Should you have any questions or comments, feel free to contact us at (704) 541-8345.

Sincerely,

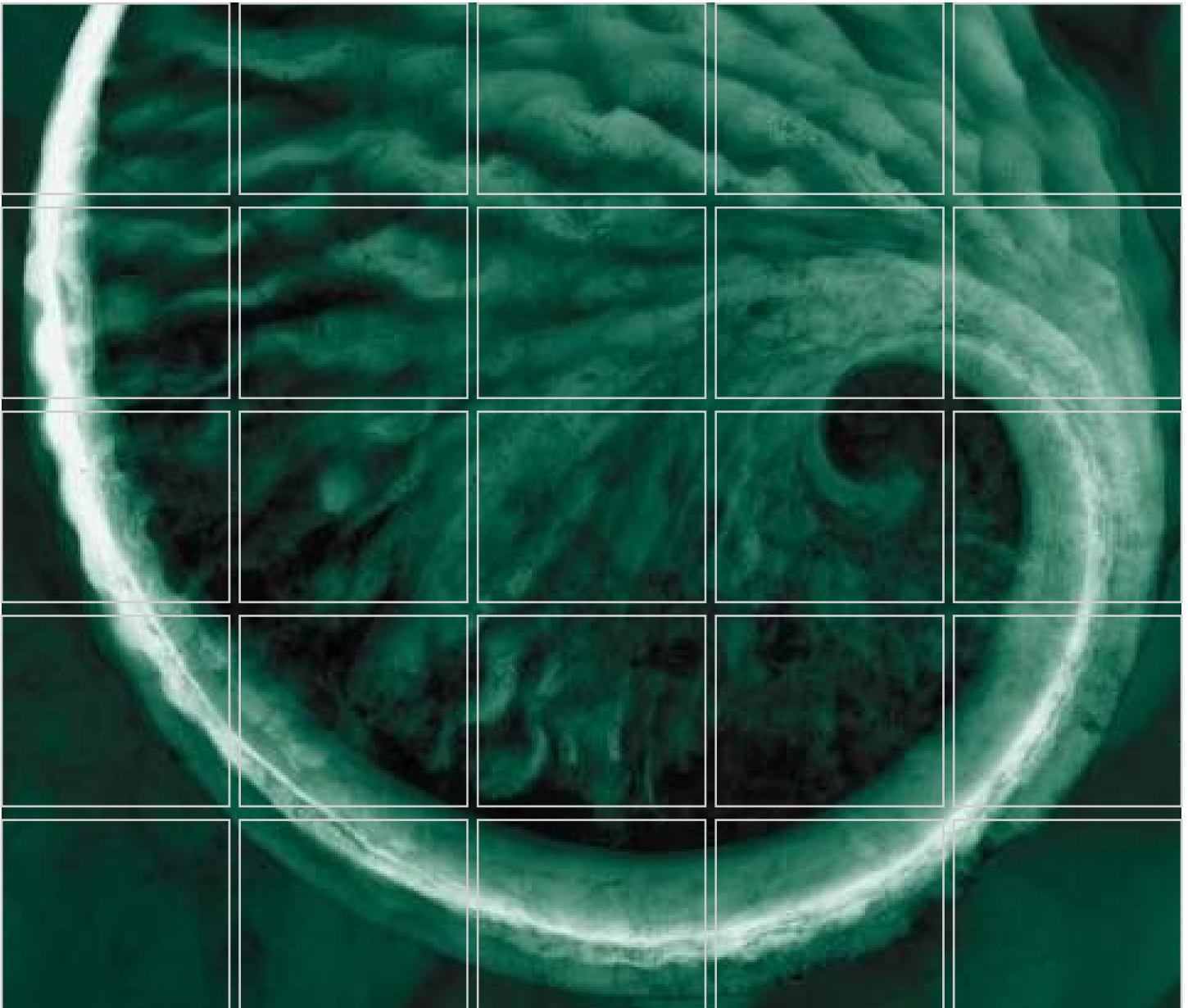
Michael Pressley
Project Manager

Rick Tarravechia, P.G.
Partner-in Charge

enclosures

cc: Mr. Carl Grabinski - Joslyn Clark Controls

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Feasibility Study Work Plan

**Joslyn Clark Controls, LLC Facility
2013 W. Meeting Street
Lancaster, South Carolina**

November 18, 2013

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Prepared For: Joslyn Clark Controls, LLC

November 18, 2013



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1.0 INTRODUCTION

This Feasibility Study Work Plan (FS Work Plan) was prepared by ERM NC, Inc. on behalf of Joslyn Clark Controls, LLC (Joslyn Clark) for the Joslyn Clark facility (Site) located at 2013 W. Meeting Street, Lancaster, Lancaster County, South Carolina (see Figure 1). The FS Work Plan has been requested by South Carolina Department of Health and Environmental Control (SCDHEC) per the requirements of the Voluntary Cleanup Contract (VCC) 13-5875-RP executed October 2, 2013 between the SCDHEC and Joslyn Clark. The purpose of this FS Work Plan is to document the preliminary evaluation and selection of appropriate remedial technologies to be employed in the source area groundwater zone, and to choose one technology for pilot testing.

1.1 SITE DESCRIPTION AND BACKGROUND

The subject property consists of 23 acres of land and is developed with two buildings. The now vacant former manufacturing building was constructed in 1964 and consists of approximately 180,000 square feet of floor space. The now vacant former warehouse/storage building was constructed in 1967 and consists of approximately 14,400 square feet of floor space. The subject property has been used to manufacture electrical control equipment for fire safety purposes since its construction in 1964. Figure 2 illustrates the general property layout.

The principal raw materials for manufacturing onsite included sheet metal, copper wire, pre-manufactured metal and plastic components, electrostatic paint, and oil-based paint. Joslyn Clark's primary production included the fabrication of metal cabinets, which were populated with various electrical, plastic, and metal components purchased from other off-site manufacturers. The Joslyn Clark facility had been a regulated source of air emissions, industrial wastewater discharge, and hazardous waste.

1.2 ENVIRONMENTAL INVESTIGATION HISTORY

Previous site assessment activities have included:

- A Phase I Environmental Site Assessment (ESA) was conducted by ERM in January 2009 that identified potential environmental concerns related to a former metal plating operation and a former degreasing operation which used trichloroethylene (TCE) as a solvent.
- Phase II ESA activities conducted in 2009 included the installation of 15 soil borings and seven permanent monitoring wells (MW-1 through MW-7) to assess areas of potential environmental concern identified in the Phase 1 ESA. TCE was detected in several soil samples at low concentrations. TCE was also detected in four monitoring wells at concentrations ranging from 7.7 µg/L to

2,700 µg/L, which is above the established South Carolina Maximum Contaminant Level (MCL) of 5.0 µg/L.

- During January of 2011, Joslyn Clark conducted a sensitive receptor survey (SRS). The SRS indicated that the closest water supply well to the site was located at a trailer park about 645 feet upgradient from the Joslyn Clark site and according to the property owner, was not in use. The next closest water well was almost 3,500 feet from the Joslyn Clark site, also in the general upgradient direction.
- Phase III ESA activities were conducted in 2011 to further delineate the volatile organic compound (VOC) plume in groundwater and collect additional soil samples. Three additional shallow monitoring wells (MW-8, MW-9 and MW-10) were installed to further evaluate the horizontal extent of the VOC plume. Two deep wells (MW-3D and MW-10D) were installed to evaluate the vertical extent of the VOC impacted groundwater at the site. Groundwater samples collected during the Phase III activities showed multiple chlorinated compounds, with TCE and PCE being the most prevalent.
- A passive soil gas survey (SGS) took place on November 27-29, 2012 with the installation of 60 soil gas points in the northwest portion of the manufacturing building. Twenty-five (25) VOCs were identified in the soil gas samples. The highest VOC concentrations were found at the two locations in the northwest portion of the building, in the vicinity of the former wastewater treatment room, and the former paint booth and sump (southwestern portion of the building).
- During March and April 2013, ERM conducted a Remedial Investigation at the facility in order to further characterize the source of the observed TCE plume originating inside the building and to collect additional information to facilitate subsequent groundwater remediation activities. Activities included the installation of five soil borings, one temporary well and three permanent monitoring wells inside the building (MW-11, MW-11I, and MW-11D). The results of these activities included:
 - The passive soil gas study indicated that PCE and TCE vapors are present within the pore space of the soil in the vicinity of the former wastewater treatment room and former paint booth and sump (southwestern portion of the building). Confirmatory samples collected from these areas did not identify the presence of chlorinated VOCs in soil.
 - 1, 4-Dioxane was detected in soil samples collected from each of the five borings at the shallow (3-5 foot) and deep (13-15 foot intervals). The concentrations ranged from 0.404 mg/kg to 0.992 mg/kg, which exceeded the risk-based protection of groundwater standard of 0.00014 mg/kg, but not the residential soil screening level of 4.9 mg/kg. 1, 4-

Dioxane was detected in only two groundwater samples, temporary well GP-19 (0.95 ug/L) and shallow well MW-11 (0.787 ug/L).

- The vertical extent of VOC-affected groundwater has not been completed defined; however, the bulk of the VOC mass in groundwater is at the shallow depths, further delineation of the vertical extent of TCE-affected groundwater is not necessary for remedial purposes.
- The horizontal extent of the TCE-affected groundwater at the site is delineated and the TCE plume is confined to the subject property.

Figure 3 illustrates the locations of all soil borings installed at the site. Figure 4 presents a groundwater isoconcentration map for TCE in groundwater using the data from the most recent comprehensive groundwater analytical sampling event (April and May 2013). Figure 3 also illustrates the locations of the onsite groundwater monitor wells. It should be noted that monitor well MW-9 was installed proximal to the two former off-site wastewater lagoons. The former lagoons are not associated with the Joslyn Clark site.

1.3 HUMAN HEALTH RISK ASSESSMENT

A human health risk assessment (HHRA) was conducted to evaluate potential health impacts for current and future occupants of the Joslyn Clark facility. Both carcinogenic and non-carcinogenic hazards were evaluated as part of the risk assessment. The results of the risk assessment described in the HHRA indicate that there is limited risk/hazard to human health receptors at the site, with the exception of site/ maintenance workers who may be exposed to organic vapors migrating from groundwater, and to a lesser extent construction workers who may contact impacted subsurface soil during future excavation or trenching activities. The HHRA identified no unacceptable risk to the Site maintenance worker or adolescent trespasser/visitor.

Under current and future conditions, the cumulative risks estimated for the facility worker receptor population is above the US EPA's acceptable cancer risk range of 1×10^{-6} to 1×10^{-4} due to the potential for inhalation of organic vapors originating from groundwater. Likewise, the cumulative non-carcinogenic hazards under future conditions are only marginally above the Hazard Index of 1.0 for the future construction worker due to potential exposure with thallium in soil at one location beneath the building at the site. Potential exposure with thallium is limited, if occurring at all.

2.0 *SITE CHARACTERISTICS*

A summary of significant Site hydrogeologic characteristics based on assessment activities is provided below.

2.1 *CURRENT LAND USE EVALUATION*

The subject property consists of 23 acres of land and is developed with two buildings. The now vacant former manufacturing building was constructed in 1964 and consists of approximately 180,000 square feet of floor space. The now vacant former warehouse/storage building was constructed in 1967 and consists of approximately 14,400 square feet of floor space. The subject property is surrounded by a chain link fence.

The subject property is located at an elevation of approximately 540 feet above mean sea level (msl) and is situated on a topographic high point that slopes, southeast, south, and southwest from the area of the manufacturing plant building. A review of the USGS Lancaster, South Carolina topographic map indicates that there are two unnamed drainage features near the subject property. One feature is located approximately 500 feet southeast of the eastern property boundary and the second is located approximately 1,100 feet west of the western property boundary. Both drainage features discharge into Cane Creek, which is located approximately one mile south-southeast of the subject property.

Adjacent properties include a mobile home park and a maintenance garage to the north, a retail gasoline station to the northwest, a multi-family apartment building and Synteen Technical Fabrics, Inc. to the east, an apparently unused stretch of railroad tracks to the south, and wooded and undeveloped land to the west.

2.2 *SITE HYDROGEOLOGY AND CONCEPTUAL MODEL*

The Site is located near the Western Piedmont Physiographic Province of South Carolina. According to the Geologic Map of South Carolina (1997) and *The Geology of the Carolinas, Horton and Zullo, 1991*, the Lancaster area is located within the Charlotte Belt and is specifically underlain by mica gneiss. Saprolite, a layer of weathered and variably decomposed bedrock, commonly mantles bedrock in this region. Saprolite has the appearance of compact clayey to sandy soil, with original bedrock textures and features preserved. A partially weathered rock (PWR) zone (transition zone) is commonly present between the saprolite and competent underlying bedrock.

Soils encountered during drilling activities consisted of light brown to orangish-brown, fine-grained, micaceous clayey silt from near the surface grade to approximately 10 feet BGS. According to Lounsbury et. al. 1914, approximately 80 percent of the subject property is underlain by Cecil sandy clay, 10 percent is Madison and Pacolet soils, 8 percent is Hiwassee sandy clay loam, and 2 percent is Catecay -

Toccoa Complex. Each soil type is well drained and has a moderate infiltration rates. The soil changes to mostly coarse-grained sand (saprolite) between 10 feet and approximately 80 feet BGS. Density of the saprolite increased with depth, resulting in hollow-stem auger refusal at approximately 35 feet BGS. Bedrock was encountered between 50 feet below grade surface (BGS) in the northeast corner of the property and 80 feet BGS in the southwest corner of the property.

Groundwater in the shallow saprolite zone occurs in the interstitial pore space of the saprolite. The depth to groundwater in the saprolitic zone at the subject site ranges from 42 to approximately 50 feet below grade. The assessment activities at the site indicated that the saprolite aquifer zone extends from depths of 42 feet to 143 feet (approximately 101 feet of saturated zone). The saprolite at the site is characterized by orangish-brown, fine-grained, sandy silt to approximately 70 feet below grade, where it then grades into a tan and greenish-grey partially weathered siltstone. Groundwater flow in the saprolite and partially weathered rock zones is governed by water table conditions. This means that groundwater will flow under unconfined conditions and generally mimic topography. Therefore, groundwater movement will be from upland areas (recharge zones) to nearby surface streams (discharge zones, such as Cane Creek and its tributaries, farther to the southeast). Contaminant transport of VOCs typically follows the advective flow of groundwater.

During the assessment activities, one double-cased, bedrock well was installed (MW-11D) into the very top of the mica gneiss bedrock. Competent bedrock surface at the site was encountered at 143 feet below land surface (bls). Above 143 feet, thin, intermittent layers of hard bedrock and weathered saprolite had been encountered. Deep well MW-11D was installed to a depth of 150 feet, 7 feet into competent bedrock (mica gneiss). Because 10 feet of well screen was utilized in MW-11D, the well straddles the saprolite/bedrock interface.

Based on the groundwater elevations obtained from onsite monitor wells, groundwater flow is to the south, towards Cane Creek under a hydraulic gradient of 0.0106.

Based on this model and the distribution of VOCs in soil and groundwater, the following conclusions are made concerning chemical transport mechanisms at the site:

1. Dense non-aqueous phase liquid (DNAPL) is not present at the Site.
2. Contaminants of concern are not present in the soil above EPA soil screening levels for residential or industrial settings (see Tables 1 and 2). TCE, the primary constituent of concern in groundwater, was detected in three soil samples, the highest concentration being 0.043 mg/kg in GP-3 under the former plating area (source area vicinity).
3. Vapor phase transport – volatilized contaminant mass may migrate through the vadose zone due to advection and diffusion, thereby creating a vapor plume near the source area. The results of the passive soil gas survey conducted in

December 2012 verified the presence of TCE in soil vapor in the vicinity of the source area.

4. Groundwater transport - dissolved phase contamination below the water table will be transported primarily by the process of advection. However, many transport processes (e.g. molecular diffusion, adsorption, chemical and biological transformation, and colloid-facilitated transport) will affect the dissolved phase contaminant transport.
5. Surface water transport - dissolved phase contamination present in the Site groundwater system is contained onsite, and has not encountered any hydrologic boundary (i.e., creeks, ponds, or intermittent drainages).

Due to the trace levels of VOCs and other compounds of concern in soil, the remainder of this FS Work Plan focuses only on the remediation of VOC affected groundwater.

3.0 SOURCE AREA GROUNDWATER CONTAMINATION

The purpose of this FS Work Plan is to document the preliminary evaluation and selection of appropriate remedial technologies to be implemented for groundwater in the source area, and to choose one technology for pilot testing. The nature and extent of the groundwater contamination in the source area is summarized below.

Several VOCs were detected in groundwater at concentrations above the respective South Carolina groundwater quality standards. The primary contaminant of concern at the site is TCE. The highest concentration of TCE detected at the source area was 3,200 µg/L in monitor well MW-3 (up to 16,900 µg/L TCE has been detected in the off-site former lagoon area, but the remediation of the off-site lagoon is the responsibility of others and is not included in this work plan). Groundwater samples collected from all five source area monitor wells had TCE concentrations above the maximum contaminant level (MCL) for TCE (5 µg/L). TCE has not been detected in the upgradient/background well (MW-1) or the downgradient most monitor wells (MW-10 and 10D).

The following table presents a summary of TCE and its daughter products detected in samples collected from Site monitor wells above South Carolina MCLs.

Maximum TCE and Daughter Product Concentrations in Source Area Groundwater (September 2009 - June 2013)

Compound	Maximum Concentration (µg/l)	SC MCL Groundwater Standard (µg/l)
Trichloroethene	3,200 (MW-3)	5
1,1-Dichloroethene	155 (MW-11)	7
<i>cis</i> 1,2-Dichloroethene	64.8 (MW-11)	70
Vinyl Chloride	Not Detected	2

µg/L = micrograms per liter

4.0 CORRECTIVE ACTION ALTERNATIVES ANALYSIS

A corrective action alternatives analysis was conducted to develop a remediation strategy for VOC mass removal in groundwater at the source area. In accordance with SCDHEC procedures, the feasibility study (FS) process outlined by USEPA, 1998 was used as general guidance for evaluating potential remedial options. Site-specific hydrogeologic conditions and the nature of COCs present at the Site were used to identify potential corrective action technologies. A scoring process has been applied to each set of potential corrective action alternatives to aid in the identification of the most technologically feasible and economically practicable alternatives.

4.1 REMEDIAL OBJECTIVES

While the ultimate source area groundwater remedial objective, consistent with prevailing regulations, is to meet the MCL, this goal is not likely to be achieved at the vast majority of chlorinated VOC sites in the source zones and “exclusive reliance on this goal inhibits the application of source depletion technologies because achieving this goal is generally beyond the capabilities of available in-situ technologies in most geologic settings” (USEPA, 2003). According to USEPA, 2008, “...well-implemented in situ remediation projects are likely to reduce source zone groundwater concentrations by about one to possibly two orders of magnitude (90 – 99% reduction) from pretreatment levels.” As such, a more appropriate source area groundwater remedial goal, based on an approach which has been accepted by USEPA (ITRC, 2010), is to reduce the mass discharge of contaminated groundwater from the source area by ninety-percent.

4.2 REMEDIAL TECHNOLOGIES

A screening evaluation was conducted to select a remediation method for the source area groundwater at the Site. Treatment options evaluated during this early stage of the process are shown below.

Source Area Remedial Technologies Evaluated

Thermal treatment	In-Situ Enhanced Anaerobic Bioremediation
Permeable Reactive Barriers	Monitored Natural Attenuation
Groundwater Pumping/Pump and Treat	Air Sparging (AS)
In-Situ Chemical Oxidation	

These technologies were reviewed and are discussed below.

4.2.1 *In-situ Enhanced Anaerobic Bioremediation*

Under anaerobic conditions (i.e. little to no dissolved oxygen) naturally occurring bacteria can transform chlorinated ethenes and ethanes, into non-chlorinated

compounds. This reaction provides energy for growth to the bacteria and reduces chlorinated compounds to naturally occurring non-chlorinated organic compounds such as ethene and ethane.

Simple organic compounds, such as lactate, can be added to the subsurface to stimulate the growth of dehalorespiring bacteria and consequently promote the reduction of chlorinated ethenes and ethanes. These organic compounds serve as “food” for the dehalorespiring bacteria, providing a source of energy and carbon for the bacteria. The bacteria required to complete the reaction are not always naturally occurring within the aquifer. A commercial culture of bacteria capable of biodegradation is available to be injected into the subsurface along with the carbon source for most COCs.

Several indicators are used to predict the potential success of anaerobic bioremediation. These indicators include DO, ORP, pH, TOC, and the presence of anaerobic degradation products in groundwater. The parameters DO, ORP, pH, and TOC should be within the operating ranges indicated below in order for anaerobic biodegradation to occur.

Parameter	Optimal Operating Range	Source Area Concentrations (Shallow/Intermediate Depths)
Dissolved Oxygen	Less than 2 mg/L	Greater than 6 mg/L
ORP	Less than 0	Greater than 150
pH	Between 5 and 7	Between 5 and 7
TOC	Greater than 20 mg/L	< 1 mg/L (3.9 mg/L in MW-11D)

The lack of naturally occurring carbon and the aerobic nature of the shallow (and intermediate depth) aquifer in the source area indicate that enhanced bioremediation may not be the best remedial option for the source area. Also, the lack of widespread TCE daughter products in groundwater at the site (see Section 3.0) appears to indicate that bioremediation is not occurring naturally under the current site conditions.

4.2.2 Air Sparging

Air sparging is an in-situ technology in which pressurized air is injected into a contaminated aquifer. Air streams traverse horizontally and vertically through the soil column, thus removing contaminants by volatilization. A SVE system is often used to then remove the vapor-phase contaminants. The technology is designed to operate at relatively high flow rates so that contact between groundwater and air is maintained.

The following factors may limit the applicability and effectiveness of the process: low permeability soils, high water tables, aquifer heterogeneity that limits uniform air flow through the saturated zone, and adverse effects on natural anaerobic degradation processes by the introduction of oxygen. The technology requires near constant

operation but generally has relatively low operation and maintenance (O&M) costs, since limited water is generated and the equipment is not complex.

4.2.3 *In-Situ Chemical Oxidation*

Chemical oxidation is a direct chemical reaction involving the application or injection of oxidants into groundwater to destroy or chemically transform the contaminants. When a material is oxidized it is converted to a higher valence state. Typically with organic chemicals (carbon based) this results in their conversion to carbon dioxide (CO₂).

A number of oxidants are effective in treating the contaminants of concern at this site. They are, in order of decreasing oxidative strength, ozone, persulfate, hydrogen peroxide, permanganate, oxygen, nitrate, and iron. Of these, ozone, peroxide, and permanganate are the most widely used and are generally commercially available.

An effective technique to deliver the oxidant involves injection of the oxidant solution into the aquifer via a direct push rig or PVC wells, thus the reaction will occur in-situ. As such, this remedial approach is often referred to as in-situ chemical oxidation (ISCO).

Oxidants injected in the subsurface will react with any organic compounds encountered, including contaminants and naturally occurring organic matter. The background oxidant demand, known as the soil oxidant demand (SOD) is measured prior to oxidant delivery so that sufficient oxidant can be delivered to the subsurface to oxidize both the naturally occurring organic matter and the contaminants targeted by ISCO. Soil samples collected from the Site were submitted for potassium permanganate SOD and sodium persulfate SOD analysis in April 2013. The SOD for potassium permanganate ranged from 4.3 to 4.9 grams per kilogram (g/kg). The SOD for sodium persulfate ranged from 6.3 to 7.4 g/kg.

4.2.4 *Thermal Treatment*

There are two main types of thermal treatment which can be employed to destroy COCs in the subsurface; 1) steam injection, and 2) electrical resistance heating (ERH). For both technologies mass reduction is principally achieved by altering the temperature-dependent properties of contaminants in order to increase their mobility and facilitate their removal.

Thermally enhanced COC recovery using steam injection involves the injection of steam into the vadose and saturated zones to enhance the mobilization of the COCs for extraction by multiphase recovery wells. Steam is injected through injection wells at and below the depth being treated, optimally bringing the entire treated volume to

the target soil temperature (over 200°F). The main recovery mechanism for contaminants in the steam zone is by steam displacement (stripping). Steam stripping occurs as the injected steam sweeps the mobilized COC to the extraction wells in response to the large pressure and thermal gradients. Steam injection will also be effective in removing any trapped ganglia of COC that cannot be removed by pumping or other viscous forces. Steam injection is most effective in subsurface geology that contains more permeable material (i.e. sands and silts). A robust aboveground infrastructure is required to generate the steam and capture, treat, and cool the recovered vapors.

ERH increases the subsurface temperature by passing electrical current between a network of electrodes embedded into the subsurface. The heating pattern in the subsurface is affected by the amount and position of the electrodes, the voltage difference applied to each electrode, and the electrical resistance of the soil. Vapor and liquid recovery wells are placed throughout the electrode network to recover contaminant vapors and impacted groundwater from the subsurface. ERH is most effective in subsurface geology with high conductivity (i.e. clays). ERH also requires an above ground treatment system to collect, treat, and cool recovered contaminant vapors and impacted groundwater.

Due to the high cost associated with thermal treatment and the health and safety concerns associated with heating the subsurface, thermal treatment is most typical employed for source area treatment.

4.2.5 Groundwater Pump and Treat

Groundwater pump and treat systems include the installation of several groundwater extraction wells placed in an array which allows for complete capture of groundwater from the subsurface over a specified design area. The groundwater capture accomplishes two goals; 1) contaminated groundwater is transferred to the surface where the contaminant mass is removed from the groundwater and 2) the groundwater plume is contained, eliminating continued contaminant migration. The number of groundwater extraction wells required to maintain hydraulic control of the groundwater plume is based on site specific considerations including groundwater flow velocity, hydraulic conductivity, the volume and shape of the contaminant plume, and subsurface geologic structures in the saturated zone.

Extracted groundwater is collected in an on-site above ground treatment facility where the contaminant mass is removed from the groundwater in sufficient quantities so that the treated groundwater meets the applicable discharge limits. Typical groundwater treatment technologies evaluated as part of a pump and treat system include air strippers and granular activated carbon. Filtration is often required prior to treatment to remove sediment particles and to prevent iron fouling of the treatment infrastructure.

Treated groundwater is discharged either to a nearby surface water body or to the municipal sewage treatment facility. An NPDES permit issued by the state is required to discharge treated groundwater to a surface water body. A local permit is typically issued by the municipal sewage treatment facility which includes a discharge fee schedule and discharge limits for the applicable COCs.

4.2.6 *Permeable Reactive Barriers (PRB)*

Permeable reactive barriers include the placement of a reactive material, such as zero valent iron (ZVI), in the subsurface where a plume of contaminated groundwater will move through it as it flows (typically under its natural gradient), thus creating a passive treatment system whereby treated water will exit the other side. The PRB is not a barrier to the water. When properly designed and implemented, PRBs are capable of remediate a number of contaminants to stringent cleanup goals.

ZVI PRBs have been shown to promote abiotic degradation of chlorinated compounds into harmless daughter products via reductive dechlorination. ZVI creates reducing conditions due to the reactions between groundwater and iron metal resulting in end products of ferrous iron, chloride ions, and the dehalogenated compound.

The lifetime of a ZVI barrier will essentially be determined by how fast and by what types of minerals precipitate within the reaction zone. As the ZVI comes in contact with water it is oxidized to ferrous ion by many substances causing dissolution and loss of metal volume. During PRB installation the reactive media must be made accessible to the contaminant by some emplacement method and, as with most remedial technologies, this becomes increasingly difficult at greater contaminant depth or for contaminants in fractured rock. Once installed, the PRB should be carefully monitored for both compliance and performance; compliance to ascertain that corrective action goals are being met, and performance to assess whether the PRB emplacement is meeting its design criteria and longevity expectations.

Several techniques for constructing ZVI PRBs have been employed. Open excavation and emplacement of granular ZVI mixed with sand is the simplest and least expensive method and can be used to a depth of approximately 20 feet. However, the soil must have sufficient strength to remain open without caving in long enough to emplace the ZVI-sand mixture. The need to dewater and/or install shoring can increase the cost substantially. A biopolymer slurry can also be placed in a trench to provide stability to the trench walls, and then granular ZVI can be added to the slurry. After some time, the biopolymer slurry breaks down allowing groundwater to flow through the treatment zone. Continuous trenchers, which allow simultaneous excavation and backfilling without an open trench, have been used to install PRBs up to three feet wide to depths up to 35 feet. For deeper applications, very fine powdered ZVI can be injected using high pressure water or nitrogen gas as a carrier fluid.

4.2.7 *Monitored Natural Attenuation (MNA)*

MNA is an in-situ remedial approach that depends upon natural processes to degrade and dissipate contaminants. Natural attenuation processes include biodegradation, adsorption to the aquifer matrix, and dilution. Geochemical field measurements and laboratory analyses were obtained from groundwater samples for the evaluation of these site-specific natural attenuation processes. Field geochemical measurements (pH, conductivity, oxidation-reduction potential, and dissolved oxygen) were recorded at each groundwater sample collection. Laboratory analyses (total organic carbon, chloride, nitrate, sulfate, iron, and manganese) were performed in key source area wells for the evaluation of geochemical conditions. The results of the laboratory analyses for these natural attenuation parameters are presented in Table 3.

The primary limitation of natural attenuation is the amount of time required to achieve the remediation objective of reducing contaminant concentrations to the remediation goals, particularly at the source area. Overall, aquifer geochemical measurements at the site indicate conditions that are marginally supportive of biological reductive de-chlorination (biological degradation) of TCE. Measurements indicate relatively aerobic conditions, whereas anaerobic conditions are necessary for efficient biological degradation of the parent chlorinated solvents present at the site. The presence of the biological degradation byproduct cis-1,2-DCE in monitor well MW-11, although, does suggest that localized conditions are present that enable some degree of biological reductive dechlorination. The relatively more widespread presence of 1,1-DCE (wells MW-3, 3D, 10, 11, 11I), is likely attributable to a separate, abiotic degradation process. Physical attenuation processes (volatilization and dilution) are likely the primary attenuation mechanisms currently active at the site.

4.3 *REMEDIAL TECHNOLOGY SCREENING*

Based on the review of the above remedial options, five remediation technologies were chosen for further review. These five technologies were subjected to a screening assessment based on EPA criteria. The screening assessment is included in [Appendix A](#). Each technology assessed was then rated with a numerical score based on the nine EPA criteria for feasibility studies. The nine criteria include the following:

- Overall protection of human health and the environment
- Compliance with regulatory requirements
- State acceptance
- Long term effectiveness and performance
- Reduction of toxicity, mobility, or volume
- Community acceptance
- Short term effectiveness
- Implementability
- Cost

The technologies chosen for further evaluation (screening) were in-situ chemical oxidation, in-situ bioremediation, monitored natural attenuation, zero valent iron, and pump and treat (see Appendix A). Thermal treatment was not retained for further consideration due to the costly nature of implementation. Air sparging was not retained for further consideration due to the technical challenges associated with treating 100 feet of saturated aquifer through volatilization.

4.4 RESULTS OF INITIAL SCREENING OF TECHNOLOGIES

For the initial screening process, the selected technologies were given a rating between 1 and 5 for the nine EPA criteria. The overall rating for the technology was taken as the sum of the ratings for each criterion. The technology with the highest preliminary rating was In-Situ Chemical Oxidation (ISCO). The remainder of this FS Work Plan addresses the need to perform a ISCO pilot test to further assess this remedial technology at the site.

5.0 PERMITTING

An underground injection control (UIC) permit will be required prior to operation of the pilot-test injection wells. Since the remediation system discharge is not co-located with a major source of hazardous air pollutants (HAPs) and the remediation system has not direct discharge of pollutants, an air emissions permit will not be required. All other necessary permits will be applied for and obtained prior to beginning pilot test activities.

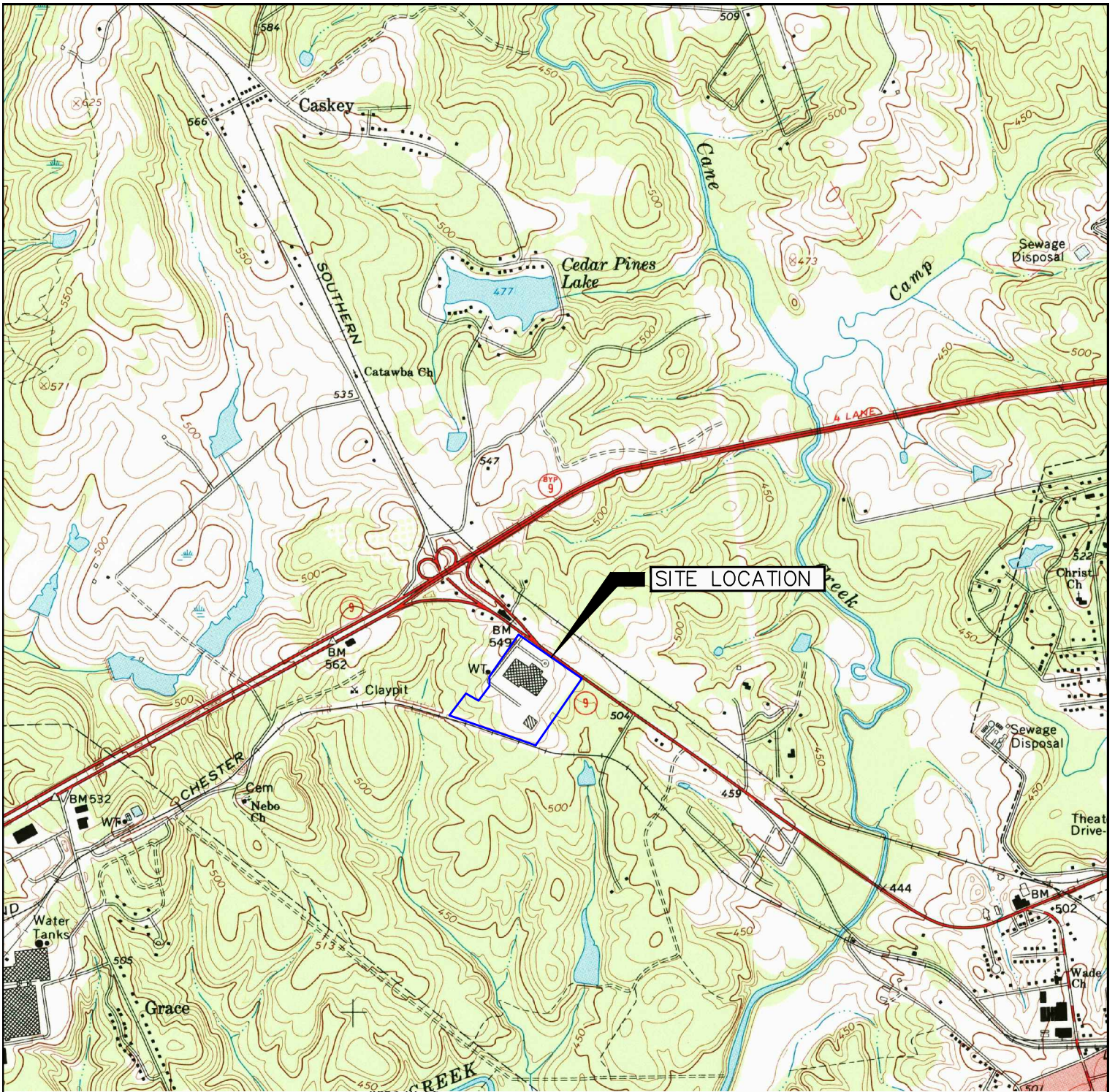
6.0 REPORTING

Following SCDHEC approval of the FS Work Plan, a Pilot Test Work Plan will be developed and submitted to SCDHEC. Upon approval, the Pilot Test Work Plan will be implemented. Based on the results from the pilot test, and assuming favorable results, a Feasibility Study will be prepared and submitted to SCDHEC.

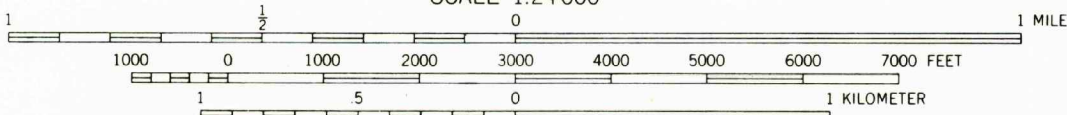
7.0 REFERENCES

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Figures



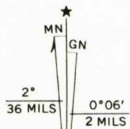
SCALE 1:24 000



QUADRANGLE LOCATION

CONTOUR INTERVAL 10 FEET
 DATUM IS MEAN SEA LEVEL
 ROAD CLASSIFICATION

Primary highway, all weather, hard surface
 Secondary highway, all weather, hard surface
 U. S. Route
 Light-duty road, all weather, improved surface
 Unimproved road, fair or dry weather
 State Route



LANCASTER, S. C.
 N3437.5—W8045/7.5

ERM NC, Inc.

FIGURE 1

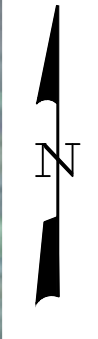
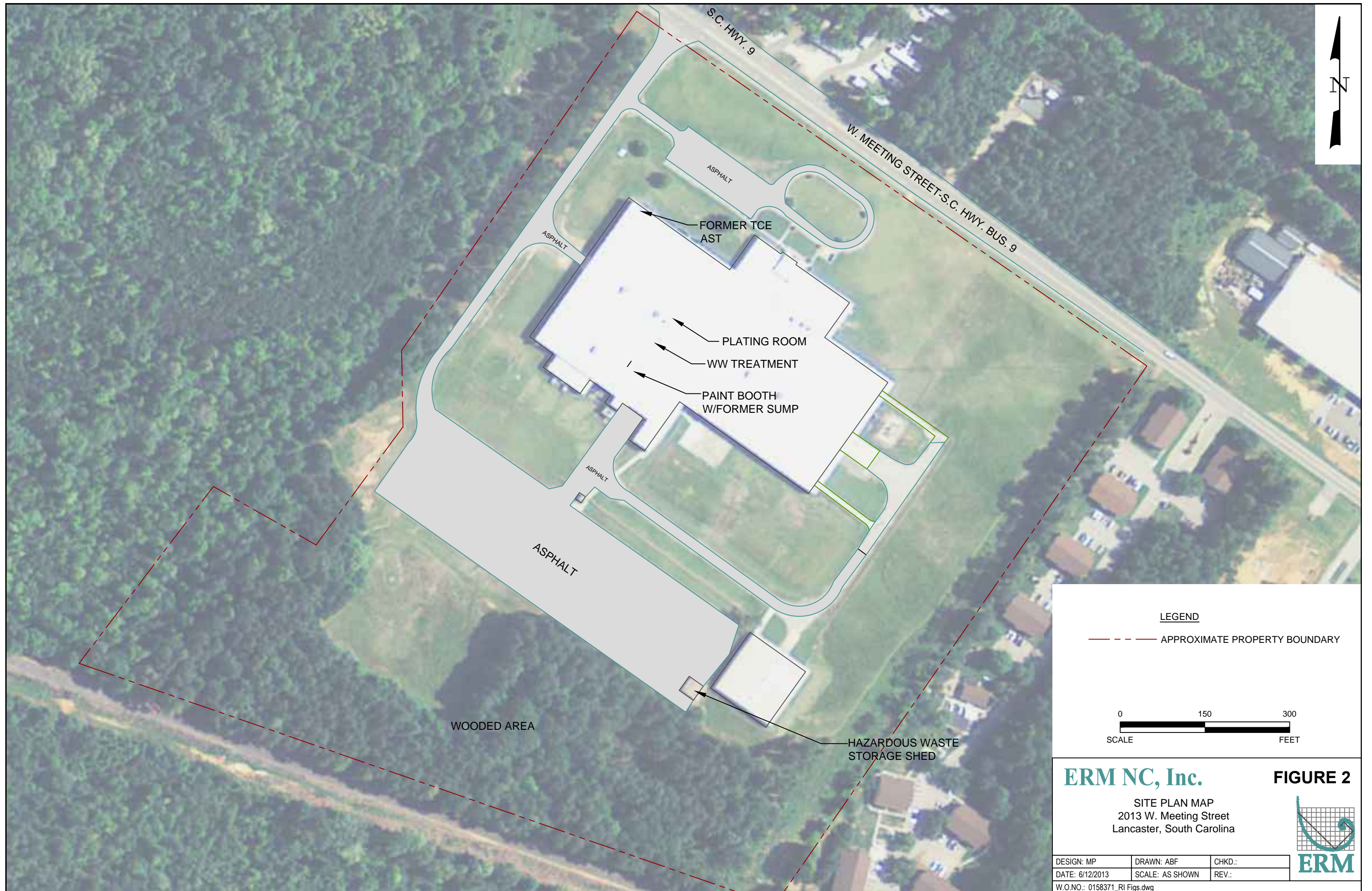
SITE LOCATION PLAN
 2013 W. Meeting Street
 Lancaster, South Carolina



DESIGN: MP	DRAWN: ABF	CHKD.:
DATE: 6/12/2013	SCALE: AS SHOWN	REV.:
W.O.NO.: 0158371_RI Figs.dwg		

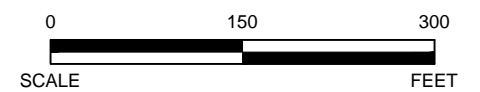
UTM GRID AND 1969 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

1969



LEGEND

--- APPROXIMATE PROPERTY BOUNDARY



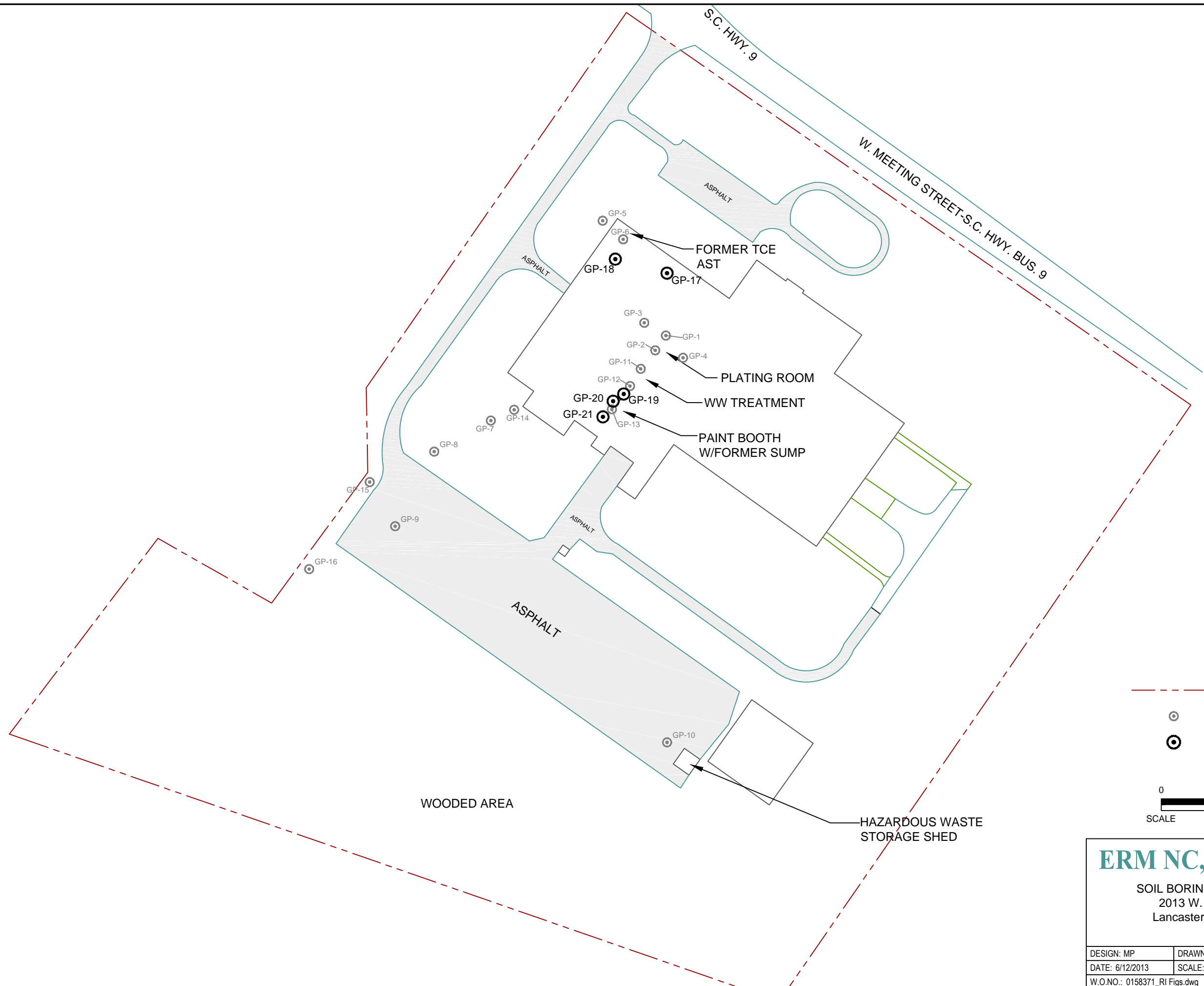
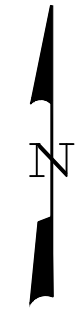
ERM NC, Inc.

FIGURE 2




SITE PLAN MAP
2013 W. Meeting Street
Lancaster, South Carolina



DESIGN: MP	DRAWN: ABF	CHKD.:
DATE: 6/12/2013	SCALE: AS SHOWN	REV.:
W.O.NO.: 0158371_RI Figs.dwg		



LEGEND


-  APPROXIMATE PROPERTY BOUNDARY
-  PREVIOUS SOIL BORING LOCATION
-  SOIL BORING LOCATION

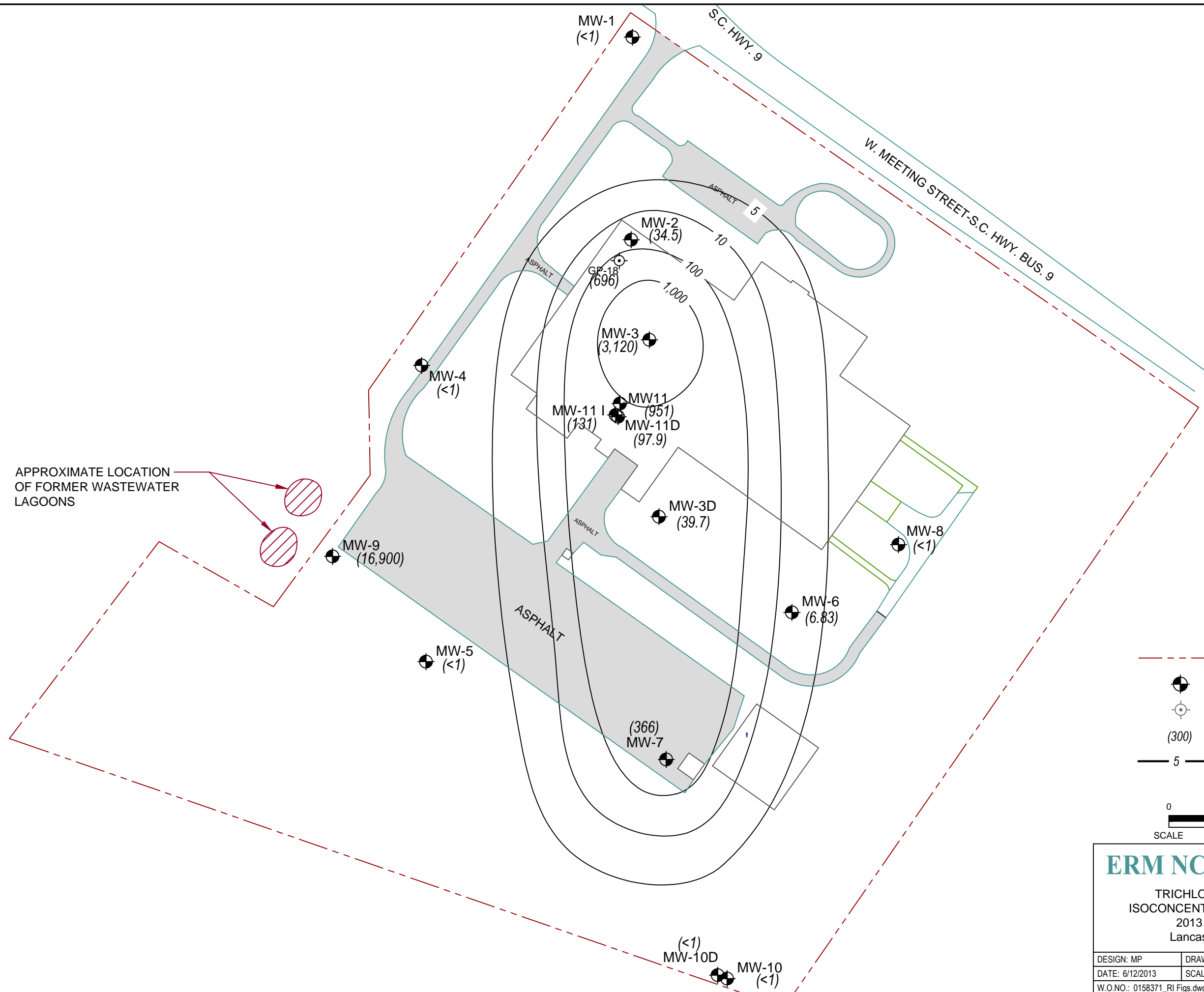
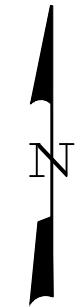


ERM NC, Inc. **FIGURE 3**

SOIL BORING LOCATION MAP
2013 W. Meeting Street
Lancaster, South Carolina

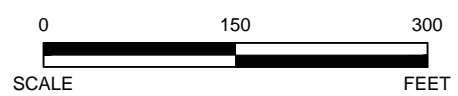
DESIGN: MP	DRAWN: ABF	CHKD.:
DATE: 6/12/2013	SCALE: AS SHOWN	REV.:
W.O.NO.: 0158371_RI Figs.dwg		






APPROXIMATE LOCATION OF FORMER WASTEWATER LAGOONS

- LEGEND**
- APPROXIMATE PROPERTY BOUNDARY
 - MONITOR WELL LOCATION
 - ⊕ TEMPORARY WELL LOCATION
 - (300) TCE CONCENTRATION IN µg/L
 - 5 — TCE CONCENTRATION CONTOUR



ERM NC, Inc.		FIGURE 4
TRICHLOROETHYLENE (TCE) ISOCONCENTRATION MAP - MAY 2013 2013 W. Meeting Street Lancaster, South Carolina		
DESIGN: MP	DRAWN: ABF	CHKD.:
DATE: 6/12/2013	SCALE: AS SHOWN	REV.:
W.O.NO.: 0158371_RI Figs.dwg		



Tables

**TABLE 1
VOC CONCENTRATIONS IN SITE SOILS
JOSLYN CLARK FACILITY
LANCASTER, SOUTH CAROLINA
Page 1 of 3**

Sample ID	Date	Potential Source Area	Total Depth of Boring (ft)	Sample Collection Depth (ft)	VOCs by EPA Method 8260B (mg/kg)								
					Acetone	Chloroform	1,1-Dichloroethene	cis-1,2-Dichloroethene	Tetrachloroethene	Trichloroethene	1,1,2-Trichloroethane	Total Xylenes	
GP-1	4/7/2009	Plating Area	39	0-4	ND	ND	ND	ND	ND	ND	ND	ND	ND
				16-20	ND	ND	ND	ND	ND	ND	ND	ND	ND
				35-39	ND	ND	ND	ND	ND	ND	ND	ND	ND
GP-2	4/7/2009	Plating Area	35	0-4	ND	ND	ND	ND	ND	ND	ND	ND	ND
				16-20	ND	ND	ND	ND	ND	ND	ND	0.0074	ND
				32-35	ND	ND	ND	ND	ND	ND	ND	ND	ND
GP-3	4/7/2009	Plating Area	40	4-8	ND	ND	ND	ND	ND	ND	ND	ND	ND
				12-16	ND	ND	ND	ND	ND	ND	ND	ND	ND
				36-40	ND	ND	ND	ND	ND	0.043	ND	ND	ND
GP-4	4/8/2009	Plating Area	40	8-10	ND	ND	ND	ND	ND	ND	ND	ND	ND
				24-26	ND	ND	ND	ND	ND	ND	ND	ND	ND
				38-40	ND	ND	ND	ND	ND	ND	ND	ND	ND
GP-5	4/7/2009	TCE AST Area	40	0-4	ND	ND	ND	ND	ND	ND	ND	ND	ND
				24-28	ND	ND	ND	ND	ND	ND	ND	ND	ND
				36-40	ND	ND	ND	ND	ND	ND	ND	ND	ND
GP-6	4/8/2009	TCE AST Area	40	4-5	ND	ND	ND	ND	ND	ND	ND	ND	ND
				14-15	ND	ND	ND	ND	ND	ND	ND	ND	ND
				36-38	ND	ND	ND	ND	ND	0.017	ND	ND	ND
EPA Screening Level - Protection of Groundwater - Risk Based					0.24	0.000053	0.0093	0.00082	0.0016	0.000092	0.000013	0.019	
EPA Screening Level - Residential					6,100	0.29	24	16	8.6	0.44	0.16	63	
EPA Screening Level - Industrial					63,000	1.5	110	200	41	2.0	0.68	270	

Notes:

BOLD values indicate an exceedance of a published regulatory threshold; (EPA Screening Level - Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 2013)

mg/kg = Milligrams/kilogram, or ppm;
 J = Estimated value (below reportable);
 ND = Not Detected;
 NA=Not analyzed;
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 N/A = Not applicable

**TABLE 1
VOC CONCENTRATIONS IN SITE SOILS
JOSLYN CLARK FACILITY
LANCASTER, SOUTH CAROLINA
Page 2 of 3**

Sample ID	Date	Potential Source Area	Total Depth of Boring (ft)	Sample Collection Depth (ft)	VOCs by EPA Method 8260B (mg/kg)							
					Acetone	Chloroform	1,1-Dichloroethene	cis-1,2-Dichloroethene	Tetrachloroethene	Trichloroethene	1,1,2-Trichloroethane	Total Xylenes
GP-7	4/8/2009	Wastewater Discharge Line	8	6-8	ND	ND	ND	ND	ND	ND	ND	ND
GP-8	4/8/2009	Wastewater Discharge Line	8	6-8	ND	ND	ND	ND	ND	ND	ND	ND
GP-9	4/8/2009	Wastewater Lagoon Area	47	10-12	ND	ND	ND	0.010	ND	0.200	ND	ND
				26-28	ND	ND	ND	ND	ND	0.039	ND	ND
				38-40	ND	ND	ND	0.0086	0.018	0.320	ND	ND
GP-10	4/8/2009	Hazardous Waste Storage Area	12	6-8	ND	ND	ND	ND	ND	0.0067	ND	ND
GP-11	4/8/2009	Plating / Wastewater Treatment Area	40	4-6	ND	ND	ND	ND	ND	ND	ND	0.097
				18-20	ND	ND	ND	ND	ND	ND	ND	ND
				38-40	ND	ND	ND	ND	ND	ND	ND	ND
GP-12	4/8/2009	Wastewater Treatment Area	37	8-10	ND	ND	ND	ND	ND	ND	ND	ND
				24-26	ND	ND	ND	ND	ND	ND	ND	ND
				35-37	ND	ND	ND	ND	ND	ND	ND	ND
GP-13	4/8/2009	Paint Booth	38	8-10	ND	ND	ND	ND	ND	ND	ND	ND
				24-26	ND	ND	ND	ND	ND	ND	ND	ND
				36-38	ND	ND	ND	ND	ND	ND	ND	ND
GP-14	10/10/2011	Wastewater Discharge Line	8	6-8	ND	ND	ND	ND	ND	ND	ND	ND
GP-15	4/7/2009		8	6-8	ND	ND	ND	ND	ND	ND	ND	ND
EPA Screening Level - Protection of Groundwater - Risk Based					0.24	0.000053	0.0093	0.00082	0.0016	0.000092	0.000013	0.019
EPA Screening Level - Residential					6,100	0.29	24	16	8.6	0.44	0.16	63
EPA Screening Level - Industrial					63,000	1.5	110	200	41	2.0	0.68	270

Notes:

BOLD values indicate an exceedance of a published regulatory threshold; (EPA Screening Level - Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 2013)

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**TABLE 1
VOC CONCENTRATIONS IN SITE SOILS
JOSLYN CLARK FACILITY
LANCASTER, SOUTH CAROLINA
Page 3 of 3**

Sample ID	Date	Potential Source Area	Total Depth of Boring (ft)	Sample Collection Depth (ft)	VOCs by EPA Method 8260B (mg/kg)							
					Acetone	Chloroform	1,1-Dichloroethene	cis-1,2-Dichloroethene	Tetrachloroethene	Trichloroethene	1,1,2-Trichloroethane	Total Xylenes
GP-16	4/7/2009	Wastewater Lagoon Area	40	10-12	ND	ND	ND	ND	ND	0.0038 J	ND	ND
				26-28	ND	0.002 J	ND	0.01	0.025	0.29	0.0019 J	ND
				26-28 (Dup-1)	ND	ND	ND	ND	0.00082 J	ND	ND	ND
				38-40	ND	0.0058 J	0.0078	0.037	0.12	2.0	0.0045 J	ND
GP-17	4/8/2013	Northwest Area of Building	20	3-5	0.00131	ND	ND	ND	ND	ND	ND	ND
				13-15	ND	ND	ND	ND	ND	ND	ND	ND
GP-18	4/8/2013	Northwest Area of Building	20	3-5	ND	ND	ND	ND	ND	ND	ND	ND
				13-15	0.00763	ND	ND	ND	ND	ND	ND	ND
GP-19	4/8/2013	Wastewater Treatment Area / Paint Booth	20	3-5	ND	ND	ND	ND	ND	ND	ND	ND
				13-15	ND	ND	ND	ND	ND	ND	ND	ND
GP-20	4/8/2013	Paint Booth	20	3-5	0.00156	ND	ND	ND	ND	ND	ND	ND
				13-15	0.00280	ND	ND	ND	ND	ND	ND	ND
				13-15 (Dup-1)	0.00137	ND	ND	ND	ND	ND	ND	ND
GP-21	4/8/2013	Paint Booth	20	3-5	0.00329	ND	ND	ND	ND	ND	ND	ND
				13-15	ND	ND	ND	ND	ND	ND	ND	ND
EPA Screening Level - Protection of Groundwater - Risk Based					0.24	0.000053	0.0093	0.00082	0.0016	0.000092	0.000013	0.019
EPA Screening Level - Residential					6,100	0.29	24	16	8.6	0.44	0.16	63
EPA Screening Level - Industrial					63,000	1.5	110	200	41	2.0	0.68	270

Notes:

BOLD values indicate an exceedance of a published regulatory threshold; (EPA Screening Level - Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 2013)

mg/kg = Milligrams/kilogram, or ppm;
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TABLE 2
SVOC AND METALS CONCENTRATIONS IN SITE SOILS
JOSLYN CLARK FACILITY
LANCASTER, SOUTH CAROLINA
Page 1 of 2

Sample ID	Date	Potential Source Area	Total Depth of Boring (ft)	Sample Collection Depth (ft)	Metals by EPA Method 6010C (mg/kg)																							EPA Method 7471B (mg/kg)	SVOCs by EPA Method 8270C (mg/kg)	PAHs by EPA Method 8270D (mg/kg)	1,4-Dioxane by EPA Method 8270D (mg/kg)		
					Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium (total)	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Nickel	Potassium	Selenium	Sodium	Silver	Thallium	Vanadium	Zinc							
BG-1	4/7/2009	Background	4	0-4	NA	ND	4.5	NA	0.44	ND	NA	13	NA	8.1	ND	13	NA	NA	4.4	NA	ND	NA	1.2	ND	NA	18	ND	NA	NA	NA			
BG-2	4/7/2009	Background	4	0-4	NA	ND	0.84	NA	0.54	0.19	NA	0.80	NA	7.5	0.19	3.9	NA	NA	2.6	NA	ND	NA	0.39	ND	NA	29	ND	NA	NA	NA			
GP-1	4/7/2009	Plating Area	39	0-4	NA	0.62	ND	NA	0.43	0.28	NA	76	NA	120	NA	7.2	NA	NA	ND	NA	ND	NA	8.8	ND	NA	200	ND	ND	NA	NA			
				16-20	NA	ND	ND	NA	0.60	0.33	NA	1.1	NA	3.6	NA	3.0	NA	NA	ND	NA	ND	NA	ND	NA	ND	NA	36	ND	ND	NA	NA		
				35-39	NA	ND	ND	NA	1.3	0.36	NA	6.7	NA	19	NA	2.0	NA	NA	ND	NA	ND	NA	ND	NA	0.48	ND	NA	35	ND	ND	NA	NA	
GP-2	4/7/2009	Plating Area	35	0-4	NA	ND	ND	NA	0.64	0.97	NA	49	NA	24	NA	4.3	NA	NA	2.4	NA	ND	NA	0.96	ND	NA	170	ND	ND	NA	NA			
				16-20	NA	ND	0.95	NA	0.76	0.33	NA	160	NA	16	NA	1.1	NA	NA	4.3	NA	ND	NA	3.2	ND	NA	21	ND	ND	NA	NA			
				32-35	NA	ND	ND	NA	1.0	0.47	NA	14	NA	3.6	NA	2.8	NA	NA	4.5	NA	ND	NA	0.34	ND	NA	27	ND	ND	NA	NA			
GP-3	4/7/2009	Plating Area	40	4-8	NA	ND	ND	NA	0.88	0.23	NA	1.4	NA	0.7	NA	7.0	NA	NA	ND	NA	ND	NA	ND	ND	NA	27	ND	ND	NA	NA			
				12-16	NA	ND	ND	NA	0.79	0.29	NA	1.6	NA	ND	NA	6.0	NA	NA	ND	NA	ND	NA	ND	ND	NA	22	ND	ND	NA	NA			
				36-40	NA	ND	0.72	NA	1.6	0.43	NA	0.65	NA	ND	NA	24	NA	NA	ND	NA	ND	NA	ND	ND	NA	34	ND	ND	NA	NA			
GP-4	4/8/2009	Plating Area	40	8-10	NA	ND	ND	NA	0.37	0.11	NA	33	NA	2.8	NA	2.8	NA	NA	ND	NA	ND	NA	0.60	ND	NA	13	ND	ND	NA	NA			
				24-26	NA	ND	0.65	NA	0.39	ND	NA	1.6	NA	0.58	NA	0.71	NA	NA	ND	NA	ND	NA	ND	ND	NA	10	ND	ND	NA	NA			
				38-40	NA	ND	0.78	NA	0.86	0.15	NA	3.0	NA	2.4	NA	2.2	NA	NA	ND	NA	ND	NA	ND	ND	NA	18	ND	ND	NA	NA			
GP-5	4/7/2009	TCE AST Area	40	0-4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA			
				24-28	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
				36-40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
GP-6	4/8/2009	TCE AST Area	40	4-5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
				14-15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
				36-38	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GP-7	4/8/2009	Wastewater Discharge Line	8	6-8	NA	ND	ND	NA	0.59	0.50	NA	4.4	NA	3.7	NA	8.8	NA	NA	5.2	NA	ND	NA	0.53	ND	NA	19	ND	ND	NA	NA			
GP-8	4/8/2009	Wastewater Discharge Line	8	6-8	NA	ND	1.2	NA	1.5	ND	NA	110	NA	56	NA	36	NA	NA	39	NA	ND	NA	3.4	ND	NA	30	ND	ND	NA	NA			
GP-9	4/8/2009	Wastewater Lagoon Area	47	10-12	NA	ND	1.5	NA	1.9	1.1	NA	170	NA	59	NA	14	NA	NA	48	NA	ND	NA	2.4	ND	NA	32	ND	ND	NA	NA			
				26-28	NA	ND	2.2	NA	0.35	ND	NA	0.70	NA	0.83	NA	ND	NA	NA	ND	NA	ND	NA	ND	ND	NA	ND	ND	NA	NA	NA	NA		
				38-40	NA	ND	ND	NA	0.84	0.40	NA	1.7	NA	6.2	NA	6.6	NA	NA	6.4	NA	ND	NA	ND	ND	NA	80	ND	ND	NA	NA	NA		
GP-10	4/8/2009	Hazardous Waste Storage Area	12	6-8	NA	ND	1.6	NA	0.39	ND	NA	16	NA	17	NA	16	NA	NA	4.1	NA	ND	NA	1.1	ND	NA	21	ND	ND	NA	NA			
GP-11	4/8/2009	Plating / Wastewater Treatment Area	40	4-6	NA	ND	0.71	NA	0.95	0.47	NA	28	NA	11	NA	15	NA	NA	11	NA	ND	NA	0.40	3.3	NA	29	ND	ND	NA	NA			
				18-20	NA	ND	ND	NA	0.66	0.14	NA	6.0	NA	3.3	NA	6.3	NA	NA	2.2	NA	ND	NA	ND	ND	NA	29	ND	ND	NA	NA			
				38-40	NA	ND	ND	NA	0.69	ND	NA	7.2	NA	1.7	NA	2.8	NA	NA	ND	NA	ND	NA	ND	ND	NA	19	ND	ND	NA	NA			
EPA Screening Level - Protection of Groundwater - Risk Based					2,300	0.027	0.0013	12	1.3	0.052	NE	180,000 *	0.021	2.2	27	14 *	NE	2.1	2.0	NE	0.04	NE	0.06	0.0011	6.3	29	0.0033	Varies	Varies	0.00014			
EPA Screening Level - Residential					7,700	3.1	0.61	1,500	16	7	NE	NE	2.3	310	5,500	400	NE	180	150	NE	39	NE	39	0.078	39	2,300	1.0	Varies	Varies	4.9			
EPA Screening Level - Industrial					99,000	41	2.4	19,000	200	80	NE	NE	30	4,100	72,000	800	NE	2,300	2,000	NE	510	NE	510	1.0	510	31,000	4.3	Varies	Varies	17			

Notes:
BOLD values indicate an exceedance of a published regulatory threshold; (EPA Screening Level - Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 2013)
 * MCL Based
 mg/kg = Milligrams/kilogram, or ppm;
 B = Detected in Blank;
 J = Estimated value (below reportable);
 ND = Not Detected;
 NA=Not analyzed;
 NE = Not Established

TABLE 2
SVOC AND METALS CONCENTRATIONS IN SITE SOILS
JOSLYN CLARK FACILITY
LANCASTER, SOUTH CAROLINA
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Sample ID	Date	Potential Source Area	Total Depth of Boring (ft)	Sample Collection Depth (ft)	Metals by EPA Method 6010C (mg/kg)																						EPA Method 7471B (mg/kg)	SVOCs by EPA Method 8270C (mg/kg)	PAHs by EPA Method 8270D (mg/kg)	1,4-Dioxane by EPA Method 8270D (mg/kg)					
					Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium (total)	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Nickel	Potassium	Selenium	Sodium	Silver	Thallium	Vanadium	Zinc									
GP-12	4/8/2009	Wastewater Treatment Area	37	8-10	NA	ND	ND	NA	0.40	0.12	NA	0.79	NA	1.7	NA	3.6	NA	NA	ND	NA	ND	NA	0.28	ND	NA	12	ND	ND	NA	NA					
				24-26	NA	ND	ND	NA	0.58	ND	NA	4.3	NA	0.58	NA	1.3	NA	NA	ND	NA	ND	NA	ND	NA	ND	ND	NA	18	ND	ND	NA	NA			
				35-37	NA	ND	ND	NA	0.66	0.15	NA	1.2	NA	0.60	NA	0.78	NA	NA	ND	NA	ND	NA	ND	NA	0.29	ND	NA	16	ND	ND	NA	NA			
GP-13	4/8/2009	Paint Booth	38	8-10	NA	ND	ND	NA	0.49	0.11	NA	1.0	NA	1.2	NA	3.7	NA	NA	ND	NA	ND	NA	ND	ND	NA	21	ND	ND	NA	NA					
				24-26	NA	ND	0.67	NA	0.75	0.17	NA	2.6	NA	1.2	NA	1.2	NA	NA	ND	NA	ND	NA	ND	ND	NA	18	ND	ND	NA	NA					
				36-38	NA	ND	ND	NA	0.78	0.22	NA	0.45	NA	ND	NA	1.2	NA	NA	ND	NA	ND	NA	ND	ND	NA	11	ND	ND	NA	NA					
GP-14	10/10/2011	Wastewater Discharge Line	8	6-8	10,000	ND	ND	9.5	0.3	ND	ND	1.7	1.5 J	3.2	22,000	4.3 B	440	39	3.2	420	ND	29 BJ	ND	ND	30	9.9	ND	NA	ND	NA					
GP-15	10/10/2011		8	6-8	17,000	ND	0.84 J	13	1.3	ND	ND	2.7	1.3 J	9.6	35,000	8.1 B	310 J	53	2.2 J	240 J	ND	ND	0.15 J	ND	98	21	ND	NA	ND	NA					
GP-16	10/10/2011	Wastewater Lagoon Area	40	10-12	11,000	ND	0.65 J	14	0.31	ND	ND	0.9	1.2 J	4.2	33,000	9.7 B	570	140	1.0 J	500	ND	ND	0.072 J	ND	46	19	ND	NA	ND	NA					
				26-28	34,000	2.5 BJ	ND	100	0.72 J	ND	ND	ND	16	1.5 J	25,000	5.7 BJ	3,000	820	3.8 J	2,600 J	ND	ND	ND	ND	32	47	ND	NA	ND	NA					
				26-28 (Dup-1)	27,000	4.3 BJ	2.6 J	150	0.81 J	ND	ND	ND	55	1.3 J	28,000	15 B	2,700 J	1800	2.7 J	2,900 J	4.2 J	ND	ND	ND	ND	7.6 J	34	54	ND	NA	ND	NA			
				38-40	26,000	ND	4.2 J	230	1.5 J	ND	720 BJ	ND	20	5.2	31,000	15 B	4,100	2500	7.4 J	2,700 J	ND	ND	ND	ND	38	82	0.037 J	NA	ND	NA					
GP-17	4/8/2013	Northwest Area of Building	20	3-5	NA	NA	NA	NA	NA	NA	0.77	NA	ND	NA	14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.404					
				13-15	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND	NA	5.02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	46.2	ND	NA	NA	0.481
GP-18	4/8/2013	Northwest Area of Building	20	3-5	NA	NA	NA	NA	NA	NA	ND	NA	3.66	NA	6.51	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	21.1	0.031	NA	NA	0.776	
				13-15	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND	NA	1.59	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	50.2	ND	NA	NA
GP-19	4/8/2013	Wastewater Treatment Area / Paint Booth	20	3-5	NA	NA	NA	NA	NA	NA	1.19	NA	ND	NA	4.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.25	ND	NA	NA	0.623	
				13-15	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND	NA	4.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.18	ND	NA	NA	0.916
GP-20	4/8/2013	Paint Booth	20	3-5	NA	NA	NA	NA	NA	NA	1.04	NA	ND	NA	4.27	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	16.8	ND	NA	NA	0.970	
				13-15	NA	NA	NA	NA	NA	NA	NA	1.22	NA	ND	NA	1.75	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.9	ND	NA	NA	0.821
				13-15 (Dup-1)	NA	NA	NA	NA	NA	NA	NA	NA	1.02	NA	ND	NA	1.38	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.22	ND	NA	NA
GP-21	4/8/2013	Paint Booth	20	3-5	NA	NA	NA	NA	NA	NA	2.54	NA	2.05	NA	6.26	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.5	ND	NA	NA	0.992	
				13-15	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND	NA	66.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	11.1	ND	NA	NA	0.723
EPA Screening Level - Protection of Groundwater - Risk Based					2,300	0.027	0.0013	12	1.3	0.052	NE	180,000 *	0.021	2.2	27	14 *	NE	2.1	2.0	NE	0.04	NE	0.06	0.0011	6.3	29	0.0033	Varies	Varies	0.00014					
EPA Screening Level - Residential					7,700	3.1	0.61	1,500	16	7	NE	NE	2.3	310	5,500	400	NE	180	150	NE	39	NE	39	0.078	39	2,300	1.0	Varies	Varies	4.9					
EPA Screening Level - Industrial					99,000	41	2.4	19,000	200	80	NE	NE	30	4,100	72,000	800	NE	2,300	2,000	NE	510	NE	510	1.0	510	31,000	4.3	Varies	Varies	17					

Notes:
BOLD values indicate an exceedance of a published regulatory threshold; (EPA Screening Level - Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 2013)
 * MCL Based
 mg/kg = Milligrams/kilogram, or ppm;
 B = Detected in Blank;
 J = Estimated value (below reportable);
 ND = Not Detected;
 NA=Not analyzed;
 NE = Not Established

TABLE 3
GEOCHEMICAL ANALYTICAL PARAMETERS
JOSLYN CLARK FACILITY
LANCASTER, SOUTH CAROLINA
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		Geochemical Parameters (µg/L)						
Sample ID	Sample Date	Iron	Manganese	Sodium	Chloride	Nitrate	Sulfate	Total Organic Carbon
MW-1	09/30/09	290	960	2,000	NA	NA	NA	NA
	11/10/11	320	10	2,100	NA	NA	NA	NA
	05/03/13	NA	25	3,890	3,010	2,040	<200	NA
MW-2	09/30/09	690	77	8,800	NA	NA	NA	NA
	11/11/11	530	10	6,900	NA	NA	NA	NA
	05/02/13	NA	<15	6,800	10,300	<500	869	NA
MW-3	09/30/09	1,100	120	11,000	NA	NA	NA	NA
	11/11/11	820	27	9,600	NA	NA	NA	NA
	05/02/13	NA	<15	8,670	8,200	2,210	543	<1000
MW-3D	11/11/11	4,800	180	14,000	NA	NA	NA	NA
	05/02/13	NA	21	11,300	7,160	862	2,670	<1000
MW-4	09/30/09	630	89	4,800	NA	NA	NA	NA
	11/10/11	180	7	4,100	NA	NA	NA	NA
	05/03/13	NA	54	5,950	1,220	<500	2,290	NA
MW-5	10/01/09	540	140	7,400	NA	NA	NA	NA
	11/10/11	3,500	92	8,100	NA	NA	NA	NA
	05/02/13	NA	<15	8,530	22,600	1,750	286	NA
MW-6	10/01/09	1,000	68	5,600	NA	NA	NA	NA
	11/11/11	1,700	49	4,300	NA	NA	NA	NA
	05/03/13	NA	<15	5,730	7,310	1,510	211	NA

Notes:

ug/l = Micrograms/liter
 NA = Not Analyzed

TABLE 3
GEOCHEMICAL ANALYTICAL PARAMETERS
JOSLYN CLARK FACILITY
LANCASTER, SOUTH CAROLINA
PAGE 2 of 2

		Geochemical Parameters (µg/L)						
Sample ID	Sample Date	Iron	Manganese	Sodium	Chloride	Nitrate	Sulfate	Total Organic Carbon
MW-7	10/01/09	8,700	560	9,200	NA	NA	NA	NA
	11/11/11	1,600	43	7,700	NA	NA	NA	NA
	05/03/13	NA	16	8,870	4,020	659	344	NA
MW-8	11/10/11	2,300	120	15,000	NA	NA	NA	NA
	05/03/13	NA	23	15,900	10,200	887	962	NA
MW-9	11/10/11	390	330	9,700	NA	NA	NA	NA
	05/03/13	NA	18	10,700	6,610	<500	498	NA
MW-10	11/10/11	3,100	130	14,000	NA	NA	NA	NA
	05/03/13	NA	18	16,700	11,400	<500	1,100	NA
MW-10D	11/10/11	130	10	14,000	NA	NA	NA	NA
	05/02/13	NA	<15	14,000	11,100	<500	688	NA
MW-11	05/02/13	<200	150	9,330	7,080	1,080	1,810	<1,000
MW-11I	05/02/13	2,020	79	16,000	7,810	1,280	16,700	<1,000
MW-11D	05/02/13	<200	42	52,700	10,200	873	35,600	3,900

Notes:

ug/l = Micrograms/liter
 NA = Not Analyzed

Appendix A
Feasibility Study

**FEASIBILITY STUDY - JOSLYN CLARK FACILITY
LANCASTER, SOUTH CAROLINA**

Evaluation Parameters	Technology 1 In Situ Chemical Oxidation (ISCO)	Technology 2 In-Situ Anaerobic Bioremediation	Technology 3 Zero Valent Iron (ZVI)	Technology 4 Monitored Natural Attenuation (MNA)	Technology 5 Pump and Treat
Technology Description	Placement of an oxidant, usually through injection, within the contaminated aquifer for the oxidation of the contaminants of concern encountered by direct contact. The oxidation reaction occurs instantaneously once the oxidant comes in contact with an oxidizable material (contaminant, naturally occurring organic material, etc.). In order for the technology to be successful, enough oxidant must be provided to oxidize the naturally occurring background oxidant demand in addition to the contaminant.	Addition of carbon substrate and nutrients to promote in situ mass conversion of contaminants to less harmful daughter products by naturally occurring or augmented bacteria. Anaerobic aquifer conditions must be present in the aquifer, or must be induced (i.e. negative ORP and low DO) so that the bacteria can be effective.	Abiotic reduction of contaminants through addition of fine grained zero valent iron material which provides the electron donor for contaminant reduction and substantially lowers the ORP. Iron must be injected as a slurry material and can be difficult to put into place through injection. Technology is typically utilized as active material for a permeable reactive barrier, but can also be used for source area treatment.	Monitored Natural Attenuation (MNA) is an in-situ remedial approach that depends upon natural processes to degrade and dissipate contaminants. Natural attenuation processes include biodegradation, adsorption to the aquifer matrix, and dilution. The progress of Monitored Natural Attenuation is usually gauged through routine groundwater monitoring for the contaminants of concern, as well as geochemical indicators.	Removal of contaminants by pumping of affected ground water followed by ex-situ treatment of ground water. Typically, pump and treat technologies will not result in a sustained decrease in dissolved phase contaminant concentrations once the system is shut down. Pump and treat is much more effective as a plume containment technology.
Site Specific Considerations	Site specific contaminants of concern are primarily chlorinated ethenes which can be oxidized by sodium permanganate. Permanganate can persist in the aquifer for periods up to several years, as opposed to other oxidants which only persist for weeks to months. The longevity of permanganate allows for a larger effective radius of influence and a more cost effective injection program.	The lack of significant daughter products in groundwater at this site (cDCE in only one well, and no VC) indicate that bioremediation is not occurring naturally. High DO (i.e. >6 mg/L) concentrations are present in the source area, as is the ORP. A considerable amount of carbon would be required to induce sufficiently low ORP and DO values.	Site specific contaminants of concern are amendable to reduction by ZVI. The deep groundwater table (i.e. 42 to 50 feet bgs) and the great depth to bedrock (i.e. 147 ft bgs) would hinder the placement of ZVI through trenching. If used, injection would be the proposed mechanism.	Site specific contaminants of concern (chlorinated ethenes) are amendable to reduction by natural processes. However, the aerobic nature of the aquifer at the site will hinder the progress of natural degradation. MNA is usually better suited for the downgradient portion of contaminant plumes (not source areas).	Groundwater at this site is located between 42 and 50 feet below ground surface. Approximately 100 feet of saturated aquifer is present above the bedrock. Significant volumes of groundwater would need to be extracted to maintain migration of the contaminant plume. Additionally, extracted groundwater would require ex-situ treatment, such as discharge to the POTW under a permit or air stripping.
On-Site Evaluation Based on EPA Screening Criteria					
EPA Criteria 1 Overall Protection of Human Health and the Environment	4 Implementation of technology will result in mass destruction of contaminant in-situ.	3 Implementation of technology will result in mass destruction of contaminant in-situ, if anaerobic conditions can be induced.	4 Implementation of technology will result in mass destruction of contaminant in-situ.	2 Implementation of technology will result in mass destruction of contaminant in-situ over long periods of time.	2 Technology will prevent plume migration, but will not result in significant contaminant mass removal from the subsurface. Although contained the contamination remains on site and consequently the risk for potential future exposure remain.
EPA Criteria 2 Compliance with Regulatory Requirements	4 Technology meets regulatory requirements. Injectant is well established in South Carolina. An Underground Injection Control Permit will be required to implement technology. Injectant will breakdown completely within a few years.	4 Technology meets regulatory requirements. Injectant is well established in South Carolina. An Underground Injection Control Permit will be required to implement technology. Injectant will breakdown completely within a few years.	3 Technology meets regulatory requirements. Injectant is not as well established in South Carolina as other injectants. An Underground Injection Control Permit will be required to implement technology. Injectant will remain in the subsurface indefinitely.	3 Technology meets regulatory requirements. No 3 permits typically required. No injection or pumping of groundwater.	2 Technology complies with regulatory requirements, however the technology will require permanent regulatory oversight and is consequently likely less desired by the regulator than a technology aimed at treatment rather than containment.
EPA Criteria 3 Long Term Effectiveness and Permanence	4 ISCO will treat contaminants present in the dissolved phase very quickly. Rebound due to desorption of contaminants from soil particle may occur. Additional injections will likely be required to address rebound.	3 Bioremediation will treat contaminants present in the dissolved phase. The steady pace of contaminant consumption and the persistence of carbon in the subsurface allows for treatment of contaminants as they desorb from soil particles. Additional injection may not be needed to address rebound. Again, the limitation is the aerobic nature of the aquifer.	2 ZVI will treat contaminants present in the dissolved phase. Sufficient ZVI slurry will be placed during the first injection to treat subsequent contaminant rebound. Only one injection will be necessary.	3 MNA will treat dissolved phase contaminants in the long-term. The process is slow.	2 System will need to be operated indefinitely to retain hydraulic control of the contaminant plume.
EPA Criteria 4 Reduction of Toxicity, Mobility, or Volume	3 Technology results in in-situ contaminant mass destruction. However, in some cases the contaminant may be pushed to other locations by the injectant.	3 Technology results in in-situ contaminant mass destruction. However, in some cases the contaminant may be pushed to other locations by the injectant.	3 Technology results in in-situ contaminant mass destruction.	2 Technology results in in-situ contaminant mass destruction over long periods of time. If the plume is not in steady shape, migration offsite could be an issue.	2 Technology is geared toward plume containment not treatment. As such, mobility is reduced, but the overall mass of contaminant will not be removed from the subsurface quickly.
EPA Criteria 5 Short Term Effectiveness	4 Chemical oxidation reactions occur immediately when the contaminant and the oxidant come in contact.	2 Aquifer conditions must be primed and sufficient volume of bacteria developed. Additionally, contaminants are sequentially dechlorinated (i.e. TCE becomes cDCE, which becomes VC, which finally becomes ethene) which requires time.	4 Chemical reduction reactions occur immediately when the contaminant and the oxidant come in contact	2 MNA will treat dissolved phase contaminants in the long-term. The process is very slow.	2 Hydraulic control of the plume is maintained when the system is running. Source area mass reduction is maintained to a limited extent.
EPA Criteria 6 Implementability	4 Involves in-situ injection of a liquid. Potential health and safety concerns due to injection of an oxidant. However, at low doses the risk is commonly managed.	4 Involves in-situ injection of a liquid. Injectant consists of non-hazardous organic material mixed with water.	2 Involves in-situ injection of a slurry.	4 MNA can be implemented easily. Only routine monitoring of groundwater is required.	4 Systems for pump and treat are commercially available and the technique is tried and true. However it requires regular maintenance.
EPA Criteria 7 Cost	3 Several injections may be required to address rebound. Oxidant cost is moderately high compared to bioremediation injectant.	3 Limited injections will be required. Injectant cost is low compared to other technologies, but the cost to induce anaerobic aquifer conditions could be high.	1 One injection will be required, however injectant cost is substantially higher than other technologies.	4 MNA is very cost effective, as the only costs are related to groundwater monitoring.	2 Groundwater extraction is normally low cost at start-up but requires costly O&M. Depth to groundwater of 42 feet will yield potentially high electrical costs.
Total On-Site Score	26	22	19	20	16

Notes:
ALL TERMS EXCEPT COST

1 = Very low relative to other technologies

2 = Low relative to other technologies

3 = Moderate relative to other technologies

4 = High relative to other technologies

5 = Very high relative to other