-DRAFT-

FOCUSED FEASIBILITY STUDY
GROUND-WATER REMEDIATION
FORMER DRUM STORAGE AREA
ROWE INDUSTRIES SITE
SAG HARBOR, NEW YORK

Prepared For:

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SUMMARY OF FOCUSED
GROUND-WATER REMEDIATION
FEASIBILITY STUDY
FORMER DRUM STORAGE AREA
ROWE INDUSTRIES SITE
SAG HARBOR, NEW YORK

1.0 INTRODUCTION

The former drum storage area (FDSA) located on the Rowe Industries Site (Site) continues to be the major contributor of the volatile organic compounds (VOCs) (primarily tetrachloroethylene (PCE)) to the ground water beneath the Site. The presence of shallow bands of clay several feet beneath the water table were identified during an investigation of the subsurface geology beneath the FDSA in June 1998 (figure 1). The bands of clay, located between 2 to 6 feet above mean sea level, varies in thickness from 0.5 feet up to about 2 feet in the middle of the FDSA. The presence of the clay has had a significant impact on the distribution of VOCs in the ground water and has apparently retarded the dissolution of the PCE into the ground water.

From 1999 to 2003 the operation of two pump-and-treat systems and a soil vapor extraction system has significantly decreased the VOC concentrations in the soil and ground water beneath the FDSA. An air sparge system was also installed in the FDSA; however, the success of this system has been limited due to the presence of the clay lens.

The purpose of this report is to summarize an evaluation of the feasibility of additional remediation technologies for decreasing VOC concentrations in ground water above the clay lens. In addition, this report presents a draft work plan to implement the preferred alternative. Several specialized vendors were contacted by LBG Engineering Services, PC (LBGES) for this evaluation. They are:

- Remediation and Natural Attenuation Services, Inc. (RNAS);
- Regenesis;
- Isotec, Inc. (ISOTEC);
- GeoCleanse International, Inc. (GeoCleanse); and
- Adventus Americas, Inc (AAI).

The focus of the feasibility study was to evaluate the available products, processes, and costs to determine the most practical technology to reduce VOC concentration to aquifer restoration goals identified in the Consent Order for the site.

2.0 BACKGROUND

2.1 Air Sparging

The FDSA is located on a private residential property. Prior to the discovery of the bands of clay, it was agreed between the potentially responsible parties and the U.S. Environmental Protection Agency (USEPA) that an air-sparge system would be constructed in the FDSA in order to minimize disruption to the residents and to pro-actively address contamination below the water table. The air-sparge system was operated in 2003, however, the presence of the clay impacted the remediation due to its location above the screened intervals of the existing air-sparge wells. The air-sparge wells were only able to address ground water below the clay lens and, therefore, had a minimal impact on the PCE concentrations in the ground water above the clay.

2.2 Pump and Treat

Prior to operating the air-sparge systems, a small Focused Pump and Treat (FPT) system was constructed in November 1999. The FPT system consisted of a pneumatic pump installed inside one 2-inch monitor well located within the FDSA (MW-98-05A). Ground water was pumped through a bag filter and into two 55-gallon liquid-phase granular activated carbon vessels (placed in series) for treatment. The recovered ground water was treated to reduce total VOCs to below 1 micrograms per liter (µg/l) prior to discharge to the unnamed pond located on Site approximately 350 feet northeast of the FDSA. The system was continuously operated between November 1999 and December 1999 and was shutdown until May 2000. The system was restarted again in June 2000 and operated continuously until it was decommissioned in December 2000.

A second, FPT system, consisting of four submersible pumps installed inside four 4-inch diameter ground-water recovery wells was constructed in the FDSA to provide a more aggressive remedial approach for the shallow ground water above the clay. The focused recovery well locations (figure 1) were selected based on the highest historical PCE concentrations detected in ground-water samples. The four recovery wells were connected to a 425-gallon capacity polyethylene tank to allow the recovered water to equalize prior to treatment by pumping the water through two 1,000 pound carbon units. This new system operated between March 2001 and December 2003. During that period, the system processed almost 5,800,000 gallons of ground water and removed close to 20 pounds of volatile organic compounds (VOCs).

VOC concentrations in ground water from the FDSA have decreased significantly as a result of the system's operation. However, the concentrations have reached an asymptote and the system has been unable to effectively reduce VOC concentrations in ground water to below the Consent Order clean-up objectives. The remediation alternatives discussed in this report are considered for enhancing remedial efforts for ground water above the clay.

2.3 Pre-Feasibility Testing

On March 8, 2004 LBGES collected six ground-water samples from the FDSA and sent the samples to Site Recovery and Management (SiREM) for microbiological analysis to determine the presence or absence of dehalococcoides microbes. Dechlorinating microbes can be an essential element in bioremedation of chlorinated VOCs. The results of the analysis indicate that dehalococcoides microbes are not present in the soil at the Site. The ground-water pH is also a critical component in determining whether or not certain remedial alternatives, such as bioremediation, will be effective at a site. Measured pH values for the groundwater beneath the FDSA collected in March 2004 range from 5.3 to 5.8. Dechlorinating microbes are most effective at pH ranging from 6 to 8, and become inhibited when pH values decrease below 5.

In September 2004, additional ground-water samples from select monitor wells were analyzed for VOCs and a variety of geochemical parameters. The geochemical parameters are being analyzed at the site to get baseline value for future assessment to evaluate monitored natural attenuation as a long-term remediation plan, therefore, the results of the geochemical parameters are not needed for inclusion in this report.

3.0 REMEDIATION ALTERNATIVES

Descriptions of each of the remediation alternatives considered and the processes required for implementation are discussed below. Several types of technologies were evaluated for this study, including products designed to create anaerobic conditions and enhance microbial activity and products which utilize dechlorinating microbes, and abiotic processes/products to oxidize contaminants (such as hydrogen peroxide, sodium permanganate and zero valent iron).

All of the remedial alternatives discussed in this report require the product that is injected into the FDSA come in direct contact with the chlorinated VOCs. As such, some vendors have indicated that more than one treatment step with their product may be needed to lower chlorinated VOC concentrations below the aquifer restoration goals that are established for the Site. It can be inferred from this information that good distribution of the products in the FDSA will be a key factor for successful remediation efforts with any of these remedial alternatives.

All of the remedial alternatives discussed in the following sections can be categorized into three processes: abiotic, biotic or a combination of abiotic and biotic. A fundamental difference between abiotic (chemical) and biotic (biological) processes is the fact that abiotic process chemicals only react one time with the contaminants. As such, vendors that supply products that rely solely on abiotic processes to breakdown chlorinated VOCs have indicated that more than one injection of their product may be required. With biotic processes, indigenous or injected microbes will continuously degrade the chlorinated VOCs provided that subsurface conditions are conducive to bacterial growth. It can be inferred from this statement that biotic processes require more subsurface conditioning before degradation of chlorinated VOCs can take place.

3.1 RNAS: Emulsified Soybean Oil Amendment and SiREM: KB-1 Dechlorinator

RNAS manufactures Newman Zone, an emulsified soybean oil amendment consisting of food grade and pharmaceutical grade additives designed to release electrons (needed for biological activity) quickly at first and then slowly over time. The Newman Zone formula consists of two main ingredients: sodium lactate and soluble vegetable oil. The sodium lactate quickly produces anaerobic conditions (preferred for chlorinated solvent degradation) in the subsurface and the vegetable oil adheres to soil particles and ferments slowly (providing a constant source of volatile fatty acids which are used as an energy source to sustain anaerobic microbial activity over extended periods of time). Newman Zone and water is injected into a treatment area via several injection points, which creates an anaerobic condition in the subsurface that is suitable for sustaining dechlorinating microbes.

As mentioned above, dehalococcoides microbes are currently not present in ground water beneath the site. Therefore, the treatment area would need to be inoculated with these anaerobic, dechlorinating microbes. RNAS recommends utilizing KB-1 Dechlorinator, a natural microbial culture that includes dehalococcoides bacteria which is manufactured by SiREM. KB-1 Dechlorinator maintains the microbes in a liquid formula that would be injected into ground water using through boreholes created by direct push technology. After an anaerobic condition has been created, the KB-1 Dechlorinator would be added to the treatment area.

The pH of the groundwater below the FDSA is currently outside the preferred pH limits for bioremediation of chlorinated solvents. As a result, the groundwater beneath the FDSA would need to be buffered in order to increase the pH to within the desired range. According to RNAS, sodium bicarbonate could be mixed with the soybean emulsion slurry on-site and injected into the FDSA during treatment.

3.2 Regenesis: Hydrogen Release Compound and Bio-dechlor INOCULUM

Regenesis manufactures products used to enhance microbial activities and for bioaugmentation. Hydrogen Release Compounds (HRC) are a liquid polylactate ester which releases lactic acid into the surrounding environment over a period of 12 to 18 months. The lactic acid creates an anaerobic condition in the subsurface which is suitable for sustaining dechlorinating microbes and stimulates microbes to more actively dechlorinate solvents. HRC is typically injected into the subsurface with direct push technology and given a minimum of 30 days to convert the area to anaerobic conditions. Bio-dechlor INOCULUM (BDI) is an enriched, naturally occurring microbe formula specifically designed to dechlorinate chlorinated solvents. BDI also is injected into ground water using direct push technology.

As mentioned above, the groundwater beneath the FDSA would need to be buffered in order to increase the pH to within the desired range. Similar to the RNAS remedial option, the sodium bicarbonate can be mixed into the slurry onsite and injected into the FDSA during treatment.

3.3 ISOTEC: Chemical Oxidation with Hydrogen Peroxide

ISOTEC utilizes a modified Fenton’s reagent chemical oxidation process to treat VOCs in ground water. The ISOTEC process consists of gravity feeding or pressure injecting catalysts (e.g. chelated iron) and oxidizers (e.g. hydrogen peroxide) into the ground water. The VOCs in ground water would be chemically broken down and remediated through a series of free-radical oxidation and reduction reactions.

Prior to treatment, ISOTEC typically conducts a bench test on soil slurry and ground-water samples collected from the potential treatment area. If the bench test indicates that the ISOTEC process would successfully remediate the ground water, then the process would be implemented full scale.

Naturally occurring iron in the ground water may promote Fenton’s Chemistry. Given that free-radicals are quickly consumed, many injection points are required to implement this process.

3.4 GeoCleanse: Chemical Oxidation with Sodium Permanganate

GeoCleanse is an in-situ oxidation technology provider, which utilizes sodium permanganate as part of a chemical oxidation process to treat VOCs in soil and ground water. Permanganate is a strong oxidant, which accomplishes complete oxidation of solvents to inert byproducts. Sodium permanganate oxidation of chlorinated VOCs results in a reduced anion in the form of manganese dioxide and an oxidized organic compound in the form of carbon dioxide. The manganese dioxide is stable and inert, and the carbon dioxide would be released as a gas or dissolve into the ground water. Overall, in-situ oxidation would lower the pH of ground water unless buffered by soil or an added buffering agent. If sufficient oxidant is applied, there is no risk of toxic daughter products, which can occur with biological treatment methods. The other byproducts would include sodium, hydrogen, and chloride ions. The GeoCleanse process would require that permanent injection wells be constructed within the treatment area in order to have the option to apply the product multiple times to effectively treat the chlorinated VOCs in the FDSA.

3.5 AAI Zero-Valent Iron (EHC ™)

This technology injects zero-valent iron (ZVI) and an organic carbon source into the saturated zone as a slurry using a high-pressure pump and a pressure activated injection probe. The EHC™ product is manufactured by AAI and is designed to treat the chlorinated VOCs in the ground-water using a number of physical, chemical and microbiological processes to create strong reducing conditions that result in dechlorination of the contaminants. In addition, the EHC™ product has a buffering agent that will control ground-water pH during the injection treatment process. The small ZVI particles provide substantial reactive surface areas that produce direct chemical dechlorination and reduces the redox potential in the groundwater. The resulting abiotic and biotic reactions result in nontoxic compounds such as ethene and chloride.

The organic component of EHC™ is nutrient rich, hydrophilic, and has high surface area; thus, supporting growth of bacteria in the ground-water. As bacteria on EHC™ particle surfaces grow, indigenous heterotrophic bacteria (i.e. bacteria that require organic compounds as their principal source of carbon for synthesis of material) consume dissolved oxygen and thereby reduce the redox potential in ground-water further. In addition, as the bacteria grow on the organic particles they ferment carbon and release a variety of volatile fatty acids, which diffuse from the site of fermentation into the groundwater and serve as electron donors for other bacteria that can degrade the contaminants of concern. EHC™ is a food-grade product that is suitable for application on the residential property. Although it was previously stated that dehalococcoides bacteria are not present, AAI indicates that the EHC™ product will work without the need to inoculate the ground-water with specific dehalogenating microbes.

The material would be injected with a high-pressure pump to a pressure activated injection probe located at the tip of the probe inserted by direct-push technology. The EHC™ slurry would be discharged through tiny holes near the tip of the injection probe assembly radially outward into the formation. The material would be injected at several depths in the saturated zone and capillary fringe.

4.0 METHODOLOGY AND COST ANALYSIS

This section summarizes information provided by each vendor and an estimated cost for implementation of each remediation alternative at the Site. The costs associated with each of the technologies described above range between $95,000 (AAI) to $158,200 (ISOTEC). For the abiotic remedial alternatives offered by Isotec and Geocleanse, two treatment steps were assumed for successful clean-up of the chlorinated VOCs. To assess the effectiveness of remediation, a post-treatment monitoring program will be conducted regardless of the treatment option selected.

The post-treatment monitoring for all the options with the exception of Regenesis would cost approximately $25,700 and would consist of sampling four wells, one month after the final treatment step for each remedial option, and then sampling the four well quarterly for one year thereafter. The established semi-annual ground-water sampling would continue to be conducted during the post-treatment monitoring activities and thereafter. All cost estimates presented in this section of the report include the post-treatment monitoring costs mentioned above.

Regenesis recommended a specific post-treatment monitoring plan estimated to cost $55,800. Details of the Regenesis post-treatment monitoring plan are summarized in Section 4.2.

The remedial alternatives and cost estimates are in Table 1. The cost associated with the established semi-annual ground-water sampling for the site are not included in any of the cost estimates. It should be noted that cost estimates will increase if additional field time is required (beyond the budgeted amount) to complete each remedial alternative.

4.1 RNAS: Emulsified Soybean Oil Amendment and SiREM: KB-1 Dechlorinator

The cost associated with the Newman Zone emulsified soybean oil amendment is based on a formal proposal prepared by RNAS specifically for the Site. The total cost associated with this option is $137,100. This cost includes the purchase of the soybean oil amendment and KB-1 sodium bicarbonate buffer, rental of the injection equipment used to inject the amendment and microbes, a limited license to use the treatment technology, one RNAS technician and one SiREM technician on-site during the initial stages of amendment injection and KB-1 injection, respectively, post-treatment monitoring LBGES's oversight of the injection activities, direct injection subcontractor costs for labor and supplies, and technical support from RNAS and SiREM.

In order to supply the volume of water necessary to maintain a pumping rate of 30 gallons per minute (gpm) for the soybean oil injection, a pipe modification to the two-inch potable water supply line in the remediation building would be needed. Other supplies required to supply the potable water to the vendor-provided injection equipment include a gate valve, and clean, high-pressure, two-inch hose.

The proposal provided by RNAS outlines the procedures for injection of Newman Zone and provides a cost estimate for each. It is estimated that approximately 1,600 gallons of amendment would be required to treat the FDSA. The amendment would be injected with a "10-channel" injection system provided by RNAS over a period of six days if the desired pumping rate of 30 gpm can be maintained. The amendment would be metered in at a 2% solution.

Approximately two weeks after the amendment injection, LBGES would collect three ground-water samples and analyze the samples for DO, ORP, nitrate, sulfate, temperature and pH to determine if anaerobic conditions prevail. When anaerobic conditions prevail within the FDSA, then the treatment area would be inoculated with dechlorinating microbes. If the results of sample analysis indicate that conditions beneath the FDSA are not optimal for the addition of the microbes, then three groundwater samples would be collected on a weekly basis until SiREM determines the subsurface environmental conditions are favorable for KB-1 injection. It is estimated that five days of KB-1 injection would be necessary to effectively inoculate the FDSA.

4.2 Regenesis: Hydrogen Release Compound and Bio-dechlor INOCULUM

The costs associated with HRC and BDI are based on a cost estimate prepared by Regenesis and are estimated to be $138,400 with vendor recommended post-treatment groundwater sampling. This cost includes the purchase of HRC and BDI rental of the equipment necessary for the injection of both (HRC and BDI) into the FDSA, sodium bicarbonate buffer, and LBGES oversight of the injection activities.

Prior to the application of HRC, three ground-water samples would be collected and analyzed for the following parameters: DO, ORP, dissolved and total Fe and Mn.

The cost estimate provided by Regenesis outlines the procedures for HRC injection. It is estimated that approximately 1,160 pounds of HRC would be required to treat the FDSA. The HRC would be injected into the FDSA in a grid pattern with direct push techniques over a period of five days. The approximate spacing between injection points would be 10 feet. LBGES personnel would be responsible for implementing the HRC injection process.

Regenesis recommended injecting BDI into the FDSA approximately one month after the HRC injection. LBGES would collect three ground-water samples and analyze the samples for DO, ORP, dissolved iron, total iron dissolved manganese and total manganese in an attempt to determine if anaerobic conditions are present within the FDSA.

Once anaerobic conditions are present within the FDSA, then the treatment area will be inoculated with dechlorinating microbes, followed by a ground-water sampling program. BDI would be injected into the FDSA through the use of the direct push technique over a period of five days.

The post-treatment ground-water monitoring program recommended by Regenesis would consist of bi-monthly (i.e., once every other month) collection and analyses of ground-water samples from the three ground-water monitor wells within the FDSA. Samples collected during this program would be analyzed for DO, ORP, dissolved and total Fe and Mn. The bi-monthly monitoring program would be conducted for a period of six months. After six months, ground-water samples would be collected and analyzed on a quarterly basis. The quarterly ground-water monitoring program would be conducted for a period of one year. The estimated cost associated with the ground-water monitoring program, is included in the costs shown above.

4.3 ISOTEC: Chemical Oxidation with Hydrogen Peroxide

The cost associated with implementing the ISOTEC remediation technology is based on a cost estimate prepared by ISOTEC. The total cost associated for one injection treatment with the ISOTEC reagents is $117,000 and includes a bench scale treatability study, reagents for one in-situ oxidation treatment of the FDSA injection by direct push techniques, technical support from ISOTEC and LBGES oversight of remediation activities.

ISOTEC recommends conducting a preliminary bench-scale treatability test prior to in-situ oxidation treatment of the FDSA. The treatability test would consist of the collection of a saturated soil sample and ground-water samples from the FDSA. These samples would be collected by LBGES and then sent to ISOTEC to be tested and evaluated.

If the bench test indicates that the ISOTEC process would successfully remediate the FDSA, then the process would be implemented on a full-scale basis. Full-scale implementation of the ISOTEC process includes the injection of the ISOTEC reagents (including hydrogen peroxide) using direct push technology. The direct push probe would be inserted into the ground water, just above the clay lens and the ISOTEC reagents would be injected under constant low pressure. It is estimated between 35 and 40 injections points would be required to effectively treat the FDSA.

According to representatives from ISOTEC, the ISOTEC process is an abiotic contact remedial treatment technology, which requires that the reagents come in direct contact with the contaminants. As such, an area treated by the ISOTEC process may not always be completely remediated by one injection treatment. In most instances the area of contamination is reduced, which decreases the cost associated with a second injection treatment. It is possible that a second injection treatment might be necessary to reduce contaminant concentrations within the FDSA to below the required clean-up criteria. The estimated cost associated with a second treatment is based on the area of contamination that remains after the primary ISOTEC injection. Assuming the initial injection treatment completely remediates one-half the initial FDSA area treated, the cost associated with a second injection treatment, including ISOTEC reagents, a direct push drill rig, and LBGES oversight is estimated to be $41,200. If a second injection treatment is necessary, the combined estimated cost for two injections would be $158,200.

4.4 GeoCleanse: Chemical Oxidation with Sodium Permanganate

The cost associated with implementing the GeoCleanse remediation technology is based on an estimate prepared by GeoCleanse. The total cost for one injection treatment associated with the GeoCleanse process, including project design, injector system installation, mobilization, direct-push injection, chemicals, project documentation by Geocleanse and LBGES oversight is $87,200.

It is estimated that six injection points would be required to effectively treat the FDSA with the GeoCleanse process and that injection activities would take three days. The injection points would be 2-inch diameter PVC pipes permanently installed within the treatment area. It may be possible to use six of the existing ground-water monitor wells within the FDSA, however, it is likely that those wells would not be available for future ground-water sampling activities.

The GeoCleanse process is also an abiotic contact remedial treatment technology. As such, an area treated by the GeoCleanse process may not always be completely remediated by one injection treatment. However, according to a representative of GeoCleanse, most sites are remediated by one injection treatment. In the event that a second injection treatment is necessary, the cost associated with a second treatment would be based on the area of contamination that remains after the primary GeoCleanse injection. Assuming the initial injection treatment completely remediates one-half the initial FDSA area treated, the cost associated with a second injection treatment, including GeoCleanse reagents and LBGES oversight is estimated to be $24,400. If a second injection treatment is necessary, the estimated combined cost for two injections would be $111,600.

Prior to initiating this technology, a bench scale test would be needed to determine the necessary mass of permanganate required to account for the soil oxidant demand.

4.5 Adventus Americas: Zero-Valent Iron (EHC ™)

The cost associated with injecting the EHC ™ product is based on an estimate provided by AAI. The total cost associated with this option is $95,000 with post-treatment monitoring activities. The cost associated with this option includes one injection of the EHC™, drilling/injection field activities and LBGES/AAI oversight and post-treatment monitoring.

Based on calculations provided by AAI, approximately 3,000 gallons of EHC™ slurry would be injected into the FDSA. Injection at each point is targeted from the top of the clay lens to the top of the water table. Seven days of field activities are anticipated for completion of this remedial option.

Once EHC™ injection activities are completed, post-monitoring activities would be conducted one month after injection and then quarterly for one year in select monitor wells. The parameters that will be tested include VOCs and various geochemical parameters (nitrate, sulfate, sulfide, iron (II), methane, total organic carbon, alkalinity, chloride, hydrogen, carbon dioxide, methane, pH, temperature, ORP, DO, conductivity, turbidity, total dissolved solids).

5.0 RECOMMENDATION

Based on the findings of the feasibility study and the estimated cost of implementing each process discussed above, LBGES recommends utilizing the EHC™ product provided by AAI. It should be noted, however, that none of these vendors guarantee reduction of chlorinated VOCs to concentrations below the aquifer restoration goal of 5 ug/L. However, many vendors indicate that the VOC concentrations will approach 5 ug/L. Advantages of the EHC™ injection remediation option include the following:

1. This option is a one-step injection process that is expected to degrade the chlorinated VOCs within one year. Complete degradation of the chlorinated VOCs is achieved (i.e. ethene and chloride would be the end-products).

2. Implementation of this remedial option requires being on the residential property only one time (not including post-monitoring activities);
3. The EHC™ injection process uses food-grade additives and, therefore, is not harmful or toxic to the environment;
4. As an ancillary benefit, the EHC™ product produces highly reducing (anaerobic) subsurface conditions, which will promote biodegradation of the chlorinated solvents with indigenous bacteria;
5. A pH buffer is included in the formulation of the product;
6. This product uses both abiotic and biotic processes to treat the contaminants, therefore, it is not necessary to produce anaerobic subsurface conditions to treat the contaminants with specific dechlorinating microbes (which would be the case if the bioaugmentation (biotic) remediation options were chosen);
7. An AAI representative will be on-site to assist with the product application for this remedial option, and;
8. The cost is relatively inexpensive compared to many other remediation options.

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TABLE

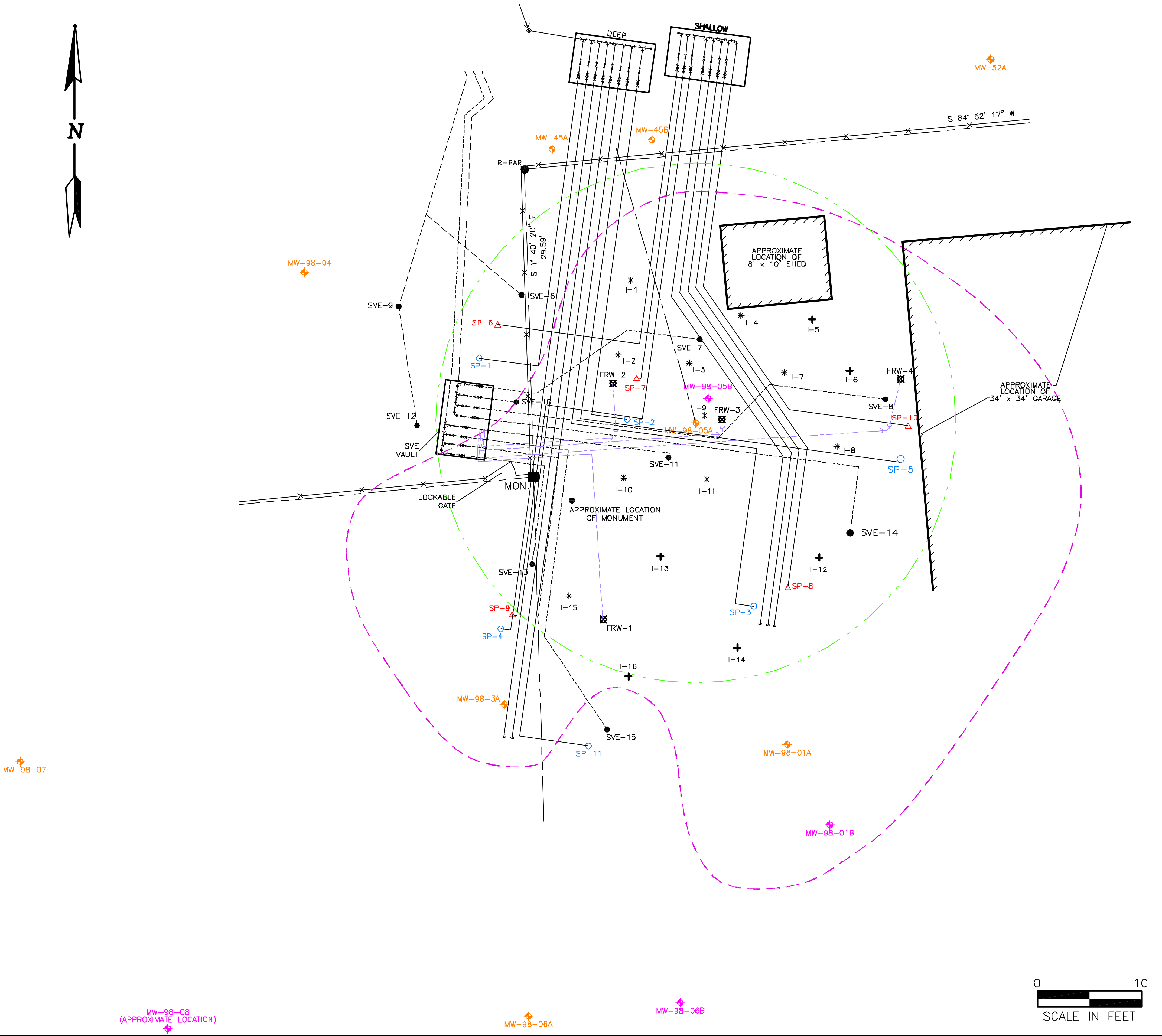
TABLE 1

GROUND-WATER REMEDIAL ACTION
ROWE INDUSTRIES SUPERFUND SITE
SAG HARBOR, NEW YORK

Summary of Remedial Alternatives

Remedial Alternative	Chemicals/Agents	Injection Requirements	Pretreatment Sampling Requirements	Post Treatment Monitoring Requirements	Estimated Cost
RNAS: Newman Zone with Sirem's KB-1 microbes	Emulsified soybean oil amendment consisting of food grade and pharmaceutical grade additives and dehalogenating microbes	Injected using a temporary feed system and existing SVE wells (Newman Zone) and direct push injection (KB-1), pretreatment with buffering solution required.	Three groundwater samples for DO, ORP, nitrate, sulfate, temperature, and pH	One month after final treatment step, quarterly for one year, and our normal semi-annual interval thereafter	$137,100 with post-treatment ground-water monitoring activities
Regenesis: Hydrogen Release Compound and Bio-dechlor INOCULUM	Liquid polylactate ester and dehalogenating microbes	Injected with direct push technology through temporary injection points pretreatment with buffering solution required.	Three groundwater samples for DO, ORP, nitrate, sulfate, temperature, and pH	One month after final treatment step, quarterly for one year, and our normal semi-annual interval thereafter	$138,400 with Vendor recommended post-treatment groundwater monitoring activities
ISOTEC: Chemical Oxidation with Hydrogen Peroxide	Catalysts (e.g. chelated iron) and oxidizers (e.g. hydrogen peroxide)	Gravity feed or pressure injected through temporary injection points	Bench scale test of soil slurry and groundwater	One month after final treatment step, quarterly for one year, and our normal semi-annual interval thereafter	$117,000 (one treatment with post-monitoring) – $158,200 (two treatments with post monitoring)
GeoCleanse: Chemical Oxidation with Sodium Permanganate	Sodium permanganate	Injected with direct push technology through permanently installed injection points (could be existing SVE wells)	GeoCleanse recommended a bench scale test, but did not provide a cost for the test	One month after final treatment step, quarterly for one year, and our normal semi-annual interval thereafter	$87,200 (one treatment with post-monitoring) – $111,000 (two treatments with post-monitoring)
Adventus Americas: Zero Valent Iron (ZVI) Injection (EHC™)	Zero Valent Iron and organic carbon source	Injected with direct push technology through temporary injection points	Typical Semi-Annual Sampling Analysis with added geochemical parameters	One month after injection, quarterly for one year and our normal semi-annual interval thereafter	$95,000 with post-treatment activities

FIGURE



LEGEND

- PROPERTY BOUNDARY
- CHAIN LINK FENCE
- APPROXIMATE LOCATION OF BELOW GRADE SVE PIPING
- APPROXIMATE LOCATION OF BELOW GRADE AIR SPARGE PIPING
- APPROXIMATE LOCATION OF BELOW GRADE FOCUSED PUMP AND TREAT TUBING
- APPROXIMATE LOCATION OF FOCUSED REMEDIATION GROUND-WATER RECOVERY PIPING
- APPROXIMATE EXTENT OF SHALLOW CLAY LENS
- APPROXIMATE EXTENT OF CONTAMINATED GROUND-WATER IN THE FDSA
- MW-98-05B — GROUND-WATER MONITOR WELL LOCATION
- SP-10 — SHALLOW AIR SPARGE WELL LOCATION
- SP-5 — DEEP AIR SPARGE WELL LOCATION
- SVE-8 — SVE WELL LOCATION
- FRW-1 — FOCUSED REMEDIATION RECOVERY WELL LOCATION
- MW-52A — MONITOR WELLS IDENTIFIED ON WORK PLAN TO CHECK WATER LEVELS
- I-6 — EHC INJECTION LOCATIONS VIA DIRECT PUSH TO 27' BELOW GRADE
- I-1 — EHC INJECTION LOCATIONS VIA DIRECT PUSH TO 27' BELOW GRADE THAT REQUIRE MANUAL DIGGING TO FOUR FEET BELOW GRADE PRIOR TO DRILLING

NOTE:

1. PROPOSED INJECTION LOCATIONS ARE APPROXIMATE. BASED ON FIELD CONDITIONS, SOME OF THESE INJECTION LOCATIONS MAY BE MOVED AS NEEDED.

GROUND-WATER REMEDIATION DESIGN
ROWE INDUSTRIES SITE
SAG HARBOR, NEW YORK

FORMER DRUM STORAGE AREA SITE MAP

DATE	REVISED

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DRAWN:	MRV	CHECKED:	MG	DATE:	10/26/04	FIGURE:	1

APPENDIX I

APPENDIX I

DRAFT
WORK PLAN FOR IMPLEMENTING FOCUSED REMEDIATION OF THE FORMER DRUM STORAGE AREA (FDSA) USING ZVI TECHNOLOGY

ROWE INDUSTRIES SUPERFUND SITE
SAG HARBOR, NEW YORK

This procedure describes the steps necessary for implementing the recommended technology for the remediation of contaminants located in the Former Drum Storage Area (FDSA) at the Rowe Industries Superfund Site in Sag Harbor, New York. From 1998 to 2003 active remediation in the FDSA included soil vapor extraction (SVE), air sparging (AS) and a focused pump and treat (FP&T) system. Zero Valent Iron (ZVI) injection was selected using the proprietary EHC™ product provided by Adventus Americas, Inc. (AAI) as a follow-up treatment program.

The step-by-step procedure necessary to implement this EHC™ injection program is described below. AAI will be on-site at the time the EHC™ is injected into the soil and ground-water at the FDSA.

A total of 7 days of field work is anticipated for the implementation of this procedure. A direct-push vendor will provide the drilling and injection services for the field work. One half-day for set-up and one half-day break-down of the equipment is anticipated. A total of 16 injection points are scheduled in the locations shown on figure 1. It is anticipated that two to three injection points can be completed per day. Hand digging will be required to at least four feet below grade for 9 of the injection points identified on figure 1.

The equipment described below is suggested for EHC™ product application, however, alternate equipment and accessories may be acceptable for use at the discretion of LBG Engineering Services, P.C. (LBGES). The equipment described below is available for purchase through Geoprobe and potentially available for rent through Rig Source (630-365-1049). Other vendors may be available to supply this equipment.

1. GS2000 Injection System: 9 HP dual reciprocating piston pump (install a throttling ball valve on the discharge side to control flow as needed because there is no flow adjustment with this pump). Pumping capacity is 3.6 gallons at 1,800 psi.

2. Injection Pull Cap: either 1 ¼ ” or 1 ½ ” depending on the size rods used in the direct-push drill rig. The purpose of the pull cap is to allow the product to be injected while pulling the rods from the bottom-up. It is attached to the top of the direct-push rods.

3. High Pressure Hosing: ½" ID hosing that connects the discharge side of the GS2000 pump to the Injection Pull Cap.

4. Pressure Activated Injection Probe: This probe threads to the lead-end of the drill rods of the direct-push rig. It has four ¼ inch diameter holes that are the injection discharge points for the EHC™ product into the formation. This probe has the ability to do top-down or bottom-up injection. The size of the probe (i.e., 1 ¼" or 1 ½") will be consistent with the rods that are being used with the direct-push rig.

5. A pump rebuild kit: so minor repairs can be made to the pump if needed.

Other equipment that shall be provided by the subcontractor include a 1,000 gallon mixing tank and a circulation pump to continuously agitate the mixture in the tank (depending on the size and the configuration of the tank; 2 circulation pumps may be required). The subcontractor shall provide a means of transferring the slurry from the mixing tank to the 12.75 gallon hopper on the GS2000 pump system. A transfer pump will be needed to pump the slurry mix from the mixing tank to the GS2000 pump system (the mixing tank and the GS2000 pump will be located approximately 50 feet away from each other, so do not rely on gravity feed). The transfer pump shall be able to pump the iron powder in the slurry (do not use impeller pumps since the impellers may get damaged by the iron powder). In addition, approximately 500 feet of garden hose will be needed between the remediation building and the mixing tank.

EHC™ Injection:

1. Prior to EHC™ injection activities, groundwater levels will be measured in monitor wells MW98-01A, MW98-03A, MW98-04, MW98-05A, MW98-06A, MW98-07, MW-45A, MW-45B and MW-52A to establish a baseline.
2. The subcontractor will set up their drill rig and equipment on-site. All equipment with the exception of the drill rig should be on the Sag Harbor Industries (SHI) side of the fence (mixing tank, injection pump, support truck). The subcontractor will provide all equipment and AAI will provide the EHC™ product.
3. The subcontractor will mix the EHC™ product in batches with the potable water supply in their mixing tank and continuously agitate the mixture with the circulation pump(s) to keep the EHC™ suspended until it is ready for injection into the FDSA.

   The mixing ratios at each injection point (assuming 16 injection locations):

   190 gallons of potable water to
   675 pounds of EHC™ product (13.5 bags assuming 50 lbs per bag)

4. The subcontractor will advance 16 borings to approximately 27 feet below grade in the locations shown on Figure 1. This depth should be the approximate position of the clay lens. Injection will take place from the bottom-up at two-foot intervals (i.e., 25-27 ft bg, 23-25 ft bg, 21-23 ft bg, 19-21 ft bg, 17-19 ft bg). The highest PCE concentrations are expected to be located closest to the clay lens.
5. After the injection at each point is completed, any soil cuttings generated to advance the boring will be placed back in the borehole.

6. At the end of each day, the depth to water in the monitor wells identified in item 1 above will be measured.
7. After all of the injections are completed, the subcontractor will breakdown and de-mobilize all equipment. All injection holes will be backfilled with sand to 6 inches below grade and top soil will be placed from 6 inches to the ground surface. The ground surface of the FDSA will be re-graded and re-seeded as needed to restore it to its original condition prior to the start of the injection activities.

<u>Post EHC™ Injection Sampling</u>

8. Collect ground-water samples in monitor wells MW-98-01A, MW-98-05A, MW-45A and recovery well FRW-2 one month after EHC™ injection activities and quarterly for one year. The ground-water samples will be analyzed for the following parameters:
   a. VOCs;
   b. Total and dissolved iron;
   c. Iron (II);
   d. pH, Temp, DO, Conductivity, TDS, ORP with Horiba meter;
   e. Sulfate/Sulfide;
   f. Nitrate;
   g. Hydrogen;
   h. Chloride;
   i. Total organic carbon (TOC);
   j. Methane;
   k. Alkalinity, and;
   l. Carbon dioxide.

9. Continue to conduct semi-annual ground-water sampling, which has already been established as part of the normal O&M activities, for the monitor wells within the FDSA.
10. Continue monitoring the ground-water concentrations to determine if VOCs (PCE, TCE, DCE, VC) have dropped below the aquifer restoration limits provided in the EPA consent decree.