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August 3, 2007

Mr. Jeffrey A. Konsella, P.E.
Environmental Engineer II
Division of Environmental Remediation
New York State Department of Environmental Conservation
270 Michigan Avenue
Buffalo, New York 14203-2999

RE: Pilot Test Work Plan
Ekonol Polyester Resins
Site # V00653-9

Dear Mr. Konsella:

On behalf of Atlantic Richfield Company, Parsons is pleased to provide you with the Pilot Test Work Plan for the former Ekonol Polyester Resins facility, Site #V00653-9 (Site). Enclosed are two copies of the work plan. Please review the document and advise us of your comments. If you have any questions, please contact Mr. William B. Barber of the Atlantic Richfield Company (a BP affiliated Company). Mr. Barber can be reached at (216) 271-8038.

Very truly yours,

Mark S. Raybuck

Mark S Raybuck
Project Manager

Enclosure

cc: W. Barber, Atlantic Richfield Company
S. Fiorenza, BP
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File (442257 No. 13)

PILOT TEST WORK PLAN FOR *IN SITU* TREATMENT USING ENHANCED BIOREMEDIATION

Ekonol Polyester Resins, NYSDEC # V00653-9
6600 Walmore Rd.
Town of Wheatfield, Niagara County, New York

Prepared for:

DEPARTMENT OF ENVIRONMENTAL CONSERVATION • NEW YORK STATE •

New York State Department of Environmental Conservation
Division of Hazardous Waste Remediation
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August 2007

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SECTION 1

PROJECT DESCRIPTION

This work plan describes the methods that will be used to assess the applicability and feasibility of enhanced *in situ* bioremediation for chlorinated compounds of concern (COCs) in bedrock groundwater at the former Ekonol Polyester Resins facility (the Site) in Wheatfield, NY.

1.1 INTRODUCTION

The former Ekonol Polyester Resins facility is located at 6600 Walmore Road, approximately one-half mile north of Niagara Falls Boulevard (Route 62) in the Town of Wheatfield, New York (Figure 1). A former concrete secondary containment tank for process water was removed from service at the facility in October 1999 (Frontier, 2000). Results of samples from the surrounding soil, wall, and floor of the tank indicated the presence of several organic compounds. Among those detected, and later included on the target parameter list, were trichloroethene (TCE), 1,2-dichloroethene (DCE isomers), vinyl chloride (VC), 1,1,1-trichloroethane (1,1,1-TCA), and 1,1-dichloroethane (1,1-DCA), aniline, phenol, and metals including lead and zinc.

The March 2001 Site Characterization Report and the Phase I, II, and III Site Characterization reports (Parsons 2001, 2003, 2004a, 2004b) presented the extent of the target COCs in soil and groundwater at the Site. The Remedial Alternatives Report (RAR) (Parsons, 2006a, 2006b and 2007) described further characterization, baseline sampling and laboratory treatability testing of several *in situ* technologies for soils, shallow groundwater and bedrock groundwater.

Previous excavation in the source area removed soils impacted with COCs. Shallow groundwater (groundwater in overburden) in the vicinity of the source area remains impacted by COCs, and will be treated with a bioreactor (Parsons, 2006a) during the remediation phase. Subsequent to removal of the containment tank, site characterization, remedial alternatives assessment, and laboratory treatability testing, enhanced *in situ* bioremediation was selected for treating COCs in bedrock groundwater. To further assess the viability of enhanced *in situ* bioremediation of bedrock groundwater, a field pilot test using the selected technology is warranted.

1.2 PILOT TEST OBJECTIVES

Based on the results of the treatability study, the overall objective of this pilot test is to determine if enhanced *in situ* bioremediation of chlorinated COCs in groundwater is a viable treatment option for COCs in bedrock groundwater at the Site. The bedrock groundwater COCs are the chlorinated ethenes and chlorinated ethanes including: TCE, cis-1,2-DCE, 1,1-DCE, VC, 1,1,1-TCA, 1,1-DCA and chloroethane. Concentrations of these compounds over time in bedrock monitoring wells are shown in Figure 2.

The pilot test has been designed with the following primary objectives:

- Create optimal geochemical conditions for anaerobic dechlorination.

- Enhance the rates of natural *in situ* biodegradation of COCs.
- Determine if enhanced *in situ* bioremediation is suitable to achieve the Site remediation goals for groundwater.
- Refine injection methodology and estimate a radius of influence.
- Assess the impacts of the injection of substrates and microorganisms on hydrogeology, especially groundwater movement.
- Assess the potential for solubility of inorganics (e.g., arsenic), generation of gases (e.g., methane, hydrogen or hydrogen sulfide), and other undesirable effects.
- Determine optimal design parameters for potential full-scale application of enhanced anaerobic bioremediation at the Site.

These objectives will be accomplished by injecting soluble/slow-release organic substrate and microorganisms into the shallow subsurface (bedrock) using five injection wells. Injection of an organic substrate and microcultures into fractured bedrock is intended to increase the rate of *in situ* anaerobic biodegradation of COCs in the groundwater. This type of treatment, referred to as bioaugmentation, includes microbes known to degrade chlorinated ethenes and ethanes to innocuous end products (i.e., ethene and ethane). After the substrates have been injected, groundwater in the pilot test area will be monitored for changes in groundwater geochemistry and reduction in contaminant concentration over a period of several months. The following subsections describe the regulatory requirements and performance objectives associated with this pilot test.

1.3 SCOPE OF WORK

The pilot test will be comprised of (1) treatment application and (2) performance monitoring. The treatment application involves all processes and monitoring related to the field application to specific sections of the bedrock groundwater. Performance monitoring includes the methods to assess the remedial technology.

1.3.1 Treatment Application

The pilot test will be performed near the source area between RMW-2D and RMW-4D (see Figure 3). It is anticipated that five injection boreholes will be used to apply the substrate to the fractured bedrock and eight monitoring wells will be included in the performance monitoring. Details of the treatment application design are provided in Section 2 of this work plan. The treatment application is anticipated to include:

- Installation of injection boreholes and monitoring wells.
- Injection and monitoring of one or more conservative tracers concurrently with the substrate injection to estimate the radius of influence and hydrogeologic parameters.

- Development of injection dosages based on a combination of field data, laboratory data, and literature design criteria.

- Development of a mitigation plan for health and safety issues including procedures for handling system leaks and injection pressure build-up.

- Application of bioaugmentation by injection of a vegetable oil emulsion followed by an injection of a microbial culture that is known to degrade all site-related COCs.

1.3.2 Performance Monitoring

Details of the performance monitoring are presented in Section 2.8 of this work plan. The performance monitoring is anticipated to include:

- Groundwater sampling and monitoring of wells located upgradient, within, and downgradient of the treatment zone.

- Monitoring of hydraulic parameters, (hydraulic gradient and hydraulic conductivity) to evaluate the effect of the substrate on formation permeability.

- Evaluation of the performance data that will include changes in COC concentration distribution, tracer distribution, geochemical parameters, calculation of degradation rates, and selective checks of *Dehalococcoides/Dehalobacter* numbers.

1.4 PREVIOUS WORK

The nature and extent of contamination at the Site was evaluated and summarized in the previous site investigations and alternatives evaluation. This previous work is summarized below.

- <u>The Phase I Site Characterization (Parsons, 2001)</u> investigated the extent of impacts on soil and groundwater in the vicinity of the former containment tank. The Phase I activities included soil borings, temporary well installations, soil and groundwater sampling, and land surveying. The Phase I work was summarized and presented to NYSDEC in a report. NYSDEC reviewed the report and requested further characterization of soil and groundwater.

- <u>The Phase II Site Characterization (Parsons, 2003)</u> addressed NYSDEC comments on the Phase I report. Phase II field activities included soil borings, soil sampling with groundwater field screening, overburden and bedrock monitoring well installation, groundwater sampling, and an investigation of site sewers. Field and analytical data from the Phase II characterization showed impacts to groundwater, including a dense non-aqueous phase liquid (DNAPL). After reviewing the Phase II data, NYSDEC concurred that additional work was warranted for groundwater in the bedrock.

- The Phase III Site Characterization (Parsons, 2004a) activities included groundwater field screening, bedrock monitoring well installation, and groundwater sampling, to investigate impacts to groundwater in bedrock. The results indicated the extent of the dissolved phase groundwater plume was reasonably defined but additional information was required.

- The Supplemental Phase III Site Characterization (Parsons, 2004b) included field work such as: installation of temporary off-site bedrock wells, installation of off-site groundwater monitoring wells, groundwater screening, and the collection of two rounds of groundwater sampling from all monitoring wells. Additionally, the report included a qualitative exposure assessment which described the potential exposure setting, exposure pathways, and fate and transport of Site COCs.

- The Remedial Alternatives Report including Addenda I and II (Parsons, August 2006, December 2006, and June 2007) compared various technologies for remediation. These documents concluded that a bioreactor is the preferred treatment for shallow groundwater. *In situ* bioremediation using injection of a carbon source with subsequent bioaugmentation was deemed the most appropriate option for bedrock groundwater. The bioremediation treatment will be evaluated with a pilot scale test, as presented in this work plan.

1.5 SUMMARY OF SITE GEOLOGY AND HYDROGEOLOGY

Geology

The overburden deposits consist of silty red-brown clay, with gray silty clay lenses with a fine sand and gravel at the interface with bedrock. In previous investigations, the observed overburden thickness ranged from 12.5 feet to 18.7 feet below ground surface (bgs).

The bedrock consists of light to dark gray dolomite of the Lockport Group. The formation has been described as consistent throughout; containing weathered bedding planes, vugs, stylolitic horizons, and fossiliferous corals. The Lockport Group has an east-planes, vugs, and a horizontal fracture zone near the stratigraphic contact with Zone 2. Zone 1 is a water-bearing zone. Core samples collected during characterization activities were largely from Zone 1. Downhole geophysical and televiewer surveys completed during the RAR (Parsons, December 2006) identified a significant fracture at approximately 10 to 15 feet below top of rock near the bottom of Zone 1. Zone 2 is described as massive and relatively unfractured; however, intermittent high angle vertical fractures do penetrate Zone 2. Zone 2 is approximately 10 to 25 feet thick (Yager, 1996).

Hydrogeology

In bedrock, the regional groundwater flow direction is to the south, at a hydraulic gradient of approximately 0.01 feet/foot (Golder, 1991). In the bedrock water-bearing zone, the gradients are low and groundwater flow is dependent upon the interconnection of fractures in bedrock. Variability in flow direction may occur due to variability in fractures intercepted and the hydraulic conductivity of the bedrock. Previous investigations at the Site reveal low hydraulic gradient with flow direction generally to the south (0.001). The range of transmissivity calculated for bedrock during pulse interference testing (RAR 2006) was 5.60 x 10^1 ft^2/day to 1.17 x 10^3 ft^2/day. As stated above, downhole geophysical and televiewer surveys during the RAR identified a significant fracture at approximately 10 to 15 feet below top of rock at both MW-7D and MW-21D. This fracture may be continuous across the Site and related to part of a water bearing zone identified previously during drilling operations and packer testing.

1.6 COC DISTRIBUTION AND NATURAL ATTENUATION

The primary volatile COCs at the Site are TCE and 1,1,1-TCA. The concentration of TCE in the source area was greater than 100,000 ug/L, whereas concentrations of 1,1,1-TCA are generally less than 1500 ug/L (Parsons, 2006a). Dechlorination products detected in groundwater that are a product of biodegradation include cis-1,2-DCE, trans-DCE, 1,1-DCE, VC, ethene, 1,1-DCA and chloroethane. Concentrations decrease downgradient of the source area to near the southern property line. During 2003 through 2006, the concentrations of COCs at all wells have generally decreased, indicting that natural attenuation may be occurring and the extent of COCs may be decreasing.

The presence of cis-1,2-DCE, VC, and ethene suggests that reductive dechlorination of TCE is occurring. The presence of 1,1-DCA and chloroethane suggest that dechlorination of 1,1,1-TCA is also occurring. However, the concentrations of VC, ethene, and ethane are low relative to the parent CVOCs, which suggests that the conditions necessary for full dechlorination of TCE are not optimal. The limited occurrence of total organic carbon (TOC) suggests that currently there is not sufficient organic substrate present. The presence of intermediate dechlorination products, however, does provide evidence that anaerobic dechlorination of chlorinated ethenes can be stimulated by providing indigenous microorganisms with an organic substrate for growth and development. This process was supported during the treatability testing (Parsons, 2007a).

1.7 HYDROGEOLOGIC FACTORS AFFECTING TREATMENT

Based on Site data, the range of average linear velocity in this section of the Lockport dolomite is approximately 1 to 10 ft/day. Groundwater velocities less than 1,800 ft/yr (4.93 ft/day) but greater 30 ft/yr (0.082 ft/day) are generally suitable for applying enhanced anaerobic bioremediation (AFCEE et al., 2004). The mass flux of alternate electron acceptors (such as DO or sulfate) is directly proportional to the rate of groundwater flow through the aquifer treatment zone. High rates of groundwater flow may inhibit the development of, or ability to sustain, a highly reducing environment. Conversely, very low rates of groundwater flow may inhibit mixing of substrate and contaminant mass, and slow development of a reactive treatment zone. Currently, there is a strongly reducing environment. Therefore, the main concerns with potential high groundwater flow are influx of sulfate from upgradient groundwater, and lack of retention time of the injected carbon source in the injection zone.

Previous hydrogeologic characterization indicated a significant fracture at approximately 10 to 15 feet below the top of rock. This fracture or fracture zone is expected to at least partially control groundwater flow and transport of COCs. If a carbon source is sustained in this fracture, the treatment of COCs may be possible both in the treatment area and further downgradient.

SECTION 2

SYSTEM DESIGN, INSTALLATION, AND MONITORING

2.1 HEALTH, SAFETY, SECURITY, AND THE ENVIRONMENT (HSSE)

The Health, Safety, Security, and Environment (HSSE) Plan will be updated prior to the start of field work related to the pilot test. The HSSE Plan will include Control of Work (CoW) forms including Authorization to Work (ATW), Job Safety Analysis (JSA), and work permits (hot work, intrusive work, working at heights, etc.) that may be required to complete the work. Any subcontractors used to complete the work will meet HSSE requirements. In addition, the HSSE plan will include an updated emergency response plan in the event of a situation or unplanned occurrence requiring assistance. The plan will provide the onsite user with critical information to be used in the event of an emergency.

At a minimum, toolbox meetings will be held daily while field work is ongoing. Toolbox meetings will include all persons working at the site each day and attendance and topics will be documented. Equipment used at the Site, especially heavy machinery (drilling rigs, for example) will be inspected daily, and the inspections will be documented.

2.2 TECHNICAL APPROACH

This pilot test will use a slow-release substrate (vegetable oil-in-water emulsion) with nutrients to support microbial growth. The vegetable oil emulsion will be used to sustain a reaction zone that supports rapid contaminant degradation over a period of 12 to 36 months. Because the hydrogeology of the site is fractured bedrock with significant aperture, a relatively uniform distribution of the slow-release substrate is expected. Nutrients will also be included in the substrate mixture to support microbial growth.

The substrate mixture that will be injected at INJ-01 (see Figure 3) will also include a sodium bromide solution tracer to determine if groundwater in downgradient locations has come into contact with injected water. The sodium bromide solution will be metered into the mixture to achieve a bromide concentration of approximately 1,000 milligrams per liter (mg/L).

This pilot test will also include a bioaugmentation injection of an enriched microbial culture that is known to rapidly and completely degrade the COCs detected at this Site. This microbial consortium will include both *Dehalococcoides* and *Deahlobacter* species to enhance degradation of chlorinated ethenes and chlorinated ethanes, respectively. The bioaugmentation injection will occur between the first (4-week) and second (13-week) performance monitoring events. The purpose of scheduling the bioaugmentation injection after the first performance monitoring event is to confirm that the substrate injection has created and maintained an anaerobic environment that is supports the long-term viability of the bioaugmentation culture. The important indicators of a suitable environment following a substrate injection are described in Section 2.9.

Proposed locations for the five injection boreholes and eight performance monitoring wells are shown in Figure 3. The well spacing shown in Figure 3 is based on a 15-foot radius of influence at each proposed injection borehole location.

Performance monitoring of the substrate injection will be accomplished using a baseline sampling event (performed immediately prior to injection) followed by three performance monitoring events at 4 weeks, 13 weeks, and 26 weeks following injection. Additional sampling events may be conducted if needed. The locations and types of analyses that will be performed at each well are presented in Table 1. The protocols that will be used to analyze the samples are listed in Table 2. Additional discussions of baseline and performance monitoring events are presented in Sections 2.6 and 2.8, respectively.

2.3 FIELD ACTIVITIES

Field activities associated with this project include mobilization, installation of system components (i.e., injection and monitoring wells), evaluation of local bedrock hydraulics, baseline characterization, injection of substrate, and performance monitoring. Each of these activities is briefly described as follows:

- **Mobilization.** Mobilization consists of project planning meetings, obtaining utility clearances, establishing staging areas for project materials and equipment, and arranging for proper handling and disposal of investigation-derived waste (IDW).

- Based on a review of the regulation, a permit for injection of the bioaugmented water or make up water is not required. The re-injection of contaminated groundwater for *in situ* remediation has been approved for Resource Conservation and Recovery Act (RCRA) sites by the USEPA Office of Solid Waste and Emergency Response (USEPA, 2002). This is a common practice for enhanced bioremediation under other programs as well because the use of native groundwater reduces adverse impacts on native anaerobic microbial populations that may result from the use of oxygenated or treated potable water supplies. This results in a more rapid acclimation period after substrate addition.

- **Installation o**f **System Components.** The proposed design for the pilot test includes installation of five injection boreholes and eight performance monitoring wells. The upgradient performance monitoring well may also be used as a groundwater extraction well during the evaluation of local bedrock hydraulics and as the source of water for mixing the organic substrate prior to injection.

- **Bedrock Characterization:** Rock core will be collected and described to confirm previous bedrock characterization. A caliper logging tool will be run on each newly installed monitoring or injection wells to characterize fractures. A downhole camera will also be used in the injection wells.

- **Evaluation of Local Bedrock Hydraulics.** During drilling or well development, selected wells will be pumped at various rates. The data generated from these tests will be used to refine hydraulic parameters within the pilot test treatment area, including the radius of influence that may be achieved during the substrate injection. The groundwater extracted during drilling or well development will be stored onsite until it can be used as a source of water for mixing the organic substrate prior to injection.

- **Baseline Characterization.** Sampling of one injection borehole and each groundwater performance monitoring well will be performed immediately preceding substrate injection to document concentrations and biogeochemical conditions.

- **Preparation and Injection of Substrate.** An emulsified vegetable oil product and nutrients will be added to Site groundwater using above-ground tanks and in-line mixers. Water level measurements and collection of bailer samples to visually document the presence of vegetable oil in performance monitoring wells will be used to document that a 15-foot radius of injection has been achieved at each injection well.

- **Performance Monitoring.** Sampling and analysis of groundwater will occur approximately 4, 13, and 26 weeks after substrate injection. Additional performance monitoring may be conducted as needed.

- **Injection of Bioaugmentation Culture.** An enriched microbial culture that is suitable for complete reductive dechlorination of COCs will be injected into the subsurface approximately five weeks after the substrate injection. Data from the performance monitoring event that will be conducted five weeks after substrate injection will be evaluated to confirm that a suitable anaerobic environment has been established prior to performing the bioaugmentation injection.

- **Waste Management.** Parsons will arrange for temporary storage and characterization of IDW at the site. Disposal of IDW will be coordinated with Atlantic Richfield.

2.4 MOBILIZATION AND SITE MANAGEMENT

The following subsections outline mobilization and site management issues pertaining to field activities that will be conducted under this project.

2.4.1 Pre-Mobilization Meetings

Before mobilizing to the site for field work, Parsons will schedule and conduct a pre-mobilization meeting to verify that all necessary preparations have been completed. The scope of work will be reviewed with key project personnel, including the Parsons field staff, subcontractor representatives, facility representatives and client representatives.

Security requirements, staging areas, IDW protocols, and health and safety requirements will be reviewed.

2.4.2 Utility Locates

On-site activities will be coordinated with property owner to ensure that any disturbance to facility operations is minimized. A pre-drilling check list and necessary HSSE permits will be completed as required. Well locations and the area to be cleared will be identified during the pre-mobilization meeting in advance of well installation.

Before commencing field activities, drilling locations will be surveyed for underground utilities. The National One Call Center (811) will be contacted for utility marking prior to arranging the subcontractor underground utility locator site visit. A subcontract underground utilities locater will conduct a geophysical survey as directed in the HSSE policy. The utility locate will cover an approximate 10-foot diameter area from the drilling location. All utility location activities will be coordinated under HSSE drilling policies.

The field team will verify and document that all utility locates have been completed prior to performing work. A signed and approved copy of the pre-drilling protocol will be on-site at all times that investigation activities are being conducted.

2.4.3 Decontamination and Staging Areas

A centralized area that is designated for decontamination of drilling and sampling equipment will be identified. All decontamination fluids will be containerized in 55-gallon drums and characterized for disposal.

2.4.4 Equipment Areas

Equipment to be employed on this project includes HSA drilling and HQ coring equipment for the installation of injection and monitoring wells, downhole equipment for testing the borehole, pumps and piping for the substrate injection, and testing instruments for baseline and performance monitoring. Equipment laydown areas will be reviewed with facility personnel prior to well installation and substrate injection.

2.5 SYSTEM INSTALLATION

System installation for the pilot test consists of installation of five injection boreholes and eight groundwater monitoring wells.

2.5.1 Injection and Groundwater Monitoring Well Locations

The proposed locations for the injection boreholes and groundwater monitoring wells are shown in Figure 3. The well spacing is based on an anticipated 15-foot radius of influence that will be achieved at each proposed injection borehole.

Eight new monitoring wells will be installed and used in combination with two existing monitoring wells (RMW-4D and MW-7D) to monitor the performance of this pilot study. One performance monitoring well (PMW-1D) will be located approximately

60 feet upgradient of the nearest injection well. PMW-1D will be used as both a background monitoring well for monitoring contaminant concentrations migrating into the pilot test area, and if needed, as an extraction well for generating groundwater for use as make-up water for the tracer study and substrate injections. Four monitoring wells (PMW-3D, PMW-4D, PMW-6D, and PMW-7D) will be installed downgradient of INJ-01. Results from these four wells will be combined with data collected from existing wells RMW-4D and MW-7D to monitor the extent of anaerobic dechlorination enhancement in the downgradient direction of groundwater flow. The last three performance monitoring wells (PMW-2D, PMW-5D, and PMW-8D) will be installed to the east and west of the line of wells that is centered on INJ-01. Results from these wells will be used to monitor the radius of influence and lateral extent of anaerobic dechlorination enhancement produced by the substrate injection.

2.5.2 Drilling and Well installation

Monitoring wells: Borehole advancement for 2-inch diameter monitoring wells will be conducted by advancing 6.25-inch hollow-stem augers (HSAs) to the top of bedrock. Two-inch diameter split spoon sampling will be conducted ahead of the augering to develop a continuous record of stratigraphy. After reaching refusal at approximately 13-15 feet BGS, a tri-cone roller bit will be used to drill a rock socket approximately two feet into competent bedrock. After drilling the rock socket, a permanent four-inch steel well casing will be placed to the bottom of the boring. The casing will be sealed in-place by tremie grouting with cement-bentonite grout from the bottom up. After allowing the grout to set for a minimum of 24 hours, an HQ-sized core barrel (nominal 3.75-inch outside diameter) will be advanced a maximum of two feet beyond drilling loss (loss of water), which may occur at approximately eight feet below the top of bedrock (six feet below the bottom of the 4 inch casing).

Prior to installing the monitoring wells, a caliper log will be run to approximate the number of fractures in the water bearing zone. Rock core will be retained and logged by an experienced geologist. The core may be submitted for effective porosity analysis.

Borehole advancement for the 4-inch diameter well PMW-1D will be conducted by advancing 8.25-inch hollow-stem augers (HSAs) to the top of bedrock. Two-inch diameter split-spoon sampling will be conducted ahead of the augering to develop a continuous record of stratigraphy. After reaching refusal at approximately 13-15 feet BGS, a tri-cone roller bit will be used to drill a rock socket approximately two feet into competent bedrock. After drilling the rock socket, a permanent six-inch steel casing will be placed to the bottom of the boring. The casing will be sealed in-place by tremie grouting with cement-bentonite grout from the bottom up. After allowing the grout to set for a minimum of 24 hours, a tri-cone bit with a nominal 6-inch diameter will be advanced a maximum of two feet past drilling loss, which may occur at approximately eight feet below the top of bedrock (six feet below the bottom of the 6-inch casing).

Caliper logging will be completed in this monitoring well to approximate the number of fractures in the water bearing zone. Rock core will be retained and logged by an experienced geologist. The core may be submitted for effective porosity analysis.

Injection Wells: The injection wells will be advanced using 6.25-inch hollow-stem augers (HSAs) to the top of bedrock. Two-inch diameter split spoon sampling will be conducted ahead of the augering to develop a continuous record of stratigraphy. After reaching refusal at approximately 13 - 15 feet BGS, a tri-cone roller bit will be used to drill a rock socket approximately two feet into competent bedrock. After drilling the rock socket, a permanent four-inch steel well casing will be placed to the bottom of the boring. The casing will be sealed in-place by tremie grouting with cement-bentonite grout from the bottom up. After allowing the grout to set for a minimum of 24 hours, an HQ-sized core barrel (nominal 3.75-inch outside diameter) will be advanced a maximum of two feet beyond drilling loss (loss of water), which may occur at approximately eight feet below the top of bedrock (six feet below the bottom of the 4 inch casing).

Caliper and downhole camera logging will be completed in the injection wells. The injection boreholes will remain open-to-bedrock. Well screens and risers will not be installed in these boreholes.

2.5.2.1 Pre-Installation Activities

Prior to beginning drilling at each well location, it will be confirmed that the location has been cleared for all subsurface utilities. Any potential overhead hazards (overhead power lines or phone lines, for example) will be identified. The work area around the location will be secured against foot and vehicle traffic.

2.5.2.2 Equipment Decontamination Procedures

Any equipment used in the drilling and/or well installation process will be decontaminated prior to downhole use. Generally, hollow stem augers, drilling rods, and cutting heads will be steam cleaned prior to use and placed on clean plastic sheeting until used. All equipment used downhole will be decontaminated prior to leaving the site.

2.5.2.3 Materials Decontamination

All completion materials will be inspected by the field scientist and determined to be clean and acceptable prior to use. If not factory sealed the riser, screen, end caps, and surface plugs will be cleaned prior to use with a high-pressure, steam/hot-water cleaner using approved water. Materials that cannot be cleaned to the satisfaction of the field scientist will not be used.

2.5.2.4 Well Completion

The monitoring wells will be drilled as described in Section 2.5.2. The monitoring wells will be completed with 2-inch nominal diameter, flush-threaded, stainless steel screen and riser. Note that the final section of riser may be PVC to allow completion with accessible threaded couplings. The screens will be factory slotted with 0.010-inch openings. The well will consist of a well screen (minimum 5-foot, varied length to fit the borehole) and riser casing to the surface. The casing string will be fitted with a locking j-cap plug.

The four-inch diameter well will be drilled as described in Section 2.5.2. The monitoring well will be completed with 4-inch nominal diameter, flush-threaded, stainless steel screen and riser. The screens will be factory slotted with 0.010-inch openings. The well will consist of a well screen (minimum 5-foot, varied length to fit the borehole) and riser casing to the surface. The casing string may be finished with a threaded fitting and a locking j-cap plug.

The field scientist will verify and record the total depth of each injection and monitoring well, the lengths of all casing sections, and the depth to the top of all completion materials. All lengths and depths will be measured to the nearest 0.1 foot.

A number #00 sand pack will be placed around the screen from the bottom of the borehole to approximately 2 feet above the top of the screened interval. A minimum 2 -foot-thick granular bentonite seal will be installed immediately above the sand pack in 0.5-foot lifts. A neat cement/bentonite grout consisting of 94 pounds of Portland cement per 4 pounds of bentonite powder will be tremied in to fill the space extending from the top of the bentonite seal to approximately 3 feet bgs. The grout will be overlain by concrete that will secure the surface completion.

Each well will be completed with a flush mount protective casing. Each injection and groundwater monitoring well will be properly identified.

2.5.2.5 Well Development

All installed injection boreholes and groundwater monitoring wells will require development prior to sampling. Development removes sediment from inside the well casing and flushes fines from the portion of the formation adjacent to the screen. Development will be accomplished using a submersible pump.

Development will be continued until approximately 1.2 times the lost drilling fluid volume is recovered and until pH, temperature, specific conductance, DO, and water clarity (turbidity) stabilize.

Development water will be collected and temporarily staged in a polyethylene tank or 55-gallon drums for later use as make-up water for mixing substrate. If needed, sediment that settles out from the development water will be collected and disposed of as soil IDW.

A development record will be maintained for each monitoring well. The development record will be completed in the field by the field scientist. Development records will include:

- Well number, date, and time of development;
- Development method;
- Pre- and post-development water level and well depth;
- Volume and description of water produced;
- Field analytical measurements, including pH, temperature, and specific conductance.

After development, downhole borehole logging will be completed on all open boreholes. Logging will be completed with a downhole camera and a caliper log.

2.5.2.6 Datum Survey

The locations and elevations of the newly installed monitoring wells and injection boreholes will be surveyed by a surveyor registered in the State of New York. Horizontal locations will be measured the nearest 0.1 foot. The elevation of the ground surface adjacent to each monitoring well and measurement datum (top of the casing) will be measured relative to an existing benchmark location. Vertical elevations will be measured with respect to the National Vertical Datum of 1988 to the nearest 0.01 foot.

2.6 TREATMENT AREA CHARACTERIZATION

Prior to injecting the substrate, the treatment area will be characterized for local hydraulic properties, COC concentrations, and biogeochemical indicator parameters listed in Table 1. Local groundwater hydraulics will be characterized by a combination of drawdown tests during drilling and well development. Table 1 lists the locations where groundwater samples will be collected along with parameters that will be measured in each sample. The analytical protocols that will be used during all pilot test sampling activities are summarized in Table 2. Groundwater samples will be submitted to a qualified laboratory for analysis of VOCs, total organic carbon (TOC), volatile fatty acids (VFAs), sulfate, bromide, and chloride. Additional samples will be analyzed for dissolved gases (methane, ethane, ethene, and dissolved hydrogen). Laboratory quality control procedures are described in Section 3.

Groundwater sampling will be performed by qualified scientists, engineers, and technicians who are trained in low-flow groundwater sampling methods, records documentation, chain-of-custody procedures, and sample handling. Dissolved oxygen (DO), pH, redox potential (ORP), specific conductance, temperature, visual appearance, and depth-to-water will be recorded during monitoring well purging to establish when parameter stabilization has occurred. The stabilized values for these parameters will also be recorded in the field notebook.

After stabilization has been achieved and samples for the fixed-laboratory analysis listed above have been collected, groundwater samples will be collected and analyzed in the field for ferrous iron, manganese(II), alkalinity, hydrogen sulfide, and carbon dioxide using the procedures listed in Table 2. Results of all field measurements will be recorded on well sampling records and in the field notebook.

Protocols for handling of samples from the time of sampling until the samples are delivered to the laboratory are specified in the Phase III QAPP (Parsons 2003). Procedures are provided for chain-of-custody procedures, sample preservation, sample containers and labels, and sample shipment. Samples will be shipped to the laboratory daily using an overnight carrier. All samples will be stored on ice prior to and during shipping.

2.7 SUBSTRATE DISTRIBUTION PLAN

The following text describes substrate selection, preparation, and injection.

2.7.1 Substrate Selection

A slow-release substrate (emulsified vegetable oil) is proposed for this pilot test. The injection substrate will also contain low concentrations of various nutrients. Sodium bromide (less than 1,000 mg/L) will also be added to the substrate as a tracer. The nutrients serve to support growth of both the existing microbial population and the microbial consortium that will be added during the bioaugmentation injection described in Section 2.9. Sodium bromide serves as a source of bromide ions that will be used as a conservative tracer for monitoring the migration of groundwater out of the substrate injection zone.

Site groundwater will be extracted from PMW-1D, and other wells as needed, for use as make-up water for the injection of the emulsified vegetable oil, nutrients, and sodium bromide into the subsurface. The re-injection of contaminated groundwater for *in situ* remediation has been approved for Resource Conservation and Recovery Act (RCRA) sites by the USEPA Office of Solid Waste and Emergency Response (USEPA, 2002). This is a common practice for enhanced bioremediation under other programs as well because the use of native groundwater reduces adverse impacts on native anaerobic microbial populations that may result from the use of oxygenated or treated potable water supplies. This results in a more rapid acclimation period after substrate addition. In the unlikely event that a sufficient volume of make-up water cannot be produced from the extraction well, the make-up water will be supplemented from a potable water source near the Site. If potable water is used, sodium bisulfate will be used to scavenge residual chlorine.

Water levels in PMW-1D, RMW-4D and RMW-7D will be monitored as the make-up water is collected. The water level data will be used to supplement hydrogeologic data.

2.7.2 Substrate Preparation and Emplacement

Upgradient performance monitoring well PMW-1D will be used to produce the make-up water for the substrate injections, if necessary. Water from PMW-1D will be pumped into an above-ground polyethylene tank that will serve as an equalization tank for mixing Site groundwater with nutrients and the conservative tracer. After sufficient water has been collected in the polyethylene tank, an in-line mixing process will be used to add and emulsify the oil at the prescribed rate. This mixture will be transferred to a second tank in preparation for injection into the five injection boreholes. Note that the substrate mixture may be re-circulated through the in-line mixer, as necessary, to achieve a uniform mixture.

Prior to substrate injection, pressure transducers will be deployed in multiple wells surrounding the injection point to measure and record changes in pressure and water level elevation during substrate injection. Injection system pressures will be monitored and flow rate adjustments made as needed to avoid excessive pressure which could constitute a health and safety risk or fracture the bedrock matrix. Injection pressures will be maintained below approximately 20 to 25 pounds per square inch (psi). The substrate injection at each borehole will continue until a radius of influence of at least 15 feet has been achieved as documented using the methodology described below or until 5,000 gallons of substrate mixture is injected.

Groundwater samples will be collected by a bailer from various performance monitoring wells during the substrate injection to document that a minimum 15-foot radius of influence has been achieved. Bailer samples will be examined for the visual presence of the vegetable emulsion, which has a milky white appearance. Field observations of the monitoring point name, injection borehole name, time of sample collection, and cumulative injection volume will be recorded in the field notebook. The total injection volume, metering rate for Site groundwater, and metering rate for emulsified vegetable oil will be recorded in the field for each injection borehole. The mass of nutrients and sodium bromide will also be recorded in the field.

Immediately following completion of the substrate injection, an injection of unamended Site groundwater will be used to help remove residual vegetable oil from the injection borehole. The volume of this groundwater push will be between 250 and 500 gallons, with the final decision on the injection volume made in the field and based on the hydraulic performance observed during the substrate injection. The final volume of the groundwater push, along with any relevant observations, will also be recorded in the field notebook.

2.8 PERFORMANCE MONITORING

The effects of the substrate injection will be monitored over time by collecting groundwater samples from the eight newly-installed performance monitoring wells, two existing monitoring wells, and one injection borehole listed in Table 3. Performance monitoring events will occur approximately 4 weeks, 13 weeks, and 26 weeks after injection of the substrate. Additional sampling may be conducted as needed.

Sampling and analysis procedures previously described for baseline sampling in Section 3.6 will also be used for performance monitoring events. Note that additional groundwater samples will be collected from selected locations at 4 weeks and 26 weeks after injection to measure the concentration of *Dehalococcoides* and *Dehalobactor* species and TCE/VC reductase in groundwater before and after bioaugmentation. These samples will be shipped to qualified laboratory for analysis.

2.9 BIOAUGMENTATION INJECTION PLAN

Data from the performance monitoring event that will be conducted 4 weeks after substrate injection will be evaluated to confirm that a suitable anaerobic environment has been established prior to performing the bioaugmentation injection. The important indicators of a suitable environment following a substrate injection are an absence of DO (less than 1.0 mg/L), a low ORP (less than -100 mV), a neutral pH (between 6 and 8 standard units), and sufficient buffering capacity (alkalinity greater than 100 mg/L as calcium carbonate). If monitoring data suggest that the subsurface environment is not suitable for sustaining the bioaugmentation culture *in situ*, the injection of additional amendments (e.g., buffering agents) may be evaluated and used to alter the subsurface environment to a condition that is more amenable to supporting complete reductive dechlorination.

Following documentation that a suitable anaerobic environment is present in the subsurface, an injection of a microbial consortium including both *Dehalococcoides* and *Deahlobacter* species will be performed at INJ-01. The microbial culture will consist of a natural, stable, non-pathogenic microbial consortia that contains the known dechlorinating bacteria. The bioaugmentation culture will not be genetically engineered or modified.

Groundwater samples will be collected from selected locations at 4 weeks and 26 weeks after injection to measure the impact that the bioaugmentation injection has on the concentration of *Dehalococcoides* and *Dehalobator* species in groundwater before and after bioaugmentation.

Prior to bioaugmentation injection, groundwater will be extracted from a performance monitoring well or injection borehole where available data indicates that a sufficiently reducing environment has been established. This extracted groundwater, which will be injected as a 'push' following the bioaugmentation injection, will be temporarily placed in a polyethylene tank and sparged with nitrogen during filling to limit contact between the atmosphere and the purge water. The purpose of the nitrogen purge is to ensure that the anaerobic geochemical conditions of the purge water is maintained during extraction and temporary storage.

The bioaugmentation culture will be shipped from the supplier in airtight containers to prevent exposure to oxygen. Injection equipment will be installed within INJ-01 to specific depth intervals. The injection lines leading from the bioaugmentation culture vessel will be connected to the injection tubing in the well and the culture will be injected through the tubing. The culture vessels will then be pressurized with inert argon or nitrogen gas (per manufacturer recommendation), forcing the culture out of the vessel, through the injection tubing, and downwards into each injection well. The bioaugmentation culture will be injected through the injection tubing to minimize the potential for contact with atmospheric air.

After the microbial culture has been injected, a field water quality instrument will be used to measure the purge water from the process monitoring event to ensure that DO and ORP measurements remain less than 0.5 mg/L and -100 mV, respectively. If the purge water geochemistry is appropriate, it will be injected into INJ-01 to improve the distribution of the microbial culture in the subsurface. If the geochemical conditions of the purge water have been altered significantly it will be sparged with nitrogen to remove excess DO and reanalyzed. The purge water will be injected into the bioaugmentation injection well using a compressed air-powered diaphragm pump, to force the bioaugmentation culture away from the injection well and out into the bedrock matrix. After bioaugmentation activities are complete, the shipping vessels will be returned to the manufacturer.

2.10 WASTE DISPOSAL

Investigation derived waste (IDW) generated during the pilot test will include soil generated during installation of the injection and monitoring wells, purge water generated during development and sampling of groundwater monitoring wells, equipment decontamination rinsate, and personal protective equipment (PPE) used during sampling activities.

Soil cuttings generated during field activities will be collected in U.S. Department of Transportation-approved 55-gallon steel drums and staged onsite. A sample of the containerized soil will be collected and submitted for VOC analysis by USEPA Method

SW8260B. In addition, the soil will be subjected to the toxicity characteristic leaching procedure, with the extract from that procedure analyzed for VOCs by Method SW8260B.

Purge water generated during monitoring well development and initial (baseline) groundwater sampling will be collected in a bulk storage tank. This purge water will be sampled for VOCs by USEPA Method SW8260B, then used as the make-up water for substrate injection as required. All other decontamination and purge water generated during subsequent sampling events will be containerized in 55-gallon drums and staged onsite. The drums will be sampled and submitted for VOC analysis by USEPA Method SW8260B.

Expendable sampling equipment that may be generated during field activities (e.g., PPE, sample tubing), will be bagged, and disposed of in a trash dumpster located onsite. Miscellaneous trash generated during field activities (i.e., empty sand bags and bentonite containers) also will be placed in the dumpster. Any equipment or PPE that appears to be visually contaminated with hazardous substances will be containerized with soil IDW for proper disposal as a solid waste.

SECTION 3

DATA QUALITY MANAGEMENT AND REPORTING

3.1 DATA QUALITY MANAGEMENT

Data collection, field and laboratory analysis, and data management will be conducted in accordance with the procedures described in this work plan and the following documents:

- Parsons. 2003. *Quality Assurance Project Plan* for Phase III Investigation at Ekonol Polyester Resins, Wheatfield, New York, NYSDEC Site # V00653-9, August.

- USEPA. 1998. *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater*: EPA/600/R-98/128. September.

Field QA/QC procedures will include collection of field duplicates and rinsate, field, and trip blanks; decontamination of all equipment that contacts the sample medium before and after each use; use of analyte-appropriate containers; and chain-of-custody procedures for sample handling and tracking. All samples to be transferred to the laboratory for analysis will be clearly labeled to indicate sample number, location, matrix (e.g., groundwater), and analyses requested. Samples will be preserved in accordance with the analytical methods to be used, and water sample containers will be packaged in coolers with ice to maintain a temperature of 4 °C or less.

All field sampling activities will be recorded in a bound, sequentially-paginated field notebook in permanent ink. All sample collection entries will include the date, time, sample locations and numbers, notations of field observations, and the sampler's name and signature. Field QC samples will be collected in accordance with the program described below, and as summarized in Table 1

QA/QC sampling will include collection and analysis of duplicate groundwater samples, trip blanks, and matrix spike samples. Internal laboratory QC procedures will involve the analysis of laboratory control samples (LCSs) and laboratory method blanks (LMBs). QA/QC objectives for each of these samples, blanks, and spikes are described below. Duplicate groundwater samples will be collected at a frequency of 1 for every 20 or fewer samples of similar matrix. Each duplicate water sample will be collected concurrently with, and by the same method as, the primary sample. Duplicate water samples will be analyzed for VOCs and geochemical parameters (i.e., methane, ethane, and ethane; TOC; nitrate and nitrite; chloride; and sulfate).

A trip blank will be analyzed to assess the effects of ambient conditions on sampling results during the transportation of samples. The trip blank will be prepared by the laboratory and will be transported inside each sample shipment containing samples for VOC analysis. Trip blanks will be analyzed for VOCs only.

Matrix spikes will be prepared in the laboratory and used to establish matrix effects for samples analyzed for VOCs. Sufficient extra sample volume will be submitted to the laboratory to allow matrix spike preparation and analysis. LCSs and LMBs will be prepared internally by the laboratory and will be analyzed each day samples from the sites are analyzed. Samples will be reanalyzed in cases where the LCS or LMB are out of the control limits. Control charts for LCSs and LMBs will be developed by the laboratory and monitored for the analytical methods used.

A data usability summary report (DUSR) will be completed in accordance with the Phase III Investigation Quality Assurance Project Plan and the NYSDEC's Data Usability Summary Report (DUSR) guidelines. The DUSR is developed by reviewing and evaluating the analytical data package. The DUSR will be used to determine whether or not the data, as presented, meet the project specific criteria for data quality and data use. Data packages will be reviewed and evaluated for items such as completeness, holding times, compliance with QC limits and specifications, analytical protocols, raw data conversion to correctly summarized results, and confirmation that the correct data qualifiers have been used. If the DUSR indicates that significant problems with some or all of the data in the package, the data will be either rejected or validated to determine if it can be used. The DUSR will discuss data deficiencies, analytical protocol deviations, and QC problems and the effect on the data. Recommendations on reanalysis and/or re-sampling will be included.

3.2 REPORTING

During the course of the pilot test, interim reporting will be completed, as appropriate. At the conclusion of the pilot test, a report will be prepared and submitted to the NYSDEC. The report will document the results of the pilot test and discuss the viability of enhanced *in situ* bioremediation for bedrock groundwater at the Site. The report will discuss the following:

- geochemical conditions observed during the test;
- observed rates of biodegradation of COCs;
- feasibility of achieving the Site remediation goals for groundwater;
- injection methodology and radius of influence;
- observed impacts of the injection on hydrogeology;
- negative effects of injection, if any, including solubility of inorganics and generation of gases; and
- design parameters for potential full-scale application of the technology.

In addition, the report will include a summary of field activities, analytical data, recommendations, and conclusions. Other information in the report will include site photographs, field notes, laboratory data, and waste manifests and disposal certificates.

SECTION 4

STAFFING

4.1 STAFFING

Addresses and telephone numbers of key project personnel are listed below.

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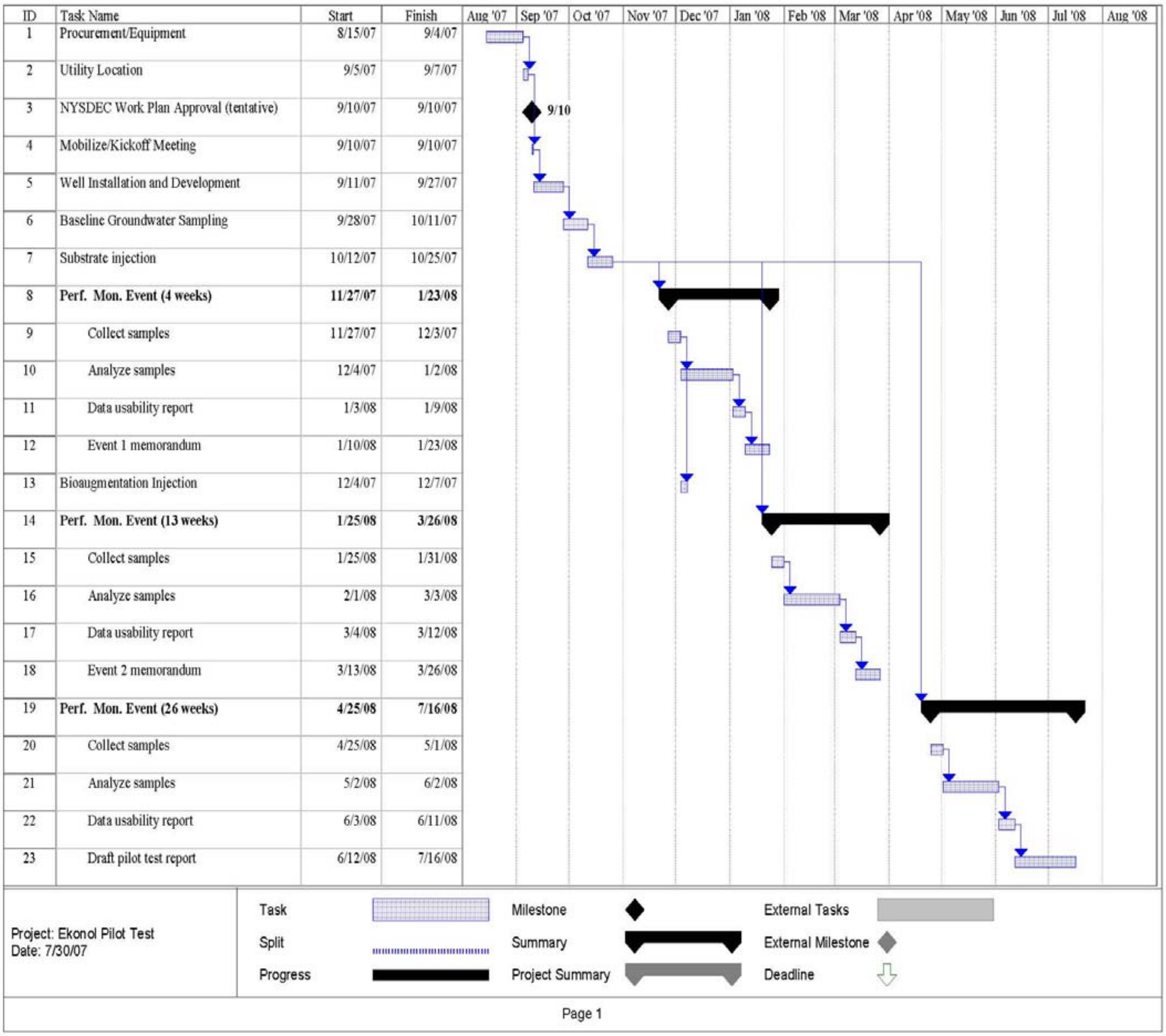
Mr. Jeffrey A. Konsella, P.E. Environmental Engineer II Division of Environmental Remediation New York State Department of Environmental Conservation 270 Michigan Avenue Buffalo, New York 14203 (716) 851-7220	George Hermance Project Geologist Parsons 40 La Riviere Drive, Suite 350 Buffalo, NY 14202 (716) 407-4990
Stephanie Fiorenza, Ph.D. BP 501 Westlake Park Blvd., Rm. 20.101C Houston, TX 77079 (281) 366-7484	Matthew Forcucci New York State Department of Health 584 Delaware Avenue Buffalo, New York 14202 (716) 847-4385

SECTION 5

PROJECT SCHEDULE

The following is the anticipated schedule of activities and deliverables for implementation of this pilot test. A Gantt chart of the schedule is shown below.



ID	Task Name	Start	Finish
1	Procurement/Equipment	8/15/07	9/4/07
2	Utility Location	9/5/07	9/7/07
3	NYSDEC Work Plan Approval (tentative)	9/10/07	9/10/07
4	Mobilize/Kickoff Meeting	9/10/07	9/10/07
5	Well Installation and Development	9/11/07	9/27/07
6	Baseline Groundwater Sampling	9/28/07	10/11/07
7	Substrate injection	10/12/07	10/25/07
8	**Perf. Mon. Event (4 weeks)**	**11/27/07**	**1/23/08**
9	Collect samples	11/27/07	12/3/07
10	Analyze samples	12/4/07	1/2/08
11	Data usability report	1/3/08	1/9/08
12	Event 1 memorandum	1/10/08	1/23/08
13	Bioaugmentation Injection	12/4/07	12/7/07
14	**Perf. Mon. Event (13 weeks)**	**1/25/08**	**3/26/08**
15	Collect samples	1/25/08	1/31/08
16	Analyze samples	2/1/08	3/3/08
17	Data usability report	3/4/08	3/12/08
18	Event 2 memorandum	3/13/08	3/26/08
19	**Perf. Mon. Event (26 weeks)**	**4/25/08**	**7/16/08**
20	Collect samples	4/25/08	5/1/08
21	Analyze samples	5/2/08	6/2/08
22	Data usability report	6/3/08	6/11/08
23	Draft pilot test report	6/12/08	7/16/08

SECTION 6

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TABLES

TABLE 1
SUMMARY OF PROPOSED PROCESS MONITORING SITE ACTIVITIES
EKONOL POLYESTER RESINS, WHEATFIELD, NEW YORK

Location	Well Diameter (inches)	Water Level Measurement	VOCs[a/] (SW8260B)	Methane, Ethane, Ethene (Lab SOP) [b/]	Bromide, Chloride, Sulfate (E300.1)	Total Organic Carbon (SW9060)	Volatile Fatty Acids (Lab SOP)	Dissolved Inorganics [c/] (SW6010B)	Microbial Population [d/] (Lab SOP)	Well Head Analyses [e/]	Mobile Lab Analysis [f/]
Existing Monitoring Wells											
RMW-2D	2	1									
RMW-3D	2	1									
RMW-4D	2	1	1	1	1	1	1		4 & 26 weeks	1	1
MW-7D	2	1	1	1	1	1	1	1		1	1
Performance Monitoring Wells											
PMW-1D	4	1	1	1	1	1	1	1		1	1
PMW-2D	2	1	1	1	1	1	1			1	1
PMW-3D	2	1	1	1	1	1	1	1	4 & 26 weeks	1	1
PMW-4D	2	1	1	1	1	1	1	1		1	1
PMW-5D	2	1	1	1	1	1	1		4 & 26 weeks	1	1
PMW-6D	2	1	1	1	1	1	1			1	1
PMW-7D	2	1	1	1	1	1	1	1		1	1
PMW-8D	2	1	1			1	1			1	1
Injection Boreholes											
TS-INJ-1	2	1	1	1	1	1	1		4 & 26 weeks	1	1
TS-INJ-2	2	1							4 & 26 weeks		
TS-INJ-3	2	1									
TS-INJ-4	2	1									
TS-INJ-5	2	1									
SUBTOTALS		17	11	10	10	11	11	5	5	11	11
QA/QC											
Duplicates			1	1	1	1	1	1	0	1	1
Matrix Spike			1								
Matrix Spike Duplicate			1								
Trip Blanks			1								
TASK TOTAL PER SAMPLING EVENT:			15	11	11	12	12	6	5	12	12

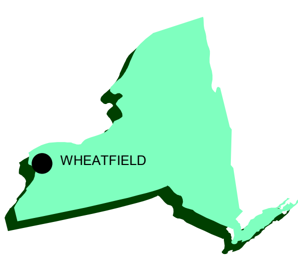
[a/] VOCs = volatile organic compounds, including aromatic and chlorinated aliphatic hydrocarbons. If present, an oil sample will also be collected and analyzed for VOCs.
[b/] Analytical method for dissolved gases will be a laboratory-specific standard operating procedure (Lab SOP).
[c/] Dissolved inorganic compounds will consist of manganese, selenium, and arsenic.
[d/] Analysis of microbial population composition will include concentration measurements of dehalococcoides and dehalobacter species in cells per milliliter..
[e/] Well head analyses include dissolved oxygen, oxidation-reduction potential, pH, temperature, electrical conductivity, and visual appearance.
[f/] Mobile lab analyses include carbon dioxide, alkalinity, sulfide, ferrous iron, and manganese.

TABLE 2
ANALYTCAL PROTOCOLS FOR
GROUNDWATER AND OIL SAMPLES
EKONOL POLYESTER RESINS, WHEATFIELD, NEW YORK

MATRIX Analyte	**METHOD**	**FIELD (F) OR ANALYTICAL LABORATORY (L)**
GROUNDWATER		
Redox Potential (ORP)	Direct-reading meter	F
Dissolved Oxygen	Direct-reading meter	F
pH	Direct-reading meter	F
Electrical Conductivity	Direct-reading meter	F
Temperature	Direct-reading meter	F
Appearance	Visual Observation	F
Alkalinity (Carbonate [$CO_3^{=}$]		
+ Bicarbonate [HCO_3^{-}])	Titrimetric, Hach Method 8221 (or similar)	F
Carbon Dioxide	Titrimetric, Hach Method 1436-01 (or similar)	F
Bromide	EPA Method 320.1	L
Chloride	EPA Method 325.3	L
Dissolved Inorganics [a/]	SW-846 Method 6010B	L
Ferrous Iron (Fe^{2+})	Colorimetric, Hach Method 8146 (or similar)	F
Hydrogen Sulfide	Hach Method 8131 or HS-C	F
Manganese (Mn^{2+})	Colorimetric, Hach Method 8034 (or similar)	F
Methane, Ethane, Ethene	Laboratory-specific Standard Operating Procedure	L
Sulfate	Colorimetric, Hach Method 8051 (or similar)	F
Sulfate	EPA Method 375.4	L
Total Organic Carbon	SW-846 9060	L
Volatile Fatty Acids	Laboratory-specific Standard Operating Procedure	L
Volatile Organic Compounds (VOCs)	SW-846 8260B	L
OIL		
VOCs	SW-846 8260B	L

[a/] Dissolved inorganic compounds will consist of manganese, selenium, and arsenic.

FIGURES



New York

LATITUDE: N43° 06' 21"
LONGITUED: W78° 55' 46"

FIGURE 1

EKONOL POLYESTER RESINS FACILITY
WHEATFIELD, NEW YORK

SITE LOCATION MAP

PARSONS

40 La Riviere Drive, Suite 350, Buffalo, New York 14202

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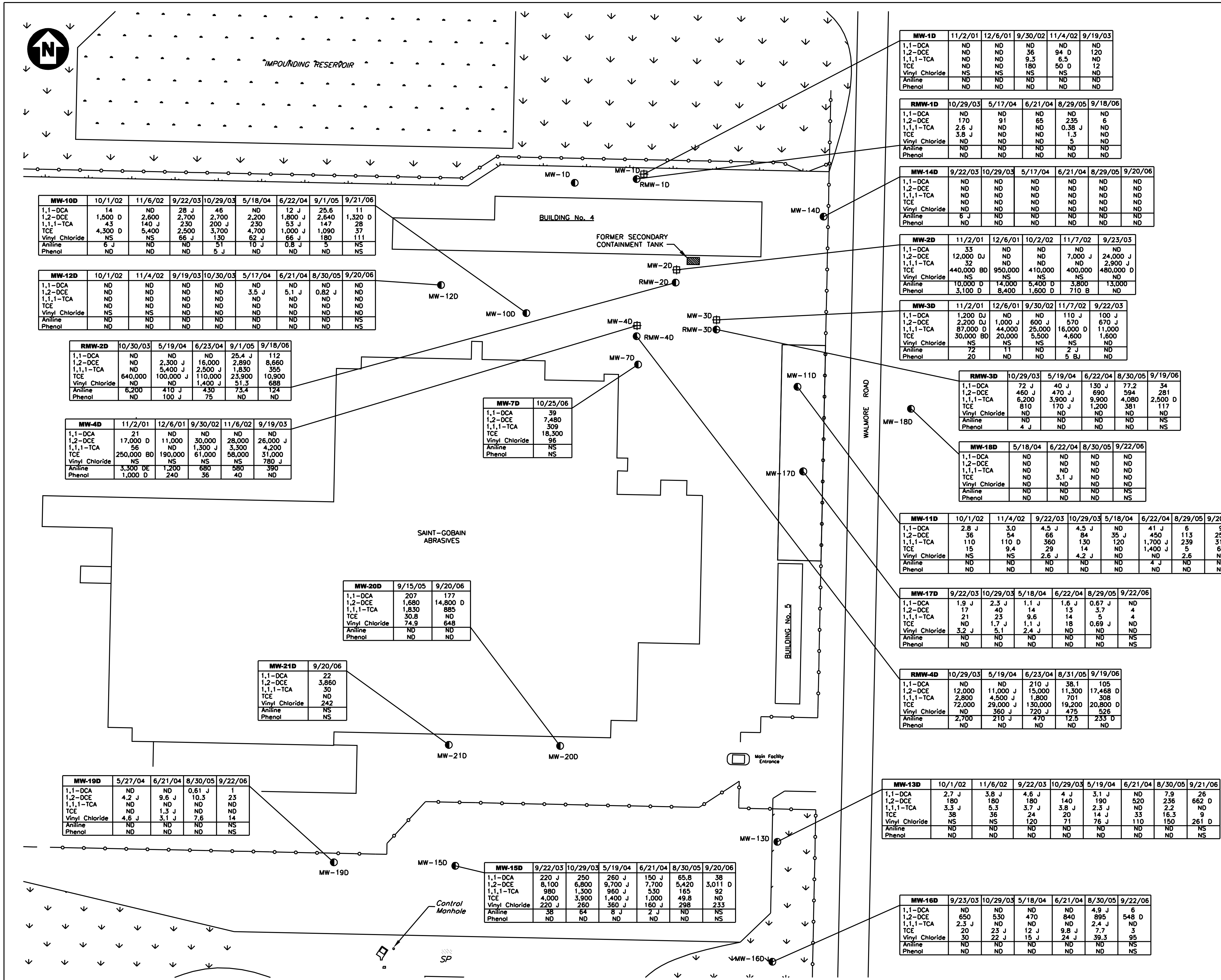

MW-1D	11/2/01	12/6/01	9/30/02	11/4/02	9/19/03
1,1-DCA	ND	ND	ND	ND	ND
1,2-DCE	ND	ND	36	94 D	120
1,1,1-TCA	ND	ND	9.3	6.5	ND
TCE	ND	ND	180	50 D	12
Vinyl Chloride	NS	NS	NS	NS	ND
Aniline	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND

RMW-1D	10/29/03	5/17/04	6/21/04	8/29/05	9/18/06
1,1-DCA	ND	ND	ND	ND	ND
1,2-DCE	170	91	65	235	6
1,1,1-TCA	2.6 J	ND	ND	0.38 J	ND
TCE	3.8 J	ND	ND	1.3	ND
Vinyl Chloride	ND	ND	ND	5	ND
Aniline	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND

MW-14D	9/22/03	10/29/03	5/17/04	6/21/04	8/29/05	9/20/06
1,1-DCA	ND	ND	ND	ND	ND	ND
1,2-DCE	ND	ND	ND	ND	ND	ND
1,1,1-TCA	ND	ND	ND	ND	ND	ND
TCE	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND
Aniline	6 J	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND

MW-2D	11/2/01	12/6/01	10/2/02	11/7/02	9/23/03
1,1-DCA	33	ND	ND	ND	ND
1,2-DCE	12,000 DJ	ND	ND	7,000 J	24,000 J
1,1,1-TCA	32	ND	ND	ND	2,900 J
TCE	440,000 BD	950,000	410,000	400,000	480,000 D
Vinyl Chloride	NS	NS	NS	NS	ND
Aniline	10,000 D	14,000	5,400 D	3,800	13,000
Phenol	3,100 D	8,400	1,600 D	710 B	ND

MW-3D	11/2/01	12/6/01	9/30/02	11/7/02	9/22/03
1,1-DCA	1,200 DJ	ND	ND	110 J	100 J
1,2-DCE	2,200 DJ	1,000 J	600 J	570	670 J
1,1,1-TCA	87,000 D	44,000	25,000	16,000 D	11,000
TCE	30,000 BD	20,000	5,500	4,600	1,600
Vinyl Chloride	NS	NS	NS	NS	ND
Aniline	72	11	ND	2 J	ND
Phenol	20	ND	ND	5 BJ	ND

RMW-3D	10/29/03	5/19/04	6/22/04	8/30/05	9/19/06
1,1-DCA	72 J	40 J	130 J	77.2	34
1,2-DCE	460 J	470 J	690	594	281
1,1,1-TCA	6,200	3,900 J	9,900	4,080	2,500 D
TCE	810	170 J	1,200	381	117
Vinyl Chloride	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	NS
Phenol	4 J	ND	ND	ND	NS

MW-18D	5/18/04	6/22/04	8/30/05	9/22/06
1,1-DCA	ND	ND	ND	ND
1,2-DCE	ND	ND	ND	ND
1,1,1-TCA	ND	ND	ND	ND
TCE	ND	3.1 J	ND	ND
Vinyl Chloride	ND	ND	ND	ND
Aniline	ND	ND	ND	NS
Phenol	ND	ND	ND	NS

MW-11D	10/1/02	11/4/02	9/22/03	10/29/03	5/18/04	6/22/04	8/29/05	9/20/06
1,1-DCA	2.8 J	3.0	4.5 J	4.5 J	ND	41 J	6	9
1,2-DCE	36	54	66	84	35 J	450	113	257
1,1,1-TCA	110	110 D	360	130	120	1,700 J	239	315
TCE	15	9.4	29	14	ND	1,400 J	5	69
Vinyl Chloride	NS	NS	2.6 J	4.2 J	ND	ND	2.6	ND
Aniline	ND	ND	ND	ND	ND	4 J	ND	NS
Phenol	ND	ND	ND	ND	ND	ND	ND	NS

MW-17D	9/22/03	10/29/03	5/18/04	6/22/04	8/29/05	9/22/06
1,1-DCA	1.9 J	2.3 J	1.1 J	1.6 J	0.67 J	ND
1,2-DCE	17	40	14	13	3.7	4
1,1,1-TCA	21	23	9.6	14	5	4
TCE	ND	1.7 J	1.1 J	18	0.69 J	ND
Vinyl Chloride	3.2 J	5.1	2.4 J	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	NS
Phenol	ND	ND	ND	ND	ND	NS

RMW-4D	10/29/03	5/19/04	6/23/04	8/31/05	9/19/06
1,1-DCA	ND	ND	210 J	38.1	105
1,2-DCE	12,000	11,000 J	15,000	11,300	17,468 D
1,1,1-TCA	2,800	4,500 J	1,800	701	308
TCE	72,000	29,000 J	130,000	19,200	20,800 D
Vinyl Chloride	ND	360 J	720 J	475	526
Aniline	2,700	210 J	470	12.5	233 D
Phenol	ND	ND	ND	ND	ND

MW-10D	10/1/02	11/6/02	9/22/03	10/29/03	5/18/04	6/22/04	9/1/05	9/21/06
1,1-DCA	14	ND	28 J	46	ND	12 J	25.6	11
1,2-DCE	1,500 D	2,600	2,700	2,700	2,200	1,800 J	2,640	1,320 D
1,1,1-TCA	43	140 J	230	200 J	230	53 J	147	28
TCE	4,300 D	5,400	2,500	3,700	4,700	1,000 J	1,090	37
Vinyl Chloride	NS	NS	66 J	130	62 J	66 J	180	111
Aniline	6 J	ND	ND	51	10 J	0.8 J	5	NS
Phenol	ND	ND	ND	5 J	ND	ND	ND	NS

MW-12D	10/1/02	11/4/02	9/19/03	10/30/03	5/17/04	6/21/04	8/30/05	9/20/06
1,1-DCA	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DCE	ND	ND	ND	ND	3.5 J	5.1 J	0.82 J	ND
1,1,1-TCA	ND	ND	ND	ND	ND	ND	ND	ND
TCE	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	NS	NS	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	NS
Phenol	ND	ND	ND	ND	ND	ND	ND	NS

RMW-2D	10/30/03	5/19/04	6/23/04	9/1/05	9/18/06
1,1-DCA	ND	ND	ND	25.4 J	112
1,2-DCE	ND	2,300 J	16,000	2,890	8,660
1,1,1-TCA	ND	5,400 J	2,500 J	1,830	355
TCE	640,000	100,000 J	110,000	23,900	10,900
Vinyl Chloride	ND	ND	1,400 J	51.3	688
Aniline	6,200	410 J	430	73.4	124
Phenol	ND	100 J	75	ND	ND

MW-4D	11/2/01	12/6/01	9/30/02	11/6/02	9/19/03
1,1-DCA	21	ND	ND	ND	ND
1,2-DCE	17,000 D	11,000	30,000	28,000	26,000 J
1,1,1-TCA	56	ND	1,300 J	3,300	4,200
TCE	250,000 BD	190,000	61,000	58,000	31,000
Vinyl Chloride	NS	NS	NS	NS	780 J
Aniline	3,300 DE	1,200	680	580	390
Phenol	1,000 D	240	36	40	ND

MW-7D	10/25/06
1,1-DCA	39
1,2-DCE	7,480
1,1,1-TCA	309
TCE	18,300
Vinyl Chloride	96
Aniline	NS
Phenol	NS

MW-20D	9/15/05	9/20/06
1,1-DCA	207	177
1,2-DCE	1,680	14,800 D
1,1,1-TCA	1,830	885
TCE	30.8	ND
Vinyl Chloride	74.9	648
Aniline	ND	ND
Phenol	ND	ND

MW-21D	9/20/06
1,1-DCA	22
1,2-DCE	3,860
1,1,1-TCA	30
TCE	ND
Vinyl Chloride	242
Aniline	NS
Phenol	NS

MW-19D	5/27/04	6/21/04	8/30/05	9/22/06
1,1-DCA	ND	ND	0.61 J	1
1,2-DCE	4.2 J	9.6 J	10.3	23
1,1,1-TCA	ND	ND	ND	ND
TCE	ND	1.3 J	ND	ND
Vinyl Chloride	4.6 J	3.1 J	7.6	14
Aniline	ND	ND	ND	NS
Phenol	ND	ND	ND	NS

MW-15D	9/22/03	10/29/03	5/19/04	6/21/04	8/30/05	9/20/06
1,1-DCA	220 J	250	260 J	150 J	65.8	38
1,2-DCE	8,100	6,800	9,700 J	7,700	5,420	3,011 D
1,1,1-TCA	980	1,300	960 J	530	165	92
TCE	4,000	3,900	1,400 J	1,000	49.8	ND
Vinyl Chloride	220 J	260	360 J	160 J	298	233
Aniline	38	64	8 J	2 J	ND	NS
Phenol	ND	ND	ND	ND	ND	NS

MW-13D	10/1/02	11/6/02	9/22/03	10/29/03	5/19/04	6/21/04	8/30/05	9/21/06
1,1-DCA	2.7 J	3.8 J	4.6 J	4 J	3.1 J	ND	7.9	26
1,2-DCE	180	180	180	140	190	520	236	662 D
1,1,1-TCA	3.3 J	5.3	3.7 J	3.8 J	2.3 J	ND	2.2	ND
TCE	38	36	24	20	14 J	33	16.3	9
Vinyl Chloride	NS	NS	120	71	76 J	110	150	261 D
Aniline	ND	ND	ND	ND	ND	ND	ND	NS
Phenol	ND	ND	ND	ND	ND	ND	ND	NS

MW-16D	9/23/03	10/29/03	5/18/04	6/21/04	8/30/05	9/22/06
1,1-DCA	ND	ND	ND	ND	4.9 J	6
1,2-DCE	650	530	470	840	895	548 D
1,1,1-TCA	2.3 J	ND	ND	ND	2.4 J	ND
TCE	20	23 J	12 J	9.8 J	7.7	3
Vinyl Chloride	30	22 J	15 J	24 J	39.3	95
Aniline	ND	ND	ND	ND	ND	NS
Phenol	ND	ND	ND	ND	ND	NS

LEGEND:

FENCE LINE

MW-5D EXISTING BEDROCK MONITORING WELL (DEEP)

MW-1D ABANDONED BEDROCK MONITORING WELL

GROUNDWATER DATA LEGEND:

1,1-Dichloroethane (1,1-DCA)	7.2 ug/L
Total 1,2-Dichloroethene (1,2-DCE)	18,000 ug/L
1,1,1-Trichloroethane (1,1,1-TCA)	13 ug/L
Trichloroethene (TCE)	110,000 ug/L
Vinyl Chloride	21 ug/L
Aniline	1,400 ug/L
Phenol	660 ug/L

"ND"= COMPOUND WAS ANALYZED FOR, BUT NOT DETECTED
"J"= INDICATES AN ESTIMATED VALUE
"E"= CONCENTRATION EXCEEDED THE CALIBRATION RANGE
"D"= COMPOUND WAS IDENTIFIED IN AN ANALYSIS AT THE SECONDARY DILUTION FACTOR

140 70 0 140 280
FEET

FIGURE 2

EKONOL POLYESTER RESINS FACILITY
WHEATFIELD, NEW YORK

BEDROCK GROUNDWATER CONCENTRATION MAP (2001 – 2006)

PARSONS
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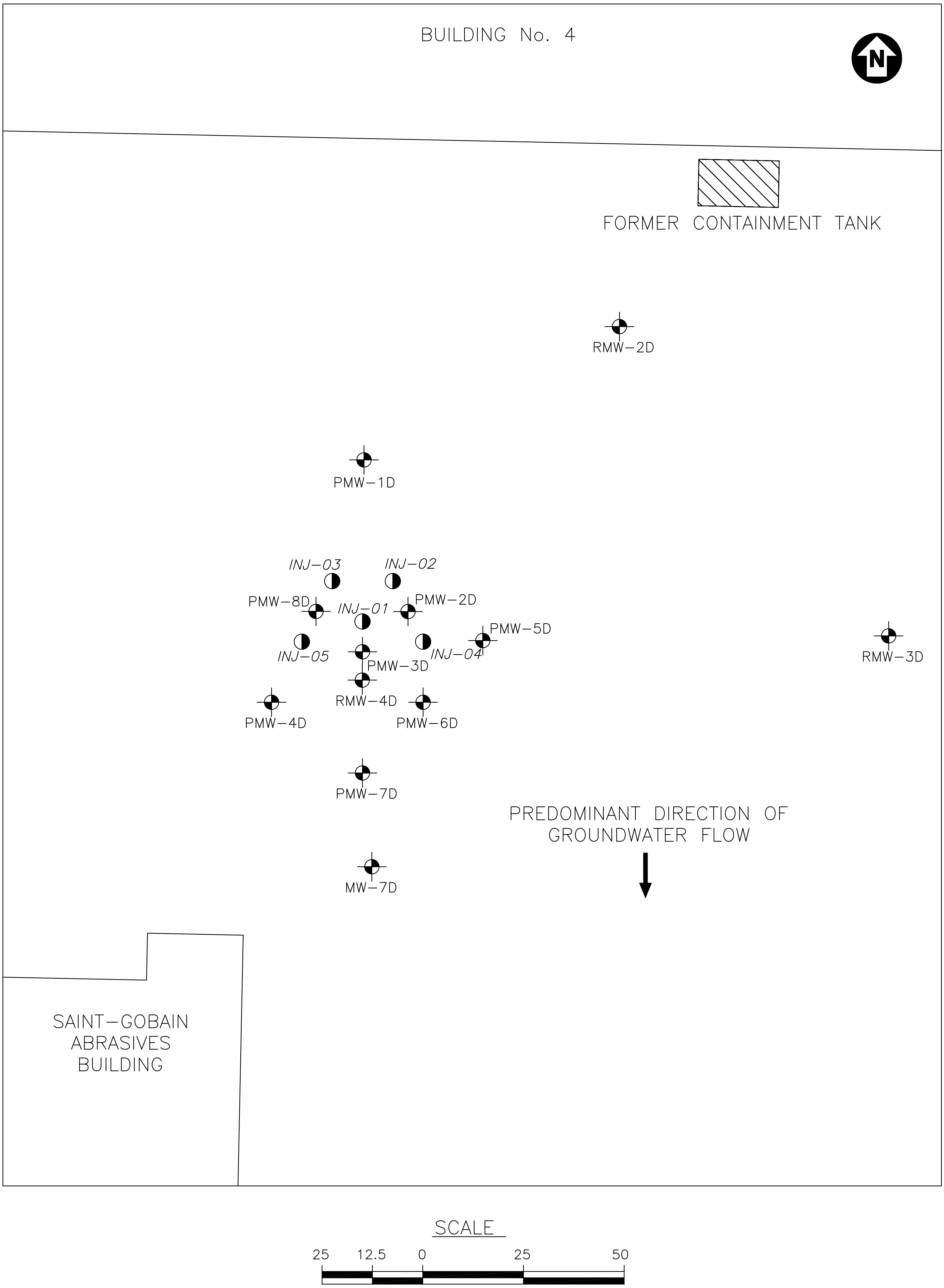

LEGEND:

PMW-1D	MONITORING WELL
INJ-01	INJECTION WELL
	PILOT TEST AREA

FIGURE 3

EKONOL POLYESTER
RESINS FACILITY
WHEATFIELD, NEW YORK

PILOT TEST INJECTION AND MONITORING WELL LOCATIONS

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