REMEDIAL ALTERNATIVES REPORT

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

Prepared for:

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

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SECTION 1
INTRODUCTION

1.1 PURPOSE

This document provides the results from recent investigation activities and presents a Remedial Alternatives Report (RAR) for the former Ekonol Polyester Resins facility, Site #V00653-9 (Site). The purpose of the RAR is to evaluate remedial alternatives for the soils, shallow groundwater and deep groundwater in accordance with the New York State Department of Environmental Conservation (NYSDEC) Voluntary Cleanup Program (VCP).

1.2 PREVIOUS INVESTIGATIONS

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), vinyl chloride (VC), trichloroethane (TCA) and dichloroethane (DCA), aniline, phenol, and metals including lead and zinc. Because some of the sample results exceeded NYSDEC Technical and Administrative Guidance Memorandum (TAGM) 4046 values, characterization of the Site was conducted.

In prelude to remediation, multiple field investigations and administrative controls have been performed as 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 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;

- Voluntary Cleanup Program (VCP). On June, 27, 2003 NYSDEC accepted the Site into the VCP. This program was designed to enhance private sector cleanups and address environmental, legal, and financial barriers that often hinder the redevelopment of contaminated properties (NYSDEC, 2002);
- 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, and;
- The ongoing monitoring program (September, 2003 though present) has included monthly water level measurements, separate phase monitoring and other maintenance work, with monthly reporting to NYSDEC.

1.3 SITE DESCRIPTION

The Site is situated at the northeast end of the Saint-Gobain Performance Plastics Corporation facility. Properties adjacent to this facility include Bell Aerospace Textron to the south, Niagara Falls Air Force Base to the north, and Niagara Falls International Airport to the west. Properties to the east of Walmore Road are primarily zoned industrial and commercial; however, residential properties do exist on the east side of Walmore Road.

The topography at the facility is relatively flat. The Site is located at an approximate elevation of 600 feet above mean sea level (AMSL), and is mostly paved with asphalt and concrete. Paved areas are used primarily for vehicle parking and equipment storage. The facility receives its potable water supply from the Town of Wheatfield, New York. The nearest groundwater supply well for domestic use is approximately one mile east-southeast of the facility (EDR, 2000).

1.4 SITE HISTORY

The former secondary containment tank at the facility received wastewater rinsates from floor drains inside the process area of the Ekonol plant. The tank was installed prior to 1977, and remained in use until October 1999. According to Frontier (2000), the tank was constructed of reinforced concrete walls, approximately 9.5 inches thick. The interior dimensions were approximately 18 feet long, 6 feet wide, and 9 feet deep (Frontier, 2000). At capacity, the maximum volume was 7,794 gallons (Frontier, 2000). The tank was an open top, rinsate collection point covered with large steel plates. The walls and floor were sound, with no obvious cracking or fractures. At the time the tank was removed, there was no protective coating visible on the inside walls or floor (Frontier, 2000). Following the tank removal, additional excavation removed impacted soils surrounding the tank. Approximately 180 cubic yards of material were removed from the area around the tank. Frontier (2000) reported the size of the excavation as 29 feet long (east to west) 16 feet wide (north to south) and 12.7 feet deep (surface to bedrock).

During the tank removal, TCE was detected in concentrations ranging from 1.2 to 200 mg/kg in soil samples collected from the excavation walls (Frontier, 2000). Cis-1,2-DCE was detected at levels ranging from 2.9 to 100 mg/kg. Phenols were detected at concentrations ranging from 4.5 to 12 mg/kg.

Following the tank closure and soil excavation, multiple field investigations and administrative controls have been conducted. These events were outlined above.

1.5 ADJACENT SITE

The Bell Aerospace Textron Wheatfield Plant, to the south of the Site, may provide insights related to the remediation strategy of the Ekonol Site. The Bell Aerospace site historically impacted the overburden and bedrock groundwater by discharging TCE to a shallow “neutralization” pond (Yager, 2000) near it northern property line. The investigations at the Bell Aerospace Site, including studies by the USGS, provide useful information as to the potential fate and transport of COCs.

Reports from the Bell Aerospace Site also provide insight into the natural processes that may be occurring there:

- Presence of DCE and VC within the Bell Aerospace plume indicates that reductive dechlorination of TCE has occurred (Yager, 2000);
- Madsen and Yager (1997) identified and documented the dechlorination of TCE to ethene by naturally occurring compounds;
- The presence of ethene from within the affected groundwater area and the absence of ethene outside the affected groundwater area indicate that VC was degraded by naturally occurring microorganisms (Yager, 2000) and;
- Microcosm studies using Bell Aerospace groundwater spiked with TCE demonstrated sequential dechlorination to ethene. The addition of pulverized dolomite to the microcosm increased the rate of reductive dechlorination. Yager (2000) suggests the increased rate may be due to naturally occurring hydrocarbons in the dolomite.

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SECTION 2
SUMMER/FALL 2005 ACTIVITIES

2.1 INTRODUCTION

The work accomplished as part of the alternatives evaluation, was described in the NYSDEC-approved work plan. Alternative evaluation activities, described herein, included drilling and new well installations, groundwater sampling, soil sampling, hydrogeologic testing, and investigation derived waste (IDW) disposal.

2.2 DRILLING

Three shallow overburden wells (MW-10s though MW-12s) and one bedrock well (MW-20D) were installed at the locations shown in Figure 2. Groundwater samples collected from these wells were used to evaluate the extent of impacts from the constituents of concern (COCs), and evaluate natural attenuation. The wells were installed in accordance with the Additional Phase II Work Plan. Appendix A contains the boring logs of the new wells.

Using direct-push technology (i.e. Geoprobe®) approximately 9 borings were advanced to the top of rock in the area near the former tank and in the area around MW-15D (Figures 3 and 4). Soils were field screened for indication of impacts and sampled for chemical analysis as described below. Soil samples were collected as described below.

Following drilling and direct-push activities, all new wells and direct push locations were surveyed by a licensed New York State surveyor for location and elevation. Water level measurements are part of the continuing monthly water level collection program.

2.3 SAMPLING

2.3.1 Groundwater Sampling

One round of groundwater sampling was completed consistent with the methodology described in the NYSDEC-approved Work Plan for the Phase III Investigation (August 2003). All existing wells were sampled during the period of August 29 through September 1, 2005. After completion and development, the new wells were sampled. The new wells were sampled from September 6 through September 12, 2005 except for well MW-12s which was sampled on November 8, 2005.

A total of 27 groundwater samples (12 shallow, and 15 deep) were collected and submitted for analysis. The samples were analyzed for site-specific volatile organic compounds (VOCs) by method 8260, and site-specific semivolatile organic compounds (SVOCs) by method 8270. Site-specific VOCs are:

- 1,1-dichloroethane (1,1-DCA);
- cis-1,2-dichloroethene (cis-1,2-DCE);
- trans-1,2-dichloroethene (trans-1,2-DCE);

- 1,1-dichloroethene (1,1-DCE);
- 1,1,1-trichloroethane (1,1,1- TCA);
- trichloroethene (TCE); and
- vinyl chloride (VC).

Site-specific SVOCs are:

- aniline; and
- phenol.

Field methods were utilized to analyze for pH, temperature, specific conductance, oxidation-reduction potential, turbidity, and dissolved oxygen.

Fourteen of the wells were also sampled for monitored natural attenuation (MNA) parameters. Laboratory MNA analyses included methane, ethane, ethene (by method Kampbell et. al., 1989 or SW3810 Modified), arsenic (EPA 200.7 or 200.9), chloride (mercuric nitrate titration A4500-CL- C), nitrate, and sulfate by IC method E300, dissolved organic carbon, and total organic carbon (SW9060). Field MNA analyses included alkalinity (Hach Model: AL-AP, MG-L), ferrous iron (Fe+2) (Hach, IR-18C), dissolved manganese (Mn2+) (Hach Model: MN-5), hydrogen sulfide (Hach HS-WR or HS-C), and carbon dioxide (Hach CA-23).

Groundwater analytical data has been reviewed for usability. The data usability summary report is provided in Appendix B. Both rounds of groundwater samples had 100% usable VOC and SVOC analytical results. Based on the QA/QC review, all data is usable for the intended purpose.

2.3.2 Soil Sampling

Soil samples were also collected in the area near the former containment tank and near MW-15D (Figure 4). These samples were intended to further refine the concentrations of COCs in the overburden and provide additional information for the evaluation of the remedial alternatives.

Nine soil samples, one from each boring, were analyzed for the site-specific COCs. Analytical methods included method 8260 for VOCs, and method 8270 for SVOCs. Additionally, five soil samples were collected and analyzed for acid-neutralization capacity (alkalinity) to evaluate the feasibility of enhanced biological remediation.

2.4 PULSE INTERFERENCE TESTING

Pulse interference tests were conducted to evaluate the hydraulic conductivity and connectivity of the overburden and bedrock water-bearing zones. A focus of the analysis was to evaluate the ability to inject the Emulsified Zero Valent Iron (EZVI) solution (or other *in situ* technology such as a bio-stimulating substrate) to treat dense non-aqueous phase liquid (DNAPL) and the dissolved VOCs in groundwater. For details regarding the methods and implementation of the tests, see Appendix E. The pulse interference tests were used to characterize the hydrogeologic parameters and evaluate the connectivity of the fracture system between boreholes. A total of nine tests were evaluated to characterize the shallow water bearing unit. Six tests characterized the bedrock zone. Figures 5 and 6 show the wells where the pulse-interference tests were conducted.

The hydraulic pulse interference tests at the Site were conducted across the monitoring well pairs as follows: source well MW-2S with receiver wells MW-3S, MW-4S, and MW9S; source well MW-3S with receiver wells MW-4S, MW-6S, and MW-7S; source well MW-4S with receiver wells MW-7S, and MW-9S; source well MW-2D with receiver wells MW-3D, MW-4D, and MW-10D; source well MW-3D with receiver wells MW-4D and MW-11D and source well MW-4D with receiver well MW-10D. No hydraulic pulse interference testing was conducted on source well MW-4S with receiver well MW-8S because the water table in the receiver well, MW-8S, was below the top of the well screen and therefore the receiver well packer could not be set.

In addition to the pulse testing between the shallow wells and between the deep wells, hydraulic pulse interference tests were also conducted to determine the hydraulic connection between the shallow clay/bedrock zone and the deeper fractured bedrock zone. This was done by pulse testing in the following monitoring well pairs: source well MW-2D with receiver well MW-2S; source well MW-3D with receiver well MW-3S; and source well MW-4D with receiver well MW-4S.

2.5 WASTE HANDLING

Disposal of the investigation derived waste (IDW) created during the installation of the monitoring wells and groundwater sampling was required. The IDW was disposed of in accordance with the appropriate regulations. Waste streams included drill cuttings, groundwater, decontamination water, and personal protective equipment. Wastes were disposed at approved disposal facilities using the established EPA Site Identification Number (NYR000103382). Manifests for the disposal of the IDW are included in Appendix C.

SECTION 3
SUMMER/FALL 2005 RESULTS

3.1 GROUNDWATER SAMPLING RESULTS

3.1.1 Groundwater Sampling from Monitoring Wells - Shallow

Analytical results from the 2005 groundwater samples collected from overburden monitoring wells are summarized in Table 1. The concentrations of the COC analytes for recent sampling rounds are plotted on Figure 7. Overall, the COC concentrations were generally lower than previous sampling rounds. Figure 9 shows the recent sampling results along with previous rounds.

Wells MW-10S, MW-11S, and MW-12S were installed, developed and sampled during the summer / fall of 2005. As shown on Table 1 and Figure 7, TCE analytical results from MW-10S and MW-11S were near the drinking water standard (5 ug/L). Other analytical results indicate that natural attenuation is degrading COCs. Results from MW-12S indicate that dissolved COCs are present south of MW-6S, but natural attenuation is active.

3.1.2 Groundwater Sampling from Monitoring Wells - Deep

Analytical results from 2005 groundwater samples collected from bedrock monitoring wells are summarized in Table 1. The concentrations of the COCs are plotted in Figure 8. In general COC concentrations have decreased from previous sampling rounds. Figure 10 shows the recent sampling results along with previous rounds.

Well MW-20D was installed, developed, and sampled, during the summer / fall 2005. As shown on Table 1 and Figure 7, analytical results from MW-20D were similar to nearby wells MW-15D and MW-13D. The results in MW-20D indicate that dissolved phase COCs exist in the downgradient direction. The extent of impacts from COCs does not appear to have changed from previous investigations.

3.2 SOIL SAMPLING RESULTS

Analytical results from recent soil sampling are summarized in Table 2. Figure 3 shows the direct-push locations near the former tank, and Figure 4 shows the locations near MW-15D.

In all the borings near the former tank, a soil sample was collected from the 8-12 foot depth interval, which was the interval above boring refusal, at the top of rock (TOR). The TCE result from sample BH-2A was 271,000 ug/kg. The TCE results from samples BH-1A, BH-3A, BH-4A and BH-5A were 186, 67.5, 615, and 28.5 ug/kg respectively. The results indicate that excavation of the former tank and surrounding soils removed the majority of impacted soil, leaving only residual impacts.

From the borings near MW-15D, alkalinity samples were taken from the 8 - 11.5 foot depth interval in BH-7A and the 8 – 10 foot depth interval in BH-8A. Alkalinity results were similar in both samples (836 mg/kg and 491 mg/kg) and are presented in Table 2.

Soil samples near MW-15D were also sampled for COCs. Analytical results are provided on Table 2. All COC concentrations around MW-15D were non-detect, except for TCE in BH-8A (3.1 J mg/kg). These results indicate there may not be an additional source of COCs in this area

3.3 HYDRAULIC PULSE INTERFERENCE TESTING (HPIT) RESULTS

A summary of the HPIT results is provided herein. Appendix E contains the test report from GeoSierra, which includes the methods, data analysis and results. Response data from source-receiver well pairs and type curve matching for the source-receiver well pairs are contained in the report of Appendix E.

The hydraulic conductivity and storativity values computed for each well pair are provided in Table 3. The hydraulic conductivity calculated for the shallow monitoring wells ranged from a low of 0.0002 feet per day (ft/day) to a high of 135 ft/day. No response was recorded between well pairs MW-3S and MW-4S or between MW-3S and MW-7S. The calculated specific storage values from the shallow monitoring well test data ranged from a low of 5.85 x 10^{-11} 1/ft to a high of 5.08 x 10^{-05} 1/ft.

The equivalent porous medium hydraulic conductivity calculated for the bedrock wells ranges from a low of 5.57 ft/day to a high of 117 ft/day. The calculated specific storage values range from a low 4.58 x 10^{-08} 1/ft to a high of 6.79 x 10^{-07} 1/ft.

No receiver pressure response was recorded between the pulse source wells in the fractured bedrock and the receiver wells in the shallow saturated zone. This indicates that these zones are not hydraulically connected in the area tested.

SECTION 4
REMEDIAL ALTERNATIVES

This section discusses the remedial alterative evaluations and recommends an alternative for each media as part of the RAR.

4.1 REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) are used for evaluating the applicability and effectiveness of remedial technologies and alternatives. RAOs consist of media-specific goals for protecting human health and the environment, and are focused on eliminating receptor exposure to the COCs via exposure routes such as dermal contact, ingestion, and inhalation.

The RAOs proposed herein have been developed based on the site-specific nature and extent of impacts to soil and groundwater as defined in several phases of investigative activity, and continuing groundwater monitoring. The RAOs also take into account the results of a qualitative exposure assessment (QEA), which consisted of characterizing the exposure setting, identifying exposure pathways, and evaluating chemical fate and transport (Parsons, 2004a). The RAOs are as follows:

- RAO 1: Eliminate or reduce, to the extent practical, potential risks to human health and the environment from impacted soil and groundwater.
- RAO 2: Reduce the migration of COCs from the soil to the groundwater, to the extent practical.
- RAO 3: Reduce concentrations of COCs in groundwater to be protective of human health, to the extent practical.

4.2 PRELIMINARY REMEDIATION GOALS

Preliminary remediation goals (PRGs) are chemical-specific long-range target cleanup goals that use NYSDEC established guidance values to assist in selecting a remedy. The primary impacted media at the Site are soils, shallow groundwater within the overburden material, and deeper groundwater within the fractured bedrock. The following PRGs were developed to address the RAOs listed above in each media. These PRGs may be refined during the remedy selection process, which may include additional risk-based evaluations, and predesign investigation.

- PRG 1 (Soils): Work to achieve NYSDEC Technical Administrative and Guidance Memorandum (TAGM) 4046 cleanup values for Site soils, to the extent practical. COCs for soil and the corresponding TAGM values are listed below.

This PRG addresses RAOs 1 and 2. Attempting to achieve TAGM cleanup values for COCs in soil would address RAO 1 by reducing human health risks associated with contacting site soils. Because of the paved nature of the property, contact with soils would primarily occur during excavation work. This PRG also directly addresses RAO 2 by setting target concentrations for remedial action.

- PRG 2 (Groundwater): Work to achieve NYSDEC Groundwater Effluent Limitations, Class GA groundwater quality standards (source of drinking water, groundwater) for shallow (overburden) and deep (bedrock) groundwater for the COCs, to the extent practical. The COCs for groundwater, and the corresponding groundwater quality standards, are listed below.

This PRG addresses RAOs 1 and 3. Attempting to achieve groundwater quality standards for COCs in shallow and bedrock groundwater would address RAO 1 by reducing human health risks associated with contacting groundwater. Because of the paved nature of the property, contact with groundwater would primarily occur during excavation work. In the unlikely event of any offsite groundwater user, this PRG also directly addresses RAO 1. This PRG also directly addresses RAO 2 by setting target concentrations for remedial action.

Preliminary Remediation Goals

COC	PRG 1 - Soil	PRG 2 - Groundwater
• 1,1-dichloroethane	200 ug/kg	5 µg/L
• 1,2-dichloroethene (total)	300 ug/kg	5 µg/L
• 1,1,1-trichloroethane	800 ug/kg	5 µg/L
• trichloroethene	700 ug/kg	5 µg/L
• vinyl chloride	200 ug/kg	2 µg/L
• aniline	100 ug/kg	5 µg/L
• phenol	30 ug/kg or MDL	1 µg/L

4.3 APPLICABLE STANDARDS, CRITERIA AND GUIDANCE

Based on Site conditions and NYSDEC guidance, a list of standards, criteria, and guidance (SCGs) were identified that may apply to the Site. SCGs may be categorized as:

- chemical-specific requirements that may define acceptable soil or groundwater concentrations;
- location-specific requirements that may set restrictions on activities within specific locations such as floodplains or wetlands, and;
- action-specific, which may set controls or restrictions for particular treatment and disposal activities related to the management of hazardous wastes.

Table 4 is a list of possible SCGs, showing their applicability to the Site.

4.4 COMPARATIVE ANALYSIS OF SELECTED ALTERNATIVES

Appendix D contains the details of the identification and evaluation of remedial alternatives. A comparative analysis of the candidate technologies is presented in this section, and categorized by type of media. The comparative analysis used Sections 7.4.1 through 7.4.6 from the VCP guide to weigh positives and negatives of alternatives that were feasible for the Site. Some of the alternatives were removed from consideration due to Site conditions.

4.4.1 Comparative Analysis – Soils

The comparative analysis was conducted on Alternative 1: Engineering/Institutional Controls and Alternative 2: Excavation. As discussed in the evaluation section (Appendix D), Alternative 3: Soil Vapor Extraction is not likely to be effective. Therefore it was not retained in the comparative analysis.

Table 5 is the comparative analysis of Alternatives 1 and 2. Typically engineering/institutional controls have a higher rating than excavation. Impacted soils around the tank have been excavated (Frontier, 2000), and only residually impacted soils were left in place. The efforts and risks required to perform additional excavation and disposal of the soils outweigh the benefits of excavation, when the objective is site remediation of soil. The engineering/institutional controls provide the lowest risk of performance, and also maintain fulfillment of the VCP guidelines and RAOs.

The excavation of soils, discussed above, differs from the removal of soils associated with a bio-enhancing treatment cell for remediation of shallow groundwater (discussed below). The removal of soils during bio-treatment cell construction, however, may target the residual COCs near the former tank. This will indirectly benefit the impacted soils, although it is not defined as part of the soil remediation.

4.4.2 Comparative Analysis – Shallow Groundwater

The comparative analysis for shallow groundwater was conducted on: Alternative 2 – Passive Bioreactor; Alternative 4 - Groundwater Extraction; and Alternative 5 - *in situ* Injection Treatments. These alternatives show potential for fulfilling the RAOs. Alternative 1 - Engineering/Institutional Controls and Alternative 3 - MNA, were not applicable as stand-alone alternatives, due to the long attenuation times that are likely needed for COCs to decrease below groundwater standards (see the evaluation in Appendix D). However, MNA may be a component to selected for other technologies, and Engineering/Institutional Controls is a component of each alternative.

Table 6 is the comparative analysis of Alternatives 2, 4 and 5. The passive bioreactor, consisting of mulch, vegetable oil, and gravel placed in an excavation, had a higher rating than both extraction and *in situ* treatments. The low permeability of the soils would likely prevent effective extraction of groundwater, and also prevent effective injection of treatment substrates. Soil removal and selected backfill emplacement into the bioreactor cell is expected to intersect small, more permeable sections of the soils (and top of rock), and thus provide a means for the carbon source to reach the COCs, both in the source area, and down-gradient. Since the mulch and vegetable oil backfill will decay over a long period, this carbon source may provide continuous support for natural biodegradation processes. The mulch and gravel materials are natural by-products that may result in lower risk than injections of *in situ* injection substrates, and may require less stringent permitting.

4.4.3 Comparative Analysis – Deep Groundwater

The comparative analysis for deep groundwater was conducted on: Alternative 3 – Groundwater Extraction; Alternative 4 – Bio-enhancing *in situ* treatment (i.e. vegetable oil); and Alternative 6 – Emulsified zero valent iron (EZVI) treatment. EZVI is an innovative technology and its application at the Ekonol Site, if undertaken, would be one of the first applications in a fractured bedrock setting. These alternatives show potential for fulfilling the RAOs. Alterative 1 – Engineering/Institutional Controls, Alternative 2 – MNA and Alternative 5 – Chemical Oxidation, were not applicable. Engineering/Institutional controls and MNA were not applicable as stand-alone alternatives due to the expected long attenuation times for COCs to decrease below groundwater standards (see the evaluation in Appendix D). However, MNA was retained as part of the treatment train for Alternatives 4 and 6, and Engineering/Institutional Controls is a component of each alternative. Chemical oxidation was not applicable because of the current pH (neutral) and anaerobic state of the groundwater.

Table 7 is the comparative analysis of Alternatives 3, 4 and 6. The *in situ* treatments are preferable over groundwater extraction. Groundwater extraction is an indefinite control that may not appreciably decrease the COCs, whereas *in situ* treatments are processes that may destroy the COCs. Therefore, groundwater extraction is considered only if other, remedial measures are ineffective.

The comparative analysis between bio-enhancing and EZVI treatments is also shown on Table 7. EZVI may be preferable to a bio-enhancing vegetable oil treatment. EZVI treatment may destroy DNAPL, where as bio-enhancing treatments are typically used for degradation of dissolved phase constituents. However, there is increasing evidence that vegetable oil treatments can be effective in source areas (ITRC, 2005). The EZVI degradation pathway may produce fewer regulated intermediate products (i.e. DCE and VC), than bio-enhancing vegetable oil treatments. The time-frame for attainment of RAOs using EZVI may be appreciably less than the bio-enhancing treatments. However, EZVI remains in the innovative stages of development, in which there are unknowns related to full-scale field applications. Field studies of EZVI (Quinn, et al. 2005 and Gavaskar et al., 2005) suggest that the decrease in COCs is not only the result of the iron component, but also the surfactant and vegetable oil components of the EZVI emulsion.

4.5 PREFERRED REMEDIAL STRATEGY

As a summary of the alternatives evaluation and comparative analysis, the following are preferred remedial alternatives, given the current knowledge of the Site.

4.5.1 Soils

Preferred Remedial Alternative: Engineering/institutional Controls

Engineering/institutional controls is the preferred remedial strategy for the following reasons:

- Previous excavation of the former containment tank and surrounding soils removed the source area. Recent soil sampling indicated that the previous excavation removed a majority of the impacted soils.
- The Site is currently paved and fenced, eliminating potential for exposure.
- The clay and silt soils have low permeability, which limits the feasibility of remedial alternatives such as SVE, ground water extraction, and *in situ* injection treatments.
- Active remediation incurs risk to workers, such as physical dangers and chemical exposure. Therefore, applying an alternative that may not benefit the Site, but may cause harm to workers, increases the overall risk of the remedial strategy.

4.5.2 Shallow (Overburden) Groundwater

Preferred Remedial Alternative: Passive Bioreactor

Construction of a passive bioreactor consists of soil removal and installation of a backfill material designed to enhance the anaerobic bioremediation of the COCs. The selected backfill would be a mixture of gravel, organic mulch, and vegetable oil (or similar materials). Engineering/institutional controls implemented for soils will also apply to shallow groundwater. This is the preferred remedial strategy for shallow groundwater for the following reasons:

- Construction of the passive bioreactor cell will remove residual COCs that have sorbed onto soils.
- The backfill material should provide a long-term organic carbon source for the natural attenuation processes already present. Within the bioreactor, organic carbon may increase COC degradation of source area groundwater as it flows through the reactor. Additionally, dissolved organic carbon will travel away from the cell and enhance biodegradation in downgradient areas.
- The large surface area of the treatment cell(s) should intersect the more permeable sections of the shallow groundwater system. Emplacing the organic substrate in more permeable zones will enhance the distribution of the hydrogen source into the shallow groundwater.
- Long-term monitoring and engineering/institutional controls would also be implemented, to control the risks to workers and the environment.

- The shallow soils exhibit heterogeneity and low permeability. Therefore, other remedial technologies such as groundwater extraction and *in situ* treatments are expected to be more costly and less effective.

4.5.3 Deep (Bedrock) Groundwater

Preferred Remedial Alternatives: *in situ* Treatment Using EZVI or Bio-enhancing Substrates

In situ treatment of deep groundwater using EZVI or a bio-enhancing substrate is the preferred alternative. Engineering/institutional controls will also apply to deep groundwater. These are the preferred remedial strategies for the following reasons:

- With EZVI thoroughly distributed in the area of source COCs, in sufficient quantity, the time period to achieve remedial objectives may be relatively short.
- It has been demonstrated in laboratory experiments conducted at the University of Central Florida (Geiger et al, 2002) that DNAPL compounds undergo rapid dechlorination in the presence of the ZVI particles.
- Bio-enhancing treatment cleanup timeframes could be longer than EZVI, but may be shorter than standard technologies (for example, pump and treat)
- Reasearch by ITRC (2005) suggests bio-enhancing treatment may enhance the bioavailability of COCs and sequester DNAPL.
- Using EZVI the degradation of COCs may occur via an abiotic pathway to ethene and ethane (through chloroacetylene, and acetylene). Therefore an increase in DCE and VC may be considerably less than would occur with an application of bio-enhancing treatments. However, some studies suggest that the decrease in COCs is not only the result of the iron, but also the surfactant and vegetable oil components of the EZVI emulsion.
- Pulse interference testing indicated that this site has a connected fracture system and hydraulic setting that may be conducive to the use of EZVI or bio-enhancing treatments.

The EZVI alternative is a relatively new technology that has not been demonstrated in comparable fractured bedrock. Therefore, uncertainties may be further investigated prior to implementation. Bio-enhanced treatments have been implemented more frequently than EZVI, yet site-specific effectiveness is uncertain. To further evaluate the EZVI and the bio-remediation options, the need for the following will be evaluated.

- Bench-scale tests demonstrating the degradation process using EZVI and bio-enhanced substrates in Site groundwater;
- Discrete fracture characterization on an open borehole well;

- Pilot tests conducted at the site prior to full-scale implementation, in part to understand the effectiveness of the ZVI portion of the emulsion compared to oil and surfactant effects; and
- Groundwater sampling for parameters that may assist in evaluating the effectiveness of EZVI (for example abiotic degradation compounds of the COCs).

4.6 PROTECTIVENESS OF THE RECOMMENDED REMEDIAL ALTERNATIVES

The VCP guidance states that an RAR must explain how the remedy would be protective of public health and the environment. This section uses the VCP guidelines to summarize these concerns for each preferred remedy:

4.6.1 Soils – Engineering/Institutional Controls

Protection of Human Heath and Environment

Engineering and institutional controls for soils should achieve the RAOs. The tank closure and subsequent excavation removed significant COCs in soil. Therefore, the potential risk from soils is relatively low. Soil sampling has shown that residual COCs exist. Impacts within the saturated zone will be addressed with the shallow groundwater remedial action. Eliminating pathways between the site workers and the residually impacted soil should eliminate or reduce the potential risks to humans.

Protection of human health and environment will be obtained through engineering and institution controls. Parsons (2004) completed a Qualitative Exposure Report (QEA) identifying exposure pathways. All pathways in relation to COCs in soils can be controlled using engineering and institutional controls. The Site is a controlled facility with limited access. Low permeability clay covers the water bearing units and limits exposure pathways. Surface pavement and/or concrete further eliminate pathways. Deed and work restrictions can prevent exposure pathways for present and future users.

Standards, Criteria and Guidance (SCGs)

Chemical-Specific SCGs

The tank closure and subsequent excavation work removed the majority of impacted soils. The COCs that remain in soil are potentially related to impacts from shallow groundwater and will be addressed accordingly

Location-Specific SCGs

There are no location specific COCs, relative to this alternative.

Action-Specific SCGs

Action-specific SCGs for this alternative include deed restrictions that can be readily complied with. These may include regulations with respect to worker safety during excavation.

Short-Term Effectiveness and Impacts

No risks would result from the implementation of engineering and institutional controls. The RAOs should be achieved for soils in less than two years using engineering and institution controls.

Long-Term Effectiveness and Impacts

The proposed remedy relies on containment. The ability of attaining RAOs will increase over time. After completion, potential risk will be controlled by elimination of exposure pathways.

Reduction of Toxicity, Mobility or Volume

None of the soils will be actively treated under the engineering and institutional controls. Natural attenuation processes currently active at the Site will reduce the toxicity, mobility and volume.

Implementability

Some engineering/institutional controls are already in place (e.g.: fencing, paving), and can readily be expanded.

4.6.2 Shallow Groundwater – Passive Bioreactor

Protection of Human Heath and Environment

A passive bioreactor, coupled with engineering/institutional controls should achieve the RAOs and be protective of human heath and environment. Natural attenuation processes already exist, but may need additional carbon for continuation of biodegradation. Due to the low permeability soils, a bioreactor may be the most appropriate means to emplace the substrate in contact with the COCs. A mulch and vegetable oil backfill may provide a long-term source of carbon to enhance degradation of COC to below the RAOs. The engineering/institutional controls, will achieve protection of human health and the environment by limiting exposure pathways. Groundwater is not used for drinking or other purposes in the area.

The production of intermediate COCs during the degrading process should be evaluated prior to implementation.

Standards Criteria and Guidance (SCG)

Chemical-Specific SCGs

A passive bioreactor has the highest potential to reduce the COCs in shallow groundwater in a reasonable time period.

Location-Specific SCGs

There are no location-specific COCs, relative to this alternative.

Action-Specific SCGs

Action specific COCs for this alternative include disposal of derived waste during the excavation, and any permitting required for backfill of selected material (i.e. gravel and mulch). Action-specific SCGs for this alternative also include deed restrictions that can be readily implemented. These may include regulations with respect to worker safety during excavation.

Short-term Effectiveness and Impacts

Short-term effects will be risks to the remediation workers, and will be addressed in the remedial design and site-specific health and safety plan. The risks will be controlled using standard health and safety protocols, evaluated for the Site conditions.

The short-term production of intermediate COCs during the degradation process can be evaluated prior to implementation.

The proposed remedy may require longer than two years to reduce COC concentrations to less than groundwater standards. After excavation, a monitoring program would asses the effectiveness. If necessary, a monitored natural attenuation evaluation could be implemented.

Long-term Effectiveness and Impacts

A passive bioreactor is a potential one-time action that may result in a permanent solution. The ability of attaining RAOs will increase over time. After implementation, potential risk will be controlled by elimination or reduction of exposure pathways through the use of engineering and institutional controls.

Reduction of Toxicity, Mobility or Volume

The passive bioreactor is a form of enhanced bio-remediation. This alternative is an active treatment that should reduce the toxicity, mobility and volume over time. Due to the natural degradation process, there may be a short-term increase in toxicity and mobility that will be controlled using engineering and institutional controls.

Implementability

The implementation of a passive bioreactor is relatively simple. The excavation will be designed to address issues such as underground utilities, and backfill will be designed for strength and compaction, as well as organic carbon content. Some engineering/institutional controls are already in place (e.g.: fencing, paving), and expansion of these controls can be conducted.

4.6.3 Deep Groundwater – EZVI / Bio-enhancing *in situ* Treatment

Protection of Human Heath and Environment

EZVI i*n situ* treatment or bio-enhancing treatment coupled with engineering/institutional controls may achieve the RAOs. EZVI shows potential to degrade the COCs rapidly, and possibly without excessive production of intermediate degradation products. The vegetable oil component of the emulsion may further degrade the COCs after the ZVI is degraded. Destruction of COCs in the deep groundwater may provide the most efficient protection. Bio-enhancing treatment may achieve the same end result as EZVI, but with a lower materials cost.

The EZVI technology is relatively new in the environmental field. Therefore, certain unknowns and risks may exist. These unknowns and risks can be mitigated through bench and pilot testing of the technology prior to full-scale implementation.

Standards Criteria and Guidance (SCG)

Chemical-Specific SCGs

EZVI and bio-enhancing treatments have the potential to reduce the COCs in deep groundwater in a reasonable time period.

Location-Specific SCGs

There are no location specific SCGs, relative to this alternative.

Action-Specific SCGs

Action-specific SCGs for this alternative include disposal of waste during drilling, as well as any permitting required for the use of EZVI or bio enhanced treatment. Complying with these SCGs may be relatively simple.

Short-term Effectiveness and Impacts

Short-term effects are risks to the remediation workers, and will be addressed in the remedial design. The risks will be controlled using standard health and safety protocols, evaluated for the Site conditions.

The proposed remedy may require longer than two years to reduce COCs. After implementation, a monitoring program would asses the effectiveness. If necessary, a monitored natural attenuation evaluation could be implemented.

Long-term Effectiveness and Impacts

EZVI and bio-enhanced treatment may demonstrate the ability of attaining RAOs within a short period of time. Based on monitoring results, additional applications of EZVI or bio-enhancing treatment may be necessary. After implementation, potential risks will be controlled by elimination or reduction of exposure pathways through the use of engineering and institutional controls. Bio-enhancing treatments may also achieve RAOs, but in a longer time frame.

Reduction of Toxicity, Mobility or Volume

EZVI and bio-enhancing treatments are active alternatives that will likely reduce the toxicity, mobility and volume over time. The entire source area will be treated, although a specific volume reduction is unknown. The degradation process for EZVI may result in minimal production of intermediate degradation compounds (compared to anaerobic dechlorination). Additional treatments may be warranted, depending on monitoring results.

Implementability

The implementation of EZVI may be complicated, as it is a new technology and has not been frequently used in fractured bedrock. Although not a new technology, implementation of bio-enhancing treatments may also be complicated. Pre-design activities need to be conducted to further evaluate the engineering and implementation associated with using this technology at this site.

After the injection, O&M procedures would include groundwater monitoring and engineering/institution controls.

SECTION 5
CONCLUSIONS

This report has provided the results from recent activities and documented the remedial alternatives evaluations in the form of an RAR for the former Ekonol Polyester Resins facility, Site #V00653-9 (Site). NYSDEC VCP guidelines have been used in the organization and content of the RAR.

The results of the recent RAR investigation indicate:

- Site COCs have continued to decrease in both the shallow and deep groundwater;
- COCs in soil are primarily limited to areas adjacent to the previous excavation;
- COCs in MW-15D groundwater are not likely to be related to soils around MW-15D;
- Results from the pulse interference test suggest low permeability in the soils, and moderate permeability in the bedrock source zone.

Based on the results of the remedial alternative evaluation, the following preferred remedial alternatives are proposed:

- Soils - engineering/institutional controls. The previous excavation removed the source area. The Site is currently paved and fenced, eliminating potential for exposure. Residual COCs are related to shallow groundwater and will be addressed as such.
- Shallow groundwater – passive bioreactor, engineering/institutional controls. The bioreactor should provide a long-term organic source and increase COC degradation of source area groundwater as it flows through the reactor. Additionally, dissolved organic carbon will travel away from the cell and enhance biodegradation in downgradient areas; and
- Deep groundwater - *in situ* treatment with EZVI or bio-enhancing treatments, engineering/institutional controls. With EZVI thoroughly distributed in the area of source COCs, in sufficient quantity, the time period to achieve remedial objectives may be relatively short.

  Bio-enhancing treatments may also degrade COCs in the source area in a reasonable time period. If the iron portion of the EZVI is not cost effective, then a bio-enhancing treatment may be a preferable approach.

Further evaluations of the remedial technologies will be conducted prior to developing the Remedial Action Work Plan. The cost-effectiveness and implementability of each of the alternatives will be further evaluated.

SECTION 6
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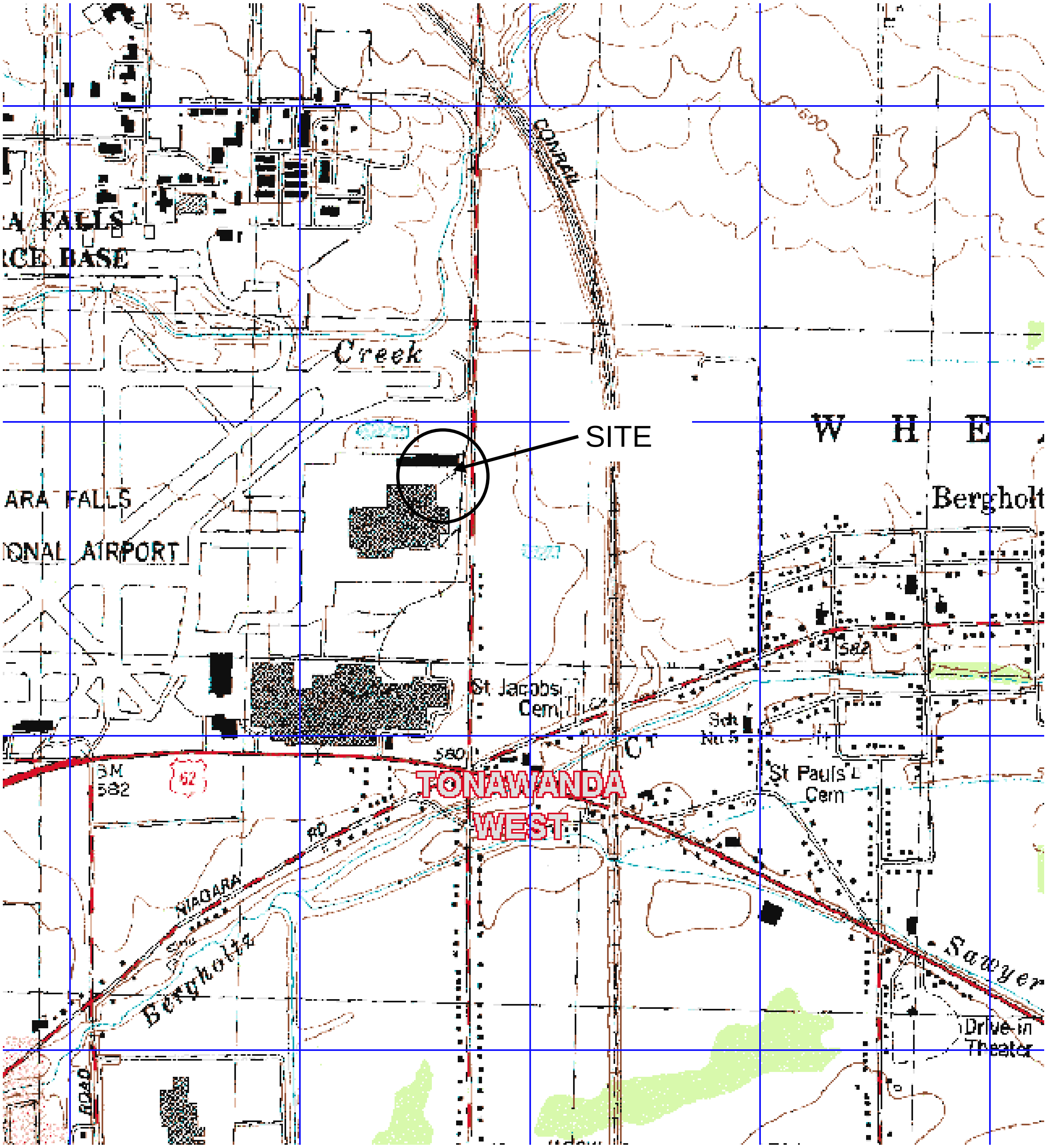
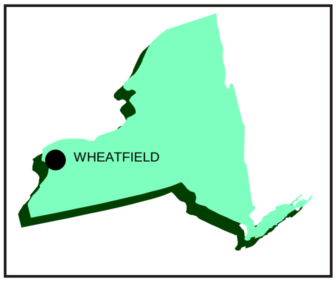
FIGURES





New York

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

SOURCE: DeLORME 3-D
TOPOQUAD PROGRAM

FIGURE 1

EKONOL POLYESTER RESINS FACILITY
WHEATFIELD, NEW YORK

SITE LOCATION MAP

PARSONS

180 LAWRENCE BELL DRIVE* WILLIAMSVILLE, NEW YORK 14221 (716) 633-7074

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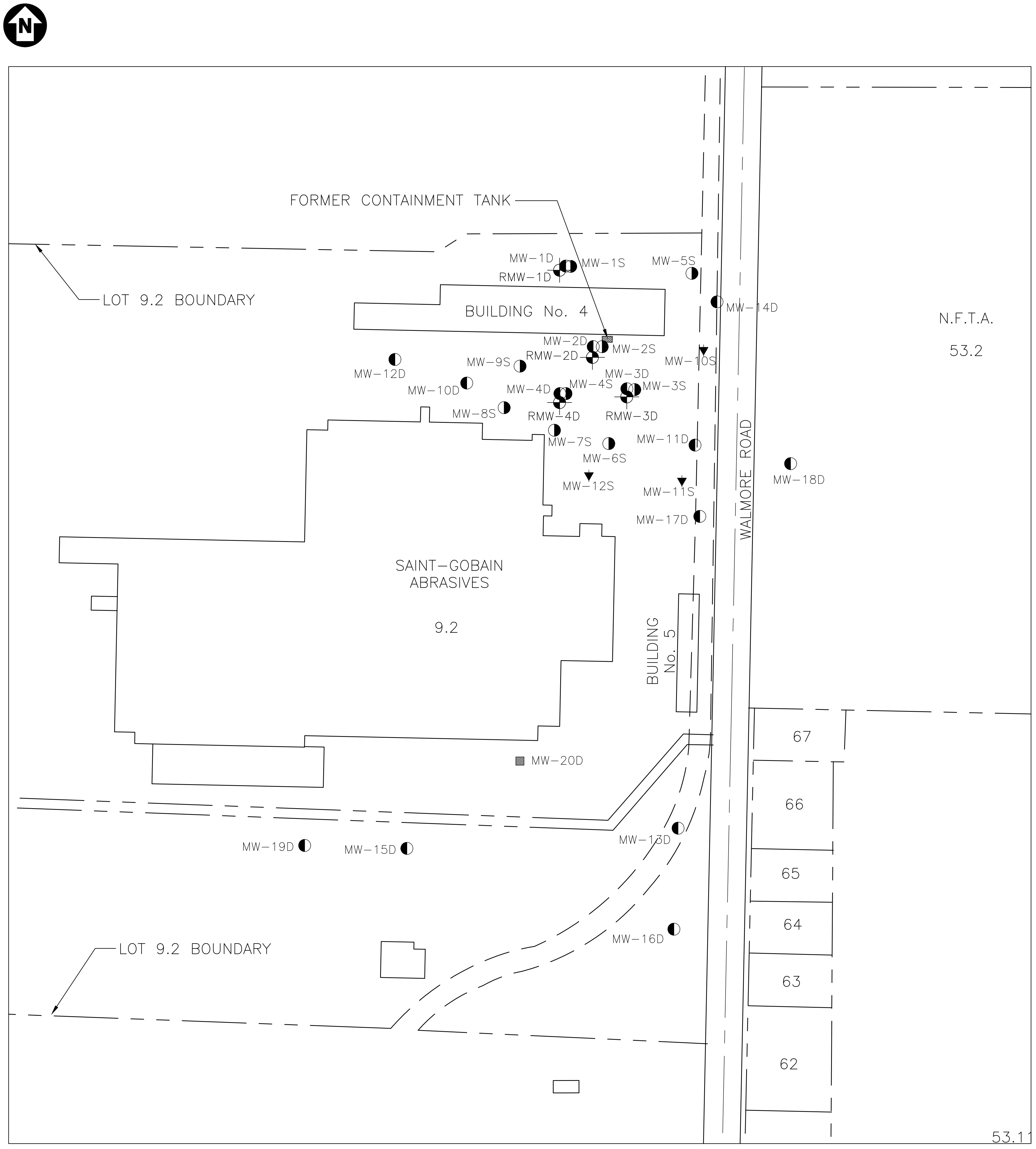

LEGEND:

◐ MW-1D	BEDROCK MONITORING WELL
◑ MW-1S	OVERBURDEN MONITORING WELL
▼ MW-10S	2005 SHALLOW MONITORING WELL
▨ MW-20D	RECENT BEDROCK MONITORING WELL
⊕RMW-1D	REPLACEMENT BEDROCK MONITORING WELL
—— — — ——	PROPERTY LINE
—— —— ——	RIGHT-OF-WAY

200 100 0 200 400

SCALE: 1"=200'

FIGURE 2

EKONOL POLYESTER
RESINS FACILITY
WHEATFIELD, NEW YORK

SITE PLAN AND
2005 WELL INSTALLATIONS

PARSONS
180 LAWRENCE BELL DRIVE, SUITE 104, WILLIAMSVILLE, N.Y. 14221, PHONE: 716-633-7074

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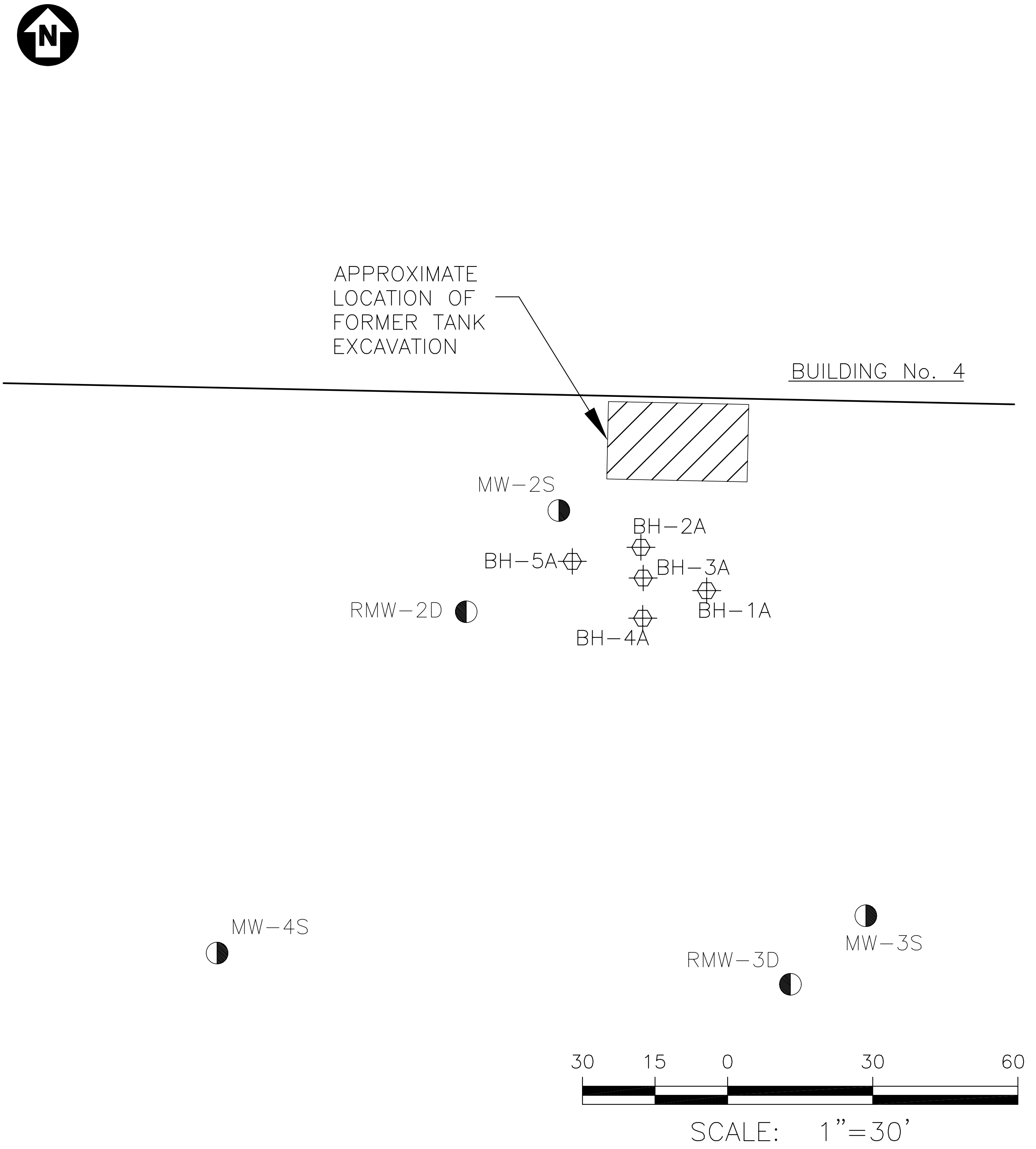

LEGEND:

—o——o— FENCE LINE

◐ MW-1D EXISTING BEDROCK MONITORING WELL (DEEP)

⊕ BH-1A SOIL SAMPLE LOCATION

FIGURE 3

EKONOL POLYESTER
RESINS FACILITY
WHEATFIELD, NEW YORK

SOIL SAMPLE LOCATIONS FORMER TANK AREA

PARSONS

180 LAWRENCE BELL DRIVE, SUITE 104, WILLIAMSVILLE, N.Y. 14221, PHONE: 716-633-7074

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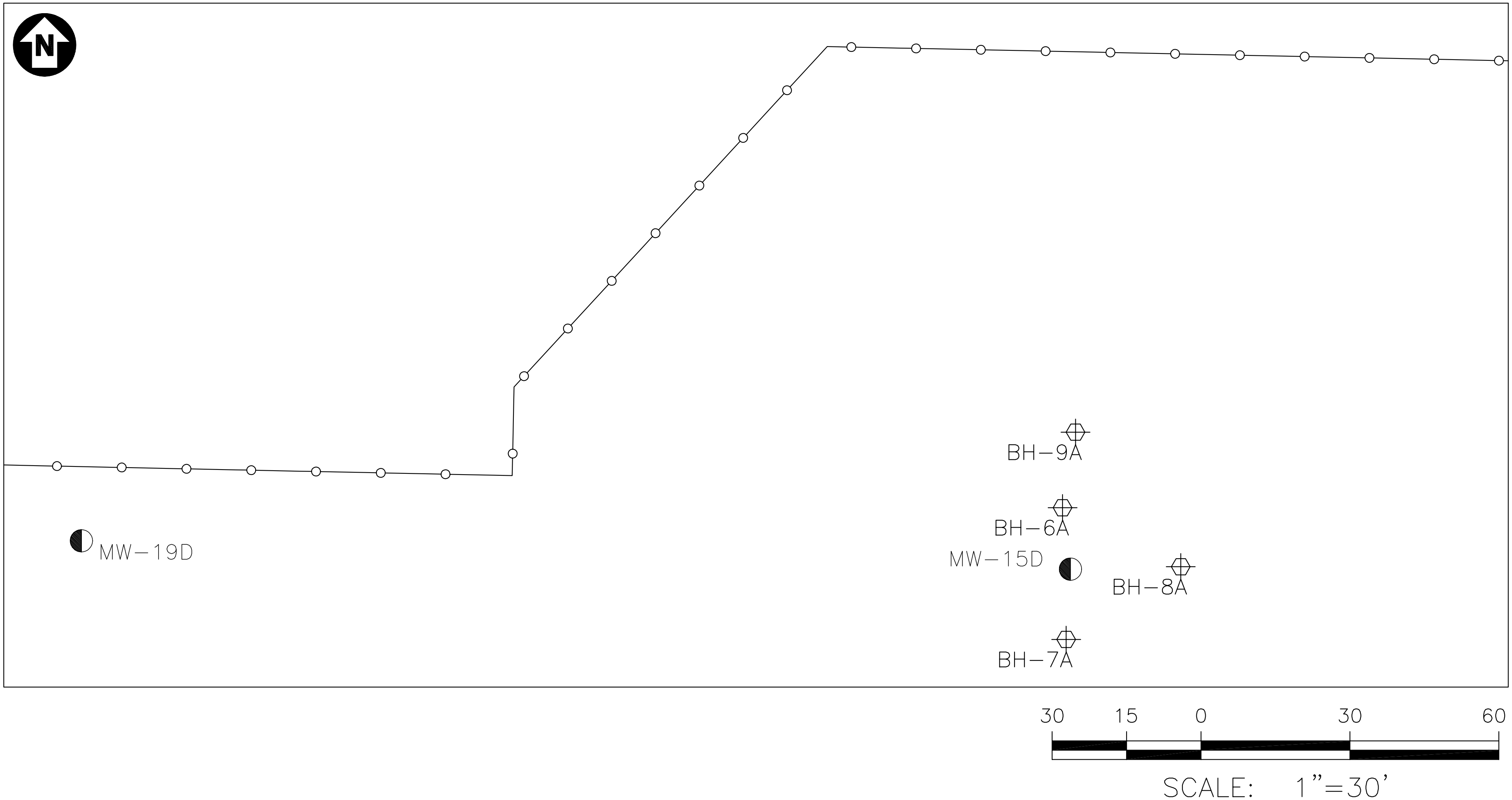

LEGEND:

—○—○—	FENCE LINE
◐ MW-1D	EXISTING BEDROCK MONITORING WELL (DEEP)
⌖ BH-1A	SOIL SAMPLE LOCATION

FIGURE 4

EKONOL POLYESTER
RESINS FACILITY
WHEATFIELD, NEW YORK

SOIL SAMPLE LOCATIONS NEAR MW-15D

PARSONS
180 LAWRENCE BELL DRIVE, SUITE 104, WILLIAMSVILLE, N.Y. 14221, PHONE: 716-633-7074

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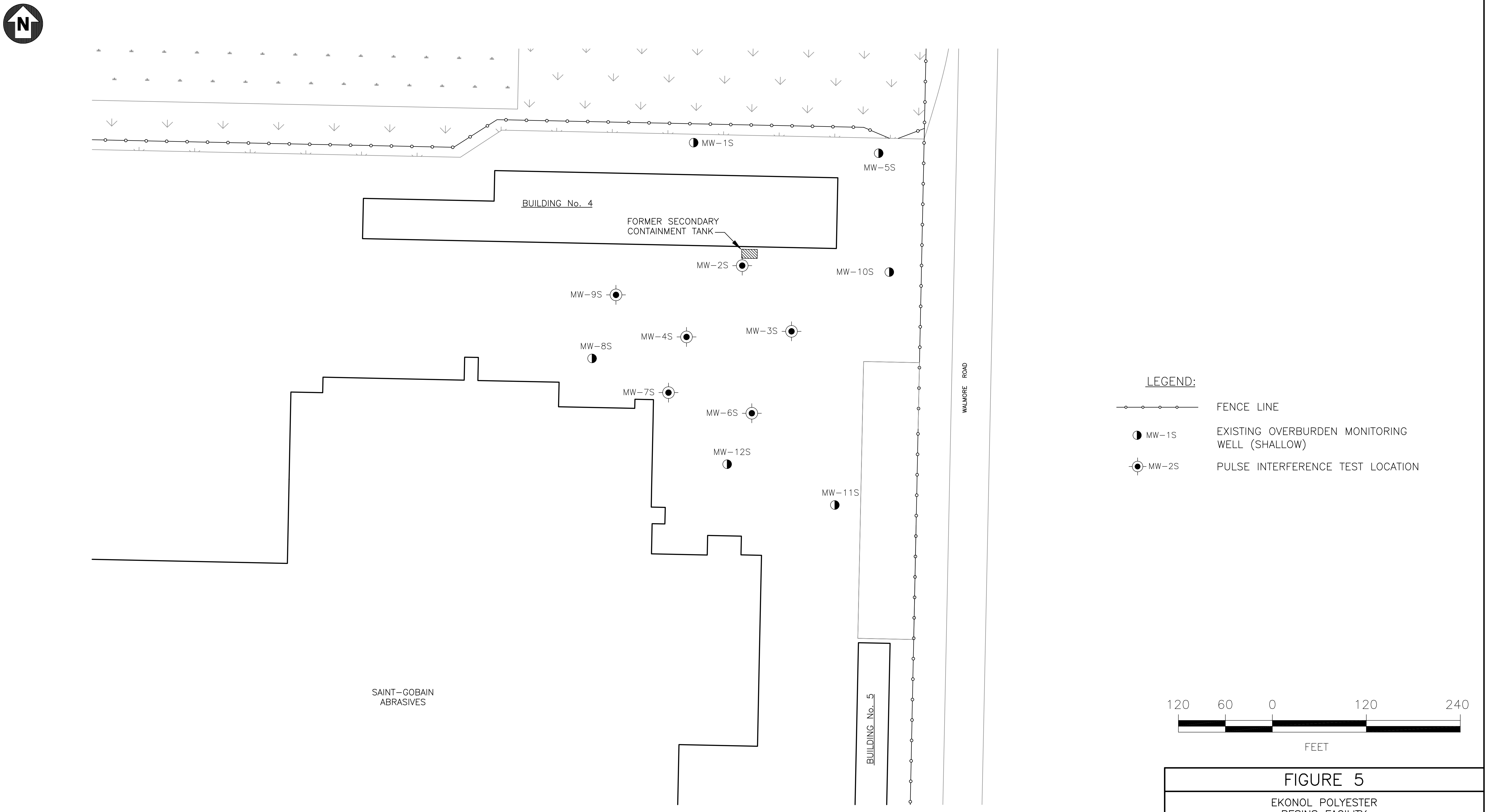

FIGURE 5

EKONOL POLYESTER
RESINS FACILITY
WHEATFIELD, NEW YORK

PULSE INTERFERENCE TEST LOCATIONS – SHALLOW WELLS

PARSONS

180 LAWRENCE BELL DRIVE, SUITE 104, WILLIAMSVILLE, N.Y. 14221, PHONE: 716-633-7074

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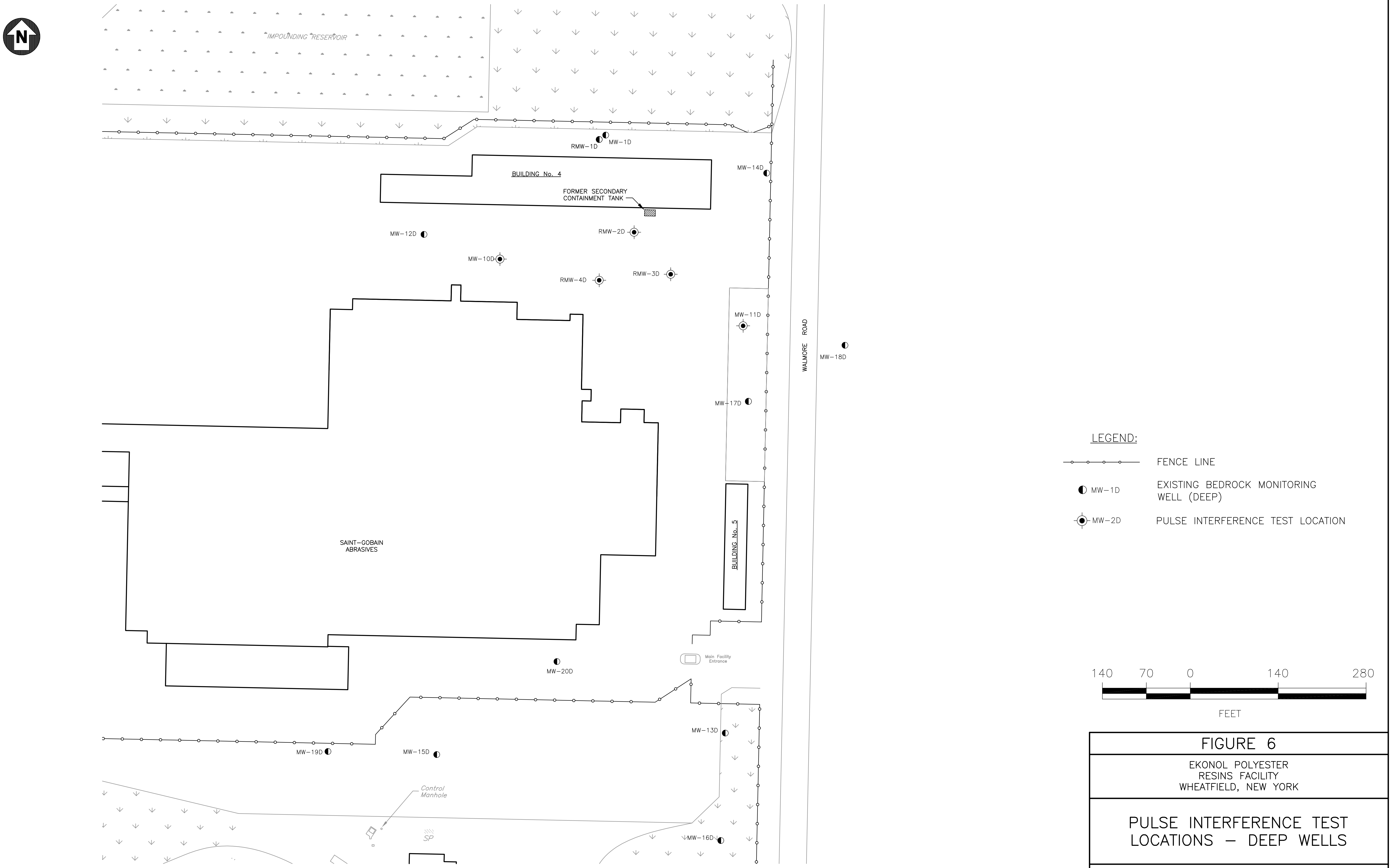

FIGURE 6

EKONOL POLYESTER
RESINS FACILITY
WHEATFIELD, NEW YORK

PULSE INTERFERENCE TEST LOCATIONS – DEEP WELLS

PARSONS

180 LAWRENCE BELL DRIVE, SUITE 104, WILLIAMSVILLE, N.Y. 14221, PHONE: 716-633-7074

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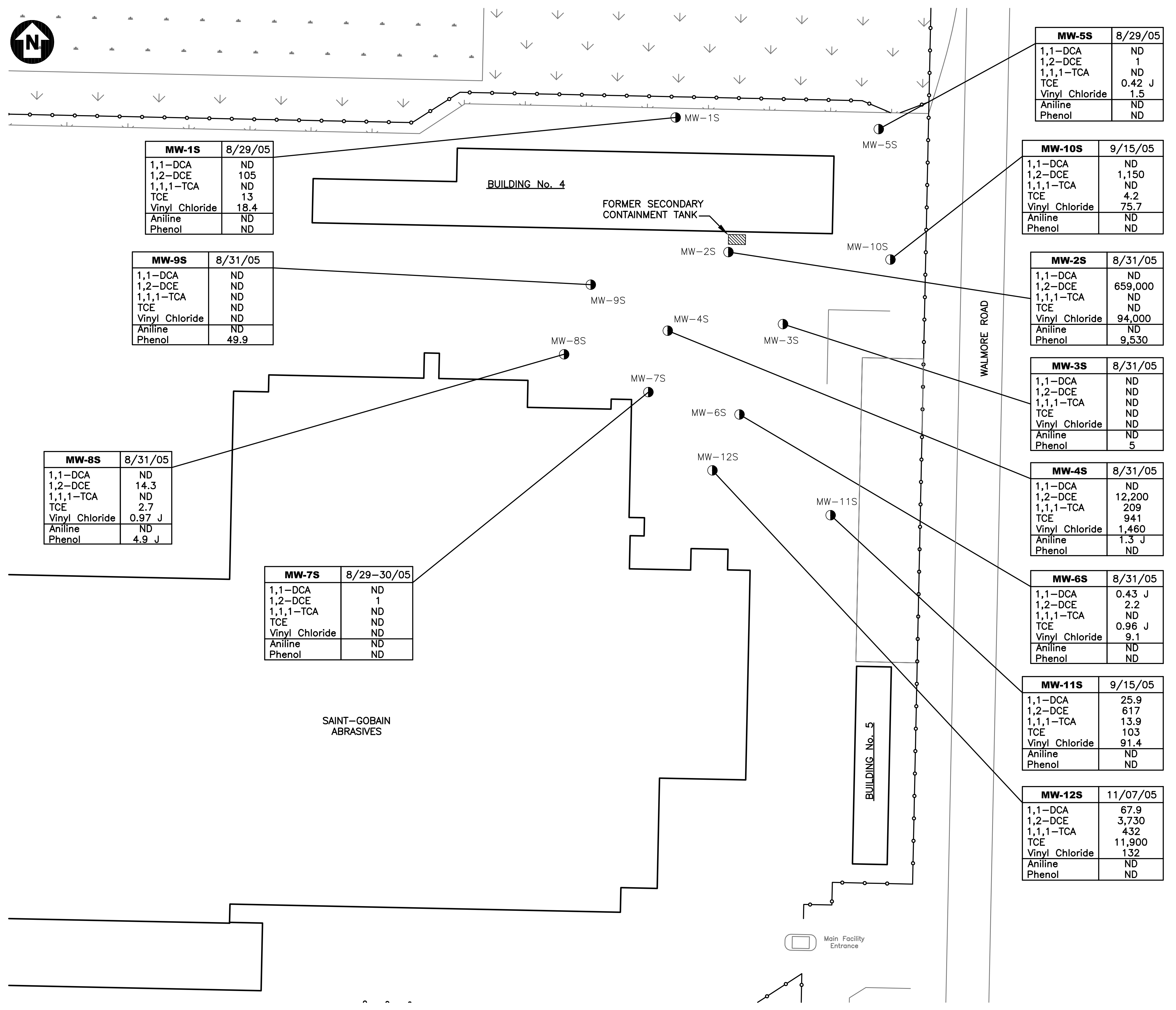

MW-1S	8/29/05
1,1-DCA	ND
1,2-DCE	105
1,1,1-TCA	ND
TCE	13
Vinyl Chloride	18.4
Aniline	ND
Phenol	ND

MW-9S	8/31/05
1,1-DCA	ND
1,2-DCE	ND
1,1,1-TCA	ND
TCE	ND
Vinyl Chloride	ND
Aniline	ND
Phenol	49.9

MW-8S	8/31/05
1,1-DCA	ND
1,2-DCE	14.3
1,1,1-TCA	ND
TCE	2.7
Vinyl Chloride	0.97 J
Aniline	ND
Phenol	4.9 J

MW-7S	8/29-30/05
1,1-DCA	ND
1,2-DCE	1
1,1,1-TCA	ND
TCE	ND
Vinyl Chloride	ND
Aniline	ND
Phenol	ND

MW-5S	8/29/05
1,1-DCA	ND
1,2-DCE	1
1,1,1-TCA	ND
TCE	0.42 J
Vinyl Chloride	1.5
Aniline	ND
Phenol	ND

MW-10S	9/15/05
1,1-DCA	ND
1,2-DCE	1,150
1,1,1-TCA	ND
TCE	4.2
Vinyl Chloride	75.7
Aniline	ND
Phenol	ND

MW-2S	8/31/05
1,1-DCA	ND
1,2-DCE	659,000
1,1,1-TCA	ND
TCE	ND
Vinyl Chloride	94,000
Aniline	ND
Phenol	9,530

MW-3S	8/31/05
1,1-DCA	ND
1,2-DCE	ND
1,1,1-TCA	ND
TCE	ND
Vinyl Chloride	ND
Aniline	ND
Phenol	5

MW-4S	8/31/05
1,1-DCA	ND
1,2-DCE	12,200
1,1,1-TCA	209
TCE	941
Vinyl Chloride	1,460
Aniline	1.3 J
Phenol	ND

MW-6S	8/31/05
1,1-DCA	0.43 J
1,2-DCE	2.2
1,1,1-TCA	ND
TCE	0.96 J
Vinyl Chloride	9.1
Aniline	ND
Phenol	ND

MW-11S	9/15/05
1,1-DCA	25.9
1,2-DCE	617
1,1,1-TCA	13.9
TCE	103
Vinyl Chloride	91.4
Aniline	ND
Phenol	ND

MW-12S	11/07/05
1,1-DCA	67.9
1,2-DCE	3,730
1,1,1-TCA	432
TCE	11,900
Vinyl Chloride	132
Aniline	ND
Phenol	ND

LEGEND:

—•—•—•—	FENCE LINE
◑ MW-1S	EXISTING OVERBURDEN MONITORING WELL (SHALLOW)

GROUNDWATER DATA LEGEND:

1,1-Dichloroethane (1,1-DCA)	7.2 µg/L
Total 1,2-Dichloroethene (1,2-DCE)	18,000 µg/L
1,1,1-Trichloroethane (1,1,1-TCA)	13 µg/L
Trichloroethene (TCE)	110,000 µg/L
Vinyl Chloride	12,000 µg/L
Aniline	1,400 µg/L
Phenol	660 µg/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

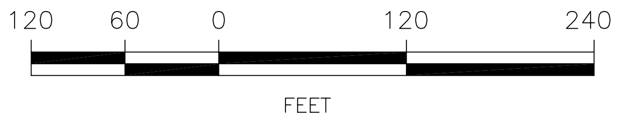

FIGURE 7

EKONOL POLYESTER
RESINS FACILITY
WHEATFIELD, NEW YORK

SHALLOW GROUNDWATER RESULTS – COCs (SUMMER/FALL 2005)

PARSONS
180 LAWRENCE BELL DRIVE, SUITE 104, WILLIAMSVILLE, N.Y. 14221, PHONE: 716-633-7074

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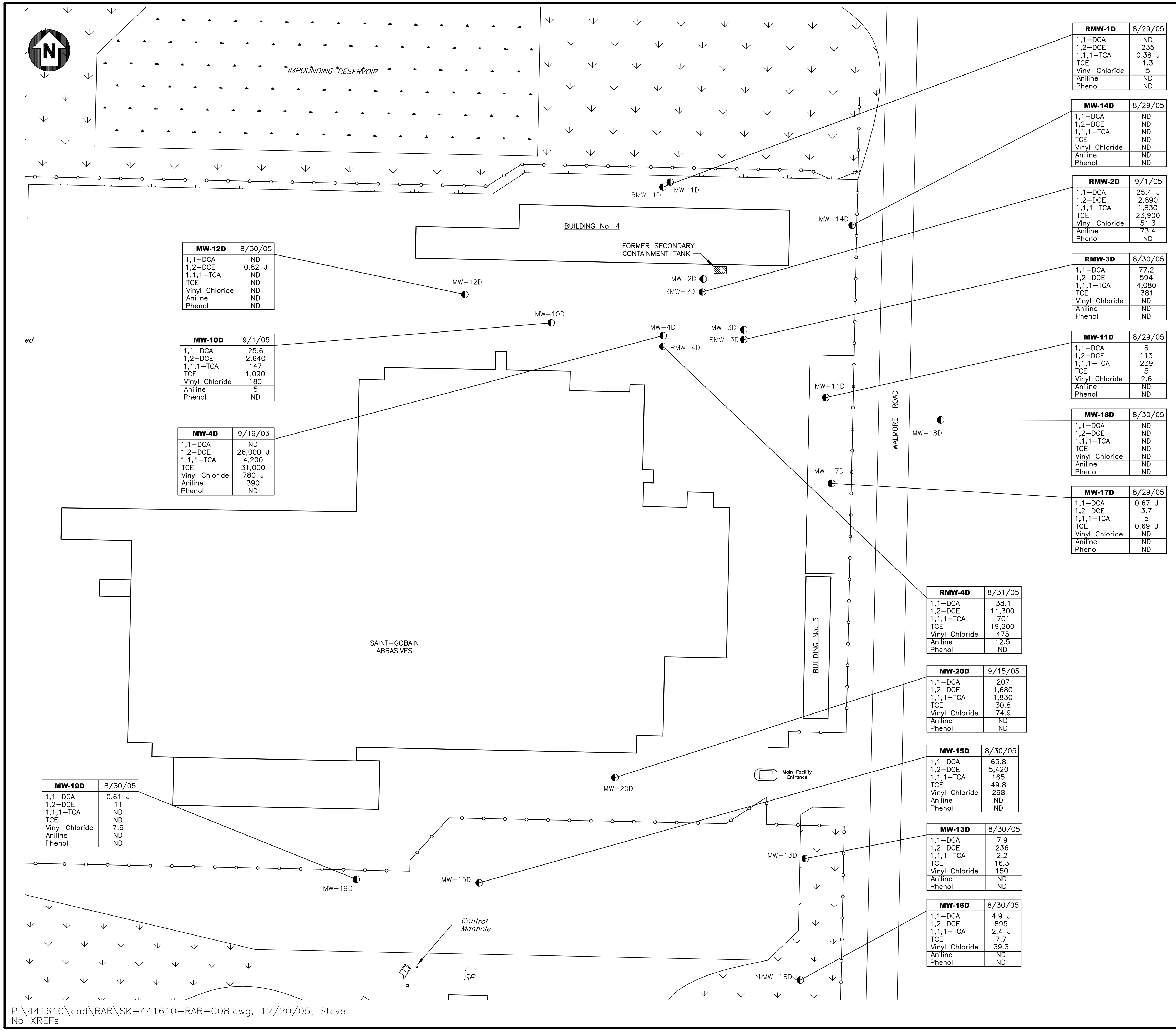

RMW-1D	8/29/05
1,1-DCA	ND
1,2-DCE	235
1,1,1-TCA	0.38 J
TCE	1.3
Vinyl Chloride	5
Aniline	ND
Phenol	ND

MW-14D	8/29/05
1,1-DCA	ND
1,2-DCE	ND
1,1,1-TCA	ND
TCE	ND
Vinyl Chloride	ND
Aniline	ND
Phenol	ND

RMW-2D	9/1/05
1,1-DCA	25.4 J
1,2-DCE	2,890
1,1,1-TCA	1,830
TCE	23,900
Vinyl Chloride	51.3
Aniline	73.4
Phenol	ND

RMW-3D	8/30/05
1,1-DCA	77.2
1,2-DCE	594
1,1,1-TCA	4,080
TCE	381
Vinyl Chloride	ND
Aniline	ND
Phenol	ND

MW-11D	8/29/05
1,1-DCA	6
1,2-DCE	113
1,1,1-TCA	239
TCE	5
Vinyl Chloride	2.6
Aniline	ND
Phenol	ND

MW-18D	8/30/05
1,1-DCA	ND
1,2-DCE	ND
1,1,1-TCA	ND
TCE	ND
Vinyl Chloride	ND
Aniline	ND
Phenol	ND

MW-17D	8/29/05
1,1-DCA	0.67 J
1,2-DCE	3.7
1,1,1-TCA	5
TCE	0.69 J
Vinyl Chloride	ND
Aniline	ND
Phenol	ND

MW-12D	8/30/05
1,1-DCA	ND
1,2-DCE	0.82 J
1,1,1-TCA	ND
TCE	ND
Vinyl Chloride	ND
Aniline	ND
Phenol	ND

MW-10D	9/1/05
1,1-DCA	25.6
1,2-DCE	2,640
1,1,1-TCA	147
TCE	1,090
Vinyl Chloride	180
Aniline	5
Phenol	ND

MW-4D	9/19/03
1,1-DCA	ND
1,2-DCE	26,000 J
1,1,1-TCA	4,200
TCE	31,000
Vinyl Chloride	780 J
Aniline	390
Phenol	ND

RMW-4D	8/31/05
1,1-DCA	38.1
1,2-DCE	11,300
1,1,1-TCA	701
TCE	19,200
Vinyl Chloride	475
Aniline	12.5
Phenol	ND

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

MW-19D	8/30/05
1,1-DCA	0.61 J
1,2-DCE	11
1,1,1-TCA	ND
TCE	ND
Vinyl Chloride	7.6
Aniline	ND
Phenol	ND

MW-15D	8/30/05
1,1-DCA	65.8
1,2-DCE	5,420
1,1,1-TCA	165
TCE	49.8
Vinyl Chloride	298
Aniline	ND
Phenol	ND

MW-13D	8/30/05
1,1-DCA	7.9
1,2-DCE	236
1,1,1-TCA	2.2
TCE	16.3
Vinyl Chloride	150
Aniline	ND
Phenol	ND

MW-16D	8/30/05
1,1-DCA	4.9 J
1,2-DCE	895
1,1,1-TCA	2.4 J
TCE	7.7
Vinyl Chloride	39.3
Aniline	ND
Phenol	ND

LEGEND:

-o-o-o- FENCE LINE

◐ MW-1D EXISTING BEDROCK MONITORING WELL (DEEP)

GROUNDWATER DATA LEGEND:

1,1-Dichloroethane (1,1-DCA)	7.2 µg/L
Total 1,2-Dichloroethene (1,2-DCE)	18,000 µg/L
1,1,1-Trichloroethane (1,1,1-TCA)	13 µg/L
Trichloroethene (TCE)	110,000 µg/L
Vinyl Chloride	21 µg/L
Aniline	1,400 µg/L
Phenol	660 µg/L
Lead	0.15 mg/L
Zinc	0.12 mg/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
"B"= THE ANALYTE WAS FOUND IN THE ASSOCIATED BLANK, AS WELL AS IN THE SAMPLE
* = DISSOLVED CONCENTRATION STANDARD
"NS"= COMPOUND WAS NOT SAMPLED FOR

FIGURE 8

EKONOL POLYESTER
RESINS FACILITY
WHEATFIELD, NEW YORK

BEDROCK GROUNDWATER RESULTS – COCs (SUMMER/FALL 2005)

PARSONS
180 LAWRENCE BELL DRIVE, SUITE 104, WILLIAMSVILLE, N.Y. 14221, PHONE: 716-633-7074

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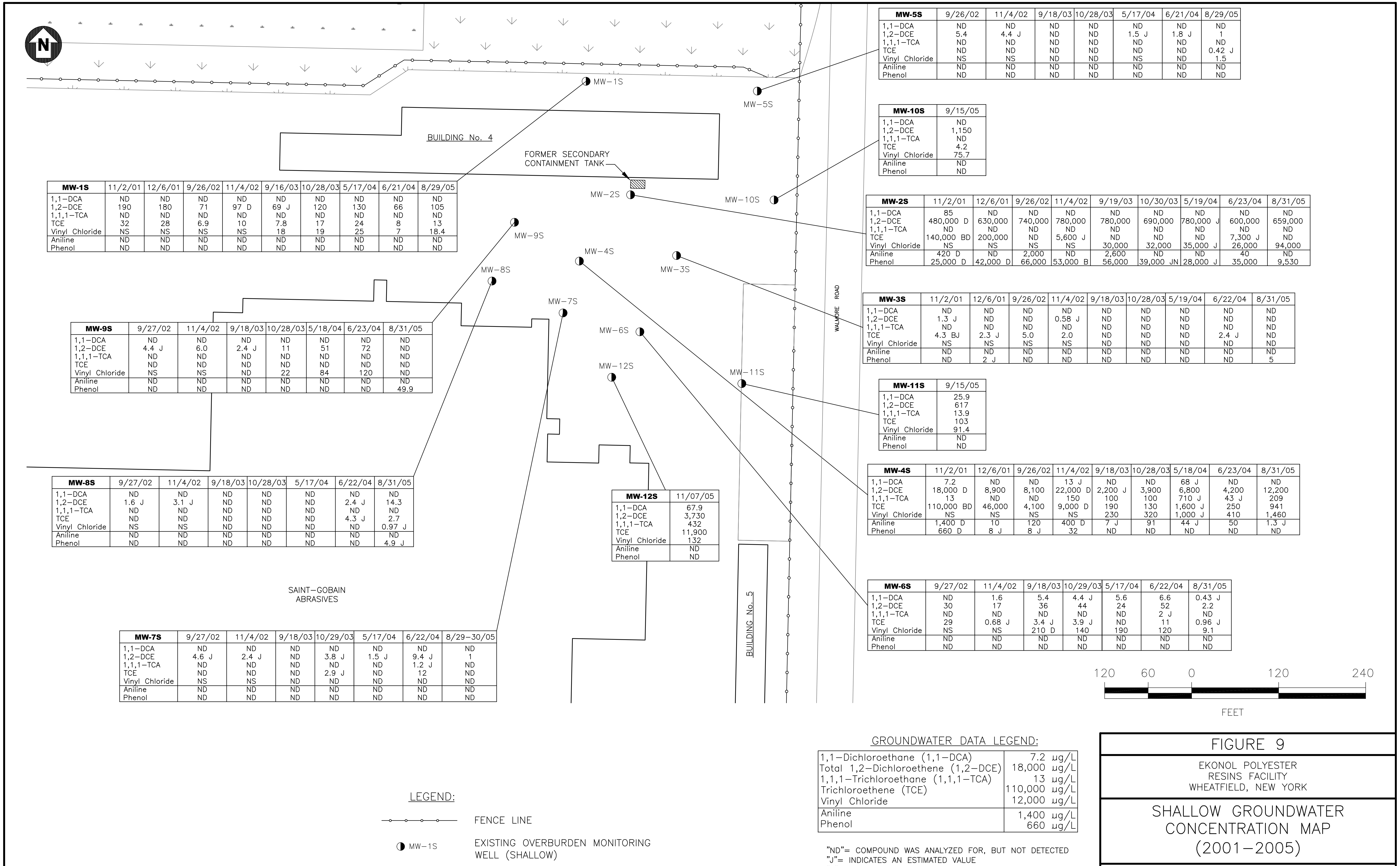

MW-1S	11/2/01	12/6/01	9/26/02	11/4/02	9/16/03	10/28/03	5/17/04	6/21/04	8/29/05
1,1-DCA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DCE	190	180	71	97 D	69 J	120	130	66	105
1,1,1-TCA	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCE	32	28	6.9	10	7.8	17	24	8	13
Vinyl Chloride	NS	NS	NS	NS	18	19	25	7	18.4
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND	ND	ND	ND

MW-5S	9/26/02	11/4/02	9/18/03	10/28/03	5/17/04	6/21/04	8/29/05
1,1-DCA	ND	ND	ND	ND	ND	ND	ND
1,2-DCE	5.4	4.4 J	ND	ND	1.5 J	1.8 J	1
1,1,1-TCA	ND	ND	ND	ND	ND	ND	ND
TCE	ND	ND	ND	ND	ND	ND	0.42 J
Vinyl Chloride	NS	NS	ND	ND	NS	ND	1.5
Aniline	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND	ND

MW-10S	9/15/05
1,1-DCA	ND
1,2-DCE	1,150
1,1,1-TCA	ND
TCE	4.2
Vinyl Chloride	75.7
Aniline	ND
Phenol	ND

MW-2S	11/2/01	12/6/01	9/26/02	11/4/02	9/19/03	10/30/03	5/19/04	6/23/04	8/31/05
1,1-DCA	85	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DCE	480,000 D	630,000	740,000	780,000	780,000	690,000	780,000 J	600,000	659,000
1,1,1-TCA	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCE	140,000 BD	200,000	ND	5,600 J	ND	ND	ND	7,300 J	ND
Vinyl Chloride	NS	NS	NS	NS	30,000	32,000	35,000 J	26,000	94,000
Aniline	420 D	ND	2,000	ND	2,600	ND	ND	40	ND
Phenol	25,000 D	42,000 D	66,000	53,000 B	56,000	39,000 JN	28,000 J	35,000	9,530

MW-9S	9/27/02	11/4/02	9/18/03	10/28/03	5/18/04	6/23/04	8/31/05
1,1-DCA	ND	ND	ND	ND	ND	ND	ND
1,2-DCE	4.4 J	6.0	2.4 J	11	51	72	ND
1,1,1-TCA	ND	ND	ND	ND	ND	ND	ND
TCE	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	NS	NS	ND	22	84	120	ND
Aniline	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND	49.9

MW-3S	11/2/01	12/6/01	9/26/02	11/4/02	9/18/03	10/28/03	5/19/04	6/22/04	8/31/05
1,1-DCA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DCE	1.3 J	ND	ND	0.58 J	ND	ND	ND	ND	ND
1,1,1-TCA	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCE	4.3 BJ	2.3 J	5.0	2.0	ND	ND	ND	2.4 J	ND
Vinyl Chloride	NS	NS	NS	NS	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	2 J	ND	ND	ND	ND	ND	ND	5

MW-11S	9/15/05
1,1-DCA	25.9
1,2-DCE	617
1,1,1-TCA	13.9
TCE	103
Vinyl Chloride	91.4
Aniline	ND
Phenol	ND

MW-8S	9/27/02	11/4/02	9/18/03	10/28/03	5/17/04	6/22/04	8/31/05
1,1-DCA	ND	ND	ND	ND	ND	ND	ND
1,2-DCE	1.6 J	3.1 J	ND	ND	ND	2.4 J	14.3
1,1,1-TCA	ND	ND	ND	ND	ND	ND	ND
TCE	ND	ND	ND	ND	ND	4.3 J	2.7
Vinyl Chloride	NS	NS	ND	ND	ND	ND	0.97 J
Aniline	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND	4.9 J

MW-12S	11/07/05
1,1-DCA	67.9
1,2-DCE	3,730
1,1,1-TCA	432
TCE	11,900
Vinyl Chloride	132
Aniline	ND
Phenol	ND

MW-4S	11/2/01	12/6/01	9/26/02	11/4/02	9/18/03	10/28/03	5/18/04	6/23/04	8/31/05
1,1-DCA	7.2	ND	ND	13 J	ND	ND	68 J	ND	ND
1,2-DCE	18,000 D	8,900	8,100	22,000 D	2,200 J	3,900	6,800	4,200	12,200
1,1,1-TCA	13	ND	ND	150	100	100	710 J	43 J	209
TCE	110,000 BD	46,000	4,100	9,000 D	190	130	1,600 J	250	941
Vinyl Chloride	NS	NS	NS	NS	230	320	1,000 J	410	1,460
Aniline	1,400 D	10	120	400 D	7 J	91	44 J	50	1.3 J
Phenol	660 D	8 J	8 J	32	ND	ND	ND	ND	ND

MW-6S	9/27/02	11/4/02	9/18/03	10/29/03	5/17/04	6/22/04	8/31/05
1,1-DCA	ND	1.6	5.4	4.4 J	5.6	6.6	0.43 J
1,2-DCE	30	17	36	44	24	52	2.2
1,1,1-TCA	ND	ND	ND	ND	ND	2 J	ND
TCE	29	0.68 J	3.4 J	3.9 J	ND	11	0.96 J
Vinyl Chloride	NS	NS	210 D	140	190	120	9.1
Aniline	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND	ND

MW-7S	9/27/02	11/4/02	9/18/03	10/29/03	5/17/04	6/22/04	8/29-30/05
1,1-DCA	ND	ND	ND	ND	ND	ND	ND
1,2-DCE	4.6 J	2.4 J	ND	3.8 J	1.5 J	9.4 J	1
1,1,1-TCA	ND	ND	ND	ND	ND	1.2 J	ND
TCE	ND	ND	ND	2.9 J	ND	12	ND
Vinyl Chloride	NS	NS	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND	ND

GROUNDWATER DATA LEGEND:

1,1-Dichloroethane (1,1-DCA)	7.2 µg/L
Total 1,2-Dichloroethene (1,2-DCE)	18,000 µg/L
1,1,1-Trichloroethane (1,1,1-TCA)	13 µg/L
Trichloroethene (TCE)	110,000 µg/L
Vinyl Chloride	12,000 µg/L
Aniline	1,400 µg/L
Phenol	660 µg/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

FIGURE 9

EKONOL POLYESTER
RESINS FACILITY
WHEATFIELD, NEW YORK

SHALLOW GROUNDWATER CONCENTRATION MAP (2001–2005)

PARSONS
180 LAWRENCE BELL DRIVE, SUITE 104, WILLIAMSVILLE, N.Y. 14221, PHONE: 716-633-7074

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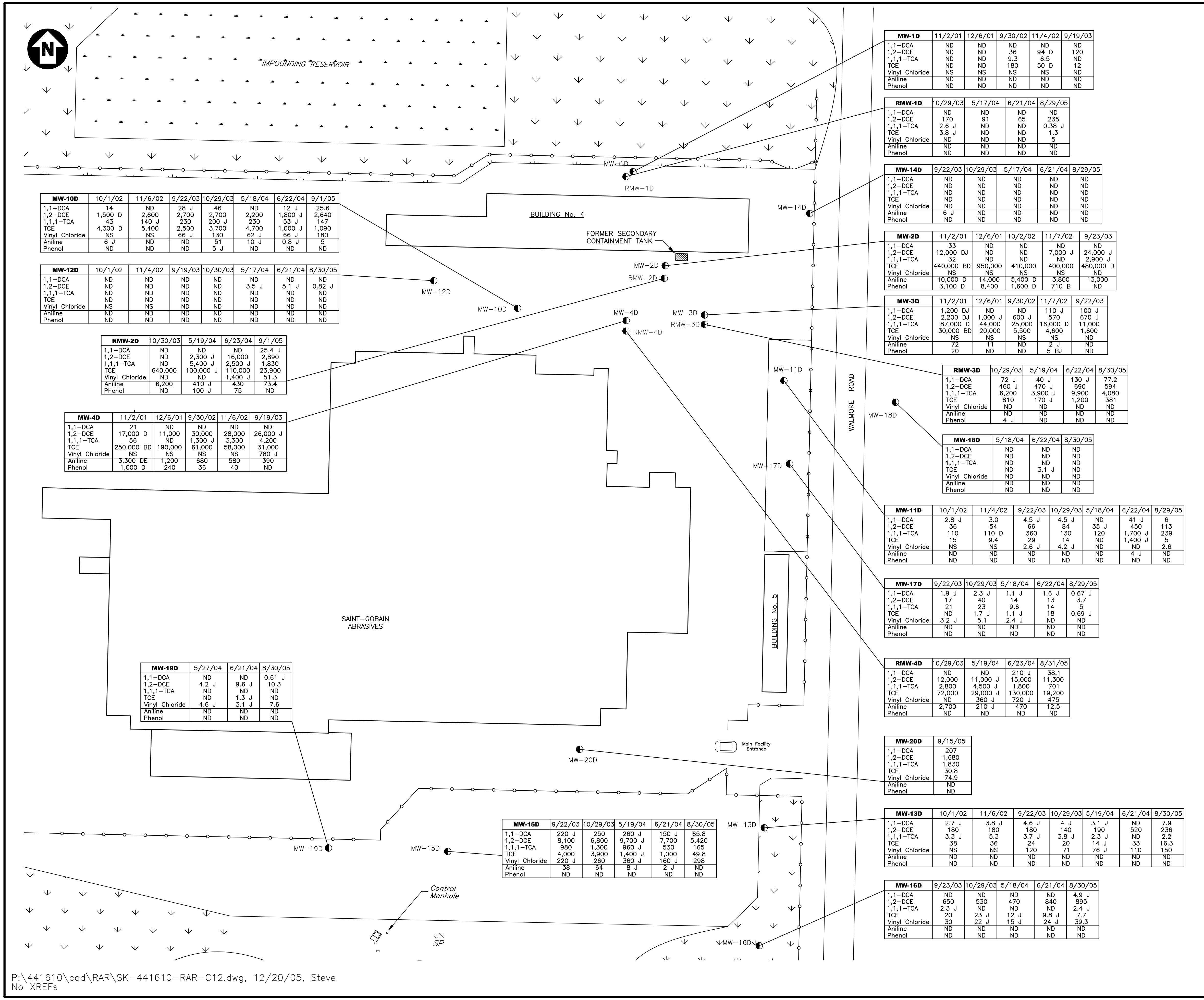

MW-1D	11/2/01	12/6/01	9/30/02	11/4/02	9/19/03
1,1–DCA	ND	ND	ND	ND	ND
1,2–DCE	ND	ND	36	94 D	120
1,1,1–TCA	ND	ND	9.3	6.5	ND
TCE	ND	ND	180	50 D	12
Vinyl Chloride	NS	NS	NS	NS	ND
Aniline	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND

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

MW-14D	9/22/03	10/29/03	5/17/04	6/21/04	8/29/05
1,1–DCA	ND	ND	ND	ND	ND
1,2–DCE	ND	ND	ND	ND	ND
1,1,1–TCA	ND	ND	ND	ND	ND
TCE	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND
Aniline	6 J	ND	ND	ND	ND
Phenol	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
1,1–DCA	72 J	40 J	130 J	77.2
1,2–DCE	460 J	470 J	690	594
1,1,1–TCA	6,200	3,900 J	9,900	4,080
TCE	810	170 J	1,200	381
Vinyl Chloride	ND	ND	ND	ND
Aniline	ND	ND	ND	ND
Phenol	4 J	ND	ND	ND

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

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

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

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

MW-20D	9/15/05
1,1–DCA	207
1,2–DCE	1,680
1,1,1–TCA	1,830
TCE	30.8
Vinyl Chloride	74.9
Aniline	ND
Phenol	ND

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

MW-16D	9/23/03	10/29/03	5/18/04	6/21/04	8/30/05
1,1–DCA	ND	ND	ND	ND	4.9 J
1,2–DCE	650	530	470	840	895
1,1,1–TCA	2.3 J	ND	ND	ND	2.4 J
TCE	20	23 J	12 J	9.8 J	7.7
Vinyl Chloride	30	22 J	15 J	24 J	39.3
Aniline	ND	ND	ND	ND	ND
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
1,1–DCA	14	ND	28 J	46	ND	12 J	25.6
1,2–DCE	1,500 D	2,600	2,700	2,700	2,200	1,800 J	2,640
1,1,1–TCA	43	140 J	230	200 J	230	53 J	147
TCE	4,300 D	5,400	2,500	3,700	4,700	1,000 J	1,090
Vinyl Chloride	NS	NS	66 J	130	62 J	66 J	180
Aniline	6 J	ND	ND	51	10 J	0.8 J	5
Phenol	ND	ND	ND	5 J	ND	ND	ND

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

RMW-2D	10/30/03	5/19/04	6/23/04	9/1/05
1,1–DCA	ND	ND	ND	25.4 J
1,2–DCE	ND	2,300 J	16,000	2,890
1,1,1–TCA	ND	5,400 J	2,500 J	1,830
TCE	640,000	100,000 J	110,000	23,900
Vinyl Chloride	ND	ND	1,400 J	51.3
Aniline	6,200	410 J	430	73.4
Phenol	ND	100 J	75	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-19D	5/27/04	6/21/04	8/30/05
1,1–DCA	ND	ND	0.61 J
1,2–DCE	4.2 J	9.6 J	10.3
1,1,1–TCA	ND	ND	ND
TCE	ND	1.3 J	ND
Vinyl Chloride	4.6 J	3.1 J	7.6
Aniline	ND	ND	ND
Phenol	ND	ND	ND

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

LEGEND:

–o–o–o–	FENCE LINE
◐ MW-1D	EXISTING BEDROCK MONITORING WELL (DEEP)

GROUNDWATER DATA LEGEND:

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

FIGURE 10

EKONOL POLYESTER
RESINS FACILITY
WHEATFIELD, NEW YORK

BEDROCK GROUNDWATER CONCENTRATION MAP (2001–2005)

PARSONS
180 LAWRENCE BELL DRIVE, SUITE 104, WILLIAMSVILLE, N.Y. 14221, PHONE: 716-633-7074

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TABLES

TABLE 1
Groundwater Sampling Results
Summer and Fall 2005

Ekonol Facility		Sample ID:	MW-1S	MW-2S	MW-3S	MW-4S
Groundwater Analytical Results		Lab Sample Id	J8266-2	J8467-5	J8467-4	J8467-3
Wheatfield, New York		Source:	ACTD	ACTD	ACTD	ACTD
Summer/Fall 2005		SDG:	J8266	J8467	J8467	J8467
		Matrix:	Water	Water	Water	Water
		Sampled:	8/29/2005	8/31/2005	8/31/2005	8/31/2005
CAS NO.	COMPOUND	UNITS:				
	VOLATILES					
75-00-3	Chloroethane	ug/l	1 U	500 U	1 U	100 U
75-34-3	1,1-Dichloroethane	ug/l	1 U	500 U	1 U	100 U
75-35-4	1,1-Dichloroethene	ug/l	1.2	1680	1 U	50.5 J
156-59-2	cis-1,2-Dichloroethene	ug/l	104	657000	1 U	12200
156-60-5	trans-1,2-Dichloroethene	ug/l	5.1	2770	1 U	100 U
71-55-6	1,1,1-Trichloroethane	ug/l	1 U	500 U	1 U	209
79-00-5	1,1,2-Trichloroethane	ug/l	1 U	500 U	1 U	100 U
79-01-6	Trichloroethene	ug/l	13	500 U	1 U	941
75-01-4	Vinyl chloride	ug/l	18.4	94000	1 U	1460
74-82-8	Methane	ug/l	13.3	178	0.2	84.8
74-84-0	Ethane	ug/l	0.29	14.8	0.1 U	5.86
74-85-1	Ethene	ug/l	0.52	450	0.1 U	13.1
	SEMIVOLATILES					
108-95-2	Phenol	ug/l	5.2 U	9530	5	5.3 U
62-53-3	Aniline	ug/l	2.1 U	2.1 U	2 U	1.3 J
	METALS					
7440-38-2	Arsenic	ug/l	5 U	11.6	5 U	5 U
	OTHER					
16887-00-6	Chloride	mg/l	40.1	1090	8.7	547
14797-55-8	Nitrogen, Nitrate	mg/l	0.11 U	0.91	0.4	0.12
NO3NO2N	Nitrogen, Nitrate + Nitrite	mg/l	0.1 U	0.91	0.42	0.12
14797-65-0	Nitrogen, Nitrite	mg/l	0.01 U	0.01 U	0.023	0.01 U
14808-79-8	Sulfate	mg/l	2230	867	13.1	2420
TOC	Total Organic Carbon	mg/l	2.3	47.1	5.3	2.9
	Field Analysis / Parameters					
	pH		7.42	6.90	7.01	6.68
	Electrical Condutivity	mS/cm	4.07	5.92	7.79	5.45
	Turbidity	NTU	29.10	39.90	2.30	840.00
	DO	mg/L	0.00	0.07	0.00	0.00
	Temperature	oC	17.15	17.63	16.41	15.98
	ORP (mv)	mV	-112.00	-115.00	-183	-187
	Alkalinity (CaCO3) as methyl orange	mg/l	250.00	860	80	500
	Carbon Dioxide	mg/l	190	526	20 mg/l	226
	Ferrous Iron	mg/l	3.80	5.60	0.00 mg/l	0.20
	Manganese	mg/l	0.20	0.60	0.00 mg/l	0.00
	Hydrogen Sulfide	mg/l	0.00	0.30	0.00 mg/l	1.00
	Comments			Dry at 1.5 gallons	Dry at 3 gallons	

U - Not detected
N/A Not Analyzed
J - Estimated

TABLE 1
Groundwater Sampling Results
Summer and Fall 2005

Ekonol Facility		Sample ID:	MW-5S	MW-6S	MW-7S	MW-8S	MW-9S
Groundwater Analytical Results		Lab Sample Id	J8266-1	J8467-2	J8265-2/J8365-3	J8467-6	J8467-1
Wheatfield, New York		Source:	ACTD	ACTD	ACTD	ACTD	ACTD
Summer/Fall 2005		SDG:	J8266	J8467	J8265/J8365	J8467	J8467
		Matrix:	Water	Water	Water	Water	Water
		Sampled:	8/29/2005	8/31/2005	8/29-30/2005	8/31/2005	8/31/2005
CAS NO.	COMPOUND	UNITS:					
	VOLATILES						
75-00-3	Chloroethane	ug/l	1 U	1 U	1 U	1 U	1 U
75-34-3	1,1-Dichloroethane	ug/l	1 U	0.43 J	1 U	1 U	1 U
75-35-4	1,1-Dichloroethene	ug/l	1 U	1 U	1 U	1 U	1 U
156-59-2	cis-1,2-Dichloroethene	ug/l	1	2.2	1	14.3	1 U
156-60-5	trans-1,2-Dichloroethene	ug/l	1 U	1 U	1 U	1 U	1 U
71-55-6	1,1,1-Trichloroethane	ug/l	1 U	1 U	1 U	1 U	1 U
79-00-5	1,1,2-Trichloroethane	ug/l	1 U	1 U	1 U	1 U	1 U
79-01-6	Trichloroethene	ug/l	0.42 J	0.96 J	1 U	2.7	1 U
75-01-4	Vinyl chloride	ug/l	1.5	9.1	1 U	0.97 J	1 U
74-82-8	Methane	ug/l	N/A	0.32	N/A	N/A	N/A
74-84-0	Ethane	ug/l	N/A	0.48	N/A	N/A	N/A
74-85-1	Ethene	ug/l	N/A	0.1 U	N/A	N/A	N/A
	SEMIVOLATILES						
108-95-2	Phenol	ug/l	5.1 U	5 U	5.1 U	4.9 J	49.9
62-53-3	Aniline	ug/l	2 U	2 U	2 U	2.2 U	2.2 U
	METALS						
7440-38-2	Arsenic	ug/l	N/A	5 U	N/A	N/A	N/A
	OTHER						
16887-00-6	Chloride	mg/l	N/A	170	N/A	N/A	N/A
14797-55-8	Nitrogen, Nitrate	mg/l	N/A	0.6	N/A	N/A	N/A
NO3NO2N	Nitrogen, Nitrate + Nitrite	mg/l	N/A	0.65	N/A	N/A	N/A
14797-65-0	Nitrogen, Nitrite	mg/l	N/A	0.049	N/A	N/A	N/A
14808-79-8	Sulfate	mg/l	N/A	21.5	N/A	N/A	N/A
TOC	Total Organic Carbon	mg/l	N/A	2.6	N/A	N/A	N/A
	Field Analysis / Parameters						
	pH		7.31	7.12	6.75	11.14	7.00
	Electrical Condutivity	mS/cm	2.92	0.00	5.13	4.45	5.16
	Turbidity	NTU	47.80	36.00	18.00	684.00	89.00
	DO	mg/L	0.00	0.00	0.00	0.00	6.23
	Temperature	oC	14.94	15.92	16.95	17.40	17.11
	ORP (mv)	mV	-59.00	-49.00	-131	-171	-34
	Alkalinity (CaCO3) as methyl orange	mg/l	N/A	100	N/A	N/A	N/A
	Carbon Dioxide	mg/l	N/A	0	N/A	N/A	N/A
	Ferrous Iron	mg/l	N/A	0.00	N/A	N/A	N/A
	Manganese	mg/l	N/A	0.00	N/A	N/A	N/A
	Hydrogen Sulfide	mg/l	N/A	0.00	N/A	N/A	N/A
	Comments				Dry at 3.2 gal		

U - Not detected
N/A Not Analyzed
J - Estimated

TABLE 1
Groundwater Sampling Results
Summer and Fall 2005

Ekonol Facility
Groundwater Analytical Results
Wheatfield, New York
Summer/Fall 2005

		Sample ID:	MW-10S	MW-11S	MW-12S	RMW-1D	RMW-2D
		Lab Sample Id	J9919-1	J9919-4	J9919-2	J8266-3	J8600-1
		Source:	ACTD	ACTD	ACTD	ACTD	ACTD
		SDG:	J9919	J9919	J9919	J8266	J8600
		Matrix:	Water	Water	Water	Water	Water
		Sampled:	9/15/2005	9/15/2005	9/15/2005	8/29/2005	9/1/2005
CAS NO.	COMPOUND	UNITS:					
	VOLATILES						
75-00-3	Chloroethane	ug/l	1 U	1 U	25 U	1 U	50 U
75-34-3	1,1-Dichloroethane	ug/l	1 U	25.9	67.9	1 U	25.4 J
75-35-4	1,1-Dichloroethene	ug/l	1.8	3.2	12.6	1.1	24.8 J
156-59-2	cis-1,2-Dichloroethene	ug/l	1120	609	3690	234	2890
156-60-5	trans-1,2-Dichloroethene	ug/l	17.2	7.5	40.7	1.4	50 U
71-55-6	1,1,1-Trichloroethane	ug/l	1 U	13.9	432	0.38 J	1830
79-00-5	1,1,2-Trichloroethane	ug/l	1 U	1 U	6 U	1 U	50 U
79-01-6	Trichloroethene	ug/l	4.2	103	11900	1.3	23900
75-01-4	Vinyl chloride	ug/l	75.7	91.4	132	5	51.3
74-82-8	Methane	ug/l	13.8	68	80.2	52.2	8.85
74-84-0	Ethane	ug/l	0.45	0.95	11.8	11.2	0.46
74-85-1	Ethene	ug/l	1.9	1.6	2.3	0.1 U	0.87
	SEMIVOLATILES						
108-95-2	Phenol	ug/l	5.6 U	6.3 U	ND	5.1 U	5 U
62-53-3	Aniline	ug/l	2.2 U	2.5 U	ND	2 U	73.4
	METALS						
7440-38-2	Arsenic	ug/l	5 U	5 U	90.3	5 U	5 U
	OTHER						
16887-00-6	Chloride	mg/l	118	449	277	164	156
14797-55-8	Nitrogen, Nitrate	mg/l	0.11 U	0.11 U	0.11 U	0.11 U	0.13
NO3NO2N	Nitrogen, Nitrate + Nitrite	mg/l	0.1 U	0.1 U	0.1 U	0.1 U	0.13
14797-65-0	Nitrogen, Nitrite	mg/l	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
14808-79-8	Sulfate	mg/l	501	2260	1650	1030	854
TOC	Total Organic Carbon	mg/l	2.5	2.2	16.7	2	2.4
	Field Analysis / Parameters						
	pH		7.43	7.00	7.56	6.91	7.36
	Electrical Condutivity	mS/cm	2.07	5.16	3.67	2.90	2.50
	Turbidity	NTU	0.20	89.00	9999	10.00	30.70
	DO	mg/L	0.00	6.23	6.78	0.00	0.00
	Temperature	oC	14.44	17.11	18.68	13.98	15.12
	ORP (mv)	mV	-138	-34	-58	-327	-169
	Alkalinity (CaCO3) as methyl orange	mg/l	N/A	N/A	360	350	320.00
	Carbon Dioxide	mg/l	N/A	N/A	180	260	292
	Ferrous Iron	mg/l	N/A	N/A	1.8	0.50	0.60
	Manganese	mg/l	N/A	N/A	0	0.00	0.00
	Hydrogen Sulfide	mg/l	N/A	N/A	0	3.00	0.50
	Comments						

U - Not detected
N/A Not Analyzed
J - Estimated

TABLE 1
Groundwater Sampling Results
Summer and Fall 2005

Ekonol Facility		Sample ID:	RMW-3D	RMW-4D	MW-10D	MW-11D	MW-12D
Groundwater Analytical Results		Lab Sample Id	J8365-7	J8467-7	J8600-2	J8265-1	J8365-8
Wheatfield, New York		Source:	ACTD	ACTD	ACTD	ACTD	ACTD
Summer/Fall 2005		SDG:	J8365	J8467	J8600	J8265	J8365
		Matrix:	Water	Water	Water	Water	Water
		Sampled:	8/30/2005	8/31/2005	9/1/2005	8/29/2005	8/30/2005
CAS NO.	COMPOUND	UNITS:					
	VOLATILES						
75-00-3	Chloroethane	ug/l	5 U	25 U	10 U	1 U	1 U
75-34-3	1,1-Dichloroethane	ug/l	77.2	38.1	25.6	6	1 U
75-35-4	1,1-Dichloroethene	ug/l	25.1	43	15.6	1.6	1 U
156-59-2	cis-1,2-Dichloroethene	ug/l	571	11300	2630	113	0.82 J
156-60-5	trans-1,2-Dichloroethene	ug/l	22.8	14.8 J	5.8 J	0.48 J	1 U
71-55-6	1,1,1-Trichloroethane	ug/l	4080	701	147	239	1 U
79-00-5	1,1,2-Trichloroethane	ug/l	5 U	25 U	10 U	1 U	1 U
79-01-6	Trichloroethene	ug/l	381	19200	1090	5	1 U
75-01-4	Vinyl chloride	ug/l	5 U	475	180	2.6	1 U
74-82-8	Methane	ug/l	10.6	32.7	N/A	44.8	N/A
74-84-0	Ethane	ug/l	1.6	2.5	N/A	6.16	N/A
74-85-1	Ethene	ug/l	0.1 U	2.7	N/A	0.1 U	N/A
	SEMIVOLATILES						
108-95-2	Phenol	ug/l	5.6 U	5.2 U	5.9 U	5.3 U	5.1 U
62-53-3	Aniline	ug/l	2.2 U	12.5	5	2.1 U	2 U
	METALS						
7440-38-2	Arsenic	ug/l	5 U	5 U	N/A	5 U	N/A
	OTHER						
16887-00-6	Chloride	mg/l	166	223	N/A	146	N/A
14797-55-8	Nitrogen, Nitrate	mg/l	0.11 U	0.11 U	N/A	0.11 U	N/A
NO3NO2N	Nitrogen, Nitrate + Nitrite	mg/l	0.1 U	0.1 U	N/A	0.1 U	N/A
14797-65-0	Nitrogen, Nitrite	mg/l	0.015	0.01 U	N/A	0.01 U	N/A
14808-79-8	Sulfate	mg/l	767	1140	N/A	1260	N/A
TOC	Total Organic Carbon	mg/l	2	2.8	N/A	3.2	N/A
	Field Analysis / Parameters						
	pH		6.83	7.26	6.83	7.20	6.73
	Electrical Condutivity	mS/cm	2.66	3.12	2.53	3.05	3.15
	Turbidity	NTU	1.45	25.30	5.10	781.00	0.00
	DO	mg/L	0.00	0.00	0.00	0.00	0.00
	Temperature	oC	14.73	15.92	14.71	13.01	15.49
	ORP (mv)	mV	-275	-298	-278	-133	-347
	Alkalinity (CaCO3) as methyl orange	mg/l	320	440.00	N/A	340.00	N/A
	Carbon Dioxide	mg/l	< 40.00	172	N/A	260	N/A
	Ferrous Iron	mg/l	0.20	0.00	N/A	0.00	N/A
	Manganese	mg/l	0.00	0.00	N/A	0.00	N/A
	Hydrogen Sulfide	mg/l	0.85	3.00	N/A	2.00	N/A
	Comments						

U - Not detected
N/A Not Analyzed
J - Estimated

TABLE 1
Groundwater Sampling Results
Summer and Fall 2005

Ekonol Facility		Sample ID:	MW-13D	MW-14D	MW-15D	MW-16D	MW-17D
Groundwater Analytical Results		Lab Sample Id	J8365-4	J8266-4	J8365-1	J8365-5	J8266-6
Wheatfield, New York		Source:	ACTD	ACTD	ACTD	ACTD	ACTD
Summer/Fall 2005		SDG:	J8365	J8266	J8365	J8365	J8266
		Matrix:	Water	Water	Water	Water	Water
		Sampled:	8/30/2005	8/29/2005	8/30/2005	8/30/2005	8/29/2005
CAS NO.	COMPOUND	UNITS:					
	VOLATILES						
75-00-3	Chloroethane	ug/l	1 U	1 U	20 U	5 U	1 U
75-34-3	1,1-Dichloroethane	ug/l	7.9	1 U	65.8	4.9 J	0.67 J
75-35-4	1,1-Dichloroethene	ug/l	1.5	1 U	27.8	3 J	1 U
156-59-2	cis-1,2-Dichloroethene	ug/l	234	1 U	5360	884	3.7
156-60-5	trans-1,2-Dichloroethene	ug/l	1.9	1 U	58.3	10.9	1 U
71-55-6	1,1,1-Trichloroethane	ug/l	2.2	1 U	165	2.4 J	5
79-00-5	1,1,2-Trichloroethane	ug/l	1 U	1 U	20 U	5 U	1 U
79-01-6	Trichloroethene	ug/l	16.3	1 U	49.8	7.7	0.69 J
75-01-4	Vinyl chloride	ug/l	150	1 U	298	39.3	1 U
74-82-8	Methane	ug/l	17.7	32.4	19.7	N/A	N/A
74-84-0	Ethane	ug/l	0.48	11.9	0.5	N/A	N/A
74-85-1	Ethene	ug/l	8.6	0.1 U	2.4	N/A	N/A
	SEMIVOLATILES						
108-95-2	Phenol	ug/l	5.4 U	5.2 U	5.4 U	5.6 U	5 U
62-53-3	Aniline	ug/l	2.2 U	2.1 U	2.2 U	2.2 U	2 U
	METALS						
7440-38-2	Arsenic	ug/l	6	N/A	5 U	N/A	N/A
	OTHER						
16887-00-6	Chloride	mg/l	275	N/A	170	N/A	N/A
14797-55-8	Nitrogen, Nitrate	mg/l	0.11 U	N/A	0.11 U	N/A	N/A
NO3NO2N	Nitrogen, Nitrate + Nitrite	mg/l	0.1 U	N/A	0.1 U	N/A	N/A
14797-65-0	Nitrogen, Nitrite	mg/l	0.01 U	N/A	0.01 U	N/A	N/A
14808-79-8	Sulfate	mg/l	1010	N/A	1610	N/A	N/A
TOC	Total Organic Carbon	mg/l	2	N/A	2.6	N/A	N/A
	Field Analysis / Parameters						
	pH		6.79	6.90	6.69	7.38	6.86
	Electrical Condutivity	mS/cm	3.33	2.86	3.39	3.05	2.97
	Turbidity	NTU	24.00	10.00	2.00	40.00	clear
	DO	mg/L	0.00	0.00	0.00	0.00	0.00
	Temperature	oC	13.12	13.05	16.00	12.34	12.75
	ORP (mv)	mV	-252	-308	-199	-37	2.66
	Alkalinity (CaCO3) as methyl orange	mg/l	460	N/A	420	N/A	N/A
	Carbon Dioxide	mg/l	216	N/A	196	N/A	N/A
	Ferrous Iron	mg/l	0.80	N/A	1.90	N/A	N/A
	Manganese	mg/l	0.00	N/A	0.00	N/A	N/A
	Hydrogen Sulfide	mg/l	1.00	N/A	0.10	N/A	N/A
	Comments						

U - Not detected
N/A Not Analyzed
J - Estimated

TABLE 1
Groundwater Sampling Results
Summer and Fall 2005

Ekonol Facility		Sample ID:	MW-18D	MW-19D	MW-20D
Groundwater Analytical Results		Lab Sample Id	J8365-6	J8365-2	J9919-3
Wheatfield, New York		Source:	ACTD	ACTD	ACTD
Summer/Fall 2005		SDG:	J8365	J8365	J9919
		Matrix:	Water	Water	Water
		Sampled:	8/30/2005	8/30/2005	9/15/2005
CAS NO.	COMPOUND	UNITS:			
	VOLATILES				
75-00-3	Chloroethane	ug/l	1 U	1 U	1 U
75-34-3	1,1-Dichloroethane	ug/l	1 U	0.61 J	207
75-35-4	1,1-Dichloroethene	ug/l	1 U	1 U	23.1
156-59-2	cis-1,2-Dichloroethene	ug/l	1 U	10.3	1670
156-60-5	trans-1,2-Dichloroethene	ug/l	1 U	1 U	9.4
71-55-6	1,1,1-Trichloroethane	ug/l	1 U	1 U	1830
79-00-5	1,1,2-Trichloroethane	ug/l	1 U	1 U	1 U
79-01-6	Trichloroethene	ug/l	1 U	1 U	30.8
75-01-4	Vinyl chloride	ug/l	1 U	7.6	74.9
74-82-8	Methane	ug/l	N/A	N/A	8.97
74-84-0	Ethane	ug/l	N/A	N/A	1.2
74-85-1	Ethene	ug/l	N/A	N/A	0.22
	SEMIVOLATILES				
108-95-2	Phenol	ug/l	5.6 U	5.6 U	5.2 U
62-53-3	Aniline	ug/l	2.2 U	2.2 U	2.1 U
	METALS				
7440-38-2	Arsenic	ug/l	N/A	N/A	5 U
	OTHER				
16887-00-6	Chloride	mg/l	N/A	N/A	171
14797-55-8	Nitrogen, Nitrate	mg/l	N/A	N/A	0.11 U
NO3NO2N	Nitrogen, Nitrate + Nitrite	mg/l	N/A	N/A	0.1 U
14797-65-0	Nitrogen, Nitrite	mg/l	N/A	N/A	0.01 U
14808-79-8	Sulfate	mg/l	N/A	N/A	852
TOC	Total Organic Carbon	mg/l	N/A	N/A	2.5
	Field Analysis / Parameters				
	pH		7.27	6.95	7.55
	Electrical Condutivity	mS/cm	2.92	5.85	2.61
	Turbidity	NTU	20.80	32.10	16.00
	DO	mg/L	0.00	0.00	0.00
	Temperature	oC	13.85	17.24	17.49
	ORP (mv)	mV	-141	-24	-181
	Alkalinity (CaCO3) as methyl orange	mg/l	N/A	N/A	85
	Carbon Dioxide	mg/l	N/A	N/A	264
	Ferrous Iron	mg/l	N/A	N/A	0.5
	Manganese	mg/l	N/A	N/A	0
	Hydrogen Sulfide	mg/l	N/A	N/A	0
	Comments				

U - Not detected
N/A Not Analyzed
J - Estimated

TABLE 2
Soil Sampling Results
September, 2005

Ekonol Facility		Sample ID:	BH-1A	BH-2A	BH-3A	BH-4A	BH-5A	BH-6A	BH-7A	BH-8A	BH-9A
Soil Analytical Results		Lab Sample Id:	J10637-1	J10637-2	J10637-3	J10637-4	J10637-5	J10637-9	J10637-8	J10637-7	J10637-6
Wheatfield, New York		Depth:	8-12'	8-12'	8-12'	8-12'	8-12'	1-2'	1-2' & 8-11.5' *	1-2' & 8-10' *	2-3'
Fall 2005		Source:	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD
		SDG:	J10637	J10637	J10637	J10637	J10637	J10637	J10637	J10637	J10637
		Matrix:	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		Sampled:	9/21/2005	9/21/2005	9/21/2005	9/21/2005	9/21/2005	9/22/2005	9/22/2005	9/22/2005	9/22/2005
CAS NO.	COMPOUND	UNITS:									
	VOLATILES										
75-00-3	Chloroethane	ug/kg	8.1 U	440 U	410 U	300 U	61 U	7.3 U	8.4 U	6.9 U	7.7 U
75-34-3	1,1-Dichloroethane	ug/kg	8.1 U	440 U	410 U	300 U	61 U	7.3 U	8.4 U	6.9 U	7.7 U
75-35-4	1,1-Dichloroethene	ug/kg	4.9 J	39.2 J	410 U	300 U	134	7.3 U	8.4 U	6.9 U	7.7 U
156-59-2	cis-1,2-Dichloroethene	ug/kg	1690	90900	64400	1870	69000	2.3 J	8.4 U	5.9 J	7.7 U
156-60-5	trans-1,2-Dichloroethene	ug/kg	35.3	286 J	448	22.9 J	1440	7.3 U	8.4 U	6.9 U	7.7 U
71-55-6	1,1,1-Trichloroethane	ug/kg	8.1 U	440 U	410 U	300 U	61 U	7.3 U	8.4 U	6.9 U	7.7 U
79-00-5	1,1,2-Trichloroethane	ug/kg	8.1 U	440 U	410 U	300 U	61 U	7.3 U	8.4 U	6.9 U	7.7 U
79-01-6	Trichloroethene	ug/kg	186	271000	67.5 J	615	28.5 J	7.3 U	8.4 U	3.1 J	7.7 U
75-01-4	Vinyl chloride	ug/kg	284	523	410 U	300 U	2140	7.3 U	8.4 U	6.9 U	7.7 U
	SEMIVOLATILES										
108-95-2	Phenol	ug/kg	220 U	15000	1510	190 U	10100	220 U	220 U	200 U	220 U
62-53-3	Aniline	ug/kg	90 U	92 U	90 U	76 U	860 U	89 U	88 U	82 U	88 U
	OTHER										
ALK	Alkalinity, Total as CaCO3	mg/kg	511	529	362	N/A	N/A	N/A	836	491	N/A
SOLID	Solids, Percent	%	73.9	71.5	73.1	87.4	76.7	74.6	74.6	80.8	75.5

U - Non-detect
J - Estimated
N/A - Not Analyzed
* 1-2' interval was sampled for volatiles and semivolatiles, 8-10' interval was sampled for alkalinity and precent solids

TABLE 3
Pulse Interference Test Results

Source Well	Receiver Well	Hydraulic Conductivity K (ft/day)	Specific Storage Ss (1/ft)
MW-2S	MW-3S	8.16E-02	1.17E-07
MW-2S	MW-4S	5.30E-02	1.27E-07
MW-2S	MW-9S	6.43E-01	6.95E-07
MW-3S	MW-4S	NR	NR
MW-3S	MW-6S	1.60E-04	5.85E-11
MW-3S	MW-7S	NR	NR
MW-4S	MW-7S	2.69E+01	4.68E-05
MW-4S	MW-8S	ND	ND
MW-4S	MW-9S	1.35E+02	5.08E-05
RMW-2D	RMW-3D	1.10E+01	3.52E-07
RMW-2D	RMW-4D	1.37E+01	2.28E-07
RMW-2D	MW-10D	1.17E+02	6.79E-07
RMW-3D	RMW-4D	5.57E+00	4.58E-08
RMW-3D	MW-11D	2.44E+01	3.24E-07
RMW-4D	MW-10D	7.07E+01	1.28E-07

NR = No response recorded
ND = No data collected, screen out of water
Results from GeoSierra (2005)

TABLE 4
Identification of Standards, Criteria and Guidance

Potential SCG	Description	Applicability Determination	Comments
Standards			
29 CFR 1910.120	Hazardous Waste Operations and Emergency Response regulation HAZWOPER	Yes	Incorporated into health and safety plan
40 CFR PART 144	EPA Safe Drinking Water Act Underground Injection Program	No	
10 NYCRR PART 67	New York Lead Poisoning Prevention Act	No	
6 NYCRR PART 361	Siting of Industrial Hazardous Waste Facilities	No	
6 NYCRR PART 371	Identification and Listing of Hazardous Wastes	Yes	Incorporated into work plans
6 NYCRR PART 372	Hazardous waste manifest system	Yes	Incorporated into work plans
6 NYCRR SUBPART 374-1	Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities	No	
6 NYCRR SUBPART 374-3	Standards For Universal Wastes	No	
6 NYCRR PART 375	State Environmental Remediation Program	No	Part of the VCP program
6 NYCRR PART 376	Land Disposal Restrictions	No	
6 NYCRR PART 608	Use and Protection of Waters	No	
6 NYCRR PART 662 - 665	Freshwater Wetlands	No	
6 NYCRR PART 700-706	Division of Environmental Remediation Oil Spill Response Guidance Policy	No	
Guidance			
TAGM 4030	Selection of Remedial Actions at Inactive Hazardous Wastes Sites	Yes	Used along with VCP guide
TAGM 4031	Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites	No	
TAGM 4042	Interim Remedial Measures	No	
TAGM 4046	Determination of Soil Clean Up Objectives	Yes	Used in developing the Preliminary Remediation Goals
TOGS	NYSDEC Technical & Operational Guidance Series - Groundwater	Yes	Used in developing the Preliminary Remediation Goals
DAR-1	Guidelines for the Control of Toxic Ambient Air Contaminants	No	Investigations to date suggest no pathway for COC to reach indoor air

TABLE 5
COMPARATIVE ANALYSIS OF ALTERNATIVES FOR SOIL

	ALTERNATIVE 1:	ALTERNATIVE 2
EVALUATION CRITERIA	**ENGINEERING AND INSTITUTIONAL CONTROLS**	**EXCAVATION AND BACKFILL**
Protection of Human Health and the Environment		
Direct contact / soil ingestion	**Good** Previous excavation removed COC impacted soils. Any residual COCs are at depth under intact concrete slabs or pavement, therefore engineering and institution controls prevent risk.	**Poor** Produces risk to excavation workers without resulting in significant benefit to soils.
Environmental Protection	**Moderate** No change in environmental protection from present conditions	**Moderate** Potential for contamination of backfill material.
Attainment of Standards, Criteria and Guidance (SCGs)		
Chemical-Specific SCGs.	**Moderate** Previous excavation removed impacted soils. Recent sampling confirmed only residually impacted soils exist.	**Moderate** Removal of residually-impacted soils
Location specific SCGs *requirements that may set restrictions on activities within specific locations such as floodplains or wetlands*	**None**	**None**

TABLE 5
COMPARATIVE ANALYSIS OF ALTERNATIVES FOR SOIL

	ALTERNATIVE 1:	ALTERNATIVE 2
EVALUATION CRITERIA	ENGINEERING AND INSTITUTIONAL CONTROLS	EXCAVATION AND BACKFILL
Action specific SCGs *may set controls or restrictions for particular treatment and disposal activities related to the management of hazardous wastes*	**None**	**Moderate** Requires management of derived waste.
Short-term Effectiveness	**Good**	**Poor** Not cost effective due to lack of impacted soils.
Long-term Effectiveness and Permanence	**Moderate** Relatively easy to apply, no technical risk or complications.	**Poor** Not cost effective due to lack of impacted soils.
Reduction of Toxicity, Mobility, and Volume Through Treatment	**Poor**	**Poor** Not cost effective due to lack of impacted soils.
Implementability	**Good**	**Moderate**
Cost	**Good** Relatively inexpensive	**Moderate** Materials are relatively low cost, but could be relatively high.

TABLE 6
COMPARATIVE ANALYSIS OF ALTERNATIVES FOR SHALLOW GROUNDWATER

	ALTERNATIVE 2	ALTERNATIVE 4	ALTERNATIVE 5
EVALUATION CRITERIA	PASSIVE BIOREACTOR	GROUNDWATER EXTRACTION	IN-SITU INJECTION TREATMENTS: BIOTREATMENT, CHEMICAL OXIDATION, OR EZVI
Protection of Human Health and the Environment			
Groundwater ingestion for future users	**Good** Soil removal will remove residual COC sources. Backfill may reduce COC over long term. May increase risk by increasing degradation products (DCE, VC).	**Poor to moderate** May not reduce COCs in reasonable time frame. Increases risk through exposure pathways of treatment operations. Reduces risk to offsite receptors.	**Poor to moderate** Low hydraulic conductivity will likely prevent thorough application.
Environmental Protection	**Good** Long-term carbon source may enhance current natural attenuation. Soil removal techniques may put carbon source in contact with permeable portions of the shallow groundwater.	**Moderate** Reduces risk to offsite receptors.	**Poor to moderate** Low hydraulic conductivity will likely prevent thorough application.
Attainment of Standards, Criteria and Guidance			
Chemical-Specific SCGs (i.e. Remedial Action Objectives, RAOs).	**Moderate to good** Enhanced bioremediation may reduce COCs	**Moderate** Provide control of COC migration, but will not reduce COCs to SCGs in	**Poor to moderate** Low hydraulic conductivity will likely prevent thorough application

TABLE 6
COMPARATIVE ANALYSIS OF ALTERNATIVES FOR SHALLOW GROUNDWATER

	ALTERNATIVE 2	ALTERNATIVE 4	ALTERNATIVE 5
EVALUATION CRITERIA	PASSIVE BIOREACTOR	GROUNDWATER EXTRACTION	IN-SITU INJECTION TREATMENTS: BIOTREATMENT, CHEMICAL OXIDATION, OR EZVI
		reasonable time frame.	
Location specific SCGs *requirements that may set restrictions on activities within specific locations such as floodplains or wetlands*	None	None	None
Action specific SCGs *may set controls or restrictions for particular treatment and disposal activities related to the management of hazardous wastes*	**Moderate** One time waste management disposal	**Poor** Initial waste management disposal Long term discharge permitting.	**Poor to moderate** Requires management of derived waste Requires permitting for injection.
Short-term Effectiveness	**Moderate** Soil removal may remove residual source. Enhanced bioremediation may increase concentrations of intermediate degradation products.	**Poor to moderate** Low permeability soils may inhibit effectiveness	**Poor** May increase degradation products (DCE, VC).

TABLE 6
COMPARATIVE ANALYSIS OF ALTERNATIVES FOR SHALLOW GROUNDWATER

	ALTERNATIVE 2	ALTERNATIVE 4	ALTERNATIVE 5
EVALUATION CRITERIA	PASSIVE BIOREACTOR	GROUNDWATER EXTRACTION	IN-SITU INJECTION TREATMENTS: BIOTREATMENT, CHEMICAL OXIDATION, OR EZVI
Long-term Effectiveness and Permanence	**Good** Passive Bioreactor cell will likely provide long-term carbon source to transmissive portions of shallow groundwater.	**Poor to moderate** Low permeability soils may inhibit effectiveness	**Poor to moderate** Low permeability soils may prevent thorough application. Yet, substrate such as vegetable oil may remain active.
Reduction of Toxicity, Mobility, and Volume Through Treatment	**Good** Some residuals will be removed with soil removal, and enhanced bioremediation would degrade COC.	**Poor** Low permeability will limit volume of COCs removed.	Low hydraulic conductivity will likely prevent thorough application. Low permeability soils may prevent thorough application.
Implementability	**Good** No specialty equipment. Materials are easy to obtain.	**Poor** Construction of collection system and treatment plant. Permitting, and discharge to municipality required.	**Moderate** Need to design injection system. State acceptance and permitting required for injection. Some materials are fairly expensive and not easy to obtain.
Qualitative Cost	Materials and construction are relatively low cost.	Long term treatment systems are typically high in cost (capital and O&M).	Materials vary from relatively inexpensive to expensive. Additional treatments may be required. Long-term costs may be relatively low.

TABLE 7
COMPARATIVE ANALYSIS OF ALTERNATIVES FOR DEEP GROUNDWATER

	ALTERNATIVE 3	ALTERNATIVE 4	ALTERNATIVE 6
EVALUATION CRITERIA	GROUNDWATER EXTRACTION	BIO-ENHANCING IN-SITU TREATMENT	EZVI IN-SITU TREATMENT
Protection of Human Health and the Environment			
Groundwater ingestion for future users	**Moderate** Reduces risk to offsite receptors. Increases risk onsite through exposure pathways of treatment operations.	**Moderate** Short-term increase of degradation products (DCE, VC). After short-term increase, COCs may decrease, reducing risk.	**Good** May effectively reduce the risk by decreasing the COCs without the production of regulated degradation products. Has not been used extensively, effectiveness relatively unknown.
Environmental Protection	**Moderate** Reduces risk to offsite receptor.	**Moderate to good** Carbon source may enhance current natural attenuation.	**Moderate** May reduce the risk by decreasing the COCs without the production of regulated degradation products. Has not been used extensively, effectiveness relatively unknown

TABLE 7
COMPARATIVE ANALYSIS OF ALTERNATIVES FOR DEEP GROUNDWATER

	ALTERNATIVE 3	ALTERNATIVE 4	ALTERNATIVE 6
EVALUATION CRITERIA	GROUNDWATER EXTRACTION	BIO-ENHANCING IN-SITU TREATMENT	EZVI IN-SITU TREATMENT
Attainment of Standards Criteria and Guidance			
Chemical-Specific SCGs (i.e. Remedial Action Objectives, RAOs).	**Poor** Will likely take 100's of years.	**Moderate to Good** Carbon source may enhance current natural attenuation and degrade COCs below groundwater standards.	**Moderate to good** May rapidly decrease the COC below groundwater standards.
Location specific SCGs *requirements that may set restrictions on activities within specific locations such as floodplains or wetlands*	None	None	None
Action specific SCGs *may set controls or restrictions for particular treatment and disposal activities related to the management of hazardous wastes*	**Moderate** Initial waste management disposal Long term discharge permitting.	**Poor to moderate** Requires management of derived waste from drilling operations. Requires permitting for injection.	**Poor to moderate** Requires management of derived waste from drilling operations. Requires permitting for injection.
Short-term Effectiveness	**Moderate** Containment provided soon after start-up.	**Poor** May increase degradation products (DCE, VC).	**Moderate to good** Has potential to show immediate reduction in COC concentrations without intermediate degradation products.

TABLE 7
COMPARATIVE ANALYSIS OF ALTERNATIVES FOR DEEP GROUNDWATER

	ALTERNATIVE 3	ALTERNATIVE 4	ALTERNATIVE 6
EVALUATION CRITERIA	GROUNDWATER EXTRACTION	BIO-ENHANCING IN-SITU TREATMENT	EZVI IN-SITU TREATMENT
Long-term Effectiveness and Permanence	**Good** Containment provided continuously.	**Moderate** Substrate such as vegetable oil will remain active for a longer period than EZVI. One application may not be sufficient for complete degradation. Not as effective on DNAPL as EZVI.	**Moderate to good** Shows potential to be effective. COC may rebound. Reacts effectively with DNAPL.
Reduction of Toxicity, Mobility, and Volume Through Treatment	**Poor** Will reduce offsite mobility but have limited reduction in COC concentrations, i.e. reducing toxicity and volume.	**Poor to Moderate** Short term increase in toxicity, long term decrease in toxicity, mobility, and volume. Not as effective on DNAPL as EZVI	**Moderate to good** Shows potential for rapid reduction in volume and toxicity without producing intermediate degradation products. Reacts effectively with DNAPL.
Implementability	**Poor** Requires construction of a collection system and treatment plant. Permitting and discharge to municipality.	**Moderate** State acceptance and permitting required for injection.	**Moderate** State acceptance and permitting required for injection. Specialty services may be required for use of patented product.

APPENDIX A – DRILLING AND GROUNDWATER SAMPLING RECORDS

PARSONS
DRILLING RECORD

BORING NO. MW-10S

Contractor:	SJB Services, Inc.
Driller:	Ron Brown, Jason Todkowski
Inspector:	Sara Chmura
Rig Type:	ACKER AD II, SoilMax
Method:	4.25-inch HSA/SS

PROJECT NAME BP/Ekonol Facility
PROJECT NUMBER 441610

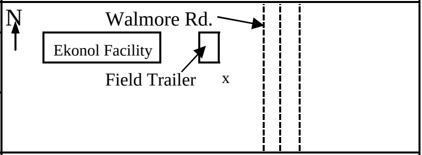
Location: Southeast of Ekonol Facility
Elevation:

Observations			
Depth of Water	NA		
Top of Boring Elevation			

Weather sun, low 80s, breezy

Date/Time Start 9/07/05 @ 1314

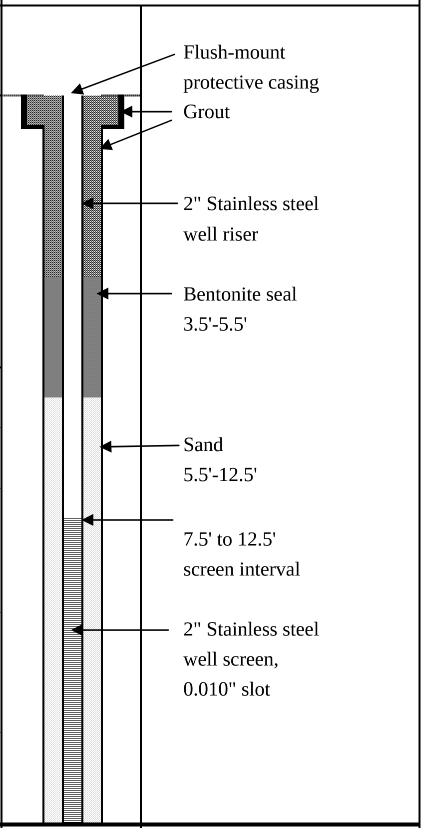
Date/Time Finish 9/09/05 @ 1115



FID Reading	Sample Code	Sample Depth	Rec. %	SPT	FIELD IDENTIFICATION OF MATERIAL
		0			
8.0 ppm			-	-	Hand cleared to 5.0' bgs. Material was 9" of concrete with blue slag then stiff brown clay.
		1			
		2			
		3			
		4			
6.7 ppm	SS-1	5	100.0	WOR	Red/brown, hard mottled clay, no odors, trace calcite mineralization, trace fine brown dry sand, some brown, silt.
				WOR	
		6		WOR	
				WOR	
0.0 ppm	SS-2	7	100.0	WOR	Brown mottled stiff clay, dry. Some mineralization, transitioning to a slightly moist brown silty clay, no odors or staining. Some red/brick colorization at foot.
				WOR	
		8		WOR	
				WOR	
17.3 ppm	SS-3	9	90.0	3	Stiff, brown clay, at 9.5' changes to mottled red/brown silty clay, moist no odors, at 10.5' changes to very moist, silty sand with red clay.
				4	
		10		4	
				3	
15.0 ppm	SS-4	11	100.0	WOR	Moist, soft red/brown silty clay with trace gravel, rock in shoe of spoon. REFUSAL at 12.5' bgs.
				WOR	
		12		WOR	

End of Boring at 12.5 ft.

WELL CONSTRUCTION DIAGRAM



TOR @ 12.5'

STANDARD PENETRATION

TOR = TOP OF ROCK
SS = SPLIT SPOON
ST = SHELBY TUBE

SUMMARY: Top of competent bedrock (TOR) defined as auger and split spoon (SS) refusal.

PARSONS

DRILLING RECORD

BORING NO. MW-11S

Contractor: SJB Services, Inc.

Driller: Ron Brown, Jason Todkowski

Inspector: Sara Chmura

Rig Type: ACKER AD II, SoilMax

Method: 4.25-inch HSA/SS

PROJECT NAME BP/Ekonol Facility

PROJECT NUMBER 441610

Location: Southeast of Ekonol Facility

Elevation:

Observations

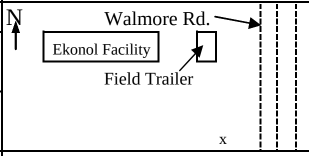
Depth of Water

Top of Boring Elevation

Weather sun, low 80s, breezy

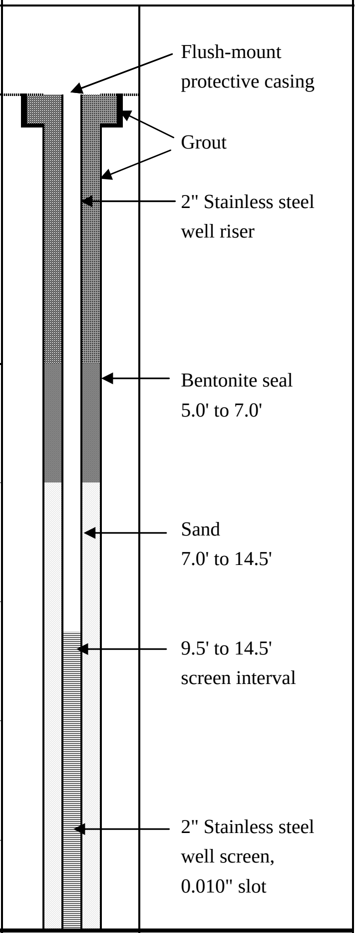
Date/Time Start 9/07/05 @ 1545

Date/Time Finish 9/08/05 @ 1200



FID Reading	Sample Code	Sample Depth	Rec. %	SPT	FIELD IDENTIFICATION OF MATERIAL
		0			
0.0 ppm			-	-	Hand cleared to 5.0' bgs.
		1			0-8" is asphault
					8"-1' is crushed stone
		2			1'-5' is hard, red clay.
		3			
		4			
16.1 ppm	SS-1	5	100.0	5	wet, mottled red/brown/grey clay, hard, no odors, no staining
				6	no gravel.
		6		6	
				9	
13.5 ppm	SS-2	7	85.0	6	saturated outside, moist inside, mottled red/brown/grey clay, trace
				9	rounded gravel, firm, some mineralization (calcite), no odors
		8		9	no staining.
				12	
13.9 ppm	SS-3	9	90.0	8	saturated, red/brown/grey mottled clay, stiff, grading to a softer
				10	red/brown, moist, mottled clay nearing 11'
		10		6	
				9	
14.4 ppm	SS-4	11	100.0	6	saturated, red/grey mottled clay, grading to a very soft saturated
				6	brown silt with clay, trace sub-rounded gravel, trace fine sand, at 13'
		12		7	dark grey fine silt/clay , rock fragments in shoe.
				9	
15.5 ppm	SS-5	13	100.0	10	moist, brown, soft caly with silt, grey rock fragments in bottom of
				10	spoon, Refusal at 14.5' bgs.
		14		50/0	
					End of Boring at 14.5 ft.
		15			
		16			

WELL CONSTRUCTION DIAGRAM



TOR @ 14.5'

STANDARD PENETRATION

TOR = TOP OF ROCK

SS = SPLIT SPOON

ST = SHELBY TUBE

SUMMARY: Top of competent bedrock (TOR) defined as auger and split spoon (SS) refusal.

PARSONS
DRILLING RECORD

BORING NO. MW-12S

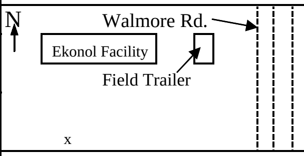
Contractor:	SJB Services, Inc.
Driller:	Ron Brown, Jason Todkowski
Inspector:	Sara Chmura
Rig Type:	ACKER AD II, SoilMax
Method:	4.25-inch HSA/SS

PROJECT NAME BP/Ekonol Facility
PROJECT NUMBER 441610

Location: South of Ekonol Facility
Elevation:

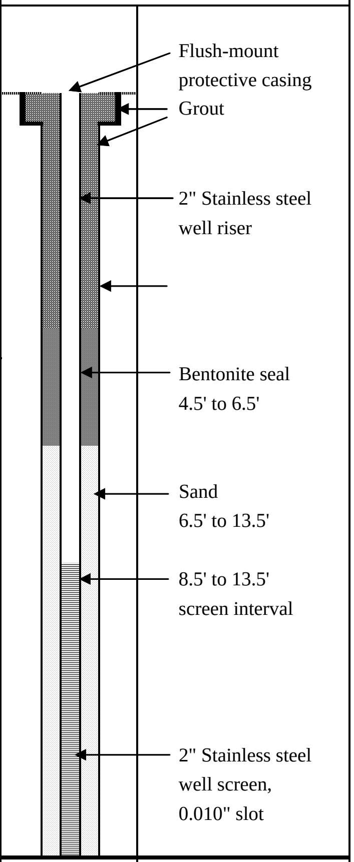
Observations			
Depth of Water			
Top of Boring Elevation			

Weather sun, low 80s, breezy
Date/Time Start 9/09/05 @ 1325
Date/Time Finish 9/09/05 @ 1440



FID Reading	Sample Code	Sample Depth	Rec. %	SPT	FIELD IDENTIFICATION OF MATERIAL
		0			
0.0 ppm			-	-	Hand cleared to 5.0' bgs.
		1			0-8" is concrete
					8" - 5' is hard brown clay.
		2			
		3			
		4			
0.0 ppm	SS-1	5	100.0	4	dry, hard, brown/grey mottled clay, crystalization (calcite) from 6.5' to 7.0', no odors, no staining.
				8	
		6		11	
				14	
0.0 ppm	SS-2	7	100.0	10	dry, hard, brown/grey mottled clay, crystalization (calcite), grading to a softer brown clay with silt.
				16	
		8		16	
				12	
0.0 ppm	SS-3	9	5.0	2	black clay with silt, no odors, poor recovery
				3	
		10		4	
				5	
0.0 ppm	SS-4	11	100.0	3	very wet, brown silty clay, trace fine grained sand, at 12' there pockets of black sediment, no odors, rock fragments in shoe.
				3	
		12		6	
				50/0	
0.0 ppm	SS-5	13	20.0	-	grey rock fragments in shoe, Refusal at 13.5' bgs.
					End of Boring at 13.5 ft
		14			
		15			
		16			

WELL CONSTRUCTION DIAGRAM



TOR @ 13.5'

STANDARD PENETRATION

TOR = TOP OF ROCK
SS = SPLIT SPOON
ST = SHELBY TUBE

SUMMARY:
Top of competent bedrock (TOR) defined as auger and split
spoon (SS) refusal.
Collected a small sample for visual reference of 5-7' interval of crystalization.
Collected a small sample for visual reference of 11-13" interval of black pockets.

PARSONS
DRILLING RECORD

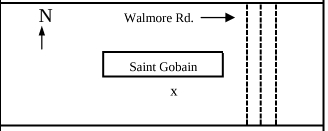
BORING NO. MW-20D

Contractor: SJB Services, Inc.
Driller: Ron Brown, Jason Todkowski
Inspector: Sara M. Chmura
Rig Type: CME 75
Method: 6.25" HSA/5.875" Roller Cone/HQ Coring

PROJECT NAME Ekonol Facility
PROJECT NUMBER 441610

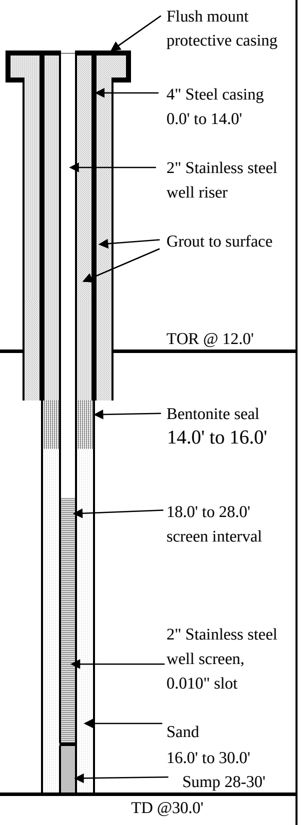
Location: South of St. Gobain facility within fence
Elevation:

Weather overcast, breezy, low 70s
Date/Time Start Coring 9/08/05 @ 1246
Date/Time Finish Coring 9/12/05 @ 1150



HQ Core Run	Range	Depth	Rec. (%)	RQD (%)	FIELD IDENTIFICATION OF MATERIAL
		0			
		1			
		2			
		3			Description of overburden material is consistent with other well locations.
		4			
		5			
		6			
		7			
		8			
		9			
		10			
		11			
		12			
		13			
		14			
# 1	14.0'-20.0'	15	87.5	53.0	Light grey dolomite, many styliolitic horizons, starting to lose some circulation at 20.0'.
		16			
		17			
		18			
		19			
		20			
# 2	20.0'-25.0'	21	96.7	91.4	20' to 21.5' grey/light grey dolomite, fewer styliolitic horizons, slightly porous, some mineralization
		22			
		23			21.5' to 25.0' grey/light grey dolomite, porous, vugs, few/none stylliolitic horizons, mineralization, slightly
		24			fossiliferous.
		25			
#3	25.0'-30.0'	26	96.0	85.0	Massive grey/dark grey dolomite, few to no stylliolitic horizons, some vugging, mineraliztion.
		27			lost circulation at 25.0'
		28			
		29			Porouse with trace fossil coral.
		30			

WELL CONSTRUCTION DIAGRAM



STANDARD PENETRATION
TOR= TOP OF ROCK

SUMMARY:
TOR was determined at HSA auger refusal.
well is 16.0' into bedrock.

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility*

Well ID: *MW-1S*

Well Diameter: 2 Inches

Samplers: *JWS, SMC*

Monitored Natural Attenuation Sample Set (Y/N)? Y

Purging Data

Method: Peristaltic Pump

Date/Time: 8/29/05 start 12:00

WELL VOLUME CALCULATION

= (Total Depth of Well - Depth To Water) x Casing Volume per Foot

= (15.1 - 6.85) x 0.16 = 1.3 gallons

Time	DTW	Pump Rate	Vol.	pH	DO	Turbidity	Spec. Cond.	Temp.	TDS	ORP	Comments
24 hr.	ft.	ml/min.	gal.		mg/L	NTU	mS/cm	°C	g/L	mv	
1222	6.10										
1231			1.00	7.27	0.00	40.00	4.25	18.99	-	-97	
1237			1.50	7.26	0.00	31.40	4.35	19.07	-	-96	
1242	7.12				0.00				-		
1247				7.29	0.00	28.70	4.38	18.66	-	-100	
1255			22.00	7.31	0.00	29.10	4.36	18.34	-	-103	
1308	7.75			7.36	0.00	29.40	4.24	17.94	-	-106	
1315			3.50	7.42	0.00	29.30	4.24	17.51	-	-105	
1320			3.90	7.42	0.00	29.10	4.07	17.15		-112	

Sampling Data

Method: *Peristaltic Pump*

Date/Time: *8/29/05 @ 14:30*

Total Volume of Water purged: 4 gal

Field Parameters

HORRIBA	
pH	7.42
Spec. Cond.(mS/cm)	4.07
Turbidity (NTU)	29.10
DO (mg/L)	0.00
Temp.(°C)	17.15
TDS (g/L)	-
ORP (mv)	-112.00

HACH TEST KITS	
Alkalinity (mg/L)	250 (methyl orange)
Carbon Dioxide (mg/L)	190.00
Ferrous Iron (mg/L)	3.80
Manganese (mg/L)	0.20
Hydrogen Sulfide (mg/L)	0.00

* NOTE * HACH test kits are only required for MNA analysis wells.

SAMPLE SET

Parameter	Bottle	Pres.	Method
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	3-40mL	HCl	SW3810 modified
Metals (MNA only)	1-1L plastic	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	1-250mL plastic	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	1-500mL plastic	none	SW9060
TOC (MNA only)	1-100mL glass	HCL	SW9060

Comments: Water was clear.

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility* Well ID: *MW-2S* Well Diameter: 2 Inches

Samplers: *SMC/DJL* Monitored Natural Attenuation Sample Set (Y/N)? Y

Purging Data

Method: Peristaltic Pump Date/Time: 8/30/05 @ 1612

WELL VOLUME CALCULATION
= (Total Depth of Well - Depth To Water) x Casing Volume per Foot
= (11.82 - 3.68) x 0.16 = 1.0 gallons

Time 24 hr.	**DTW** ft.	**Pump Rate** ml/min.	**Vol.** gal.	**pH**	**DO** mg/L	**Turbidity** NTU	**Spec. Cond.** mS/cm	**Temp.** °C	**TDS** g/L	**ORP** mv	**Comments**
1612	5.20	500	start	6.92	0.69	85.00	6.73	22.07	-	-111	
1617	8.01	500	1.00	6.95	2.24	41.00	5.81	19.91	-	-107	
1622	10.30	500	1.50	6.90	0.07	39.90	5.92	17.63	-	-115	DRY

Sampling Data

Method: *Peristaltic Pump* Date/Time: *8/21/05 @ 1545* Total Volume of Water purged: 2 gal

Field Parameters

HORRIBA		**HACH TEST KITS**	
pH	6.90	Alkalinity (mg/L)	860 mg/l (methyl orange)
Spec. Cond.(mS/cm)	5.92	Carbon Dioxide (mg/L)	526.00
Turbidity (NTU)	39.90	Ferrous Iron (mg/L)	5.60
DO (mg/L)	0.07	Manganese (mg/L)	0.60
Temp.(°C)	17.63	Hydrogen Sulfide (mg/L)	0.30
TDS (g/L)	-	* NOTE * HACH test kits are only required for MNA analysis wells.	
ORP (mv)	-115.00		

SAMPLE SET

Parameter	**Bottle**	**Pres.**	**Method**
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	3-40mL	HCl	SW3810 modified
Metals (MNA only)	1-1L plastic	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	1-250mL plastic	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	1-500mL plastic	none	SW9060
TOC (MNA only)	1-100mL glass	HCL	SW9060

Comments: Insufficient recharge rate, well sample on 8/31/05.

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility*

Well ID: *MW-3S*

Well Diameter: 2 Inches

Samplers: *DJL/SMC*

Monitored Natural Attenuation Sample Set (Y/N)? Y

Purging Data

WELL VOLUME CALCULATION
= (Total Depth of Well - Depth To Water) x Casing Volume per Foot
= (12.12 - 5.60) x 0.16 = 1.0 gallons

Method: Peristaltic Pump

Date/Time: 8/30/05 @ 1510

Time 24 hr.	**DTW** ft.	**Pump Rate** ml/min.	**Vol.** gal.	**pH**	**DO** mg/L	**Turbidity** NTU	**Spec. Cond.** mS/cm	**Temp.** ^{o}C	**TDS** g/L	**ORP** mv	**Comments**
1510	6.35	360.00	0.50								
1513	7.51			6.90	0.00	> 10.00	6.84	20.56	4.30	-141	
1518	7.64	200.00	1.00	6.83	0.00	>10.00	7.07	19.31	4.40	-130	
1526		200.00	1.75	6.96	0.00	30.00	8.35	16.64	5.30	-134	starting to go dry
1531		200.00	2.00	6.88	0.00	30.00	7.59	17.13	4.70	-136	moved tubing to bottom
1539		200.00	2.50	6.87	0.00	25.00	7.33	17.19	4.60	-175	
1544		200.00	2.75	6.90	0.00	2.30	7.31	16.89	4.60	-182	
1555	10.61	200.00	3.00	7.01	0.00	2.30	7.79	16.41	5.00	-183	DRY @ 3.0 g, will sample 8/31/05, not re-charging sufficiently

Sampling Data

Method: *Peristaltic Pump*

Date/Time: *8/31/05 @ 1520*

Total Volume of Water purged: 3 gal

Field Parameters

HORRIBA		**HACH TEST KITS**	
pH	7.01	Alkalinity (mg/L)	80 mg/l (methyl orange)
Spec. Cond.(mS/cm)	7.79	Carbon Dioxide (mg/L)	20 mg/l
Turbidity (NTU)	2.30	Ferrous Iron (mg/L)	0.00 mg/l
DO (mg/L)	0.00	Manganese (mg/L)	0.00 mg/l
Temp.(^{o}C)	16.41	Hydrogen Sulfide (mg/L)	0.00 mg/l
TDS (g/L)	5.00		
ORP (mv)	-183		

* NOTE * HACH test kits are only required for MNA analysis wells.

SAMPLE SET

Parameter	**Bottle**	**Pres.**	**Method**
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	3-40mL	HCl	SW3810 modified
Metals (MNA only)	1-1L plastic	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	1-250mL plastic	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	1-500mL plastic	none	SW9060
TOC (MNA only)	1-100mL glass	HCL	SW9060

Comments: Well was purged on 8/30/05 and sampled on 8/31/05 due to insufficient recharge rate.

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility* Well ID: *MW-4S* Well Diameter: 2 Inches

Samplers: *DJL* Monitored Natural Attenuation Sample Set (Y/N)? Y

Purging Data

Method: Peristaltic Pump Date/Time: 8/31/05 @ 1345

WELL VOLUME CALCULATION

= (Total Depth of Well - Depth To Water) x Casing Volume per Foot

= (12.43 - 8.10) x 0.16 = .7 gallons

Time 24 hr.	DTW ft.	Pump Rate ml/min.	Vol. gal.	pH	DO mg/L	Turbidity NTU	Spec. Cond. mS/cm	Temp. ^oC	TDS g/L	ORP mv	Comments
1350	-	start	-	6.62	0.00	> 1000*	5.87	16.37	3.70	-122	*Turb. Meter not working properly
1357	8.33	500.00	1.00	6.66	0.00	> 1000*	5.62	16.15	3.50	-164	
1402	-	-	2.00	6.67	0.00	887*	5.47	15.97	3.40	-179	
1410	8.15	500.00	3.00	6.68	0.00	872*	5.44	15.95	3.40	-185	

Sampling Data

Method: *Peristaltic Pump* Date/Time: *8/31/05 @ 1415* Total Volume of Water purged: 3 gal

Field Parameters

HORRIBA		HACH TEST KITS	
pH	6.68	Alkalinity (mg/L)	500 (methyl orange)
Spec. Cond.(mS/cm)	5.45	Carbon Dioxide (mg/L)	226.00
Turbidity (NTU)	840.00	Ferrous Iron (mg/L)	0.20
DO (mg/L)	0.00	Manganese (mg/L)	0.00
Temp.(^oC)	15.98	Hydrogen Sulfide (mg/L)	1.00
TDS (g/L)	3.40	* NOTE * HACH test kits are only required for MNA analysis wells.	
ORP (mv)	-187		

SAMPLE SET

Parameter	Bottle	Pres.	Method
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	3-40mL	HCl	SW3810 modified
Metals (MNA only)	1-1L plastic	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	1-250mL plastic	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	1-500mL plastic	none	SW9060
TOC (MNA only)	1-100mL glass	HCL	SW9060

Comments: Turbidy meter not working properly, water is less than 50 NTU upon sampling.

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility* Well ID: *MW-5S* Well Diameter: 2 Inches

Samplers: *JSW, DJL, SMC* Monitored Natural Attenuation Sample Set (Y/N)? N

Purging Data

Method: Peristaltic Pump Date/Time: 8/29/05 @ 0930

WELL VOLUME CALCULATION
= (Total Depth of Well - Depth To Water) x Casing Volume per Foot
= (14.4 - 8.75) x 5.65 = .9 gallons

Time	DTW	Pump Rate	Vol.	pH	DO	Turbidity	Spec. Cond.	Temp.	TDS	ORP	Comments
24 hr.	ft.	ml/min.	gal.		mg/L	NTU	mS/cm	^{o}C	g/L	mv	
930	9.12			7.04	0.00	High	5.24	16.72		-24	Turb with flow thru cell
940		250.00	1.00	7.23	0.00	280.00	5.29	15.36		-56	Turb with flow thru cell
946	8.98	250.00		7.26	0.00	213.00	4.93	15.11		-58	Turb with flow thru cell
952				7.28	0.00	153.00	4.43	15.36		-60	Turb with flow thru cell
1002			2.00	7.31	0.00	80.10	3.67	16.09		-61	Turb clearing up
1005				7.30	0.00	59.20	3.54	15.97		-61	
1010				7.31	0.00	56.20	3.31	15.11		-60	
1020	8.99	250.00	2.30	7.30	0.00	47.20	3.04	15.01		-59	
1025		250.00		7.31	0.00	47.80	2.92	14.94		-59	

Sampling Data

Method: *Peristaltic Pump* Date/Time: *8/29/05 @ 1030* Total Volume of Water purged: ~ 4 gal

Field Parameters

HORRIBA		HACH TEST KITS	
pH	7.31	Alkalinity (mg/L)	N/A
Spec. Cond.(mS/cm)	2.92	Carbon Dioxide (mg/L)	N/A
Turbidity (NTU)	47.80	Ferrous Iron (mg/L)	N/A
DO (mg/L)	0.00	Manganese (mg/L)	N/A
Temp.(^{o}C)	14.94	Hydrogen Sulfide (mg/L)	N/A
TDS (g/L)			
ORP (mv)	-59.00		

<u>* NOTE *</u> HACH test kits are only required for MNA analysis wells.

SAMPLE SET			
Parameter	**Bottle**	**Pres.**	**Method**
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	3-40mL	HCl	SW3810 modified
Metals (MNA only)	1-1L plastic	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	1-250mL plastic	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	1-500mL plastic	none	SW9060
TOC (MNA only)	1-100mL glass	HCL	SW9060

Comments:

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility* Well ID: *MW-6S* Well Diameter: 2 Inches

Samplers: *DJL* Monitored Natural Attenuation Sample Set (Y/N)? Y

Purging Data

WELL VOLUME CALCULATION
= (Total Depth of Well - Depth To Water) x Casing Volume per Foot
= (14.0 - 9.05) x 0.16 = 0.7 gallons

Method: Peristaltic Pump Date/Time: 8/30/2005 @ 1500

Time 24 hr.	DTW ft.	Pump Rate ml/min.	Vol. gal.	pH	DO mg/L	Turbidity NTU	Spec. Cond. mS/cm	Temp. ^{o}C	TDS g/L	ORP mv	Comments
1630	-	500.00	start	7.13	0.00	60.00	5.60	17.55	-	-22	
1636	-	500.00	1.00	7.30	5.00	54.00	5.64	17.36	-	-19	
1642	-	500.00	1.50	7.36	3.90	106.00	5.98	15.93	-	-29	
1648	-	500.00	2.50	7.12	0.00	34.00	5.61	16.01	-	-42	
1651	-	500.00	3.00	7.12	0.00	36.00	5.62	15.92	-	-49	

Sampling Data

Method: *Peristaltic Pump* Date/Time: *8/31/05 @ 1400* Total Volume of Water purged: 3 gal

Field Parameters

HORRIBA		HACH TEST KITS	
pH	7.12	Alkalinity (mg/L)	100 mg/l (phenolpthlalene)
Spec. Cond.(mS/cm)	5.62	Carbon Dioxide (mg/L)	0.00
Turbidity (NTU)	36.00	Ferrous Iron (mg/L)	0.00
DO (mg/L)	0.00	Manganese (mg/L)	0.00
Temp.(^{o}C)	15.92	Hydrogen Sulfide (mg/L)	0.00
TDS (g/L)	-		
ORP (mv)	-49.00		

* NOTE * HACH test kits are only required for MNA analysis wells.

SAMPLE SET			
Parameter	**Bottle**	**Pres.**	**Method**
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	3-40mL	HCl	SW3810 modified
Metals (MNA only)	1-1L plastic	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	1-250mL plastic	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	1-500mL plastic	none	SW9060
TOC (MNA only)	1-100mL glass	HCL	SW9060

Comments:

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility*　　Well ID: *MW-7S*　　Well Diameter: 2 Inches

Samplers: *JWS/SMC*　　Monitored Natural Attenuation Sample Set (Y/N)? N

Purging Data

Method: Peristaltic Pump　　Date/Time: 8/29/05 @ 1455

WELL VOLUME CALCULATION

= (Total Depth of Well - Depth To Water) x Casing Volume per Foot

= (13.5 - 7.18) x 0.16 = 1.0 gallons

Time 24 hr.	DTW ft.	Pump Rate ml/min.	Vol. gal.	pH	DO mg/L	Turbidity NTU	Spec. Cond. mS/cm	Temp. °C	TDS g/L	ORP mv	Comments
1700	start										
1705	7.95	225.00	0.10	6.66	0.00	52.00	5.04	19.48	3.20	-146	
1712	8.35	225.00		6.66	0.00	36.20	5.10	19.21	3.20	-137	
1717	9.40	100.00	1.20	6.66	0.00	28.00	5.12	19.26	3.20	-139	
1725				6.68	0.03	20.00	5.17	18.92	3.20	-137	Clear
1733	11.21	400+	3.00	6.70	0.00	20.00	5.15	16.43	3.20	-135	Pump up
1738	11.48	200.00	3.10	6.73	0.00	18.00	5.13	17.01	3.20	-126	Turned pump down
1743		170.00	3.20	6.75	0.00	18.00	5.13	16.95	3.20	-131	Turned pump down again
1749		well	went	dry							

Sampling Data

Method: *Peristaltic Pump*　　Date/Time: *8/29/05 @1800*
8/30/05 @ 0900　　Total Volume of Water purged: 3.2 gal

Field Parameters

HORRIBA		HACH TEST KITS	
pH	6.75	Alkalinity (mg/L)	N/A
Spec. Cond.(mS/cm)	5.13	Carbon Dioxide (mg/L)	N/A
Turbidity (NTU)	18.00	Ferrous Iron (mg/L)	N/A
DO (mg/L)	0.00	Manganese (mg/L)	N/A
Temp.(°C)	16.95	Hydrogen Sulfide (mg/L)	N/A
TDS (g/L)	3.20		
ORP (mv)	-131		

* NOTE * HACH test kits are only required for MNA analysis wells.

SAMPLE SET

Parameter	Bottle	Pres.	Method
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	3-40mL	HCl	SW3810 modified
Metals (MNA only)	1-1L plastic	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	1-250mL plastic	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	1-500mL plastic	none	SW9060
TOC (MNA only)	1-100mL glass	HCL	SW9060

Comments: Well had insufficient water to fill bottle set. VOCs were sampled and sent to the lab on 8/30/05 and SVOCs were collected and sent to the lab on 8/31/05.

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility*
Well ID: *MW-8S*
Well Diameter: 2 Inches

Samplers: *DJL*
Monitored Natural Attenuation Sample Set (Y/N)? N

Purging Data

Method: Peristaltic Pump
Date/Time: 8/31/05 @ 1645

WELL VOLUME CALCULATION
= (Total Depth of Well - Depth To Water) x Casing Volume per Foot
= (13.60 - 6.22) x 0.16 = 1.2 gallons

Time 24 hr.	**DTW** ft.	**Pump Rate** ml/min.	**Vol.** gal.	**pH**	**DO** mg/L	**Turbidity** NTU	**Spec. Cond.** mS/cm	**Temp.** ^oC	**TDS** g/L	**ORP** mv	**Comments**
1612	-	400.00	0.50	11.16	3.49	735.00	2.62	20.47	1.80	-131	
1617	-	400.00	1.00	11.23	0.44	724.00	4.03	19.65	2.60	-151	
1623	-	400.00	2.00	10.61	1.10	757.00	4.43	18.13	3.10	-147	
1628	-	400.00	2.50	11.26	0.32	724.00	4.60	17.86	3.10	-162	
1633	-	400.00	3.00	11.41	0.23	684.00	4.80	17.73	3.10	-161	
1638	11.70	400.00	3.50	11.04	0.00	684.00	4.50	17.41	2.90	-175	

Sampling Data

Method: *Peristaltic Pump*
Date/Time: *8/31/05 @ 1645*
Total Volume of Water purged: 3.8 gal

Field Parameters

HORRIBA	
pH	11.14
Spec. Cond.(mS/cm)	4.45
Turbidity (NTU)	684.00
DO (mg/L)	0.00
Temp.(^oC)	17.40
TDS (g/L)	2.80
ORP (mv)	-171

HACH TEST KITS	
Alkalinity (mg/L)	N/A
Carbon Dioxide (mg/L)	N/A
Ferrous Iron (mg/L)	N/A
Manganese (mg/L)	N/A
Hydrogen Sulfide (mg/L)	N/A

* NOTE * HACH test kits are only required for MNA analysis wells.

SAMPLE SET

Parameter	**Bottle**	**Pres.**	**Method**
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	3-40mL	HCl	SW3810 modified
Metals (MNA only)	1-1L plastic	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	1-250mL plastic	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	1-500mL plastic	none	SW9060
TOC (MNA only)	1-100mL glass	HCL	SW9060

Comments: Turbidity meter not functioning properly, water is clear upon sampling (less than 50 NTU).

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility*　Well ID: *MW-9S*　Well Diameter: 2 Inches

Samplers: *DJL/SMC*　Monitored Natural Attenuation Sample Set (Y/N)? N

Purging Data

WELL VOLUME CALCULATION
= (Total Depth of Well - Depth To Water) x Casing Volume per Foot
= (13.98 - 9.33) x 0.16 = 0.74 gallons

Method: Peristaltic Pump　Date/Time: 8/30/05 @ 1540

Time 24 hr.	DTW ft.	Pump Rate ml/min.	Vol. gal.	pH	DO mg/L	Turbidity NTU	Spec. Cond. mS/cm	Temp. ^{o}C	TDS g/L	ORP mv	Comments
1540	9.65	400.00	start	7.03	0.23	200.00	5.36	18.49	-	-50	
1550	10.61	400.00	1.50	6.99	1.20	170.00	4.22	17.71	-	-30	
1558	-	400.00	2.50	7.20	6.89	153.00	4.74	18.17	-	-45	
1602	-	200.00	3.00	7.00	6.23	89.00	5.16	17.11	-	-34	

Sampling Data

Method: *Peristaltic Pump*　Date/Time: *8/31/05 @ 1325*　Total Volume of Water purged: 3 gal

Field Parameters

HORRIBA		HACH TEST KITS	
pH	7.00	Alkalinity (mg/L)	N/A
Spec. Cond.(mS/cm)	5.16	Carbon Dioxide (mg/L)	N/A
Turbidity (NTU)	89.00	Ferrous Iron (mg/L)	N/A
DO (mg/L)	6.23	Manganese (mg/L)	N/A
Temp.(^{o}C)	17.11	Hydrogen Sulfide (mg/L)	N/A
TDS (g/L)	-	* NOTE * HACH test kits are only required for MNA analysis wells.	
ORP (mv)	-34		

SAMPLE SET

Parameter	Bottle	Pres.	Method
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	3-40mL	HCl	SW3810 modified
Metals (MNA only)	1-1L plastic	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	1-250mL plastic	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	1-500mL plastic	none	SW9060
TOC (MNA only)	1-100mL glass	HCL	SW9060

Comments: Replaced tubing in well. Turbidity meter not functioning correctly, water is clear (below 50 NTU) upon sampling, insufficient recharge; well sampled on 8/31/05.

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility*
Well ID: *MW-10S*
Well Diameter: 2 Inches

Samplers: *DJL*
Monitored Natural Attenuation Sample Set (Y/N)? Y

Purging Data

WELL VOLUME CALCULATION
= (Total Depth of Well - Depth To Water) x Casing Volume per Foot
= (11.75 - 9.00) x 0.16 = .44 gallons x 3 = 1.3

Method: Peristaltic Pump
Date/Time: 9/15/2005

Time	**DTW**	**Pump Rate**	**Vol.**	**pH**	**DO**	**Turbidity**	**Spec. Cond.**	**Temp.**	**TDS**	**ORP**	**Comments**
24 hr.	ft.	ml/min.	gal.		mg/L	NTU	mS/cm	°C	g/L	mv	
start	9.00	350.00	0.00	7.22	1.44	542.00	2.66	15.70	-	-93	
1153	-	-	0.50	7.40	0.81	431.00	2.49	14.76	-	-120	
1157	-	-	1.00	7.42	0.61	183.00	2.30	14.68	-	-121	
1204	9.05			7.42	0.77	122.00	2.21	14.54	-	-123	
1209	9.05	350.00	2.50	7.44	0.00	22.10	2.11	14.40	-	-133	
1213		350.00	3.00	7.44	0.00	9.10	2.08	14.45	-	-135	
1211	9.05	350.00	4.00	7.43	0.00	0.20	2.07	14.44	-	-138	

Sampling Data

Method: *Peristaltic Pump*
Date/Time: *9/15/05 @ 1230*
Total Volume of Water purged: 4.4 gal

Field Parameters

HORRIBA	
pH	7.43
Spec. Cond.(mS/cm)	2.07
Turbidity (NTU)	0.20
DO (mg/L)	0.00
Temp.(°C)	14.44
TDS (g/L)	-
ORP (mv)	-138

HACH TEST KITS	
Alkalinity (mg/L)	Phenol Alk = 0 320 methyl orange
Carbon Dioxide (mg/L)	195
Ferrous Iron (mg/L)	1.2
Manganese (mg/L)	0
Hydrogen Sulfide (mg/L)	0

* NOTE * HACH test kits are only required for MNA analysis wells.

SAMPLE SET

Parameter	**Bottle**	**Pres.**	**Method**
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	3-40mL	HCl	SW3810 modified
Metals (MNA only)	1-1L plastic	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	1-250mL plastic	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	1-500mL plastic	none	SW9060
TOC (MNA only)	1-100mL glass	HCL	SW9060

Comments:

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility*
Well ID: *MW-11S*
Well Diameter: 2 Inches
Samplers: *DJL*
Monitored Natural Attenuation Sample Set (Y/N)? Y

Purging Data

Method: Peristaltic Pump
Date/Time: 9/15/05 @ 1317

WELL VOLUME CALCULATION
= (Total Depth of Well - Depth To Water) x Casing Volume per Foot
= (13.78 - 10.02) x 0.16 = .6 gallons x 3 = 1.8

Time	**DTW**	**Pump Rate**	**Vol.**	**pH**	**DO**	**Turbidity**	**Spec. Cond.**	**Temp.**	**TDS**	**ORP**	**Comments**
24 hr.	ft.	ml/min.	gal.		mg/L	NTU	mS/cm	^{o}C	g/L	mv	
1318	-	400.00	0.00	7.24	0.01	> 1000	509.00	17.02	-	-36	
1325	10.15	400.00	1.00	7.20	0.00	> 1000	4.96	16.51	-	-28	
1338	-	-	2.00	7.22	0.00	443.00	4.81	16.59	-	-28	
1340	-	-	3.00	7.24	0.00	151.00	4.66	16.44	-	-27	
1345		-	3.20	7.23	0.00	40.00	4.63	16.45	-	-27	

Sampling Data

Method: *Peristaltic Pump*
Date/Time: *9/15/05 @ 1345*
Total Volume of Water purged: 3 gal

Field Parameters

HORRIBA		**HACH TEST KITS**	
pH	7.23	Alkalinity (mg/L)	0 phenol alk 360 methyl orange
Spec. Cond.(mS/cm)	4.63	Carbon Dioxide (mg/L)	313
Turbidity (NTU)	40.00	Ferrous Iron (mg/L)	1.5
DO (mg/L)	0.00	Manganese (mg/L)	0
Temp.(^{o}C)	16.45	Hydrogen Sulfide (mg/L)	
TDS (g/L)	-		
ORP (mv)	-27		

* NOTE * HACH test kits are only required for MNA analysis wells.

SAMPLE SET			
Parameter	**Bottle**	**Pres.**	**Method**
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	3-40mL	HCl	SW3810 modified
Metals (MNA only)	1-1L plastic	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	1-250mL plastic	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	1-500mL plastic	none	SW9060
TOC (MNA only)	1-100mL glass	HCL	SW9060

Comments:

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility* Well ID: *MW-12S* Well Diameter: 2 Inches

Samplers: *DJL* Monitored Natural Attenuation Sample Set (Y/N)? Y

Purging Data

WELL VOLUME CALCULATION
= (Total Depth of Well - Depth To Water) x Casing Volume per Foot
= (-) x 0.16 = gallons

Method: Peristaltic Pump Date/Time: 9/15/2005

Time	DTW	Pump Rate	Vol.	pH	DO	Turbidity	Spec. Cond.	Temp.	TDS	ORP	Comments
24 hr.	ft.	ml/min.	gal.		mg/L	NTU	mS/cm	^oC	g/L	mv	
Not enough water for these parameters. Well went dry.											

Sampling Data

Method: *Peristaltic Pump* Date/Time: *9/15/05 @ 1530* Total Volume of Water purged: 1 gal

Field Parameters

HORRIBA		HACH TEST KITS	
pH	7.56	Alkalinity (mg/L)	0 phenol alk 360 methyl orange
Spec. Cond.(mS/cm)	3.67	Carbon Dioxide (mg/L)	180
Turbidity (NTU)	9999.00	Ferrous Iron (mg/L)	1.8
DO (mg/L)	6.78	Manganese (mg/L)	0
Temp.(^oC)	18.68	Hydrogen Sulfide (mg/L)	0
TDS (g/L)	-		
ORP (mv)	-58		

* NOTE * HACH test kits are only required for MNA analysis wells.

SAMPLE SET

Parameter	Bottle	Pres.	Method
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	3-40mL	HCl	SW3810 modified
Metals (MNA only)	1-1L plastic	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	1-250mL plastic	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	1-500mL plastic	none	SW9060
TOC (MNA only)	1-100mL glass	HCL	SW9060

Comments: Well went dry, brown muddy water for sample jars, except VOCs and MEE which were sampled first. Well was purged dry and allowed to recover.

LOW FLOW WELL SAMPLING RECORD

Site Name: *Ekonol Facility*

Well ID: *MW-12S*

Well Diameter: 2 Inches

Samplers: *JWS DJL*

Monitored Natural Attenuation Sample Set (Y/N)? N

Purging Data

Method: Bailer

Date/Time: 11/7/2005

WELL VOLUME CALCULATION
= (Total Depth of Well - Depth To Water) x Casing Volume per Foot
= (12.49 - 8.42) x 0.16 = 0.65 gallons

Time	**DTW**	**Pump Rate**	**Vol.**	**pH**	**DO**	**Turbidity**	**Spec. Cond.**	**Temp.**	**TDS**	**ORP**	**Comments**
24 hr.	ft.	ml/min.	gal.		mg/L	NTU	mS/cm	^oC	g/L	mv	
1310	8.42	NA	2	6.88	NS	Turbidity	4.39	62.40	NS	NS	Well went dry

Sampling Data

Method: *bailer*

Date/Time: *11/7/05 1400*

Total Volume of Water purged: 2.1

Field Parameters

HORRIBA		**HACH TEST KITS**	
pH	6.79	Alkalinity (mg/L)	NS
Spec. Cond.(mS/cm)	3.34	Carbon Dioxide (mg/L)	NS
Turbidity (NTU)	turbid	Ferrous Iron (mg/L)	NS
DO (mg/L)	NS	Manganese (mg/L)	NS
Temp.(^oC)	6.25	Hydrogen Sulfide (mg/L)	NS
TDS (g/L)	NS		
ORP (mv)	NS		

* NOTE * HACH test kits are only required for MNA analysis wells. This well was previously sampled.

SAMPLE SET

Parameter	**Bottle**	**Pres.**	**Method**
Select VOCs	3-40mL	HCl	EPA 8260
Select SVOCs	2-1L amber	none	EPA 8270
MEE (MNA only)	NS	HCl	SW3810 modified
Metals (MNA only)	NS	HNO_3	EPA 200.7 or 200.9
XNO3O (MNA only)	NS	H_2SO_4	IC E300
XNO3/CHL/SO4 (MNA only)	NS	none	SW9060
TOC (MNA only)	NS	HCL	SW9060

Comments: Resampled well.

NS = not sampled

APPENDIX B – LABORATORY DATA USABILITY REPORT AND ANALYTICAL DATA

DATA USABILITY SUMMARY REPORT

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

Prepared for:

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

270 Michigan Avenue

Buffalo, New York 14203

Submitted by:

Atlantic Richfield Company

A BP affiliated company

4850 East 49th Street
Cuyahoga Heights, Ohio 44125

Prepared by:

PARSONS

180 LAWRENCE BELL DRIVE, SUITE 104

WILLIAMSVILLE, NEW YORK 14221

December 2005

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SECTION 1

DATA USABILITY SUMMARY

Groundwater and soil samples were collected from the Ekonol site in Wheatfield, New York from August 29, 2005 through November 7, 2005. Analytical results from these samples were reviewed by Parsons for usability with respect to the following requirements:

- Work Plan,
- NYSDEC Analytical Services Protocol (ASP), and
- USEPA Region II Standard Operating Procedures (SOPs).

The analytical laboratory for this project was Accutest Laboratories, Inc. (Accutest).

1.1 LABORATORY DATA PACKAGES

The laboratory data package turnaround time, defined as the time from sample receipt by the laboratory to receipt of the analytical data packages by Parsons, was 34 days on average for the Ekonol samples.

The data packages received from Accutest were paginated, complete, and overall were of good quality. Comments on specific quality control (QC) and other requirements are discussed in detail in the attached data validation report.

1.2 SAMPLING AND CHAIN-OF-CUSTODY

The samples were collected, properly preserved, shipped under a COC record, and received at Accutest within one day of sampling. All samples were received intact and in good condition at Accutest.

1.3 LABORATORY ANALYTICAL METHODS

The groundwater samples collected from the Ekonol site were analyzed for volatile organic compounds (VOCs) including methane, ethane, and ethene, the semivolatile organic compounds (SVOCs) phenol and aniline, arsenic, chloride, nitrate, nitrite, nitrate/nitrite, sulfate, and total organic carbon (TOC). The soil samples were collected from the site and analyzed for VOCs, the SVOCs phenol and aniline, and total alkalinity. Summaries of issues concerning these laboratory analyses are presented in Subsections 1.3.1 through 1.3.4. The data qualifications resulting from the data review and statements on the laboratory analytical precision, accuracy, representativeness, completeness, and comparability (PARCC) are discussed for each analytical method in Section 2. The laboratory data were reviewed and may be qualified with the following validation flags:

"U" - not detected at the value given,

"UJ" - estimated and not detected at the value given,

"J" - estimated at the value given,

"N" - presumptive evidence at the value given, and

"R" - unusable value.

The validated laboratory data were tabulated and are presented in Attachment A.

1.3.1 Volatile Organic Analysis

The groundwater and soil samples collected from the Ekonol site were analyzed for certain VOCs using the NYSDEC ASP 8260B analytical method. In addition, the groundwater samples were analyzed for methane, ethane, and ethene using the NYSDEC ASP 8015D analytical method. Certain reported results for the VOC samples were qualified as unusable due to grossly exceeded holding times. However, the final reported VOC and methane, ethane, and ethene analytical results were 100% complete (i.e., usable) for the groundwater and soil data presented by Accutest. PARCC requirements were met overall.

1.3.2 Semivolatile Organic Analysis

The groundwater and soil samples collected from the Ekonol site were analyzed by Accutest for certain SVOCs using the NYSDEC ASP 8270C analytical method. The reported SVOC results did not require qualification resulting from review of the data. Therefore, the reported SVOC analytical results were 100% complete (i.e., usable) for the groundwater and soil data presented by Accutest. PARCC requirements were met overall.

1.3.3 Arsenic Analysis

The groundwater samples collected from the Ekonol site were analyzed for arsenic using the NYSDEC ASP 200.7 analytical method. The reported arsenic results did not require qualification resulting from data validation. Therefore, the reported arsenic analytical results were 100% complete (i.e., usable) for the groundwater data presented by Accutest. PARCC requirements were met overall.

1.3.4 Other Parameters

The groundwater samples collected from the Ekonol site were analyzed for chloride, nitrate, nitrate/nitrite, nitrite, sulfate, and TOC using the NYSDEC ASP 300.0/9056, 353.2, 353.2, SM19 4500NO2B, 300.0/9056, and 415.1/9060M analytical methods, respectively; and soil samples were collected and analyzed for total alkalinity using the NYSDEC ASP 310.1 analytical method. All holding times, calibrations, laboratory blanks, control samples, field duplicate precision, and instrumentation were reviewed for compliance. The reported results for these parameters did not require qualification resulting from data validation, with the exception of the nondetected nitrite results for samples MW-12S, MW-20D, and MW-11S. These results were considered estimated and qualified “UJ” since the 48-hour holding time was exceeded by two days. Therefore, the reported analytical results for these parameters were 100% complete (i.e., usable) for the groundwater and soil data presented by Accutest. PARCC requirements were met overall.

SECTION 2

DATA VALIDATION REPORT

2.1 GROUNDWATER

Data review has been completed for data packages generated by Accutest containing groundwater samples collected from the Ekonol site. The specific samples contained in these data packages, the analyses performed, and a usability summary are presented in Table 2.1-1. All of these samples were properly preserved, shipped under a COC record, and received intact by the analytical laboratory. The validated laboratory data are presented in Attachment A-1.

Data validation was performed for all samples in accordance with the most current editions of the USEPA Region II SOPs and the NYSDEC ASP for organic and inorganic data review. This data validation and usability report is presented by analysis type.

2.1.1 Volatiles Including Methane, Ethane, and Ethene

The following items were reviewed for compliancy in the volatile analysis:

- Custody documentation
- Holding times
- Surrogate recoveries
- Matrix spike/matrix spike duplicate (MS/MSD) precision and accuracy
- Matrix spike blank (MSB) recoveries
- Laboratory method blank and trip blank contamination
- GC/MS instrument performance
- Sample result verification and identification
- Initial and continuing calibrations
- Internal standard area counts and retention times
- Field duplicate precision
- Quantitation limits
- Data completeness

These items were considered compliant and acceptable in accordance with the validation protocols with the exception of holding times and MS/MSD precision and accuracy.

<u>Holding Times</u>

All analytical holding times were compliant for all samples with the exception of MW-12S. Due to laboratory error, this sample grossly exceeded the analytical holding time by 26 days. Therefore, results for this sample were considered unusable and qualified “R”. As a result, MW-12S was resampled with the results reported in the validated laboratory data table in Attachment A-1.

MS/MSD Precision and Accuracy

All MS/MSD precision results (relative percent differences; RPDs) and accuracy results (percent recoveries; %Rs) were considered compliant and within QC acceptance limits during spiked analyses with the exception of the MS/MSD recoveries during the spiked analyses of MW-15D, MW-2S, RMW-4D, and RMW-2D. Validation qualification of the unspiked samples MW-15D, MW-2S, RMW-4D, and RMW-2D was not warranted due to large sample concentrations and compliant surrogate recoveries and internal standard responses.

Usability

All final volatile groundwater sample results including methane, ethane, and ethene were considered usable following data validation.

Summary

The quality assurance objectives for measurement data included considerations for precision, accuracy, representativeness, completeness, and comparability. The final volatile groundwater data presented by Accutest were 100% complete with all volatile data considered usable and valid. The validated volatile laboratory data are tabulated and presented in Attachment A-1.

2.1.2 Semivolatiles

The following items were reviewed for compliancy in the semivolatile analysis:

- Custody documentation
- Holding times
- Surrogate recoveries
- MS/MSD precision and accuracy
- MSB recoveries
- Laboratory method blank contamination
- GC/MS instrument performance
- Sample result verification and identification
- Initial and continuing calibrations
- Internal standard area counts and retention times
- Field duplicate precision
- Quantitation limits
- Data completeness

These items were considered compliant and acceptable in accordance with the validation protocols.

Usability

All semivolatile groundwater sample results were considered usable following data validation.

Summary

The quality assurance objectives for measurement data included considerations for precision, accuracy, representativeness, completeness, and comparability. The semivolatile groundwater data presented by Accutest were 100% complete with all data considered usable and valid. The validated semivolatile laboratory data are tabulated and presented in Attachment A-1.

2.1.3 Arsenic

The following items were reviewed for compliancy in the arsenic analysis:

- Custody documentation
- Holding times
- Initial and continuing calibration verifications
- Initial and continuing calibration, and laboratory preparation blank contamination
- Matrix spike recoveries
- Laboratory duplicate precision
- Field duplicate precision
- Laboratory control sample
- Sample result verification and identification
- Quantitation limits
- Data completeness

These items were considered compliant and acceptable in accordance with the validation protocols.

Usability

All arsenic sample results were considered usable following data validation.

Summary

The quality assurance objectives for measurement data included considerations for precision, accuracy, representativeness, completeness, and comparability. The arsenic data presented by Accutest were 100% complete (i.e., usable). The validated groundwater arsenic laboratory data are tabulated and presented in Attachment A-1.

2.2 SOIL

Data review has been completed for data packages generated by Accutest containing soil samples collected from the Ekonol site. The specific samples contained in these data packages, the analyses performed, and a usability summary are presented in Table 2.2-1. All of these samples were properly preserved, shipped under a COC record, and received intact by the analytical laboratory. The validated laboratory data are presented in Attachment A-2.

Data validation was performed for all samples in accordance with the most current editions of the USEPA Region II SOPs and the NYSDEC ASP for organic and inorganic data review. This data validation and usability report is presented by analysis type.

2.2.1 Volatiles

The following items were reviewed for compliancy in the volatile analysis:

- Custody documentation
- Holding times
- Surrogate recoveries
- Matrix spike/matrix spike duplicate (MS/MSD) precision and accuracy
- Matrix spike blank (MSB) recoveries
- Laboratory method blank and trip blank contamination
- GC/MS instrument performance
- Sample result verification and identification
- Initial and continuing calibrations
- Internal standard area counts and retention times
- Quantitation limits
- Data completeness

These items were considered compliant and acceptable in accordance with the validation protocols with the exception of MS/MSD precision and accuracy.

MS/MSD Precision and Accuracy

All MS/MSD precision results (relative percent differences; RPDs) and accuracy results (percent recoveries; %Rs) were considered compliant and within QC acceptance limits during spiked analyses with the exception of MS/MSD recoveries during the spiked analyses of BH-1A. Validation qualification of BH-1A was not warranted since surrogate recoveries and internal standard responses in this sample were compliant confirming the absence of matrix effects.

Usability

All volatile soil sample results were considered usable following data validation.

Summary

The quality assurance objectives for measurement data included considerations for precision, accuracy, representativeness, completeness, and comparability. The volatile soil data presented by Accutest were 100% complete with all volatile data considered usable and valid. The validated volatile laboratory data are tabulated and presented in Attachment A-2.

2.2.2 Semivolatiles

The following items were reviewed for compliancy in the semivolatile analysis:

- Custody documentation
- Holding times
- Surrogate recoveries
- MS/MSD precision and accuracy
- MSB recoveries
- Laboratory method blank contamination
- GC/MS instrument performance
- Sample result verification and identification
- Initial and continuing calibrations
- Internal standard area counts and retention times
- Quantitation limits
- Data completeness

These items were considered compliant and acceptable in accordance with the validation protocols.

Usability

All semivolatile soil sample results were considered usable following data validation.

Summary

The quality assurance objectives for measurement data included considerations for precision, accuracy, representativeness, completeness, and comparability. The semivolatile soil data presented by Accutest were 100% complete with all data considered usable and valid. The validated semivolatile laboratory data are tabulated and presented in Attachment A-2.

TABLE 2.1-1

SUMMARY OF SAMPLE ANALYSES AND USABILITY EKONOL - GROUNDWATER

SAMPLE ID	MATRIX	SAMPLE DATE	VOCs	METHANE, ETHANE, ETHENE	SVOCs	ARSENIC	OTHER	FOOTNOTES
MW-11D	WATER	8/29/05	OK	OK	OK	OK	OK	
MW-7S	WATER	8/29/05	OK		OK			
TRIP BLANK	WATER	8/29/05	OK					
MW-5S	WATER	8/29/05	OK		OK			
MW-1S	WATER	8/29/05	OK	OK	OK	OK	OK	
MW-14D	WATER	8/29/05	OK	OK	OK			
MW-17D	WATER	8/29/05	OK		OK			
RMW-1D	WATER	8/29/05	OK	OK	OK	OK	OK	
RMW-100D	WATER	8/29/05	OK	OK	OK	OK	OK	
TRIP BLANK	WATER	8/29/05	OK					
MW-15D	WATER	8/30/05	OK	OK	OK	OK	OK	
MW-19D	WATER	8/30/05	OK		OK			
MW-7S	WATER	8/30/05	OK	OK	OK			
MW-13D	WATER	8/30/05	OK	OK	OK	OK	OK	
MW-16D	WATER	8/30/05	OK		OK			
MW-18D	WATER	8/30/05	OK		OK			
MW-12D	WATER	8/30/05	OK		OK			
RMW-3D	WATER	8/30/05	OK	OK	OK	OK	OK	
TRIP BLANK	WATER	8/30/05	OK					
MW-9S	WATER	8/31/05	OK		OK			
MW-6S	WATER	8/31/05	OK	OK	OK	OK	OK	
MW-4S	WATER	8/31/05	OK	OK	OK	OK	OK	
MW-3S	WATER	8/31/05	OK	OK	OK	OK	OK	
MW-2S	WATER	8/31/05	OK	OK	OK	OK	OK	
MW-8S	WATER	8/31/05	OK		OK			
RMW-4D	WATER	8/31/05	OK	OK	OK	OK	OK	
TRIP BLANK	WATER	8/31/05	OK					
RMW-2D	WATER	9/1/05	OK	OK	OK	OK	OK	
MW-10D	WATER	9/1/05	OK		OK			
TRIP BLANK	WATER	9/1/05	OK					

TABLE 2.1-1 - CONTINUED

SUMMARY OF SAMPLE ANALYSES AND USABILITY
EKONOL - GROUNDWATER

SAMPLE ID	MATRIX	SAMPLE DATE	VOCs	METHANE, ETHANE, ETHENE	SVOCs	ARSENIC	OTHER	FOOTNOTES
MW-10S	WATER	9/15/05	OK	OK	OK	OK	OK	
MW-12S	WATER	9/15/05	NO			OK	OK	1
MW-20D	WATER	9/15/05	OK	OK	OK	OK	OK	
MW-11S	WATER	9/15/05	OK	OK	OK	OK	OK	
TRIP BLANK	WATER	9/15/05	OK					
MW-12S	WATER	11/7/05	OK	OK	OK			
TRIP BLANK	WATER	11/7/05	OK					
TOTAL SAMPLES			37	19	29	17	17	

NOTES: OK - Sample analysis considered valid and usable.
NO - Sample analysis has noncompliances resulting in unusable data. See appropriate footnote.

FOOTNOTES: 1 - Volatile sample grossly exceeded holding times. This sample was recollected.

TABLE 2.2-1

SUMMARY OF SAMPLE ANALYSES AND USABILITY EKONOL - SOIL

SAMPLE ID	MATRIX	SAMPLE DATE	VOCs	SVOCs	OTHER
BH-1A	SOIL	9/21/05	OK	OK	OK
BH-2A	SOIL	9/21/05	OK	OK	OK
BH-3A	SOIL	9/21/05	OK	OK	OK
BH-4A	SOIL	9/21/05	OK	OK	
BH-5A	SOIL	9/21/05	OK	OK	
BH-6A	SOIL	9/22/05	OK	OK	
BH-7A	SOIL	9/22/05	OK	OK	OK
BH-8A	SOIL	9/22/05	OK	OK	OK
BH-9A	SOIL	9/22/05	OK	OK	
TOTAL SAMPLES			9	9	5

ATTACHMENT A

VALIDATED LABORATORY DATA

ATTACHMENT A-1

VALIDATED GROUNDWATER LABORATORY DATA

Ekonol Polyester Resins Facility Wheatfield, NY
Groundwater Analytical Data October 2005

Ekonol Facility		Sample ID:	MW-1S	MW-2S	MW-3S	MW-4S	MW-5S	MW-6S	MW-7S	MW-8S
Validated Groundwater Analytical Results		Lab Sample Id	J8266-2	J8467-5	J8467-4	J8467-3	J8266-1	J8467-2	J8265-2/J8365-3	J8467-6
Wheatfield, New York		Source:	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD
September 2005		SDG:	J8266	J8467	J8467	J8467	J8266	J8467	J8265/J8365	J8467
		Matrix:	Water	Water	Water	Water	Water	Water	Water	Water
		Sampled:	8/29/2005	8/31/2005	8/31/2005	8/31/2005	8/29/2005	8/31/2005	8/29-30/2005	8/31/2005
		Validated:	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005
CAS NO.	COMPOUND	UNITS:								
	VOLATILES									
75-00-3	Chloroethane	ug/l	1 U	500 U	1 U	100 U	1 U	1 U	1 U	1 U
75-34-3	1,1-Dichloroethane	ug/l	1 U	500 U	1 U	100 U	1 U	0.43 J	1 U	1 U
75-35-4	1,1-Dichloroethene	ug/l	1.2	1680	1 U	50.5 J	1 U	1 U	1 U	1 U
156-59-2	cis-1,2-Dichloroethene	ug/l	104	657000	1 U	12200	1	2.2	1	14.3
156-60-5	trans-1,2-Dichloroethene	ug/l	5.1	2770	1 U	100 U	1 U	1 U	1 U	1 U
71-55-6	1,1,1-Trichloroethane	ug/l	1 U	500 U	1 U	209	1 U	1 U	1 U	1 U
79-00-5	1,1,2-Trichloroethane	ug/l	1 U	500 U	1 U	100 U	1 U	1 U	1 U	1 U
79-01-6	Trichloroethene	ug/l	13	500 U	1 U	941	0.42 J	0.96 J	1 U	2.7
75-01-4	Vinyl chloride	ug/l	18.4	94000	1 U	1460	1.5	9.1	1 U	0.97 J
74-82-8	Methane	ug/l	13.3	178	0.2	84.8		0.32		
74-84-0	Ethane	ug/l	0.29	14.8	0.1 U	5.86		0.48		
74-85-1	Ethene	ug/l	0.52	450	0.1 U	13.1		0.1 U		
	SEMIVOLATILES									
108-95-2	Phenol	ug/l	5.2 U	9530	5	5.3 U	5.1 U	5 U	5.1 U	4.9 J
62-53-3	Aniline	ug/l	2.1 U	2.1 U	2 U	1.3 J	2 U	2 U	2 U	2.2 U
	METALS									
7440-38-2	Arsenic	ug/l	5 U	11.6	5 U	5 U		5 U		
	OTHER									
16887-00-6	Chloride	mg/l	40.1	1090	8.7	547		170		
14797-55-8	Nitrogen, Nitrate	mg/l	0.11 U	0.91	0.4	0.12		0.6		
NO3NO2N	Nitrogen, Nitrate + Nitrite	mg/l	0.1 U	0.91	0.42	0.12		0.65		
14797-65-0	Nitrogen, Nitrite	mg/l	0.01 U	0.01 U	0.023	0.01 U		0.049		
14808-79-8	Sulfate	mg/l	2230	867	13.1	2420		21.5		
TOC	Total Organic Carbon	mg/l	2.3	47.1	5.3	2.9		2.6		

Ekonol Facility		Sample ID:	MW-9S	MW-10D	MW-10S	MW-11D	MW-11S	MW-12D	MW-12S
Validated Groundwater Analytical Results		Lab Sample Id	J8467-1	J8600-2	J9919-1	J8265-1	J9919-4	J8365-8	J9919-2
Wheatfield, New York		Source:	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD
September 2005		SDG:	J8467	J8600	J9919	J8265	J9919	J8365	J9919
		Matrix:	Water	Water	Water	Water	Water	Water	Water
		Sampled:	8/31/2005	9/1/2005	9/15/2005	8/29/2005	9/15/2005	8/30/2005	9/15/2005
		Validated:	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005	12/19/2005
CAS NO.	COMPOUND	UNITS:							
	VOLATILES								
75-00-3	Chloroethane	ug/l	1 U	10 U	1 U	1 U	1 U	1 U	R
75-34-3	1,1-Dichloroethane	ug/l	1 U	25.6	1 U	6	25.9	1 U	R
75-35-4	1,1-Dichloroethene	ug/l	1 U	15.6	1.8	1.6	3.2	1 U	R
156-59-2	cis-1,2-Dichloroethene	ug/l	1 U	2630	1120	113	609	0.82 J	R
156-60-5	trans-1,2-Dichloroethene	ug/l	1 U	5.8 J	17.2	0.48 J	7.5	1 U	R
71-55-6	1,1,1-Trichloroethane	ug/l	1 U	147	1 U	239	13.9	1 U	R
79-00-5	1,1,2-Trichloroethane	ug/l	1 U	10 U	1 U	1 U	1 U	1 U	R
79-01-6	Trichloroethene	ug/l	1 U	1090	4.2	5	103	1 U	R
75-01-4	Vinyl chloride	ug/l	1 U	180	75.7	2.6	91.4	1 U	R
74-82-8	Methane	ug/l			13.8	44.8	68		
74-84-0	Ethane	ug/l			0.45	6.16	0.95		
74-85-1	Ethene	ug/l			1.9	0.1 U	1.6		
	SEMIVOLATILES								
108-95-2	Phenol	ug/l	49.9	5.9 U	5.6 U	5.3 U	6.3 U	5.1 U	
62-53-3	Aniline	ug/l	2.2 U	5	2.2 U	2.1 U	2.5 U	2 U	
	METALS								
7440-38-2	Arsenic	ug/l			5 U	5 U	5 U		90.3
	OTHER								
16887-00-6	Chloride	mg/l			118	146	449		277
14797-55-8	Nitrogen, Nitrate	mg/l			0.11 U	0.11 U	0.11 U		0.11 U
NO3NO2N	Nitrogen, Nitrate + Nitrite	mg/l			0.1 U	0.1 U	0.1 U		0.1 U
14797-65-0	Nitrogen, Nitrite	mg/l			0.01 U	0.01 U	0.01 UJ		0.01 UJ
14808-79-8	Sulfate	mg/l			501	1260	2260		1650
TOC	Total Organic Carbon	mg/l			2.5	3.2	2.2		16.7

Ekonol Polyester Resins Facility Wheatfield, NY
Groundwater Analytical Data October 2005

Ekonol Facility		Sample ID:	MW-12S	MW-13D	MW-14D	MW-15D	MW-16D	MW-17D	MW-18D	MW-19D
Validated Groundwater Analytical Results		Lab Sample Id	J14930-1	J8365-4	J8266-4	J8365-1	J8365-5	J8266-6	J8365-6	J8365-2
Wheatfield, New York		Source:	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD
September 2005		SDG:	J14930	J8365	J8266	J8365	J8365	J8266	J8365	J8365
		Matrix:	Water	Water	Water	Water	Water	Water	Water	Water
		Sampled:	11/7/2005	8/30/2005	8/29/2005	8/30/2005	8/30/2005	8/29/2005	8/30/2005	8/30/2005
		Validated:	12/19/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005
CAS NO.	COMPOUND	UNITS:								
	VOLATILES									
75-00-3	Chloroethane	ug/l	25 U	1 U	1 U	20 U	5 U	1 U	1 U	1 U
75-34-3	1,1-Dichloroethane	ug/l	67.9	7.9	1 U	65.8	4.9 J	0.67 J	1 U	0.61 J
75-35-4	1,1-Dichloroethene	ug/l	12.6 J	1.5	1 U	27.8	3 J	1 U	1 U	1 U
156-59-2	cis-1,2-Dichloroethene	ug/l	3690	234	1 U	5360	884	3.7	1 U	10.3
156-60-5	trans-1,2-Dichloroethene	ug/l	40.7	1.9	1 U	58.3	10.9	1 U	1 U	1 U
71-55-6	1,1,1-Trichloroethane	ug/l	432	2.2	1 U	165	2.4 J	5	1 U	1 U
79-00-5	1,1,2-Trichloroethane	ug/l	25 U	1 U	1 U	20 U	5 U	1 U	1 U	1 U
79-01-6	Trichloroethene	ug/l	11900	16.3	1 U	49.8	7.7	0.69 J	1 U	1 U
75-01-4	Vinyl chloride	ug/l	132	150	1 U	298	39.3	1 U	1 U	7.6
74-82-8	Methane	ug/l	80.2	17.7	32.4	19.7				
74-84-0	Ethane	ug/l	11.8	0.48	11.9	0.5				
74-85-1	Ethene	ug/l	2.3	8.6	0.1 U	2.4				
	SEMIVOLATILES									
108-95-2	Phenol	ug/l	5.6 U	5.4 U	5.2 U	5.4 U	5.6 U	5 U	5.6 U	5.6 U
62-53-3	Aniline	ug/l	2.2 U	2.2 U	2.1 U	2.2 U	2.2 U	2 U	2.2 U	2.2 U
	METALS									
7440-38-2	Arsenic	ug/l		6		5 U				
	OTHER									
16887-00-6	Chloride	mg/l		275		186				
14797-55-8	Nitrogen, Nitrate	mg/l		0.11 U		0.11 U				
NO3NO2N	Nitrogen, Nitrate + Nitrite	mg/l		0.1 U		0.1 U				
14797-65-0	Nitrogen, Nitrite	mg/l		0.01 U		0.01 U				
14808-79-8	Sulfate	mg/l		1010		1610				
TOC	Total Organic Carbon	mg/l		2		2.6				

Ekonol Polyester Resins Facility Wheatfield, NY
Groundwater Analytical Data October 2005

					Dup of RMW-1D					
Ekonol Facility		Sample ID:	MW-20D	RMW-1D	RMW-100D	RMW-2D	RMW-3D	RMW-4D	TRIP BLANK-1	TRIP BLANK-2
Validated Groundwater Analytical Results		Lab Sample Id	J9919-3	J8266-3	J8266-5	J8600-1	J8365-7	J8467-7	J8265-3	J8266-7
Wheatfield, New York		Source:	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD
September 2005		SDG:	J9919	J8266	J8266	J8600	J8365	J8467	J8265	J8266
		Matrix:	Water	Water	Water	Water	Water	Water	Water	Water
		Sampled:	9/15/2005	8/29/2005	8/29/2005	9/1/2005	8/30/2005	8/31/2005	8/29/2005	8/29/2005
		Validated:	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005	10/18/2005
CAS NO.	COMPOUND	UNITS:								
	VOLATILES									
75-00-3	Chloroethane	ug/l	1 U	1 U	1 U	50 U	5 U	25 U	1 U	1 U
75-34-3	1,1-Dichloroethane	ug/l	207	1 U	1 U	25.4 J	77.2	38.1	1 U	1 U
75-35-4	1,1-Dichloroethene	ug/l	23.1	1.1	1	24.8 J	25.1	43	1 U	1 U
156-59-2	cis-1,2-Dichloroethene	ug/l	1670	234	234	2890	571	11300	1 U	1 U
156-60-5	trans-1,2-Dichloroethene	ug/l	9.4	1.4	1.4	50 U	22.8	14.8 J	1 U	1 U
71-55-6	1,1,1-Trichloroethane	ug/l	1830	0.38 J	1 U	1830	4080	701	1 U	1 U
79-00-5	1,1,2-Trichloroethane	ug/l	1 U	1 U	1 U	50 U	5 U	25 U	1 U	1 U
79-01-6	Trichloroethene	ug/l	30.8	1.3	1.3	23900	381	19200	1 U	1 U
75-01-4	Vinyl chloride	ug/l	74.9	5	4.7	51.3	5 U	475	1 U	1 U
74-82-8	Methane	ug/l	8.97	52.2	54.6	8.85	10.6	32.7		
74-84-0	Ethane	ug/l	1.2	11.2	12	0.46	1.6	2.5		
74-85-1	Ethene	ug/l	0.22	0.098 J	0.11	0.87	0.1 U	2.7		
	SEMIVOLATILES									
108-95-2	Phenol	ug/l	5.2 U	5.1 U	5.2 U	5 U	5.6 U	5.2 U		
62-53-3	Aniline	ug/l	2.1 U	2 U	2.1 U	73.4	2.2 U	12.5		
	METALS									
7440-38-2	Arsenic	ug/l	5 U	5 U	5 U	5 U	5 U	5 U		
	OTHER									
16887-00-6	Chloride	mg/l	171	164	154	156	166	223		
14797-55-8	Nitrogen, Nitrate	mg/l	0.11 U	0.11 U	0.11 U	0.13	0.11 U	0.11 U		
NO3NO2N	Nitrogen, Nitrate + Nitrite	mg/l	0.1 U	0.1 U	0.1 U	0.13	0.1 U	0.1 U		
14797-65-0	Nitrogen, Nitrite	mg/l	0.01 UJ	0.01 U	0.01 U	0.01 U	0.015	0.01 U		
14808-79-8	Sulfate	mg/l	852	1030	1040	854	767	1140		
TOC	Total Organic Carbon	mg/l	2.5	2	1.9	2.4	2	2.8		

Ekonol Facility		Sample ID:	TRIP BLANK-3	TRIP BLANK-4	TRIP BLANK-5	TRIP BLANK-6	TRIP BLANK-7
Validated Groundwater Analytical Results		Lab Sample Id	J8365-9	J8467-8	J8600-3	J9919-8	J14930-2
Wheatfield, New York		Source:	ACTD	ACTD	ACTD	ACTD	ACTD
September 2005		SDG:	J8365	J8467	J8600	J9919	J14930
		Matrix:	Water	Water	Water	Water	Water
		Sampled:	8/30/2005	8/31/2005	9/1/2005	9/15/2005	11/7/2005
		Validated:	10/18/2005	10/18/2005	10/18/2005	10/18/2005	12/19/2005
CAS NO.	COMPOUND	UNITS:					
	VOLATILES						
75-00-3	Chloroethane	ug/l	1 U	1 U	1 U	1 U	1 U
75-34-3	1,1-Dichloroethane	ug/l	1 U	1 U	1 U	1 U	1 U
75-35-4	1,1-Dichloroethene	ug/l	1 U	1 U	1 U	1 U	1 U
156-59-2	cis-1,2-Dichloroethene	ug/l	1 U	1 U	1 U	1 U	1 U
156-60-5	trans-1,2-Dichloroethene	ug/l	1 U	1 U	1 U	1 U	1 U
71-55-6	1,1,1-Trichloroethane	ug/l	1 U	1 U	1 U	1 U	1 U
79-00-5	1,1,2-Trichloroethane	ug/l	1 U	1 U	1 U	1 U	1 U
79-01-6	Trichloroethene	ug/l	1 U	1 U	1 U	1 U	1 U
75-01-4	Vinyl chloride	ug/l	1 U	1 U	1 U	1 U	1 U
74-82-8	Methane	ug/l					
74-84-0	Ethane	ug/l					
74-85-1	Ethene	ug/l					
	SEMIVOLATILES						
108-95-2	Phenol	ug/l					
62-53-3	Aniline	ug/l					
	METALS						
7440-38-2	Arsenic	ug/l					
	OTHER						
16887-00-6	Chloride	mg/l					
14797-55-8	Nitrogen, Nitrate	mg/l					
NO3NO2N	Nitrogen, Nitrate + Nitrite	mg/l					
14797-65-0	Nitrogen, Nitrite	mg/l					
14808-79-8	Sulfate	mg/l					
TOC	Total Organic Carbon	mg/l					

ATTACHMENT A-2

VALIDATED SOIL LABORATORY DATA

Ekonol Polyester Resins Facility Wheatfield, NY
Soil Analytical Data September 2005

Ekonol Facility		Sample ID:	BH-1A	BH-2A	BH-3A	BH-4A	BH-5A	BH-6A	BH-7A	BH-8A	BH-9A
Validated Soil Analytical Results		Lab Sample Id:	J10637-1	J10637-2	J10637-3	J10637-4	J10637-5	J10637-9	J10637-8	J10637-7	J10637-6
Wheatfield, New York		Depth:	8-12'	8-12'	8-12'	8-12'	8-12'	1-2'	1-2' & 8-11.5'	1-2' & 8-10'	2-3'
September 2005		Source:	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD	ACTD
		SDG:	J10637	J10637	J10637	J10637	J10637	J10637	J10637	J10637	J10637
		Matrix:	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		Sampled:	9/21/2005	9/21/2005	9/21/2005	9/21/2005	9/21/2005	9/22/2005	9/22/2005	9/22/2005	9/22/2005
		Validated:	10/20/2005	10/20/2005	10/20/2005	10/20/2005	10/20/2005	10/20/2005	10/20/2005	10/20/2005	10/20/2005
CAS NO.	COMPOUND	UNITS:									
	VOLATILES										
75-00-3	Chloroethane	ug/kg	8.1 U	440 U	410 U	300 U	61 U	7.3 U	8.4 U	6.9 U	7.7 U
75-34-3	1,1-Dichloroethane	ug/kg	8.1 U	440 U	410 U	300 U	61 U	7.3 U	8.4 U	6.9 U	7.7 U
75-35-4	1,1-Dichloroethene	ug/kg	4.9 J	39.2 J	410 U	300 U	134	7.3 U	8.4 U	6.9 U	7.7 U
156-59-2	cis-1,2-Dichloroethene	ug/kg	1690	90900	64400	1870	69000	2.3 J	8.4 U	5.9 J	7.7 U
156-60-5	trans-1,2-Dichloroethene	ug/kg	35.3	286 J	448	22.9 J	1440	7.3 U	8.4 U	6.9 U	7.7 U
71-55-6	1,1,1-Trichloroethane	ug/kg	8.1 U	440 U	410 U	300 U	61 U	7.3 U	8.4 U	6.9 U	7.7 U
79-00-5	1,1,2-Trichloroethane	ug/kg	8.1 U	440 U	410 U	300 U	61 U	7.3 U	8.4 U	6.9 U	7.7 U
79-01-6	Trichloroethene	ug/kg	186	271000	67.5 J	615	28.5 J	7.3 U	8.4 U	3.1 J	7.7 U
75-01-4	Vinyl chloride	ug/kg	284	523	410 U	300 U	2140	7.3 U	8.4 U	6.9 U	7.7 U
	SEMIVOLATILES										
108-95-2	Phenol	ug/kg	220 U	15000	1510	190 U	10100	220 U	220 U	200 U	220 U
62-53-3	Aniline	ug/kg	90 U	92 U	90 U	76 U	860 U	89 U	88 U	82 U	88 U
	OTHER										
ALK	Alkalinity, Total as CaCO3	mg/kg	511	529	362				836	491	
SOLID	Solids, Percent	%	73.9	71.5	73.1	87.4	76.7	74.6	74.6	80.8	75.5

APPENDIX B (continued) – LABORATORY ANALYTICAL DATA

LABORATORY ANALYTICAL DATA

Click here to view J8265

Click here to view J8266

Click here to view J8365

Click here to view J8467

Click here to view J8600

Click here to view J9919

Click here to view J10637

Click here to view J14930

APPENDIX C – WASTE DISPOSAL MANIFESTS

ONYX

ENVIRONMENTAL SERVICES

Please type or print in block letters. (Form designed for use on elite (12-pitch) typewriter.)

NON-HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. NYR000103382 Manifest Document No. 05037
2. Page 1 of 1

A. Non-hazardous Manifest Document Number Z 169095

3. Generator's Name and Mailing Address
GROUP ENVIRONMENTAL MANAGEMENT
4850 EAST 49TH STREET
MBC3 - 147
CAYAHOGA HEIGHTS, OH 41125

4. Generator's Phone (216) 271-8038

B. State Generator's ID 6600 WALMORE RD.
WHEATFIELD, NY 14304

5. Transporter 1 Company Name ONYX ENVIRONMENTAL SVCS L L C
6. US EPA ID Number NJD080631369

C. State Trans. ID P206997 IL

D. Transporter's Phone (973) 347-7111

7. Transporter 2 Company Name
8. US EPA ID Number

E. State Trans. ID

F. Transporter's Phone ( )

9. Designated Facility Name and Site Address
CWM CHEMICAL SERVICES, L.L.C
1550 BALMER ROAD
MODEL CITY, NY 14107

10. US EPA ID Number NYD049836679

G. State Facility's ID

H. Facility's Phone (716) 754-8231

GENERATOR

	11. US DOT Description *(Including Proper Shipping Name, Hazard Class, and ID Number)* HM	12. Containers No.	12. Containers Type	13. Total Quantity	14. Unit Wt/Vol	I. Waste No.
a.	NON-REGULATED MATERIAL PER 40 & 49 CFR, (SOIL, DIRT), NONE, NONE	007	D M	03000	P	N O N E
b.	NON-REGULATED MATERIAL PER 40 & 49 CFR, (PLASTIC, PPE), NONE, NONE	001	D M	00150	P	N O N E
c.						
d.						

J. Additional Descriptions for Materials Listed Above
a. S/- 510608,#1,7-55GAL
b. S/- MDC497493/510609,#2,55GAL
c.
d.

K. Handling Codes for Wastes Listed Above
a. L
b. L
c.
d.

15. Special Handling Instructions and Additional Information
PACKING SLIPS ATTACHED FOR CLARIFICATION -ONYX EMERGENCY NUMBER-INFOTRAC: 1-800-535-5053
INVOICE ONYX-TONAWANDA,NY

16. **GENERATOR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labelled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations.

I hereby certify that the above-named material is not hazardous waste as defined by 40 CFR Part 261 or any applicable state law.

Printed/Typed Name Mr. Daniel Lippi Senior Technician, Parsons, on behalf of B.P Amoco Chemical Company
Signature Mr. Daniel Lippi, Senior Technician, Parsons, on behalf of B.P Amoco Chemical Company
Month Day Year 12 05 05

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials
Printed/Typed Name Michael J. Fose
Signature
Month Day Year 12 05 05

18. Transporter 2 Acknowledgement of Receipt of Materials
Printed/Typed Name
Signature
Month Day Year

FACILITY

19. Discrepancy Indication Space

20. Facility Owner or Operator: Certification of receipt of non-hazardous materials covered by this manifest except as noted in Item 19.
Printed/Typed Name
Signature
Month Day Year

1-GENERATOR COPY

SIGNATURE AND INFORMATION *MUST* BE LEGIBLE ON ALL COPIES

NYH0646722

STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF SOLID & HAZARDOUS MATERIALS

HAZARDOUS WASTE MANIFEST

P.O. Box 12820, Albany, New York 12212

Please type or print. Do not staple.

(Hazardous Waste Manifest 5/00)

In case of emergency or spill immediately call the National Response Center (800) 424-8802 and the NYS Department of Environmental Conservation (518) 457-7362

GENERATOR

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA No. NYR000103382 Manifest Doc. No. 05036

2. Page 1 of 1

Information within heavy bold line is not required by Federal Law.

3. Generator's Name and Mailing Address
GROUP ENVIRONMENTAL MANAGEMENT
4850 EAST 49TH STREET
MBC3 - 147
CAYAHOGA HEIGHTS, OH 41125

4. Generator's Telephone Number (216) 271-8038

A. NYH0646722

B. Generator's ID 6800 WALMORE RD.
WHEATFIELD, NY 14304

5. Transporter 1 (Company Name) ONYX ENVIRONMENTAL SVCS L.L.C.

6. US EPA ID Number NJD080631969

C. State Transporter's ID P206997-IL

D. Transporter's Telephone (973) 347-7111

7. Transporter 2 (Company Name)

8. US EPA ID Number

E. State Transporter's ID

F. Transporter's Telephone ( )

9. Designated Facility Name and Site Address
ONYX ENVIRONMENTAL SERVICES,
4301 INFIRMARY ROAD

WEST CARROLLTON, OH 45449

10. US EPA ID Number OHD093945293

G. State Facility ID

H. Facility Telephone (937) 859-6101

11. US DOT Description (Including Proper Shipping Name, Hazard Class and ID Number)	12. Containers Number	12. Containers Type	13. Total Quantity	14. Unit Wt/Vol	I. Waste No.
a. RQ, HAZARDOUS WASTE, LIQUID, n.o.s., (WATER WITH TRICHLOROETHYLENE, DICHLOROETHANE), 9, NA3082, III, (D040,D028,D043)	002	DM	00800	P	EPA D040 STATE
b. NON-REGULATED MATERIAL PER 40 & 49 CFR, (NON-HAZARDOUS GROUND WATER), NONE, NONE	008	DM	02400	P	EPA NONE STATE
c.					EPA STATE
d.					EPA STATE

J. Additional Descriptions for Materials listed Above
a. L/E SRRNEUTRAL-HAZ/510610,2-55G,ERG#171
b. L/- SRRNEUTRAL-NH/509713,8- 55GAL
c.
d.

K. Handling Codes for Wastes Listed Above
a. T
b. T
c. ☐
d. ☐

15. Special Handling Instructions and Additional Information
PACKING SLIPS ATTACHED FOR CLARIFICATION -ONYX EMERGENCY NUMBER-INFOTRAC: 1-800-535-5053
INVOICE ONYX-TONAWANDA,NY **NEED CERTIFICATES OF DISPOSAL**
LINE ITEM 11/B FOR TRACKING PURPOSES ONLY

16. **GENERATOR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations and state laws and regulations.

If I am large quantity generator. I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR if I am a smaller generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.

Printed/Typed Name Mr Daniel Lipp, Senior [illegible] on behalf of [illegible] Company of BP

Signature [illegible] on behalf of [illegible] BP

Mo. 12 Day 06 Year 05

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials

Printed/Typed Name J. Fair

Signature

Mo. Day Year

18. Transporter 2 Acknowledgement of Receipt of Materials

Printed/Typed Name

Signature

Mo. Day Year

FACILITY

19. Discrepancy Indication Space

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.

Printed/Typed Name

Signature

Mo. Day Year

COPY 8 - GENERATOR - RETAINED BY GENERATOR

APPENDIX D
IDENTIFICATION AND EVALUATION OF REMEDIAL ALTERNATIVES

APPENDIX D – Identification and Evaluation of Technologies

This appendix identifies and evaluates remedial technologies using a process similar to that outlined in USEPA RI/FS guidance and the NCP (USEPA, 1988, 1990, and 1993a), but also complies with NYSDEC VCP Guidelines. In situations where there was a conflict between Federal and State Programs, the VCP method was used. As part of the identification process, a list of potential technologies was developed that could be used for remediation. An extensive list of potential technologies, representing a range of general response actions (i.e., no action, institutional controls, containment, collection, treatment, and disposal) was identified to develop the candidate remedial alternatives. These alternatives were then evaluated based on their applicability to the Site media. The purpose of the evaluation was to provide thorough discussion of the conceptual approach, how effective the alternative may be at the site, and uncertainties about the technology.

The following sections of this report summarize the technology identification and evaluations. The three media (soils, shallow groundwater and deep groundwater) are considered separately in the evaluation.

D.1 Alternative Identification for Soils

The following alternatives were identified for soils:

- Alternative 1: No action and Engineering/Institutional Controls;
- Alternative 2: Excavation and selected backfill; and
- Alternative 3: Soil Vapor Extraction (SVE).

These technologies were identified as alternatives because they are either common remedial solutions or are potentially feasible. In the evaluation section below, each alternative is reviewed for its applicability to the site.

D.2 Alternative Evaluation for Soils

Alternative 1: Engineering/Institutional Controls

Engineering/institutional controls are grouped as one alternative. Engineering controls would prevent completion of exposure pathways from residual COC by isolating the COCs that remain. Institutional controls include deed restrictions and other land use controls that restrict the type of activities that are permitted and therefore reduce/eliminate exposure pathways. For instance, deed restrictions may require the use of personal protective equipment (PPE) and preparation of a health and safety plan (HASP) prior to excavation.

For the Ekonol facility, potential engineering controls that could be used to prevent completion of exposure pathways include:

- Continued maintenance and repair, as needed, of paved surfaces to reduce the potential for receptor exposure to vapors and shallow soils; and
- Continued maintenance of a security fence to restrict access to the Site.

Potential institutional controls to prevent completion of exposure pathways include:

- Deed restrictions that prohibit extraction and use of groundwater for any purpose;
- Deed restrictions and onsite signage that notify construction workers that intrusive work is prohibited unless proper personal protective equipment or other necessary precautions are implemented, and;
- Deed restrictions that prevent any future land use that would allow access by potential receptors that could result in unacceptable exposure to COCs.

Under this alternative, long-term monitoring (LTM) of Site conditions (e.g., condition of paved surfaces and security fence), and concentrations of COCs in groundwater may be required. In the event that chemical concentrations exceed applicable risk-based standards for receptor exposure, contingency plans would need to be in place to mitigate receptor exposure.

No action and engineering/institutional controls is a viable and preferable alterative for the soils media. Previous excavation(s) of the tank and surrounding soils removed impacted soils in the source area. Parsons (2003) results indicated that non-source area soils were not impacted. Recent soil sampling results confirmed that soils outside the tank excavation were not impacted, and COCs in soil media were related to residual COCs and shallow groundwater. Due to the low hydraulic conductivity and other properties of the shallow clay, the residual COCs in soil are relatively immobile and pose little risk to human health and the environment.

Alternative 2: Excavation and Backfill

The excavation and backfill alternative assumes there are impacted soils, which would be excavated and properly disposed. As discussed, excavation of the source and sampling demonstrated the impacts to soils were primarily limited to the area near the former tank, and were previously excavated. During the tank closure, all but residually impacted soils were excavated. This was confirmed by Parsons (2003) sampling and the 2005 soil sampling.

Excavation as a remedial alternative for soils would, likely provide little or no remedial benefit. The activities would create application risks to the excavation workers (i.e. work injury) as well as financial cost, with minimal, if any benefit to soils.

Alternative 3: Soil Vapor Extraction

Soil vapor extraction (SVE) is an *in situ* unsaturated (vadose) zone soil remediation technology, in which a vacuum is applied to the soil to induce the controlled flow and removal of vapor-phase COCs from the subsurface.

The factors that limit the applicability and/or effectiveness of the SVE system include: little COC mass available for extraction, a high percentage of fines and organic content (such as silts and clays), variability in porosity and permeability, and potential requirement for extensive treatment of extracted vapors. Site observations indicate the low permeability of the soils have prevented significant vapor migration; therefore, there is little mass in the vadose zone to extract. The high percentage of fines also indicates there is a potentially limited radius of influence of vacuum. Additionally, other sites have demonstrated that using an SVE system in this type of soil provides little benefit at relatively high costs.

D.3 Alternative Identification for Shallow Groundwater

The following alternatives were identified for the shallow groundwater.

- Alternative 1: No Action and Engineering/Institutional Controls;
- Alternative 2: Passive Bioreactor;
- Alternative 3: Monitored Natural Attenuation (MNA);
- Alternative 4: Groundwater Extraction; and
- Alternative 5: Injection of Bio-enhancing *in situ* Treatments such as Bio-enhancing Substrate, Chemical Oxidant and EZVI

These were identified as alternatives because they were the most likely be applicable to the Site. In the evaluation section below each alternative is reviewed for its applicability to the Site.

D.4 Alternative Evaluations for Shallow Groundwater

Alternative 1: Engineering/Institutional Controls

The approach of engineering/institutional control for shallow groundwater is similar to that discussed above in Section D.2

In the process of assessing engineering/institutional controls as an alternative, the groundwater concentrations over time were evaluated for natural attenuation. There has been little or no decrease in total 1,2-dichloroethene (DCE) concentrations in shallow monitoring well MW-2S, and the concentration is greater than five orders of magnitude higher than the groundwater standard

Alternative 2: Passive Bioreactor

One innovative, cost-effective approach to shortening the remediation time frame is to use a bioreactor to enhance the natural bioremediation process. Construction of a bio-treatment cell consists of removal of residually impacted shallow soils, and subsequent placement of a backfill material consisting of bark mulch, vegetable oil and gravel into the excavated area, including soils above and below the water table. This will create a passive bioreactor cell in the shallow groundwater. The goals of this cell would be to 1) decrease chemical loading to shallow groundwater by reducing the mass of residual chemical constituents in the subsurface; 2) enhance natural attenuation of source area shallow groundwater, and 3) provide a long-term source of organic carbon that can be transported into the surrounding soil, downgradient, and possibly into bedrock, to enhance the anaerobic bioremediation of COCs. Additionally, a bioreactor wall situated downgradient from the source area may provide further treatment.

Installation of a passive mulch/oil bioreactor is expected to be technically-feasible at a reasonable cost. The primary challenge to implementing the bioreactor remedy is the potential production of intermediate degradation products (i.e. DCE, VC).

This remedy could be implemented in a progressive fashion, with the initial bioreactor installation monitored to evaluate whether the rate and extent of treatment will achieve remedial endpoints in shallow groundwater in a reasonable timeframe. If further acceleration of the rate of chemical removal is needed, the relative merits of substrate injections, bioaugmentation additions and/or shallow recirculation wells could be evaluated and implemented in or around the bioreactor.

Alternative 3: Monitored Natural Attenuation (MNA)

An MNA approach would rely on natural attenuation processes to achieve Site restoration. During the time that the MNA process is active, maintenance of engineering and institutional controls would continue to be implemented. Observations of COC groundwater concentrations and MNA indicator parameters would provide data to predict the time for COCs to decrease below groundwater remedial goals. However, MNA may be a viable component incorporated into other technologies.

In the process of assessing MNA as an alternative, the groundwater concentrations over time were evaluated for evidence of natural attenuation. Available data shows that natural attenuation processes are actively degrading the parent compounds (e.g., TCE, 1,1,1-TCA). Primary evidence to support this conclusion includes the observed presence of both intermediate degradation products (e.g., cis-1,2-DCE, vinyl chloride, 1,1-DCA) and complete mineralization products (e.g., ethene, ethane, chloride). Total organic carbon concentrations have been observed, along with geochemical indicators that suggest the presence of reducing (anaerobic) conditions.

These observations support a conclusion that biologically-mediated reductive dechlorination is an active degradation mechanism. Based on the relatively higher concentrations of degradation products in the shallow groundwater, compared to the deeper groundwater, the rate and influence of reductive dechlorination on chemical concentrations may be higher in shallow groundwater than it is in deep groundwater.

The primary limitation for an MNA remedy that does not include active reduction of chemical concentrations in the residual source area, is that this remedy will likely require longer time-frames than other alternatives. As such, it is anticipated that a formal MNA evaluation would find that the timeframe to achieve site restoration is not “reasonable” relative to other remedial alternatives, unless there are no other alternatives that are feasible in terms of constructability and cost.

It is important to note that all remedies for groundwater (shallow and deep) are likely to have an MNA component. This component would be applied as a final step that will continue to degrade chemical constituents over time.

Alternative 4: Groundwater Extraction

Groundwater pump and treat uses groundwater extraction wells to remove impacted water from the subsurface. The water is then sent to an *ex situ* treatment system to remove the COCs. Aquifer restoration has been found to be infeasible where non-aqueous-phase liquid (NAPL) or heavy residuals were present above or below the water table (such as the Ekonol Site), at older sites where diffusion has allowed contaminants to enter soil grains and rock, and where the precise distribution of sources was not known. Therefore, in these conditions groundwater pump and treat systems are used only to contain Site groundwater. This would reduce chemical loading to the remainder of the aquifer, such that natural processes can attenuate COCs located downgradient of the containment area.

The conceptual design for overburden groundwater remediation would be a series of extraction wells installed to provide hydraulic containment. The number of wells is determined by the area to be covered and the area of containment provided by each well. The hydraulic radius of influence (for the purposes of containment) of a single well is calculated to be approximately 30 feet. If extraction wells were placed to enclose the area from monitoring well 4S northward to the south wall of Building No. 4, then eastward to MW-10S, approximately 10 groundwater extraction wells would be needed.

The hydraulic area of influence (30 feet) was calculated using the Theis (1935) equation. The estimated pumping rate per well is approximately 0.004 gpm, based on a saturated thickness of approximately four feet, and a hydraulic conductivity of 0.03 ft/day (1×10^{-5} cm/sec).

Groundwater pump and treat would be able to provide containment in the overburden at low pumping rates. However, because it is unlikely that the pump and treatment systems would restore groundwater quality in the foreseeable future, there is no projected end date to system operations. Capital and long-term costs would be relatively higher than other alternatives. Therefore, groundwater pump and treat is not a viable alternative at this time.

Alternative 5: In situ Treatments such as Bio-enhancing Substrate, Chemical Oxidant and EZVI

Injections of *in situ* substrates such as bio-enhancing emulsions (i.e. vegetable oil), chemical oxidants and EZVI for shallow groundwater are limited by the feasibility of injecting the substrate into the low permeability soils. Additionally, each technology has other limiting factors (bio-enhancing treatments may increase the concentrations of degradation products prior to decreasing them; chemical oxidation would have to overcome the natural anaerobic environment before a reduction in COCs would occur, and EZVI is experimental and relatively high cost).

Due to these considerations, the feasibility of using an injection of an *in situ* remediation substrate is limited for shallow groundwater.

D.5 Alternative Identification for Deep Groundwater

The following alternatives were identified for the deep groundwater.

- Alternative 1: Engineering/Institutional Controls;
- Alternative 2: Monitored Natural Attenuation (MNA);
- Alternative 3: Groundwater Extraction;
- Alternative 4: Bio-enhancing *in situ* Treatment;
- Alternative 5: Chemical Oxidation *in situ* Treatments; and
- Alternative 6: EZVI *in situ* Treatments.

Other technologies exist, but these were identified for consideration because they are either common remedial solutions or are potentially feasible. The alternatives are evaluated below.

D.6 Alternative Evaluations for Deep Groundwater

Alternative 1: Engineering/Institutional Controls

The approach and evaluation of engineering/institutional control for deep groundwater is similar to for shallow groundwater (see Section D.4, 1).

Alternative 2: Monitored Natural Attenuation (MNA)

The evaluation of MNA in bedrock is similar that in shallow groundwater (see Section E 4, 3). MNA is a final step in the groundwater remediation option.

Alternative 3: Groundwater Extraction

The conceptual design for a groundwater extraction system in bedrock consists of two to three groundwater extraction wells, installed to provide hydraulic containment of the source area. The number of wells is based on an estimate that the area to be contained is a roughly triangular area bounded by wells MW-4D, MW-2D and MW-3D. The hydraulic radius of influence (for the purposes of containment) of a single well was calculated to be about 60 feet.

The hydraulic area of influence was calculated using the Theis (1935) equation. The estimated pumping rate per well is approximately two gallons per minute, based on a geometric mean transmissivity of 235 ft^2/day (well transmissivities presented on Table 3 of the Hydraulic Pulse Interference Report, GeoSierra, 2005).

Groundwater pump and treat would be able to provide containment in the bedrock at relatively low pumping rates. However, because it is unlikely that the pump and treatment systems would restore groundwater quality in the foreseeable future, there is no projected end date to system operations. Capital and operational costs will be higher than other alternatives. Therefore, groundwater pump and treat is not considered a viable option at this time.

Alternative 4: Bio-enhancing in situ Treatment

Bio-enhancing substrate injections could be used in deep groundwater for source area treatment, and possibly as linear treatment zones that intersect the area outside the source zone (i.e., ‘biobarriers’). It is anticipated that treatment of the entire area of dissolved COCs in deep groundwater would be cost-prohibitive. It is further anticipated that a combined substrate of emulsified vegetable oil and a soluble substrate would be used in the source area(s) to create a longer-term treatment zone (longer than using soluble substrate alone).

The primary concern of using a bio-enhancing *in situ* treatment is temporary production of regulated intermediates during the anaerobic degradation (Parsons, 2004c). Additional challenges include obtaining sufficient distribution of the injected compound to achieve the desired treatment effectiveness. Because organic substrates are inexpensive relative to chemical reductants (e.g., EZVI) and chemical oxidants (e.g., hydrogen peroxide, permanganate), a larger mass of organic substrate can be injected into bedrock for the same cost as chemical treatment, offering the advantage of creating a larger treatment zone. This advantage may be partially offset by the fact that enhanced anaerobic bioremediation treatment methods rely on sequential reductive dechlorination of multiple regulated compounds, and may be less effective on DNAPL. However, recent studies show that vegetable oil substrates can increase the bio-availability of compounds and sequester the DNAPL. This indicates that the use of vegetable oils may be more effective than previously thought.

Alternative 5: Injection of Chemical Oxidation in situ Treatments

Chemical oxidation as a remediation technology utilizes one or more chemical oxidizing reagents to oxidize and destroy organic COCs and convert them into innocuous material such as salts and carbon dioxide. The oxidants used for *in situ* chemical oxidation may include gaseous reagents such as ozone, or liquid reagents such as Fenton's reagent (hydrogen peroxide and ferrous ion), permanganate (sodium permanganate or potassium permanganate) and sodium persulfate solution, and activating compounds such as ferrous ion, heat or hydrogen peroxide.

Chemical oxidation technology could work, based on the COCs present at the Site. However, the reagents mentioned above are non-specific oxidizers and would oxidize all organic carbon, including those associated with native soils and bedrock reduce the ability of the natural attenuation processes. Due to the current anaerobic and pH of the deep groundwater system pH, near neutral in most areas, and large treatment area chemical oxidation has limited potential. High demands of oxidants or reagents would be required to first convert the anaerobic environment to aerobic, and then promote oxidation of almost all organic carbon, such as that associated with the native soil material, and finally oxidize the COCs.

Alternative 6: Injection of EZVI in situ Treatments

This is an innovative technology approach which injects an emulsion consisting of zero-valent metal particles, a surfactant, vegetable oil, and water into the subsurface. The metal, surfactant, and oil contribute to the dehalogenation of chlorinated, organic compounds and dense non-aqueous phase liquids (DNAPLs), such as trichloroethylene (TCE). Typically, the zero-valent metal particles consist of nanoscale and microscale zero-valent iron. The zero-valent iron is believed to degrade the DNAPL abiotically, whereas the vegetable oil and surfactant promote longer-term, anaerobic biodegradation.

It has been suggested that DNAPL compounds (e.g., TCE) diffuse through the oil membrane of the emulsion particle, and undergo reductive dechlorination in the presence of the ZVI particles in the interior aqueous phase. The target chemicals undergo dechlorination steps, with the EZVI droplets resulting in the formation of non-chlorinated hydrocarbon products (e.g., ethene, ethane). In laboratory tests, the degradation of TCE may occur primarily via the abiotic pathway, where TCE is converted to chloroacetylene, which in turn is dehalogenated to acetylene. Acetylene is subsequently degraded to ethene and ethane. In field tests, however, degradation of TCE occurs through both the abiotic and biotic pathways. This is the result of less reactivity of the iron than anticipated, leaving the vegetable oil to enhance the biodegradation of TCE.

The 2005 investigations focused on the feasibility of using EZVI, yet the results are applicable to other alternatives. Interpretation from the pulse interference tests in the deep groundwater zone indicated that the transmissivity of the bedrock may enable injection of the EZVI into this formation at low injection pressures (<1 psi). However, the effectiveness of EZVI in Site groundwater and fractured bedrock should be further evaluated, if this alternative in considered for implementation. Further work could involve bench-scale testing of the degradation processes using impacted Site groundwater and EZVI solution, as well as open-hole bedrock well(s) for discrete fracture characterization.

APPENDIX E
HYDRAULIC INTERFERENCE TEST REPORT

APPENDIX D – Identification and Evaluation of Technologies

This appendix identifies and evaluates remedial technologies using a process similar to that outlined in USEPA RI/FS guidance and the NCP (USEPA, 1988, 1990, and 1993a), but also complies with NYSDEC VCP Guidelines. In situations where there was a conflict between Federal and State Programs, the VCP method was used. As part of the identification process, a list of potential technologies was developed that could be used for remediation. An extensive list of potential technologies, representing a range of general response actions (i.e., no action, institutional controls, containment, collection, treatment, and disposal) was identified to develop the candidate remedial alternatives. These alternatives were then evaluated based on their applicability to the Site media. The purpose of the evaluation was to provide thorough discussion of the conceptual approach, how effective the alternative may be at the site, and uncertainties about the technology.

The following sections of this report summarize the technology identification and evaluations. The three media (soils, shallow groundwater and deep groundwater) are considered separately in the evaluation.

D.1 Alternative Identification for Soils

The following alternatives were identified for soils:

- Alternative 1: No action and Engineering/Institutional Controls;
- Alternative 2: Excavation and selected backfill; and
- Alternative 3: Soil Vapor Extraction (SVE).

These technologies were identified as alternatives because they are either common remedial solutions or are potentially feasible. In the evaluation section below, each alternative is reviewed for its applicability to the site.

D.2 Alternative Evaluation for Soils

Alternative 1: Engineering/Institutional Controls

Engineering/institutional controls are grouped as one alternative. Engineering controls would prevent completion of exposure pathways from residual COC by isolating the COCs that remain. Institutional controls include deed restrictions and other land use controls that restrict the type of activities that are permitted and therefore reduce/eliminate exposure pathways. For instance, deed restrictions may require the use of personal protective equipment (PPE) and preparation of a health and safety plan (HASP) prior to excavation.

For the Ekonol facility, potential engineering controls that could be used to prevent completion of exposure pathways include:

- Continued maintenance and repair, as needed, of paved surfaces to reduce the potential for receptor exposure to vapors and shallow soils; and
- Continued maintenance of a security fence to restrict access to the Site.

Potential institutional controls to prevent completion of exposure pathways include:

- Deed restrictions that prohibit extraction and use of groundwater for any purpose;
- Deed restrictions and onsite signage that notify construction workers that intrusive work is prohibited unless proper personal protective equipment or other necessary precautions are implemented, and;
- Deed restrictions that prevent any future land use that would allow access by potential receptors that could result in unacceptable exposure to COCs.

Under this alternative, long-term monitoring (LTM) of Site conditions (e.g., condition of paved surfaces and security fence), and concentrations of COCs in groundwater may be required. In the event that chemical concentrations exceed applicable risk-based standards for receptor exposure, contingency plans would need to be in place to mitigate receptor exposure.

No action and engineering/institutional controls is a viable and preferable alterative for the soils media. Previous excavation(s) of the tank and surrounding soils removed impacted soils in the source area. Parsons (2003) results indicated that non-source area soils were not impacted. Recent soil sampling results confirmed that soils outside the tank excavation were not impacted, and COCs in soil media were related to residual COCs and shallow groundwater. Due to the low hydraulic conductivity and other properties of the shallow clay, the residual COCs in soil are relatively immobile and pose little risk to human health and the environment.

Alternative 2: Excavation and Backfill

The excavation and backfill alternative assumes there are impacted soils, which would be excavated and properly disposed. As discussed, excavation of the source and sampling demonstrated the impacts to soils were primarily limited to the area near the former tank, and were previously excavated. During the tank closure, all but residually impacted soils were excavated. This was confirmed by Parsons (2003) sampling and the 2005 soil sampling.

Excavation as a remedial alternative for soils would, likely provide little or no remedial benefit. The activities would create application risks to the excavation workers (i.e. work injury) as well as financial cost, with minimal, if any benefit to soils.

Alternative 3: Soil Vapor Extraction

Soil vapor extraction (SVE) is an *in situ* unsaturated (vadose) zone soil remediation technology, in which a vacuum is applied to the soil to induce the controlled flow and removal of vapor-phase COCs from the subsurface.

The factors that limit the applicability and/or effectiveness of the SVE system include: little COC mass available for extraction, a high percentage of fines and organic content (such as silts and clays), variability in porosity and permeability, and potential requirement for extensive treatment of extracted vapors. Site observations indicate the low permeability of the soils have prevented significant vapor migration; therefore, there is little mass in the vadose zone to extract. The high percentage of fines also indicates there is a potentially limited radius of influence of vacuum. Additionally, other sites have demonstrated that using an SVE system in this type of soil provides little benefit at relatively high costs.

D.3 Alternative Identification for Shallow Groundwater

The following alternatives were identified for the shallow groundwater.

- Alternative 1: No Action and Engineering/Institutional Controls;
- Alternative 2: Passive Bioreactor;
- Alternative 3: Monitored Natural Attenuation (MNA);
- Alternative 4: Groundwater Extraction; and
- Alternative 5: Injection of Bio-enhancing *in situ* Treatments such as Bio-enhancing Substrate, Chemical Oxidant and EZVI

These were identified as alternatives because they were the most likely be applicable to the Site. In the evaluation section below each alternative is reviewed for its applicability to the Site.

D.4 Alternative Evaluations for Shallow Groundwater

Alternative 1: Engineering/Institutional Controls

The approach of engineering/institutional control for shallow groundwater is similar to that discussed above in Section D.2

In the process of assessing engineering/institutional controls as an alternative, the groundwater concentrations over time were evaluated for natural attenuation. There has been little or no decrease in total 1,2-dichloroethene (DCE) concentrations in shallow monitoring well MW-2S, and the concentration is greater than five orders of magnitude higher than the groundwater standard

Alternative 2: Passive Bioreactor

One innovative, cost-effective approach to shortening the remediation time frame is to use a bioreactor to enhance the natural bioremediation process. Construction of a bio-treatment cell consists of removal of residually impacted shallow soils, and subsequent placement of a backfill material consisting of bark mulch, vegetable oil and gravel into the excavated area, including soils above and below the water table. This will create a passive bioreactor cell in the shallow groundwater. The goals of this cell would be to 1) decrease chemical loading to shallow groundwater by reducing the mass of residual chemical constituents in the subsurface; 2) enhance natural attenuation of source area shallow groundwater, and 3) provide a long-term source of organic carbon that can be transported into the surrounding soil, downgradient, and possibly into bedrock, to enhance the anaerobic bioremediation of COCs. Additionally, a bioreactor wall situated downgradient from the source area may provide further treatment.

Installation of a passive mulch/oil bioreactor is expected to be technically-feasible at a reasonable cost. The primary challenge to implementing the bioreactor remedy is the potential production of intermediate degradation products (i.e. DCE, VC).

This remedy could be implemented in a progressive fashion, with the initial bioreactor installation monitored to evaluate whether the rate and extent of treatment will achieve remedial endpoints in shallow groundwater in a reasonable timeframe. If further acceleration of the rate of chemical removal is needed, the relative merits of substrate injections, bioaugmentation additions and/or shallow recirculation wells could be evaluated and implemented in or around the bioreactor.

Alternative 3: Monitored Natural Attenuation (MNA)

An MNA approach would rely on natural attenuation processes to achieve Site restoration. During the time that the MNA process is active, maintenance of engineering and institutional controls would continue to be implemented. Observations of COC groundwater concentrations and MNA indicator parameters would provide data to predict the time for COCs to decrease below groundwater remedial goals. However, MNA may be a viable component incorporated into other technologies.

In the process of assessing MNA as an alternative, the groundwater concentrations over time were evaluated for evidence of natural attenuation. Available data shows that natural attenuation processes are actively degrading the parent compounds (e.g., TCE, 1,1,1-TCA). Primary evidence to support this conclusion includes the observed presence of both intermediate degradation products (e.g., cis-1,2-DCE, vinyl chloride, 1,1-DCA) and complete mineralization products (e.g., ethene, ethane, chloride). Total organic carbon concentrations have been observed, along with geochemical indicators that suggest the presence of reducing (anaerobic) conditions.

These observations support a conclusion that biologically-mediated reductive dechlorination is an active degradation mechanism. Based on the relatively higher concentrations of degradation products in the shallow groundwater, compared to the deeper groundwater, the rate and influence of reductive dechlorination on chemical concentrations may be higher in shallow groundwater than it is in deep groundwater.

The primary limitation for an MNA remedy that does not include active reduction of chemical concentrations in the residual source area, is that this remedy will likely require longer time-frames than other alternatives. As such, it is anticipated that a formal MNA evaluation would find that the timeframe to achieve site restoration is not “reasonable” relative to other remedial alternatives, unless there are no other alternatives that are feasible in terms of constructability and cost.

It is important to note that all remedies for groundwater (shallow and deep) are likely to have an MNA component. This component would be applied as a final step that will continue to degrade chemical constituents over time.

Alternative 4: Groundwater Extraction

Groundwater pump and treat uses groundwater extraction wells to remove impacted water from the subsurface. The water is then sent to an *ex situ* treatment system to remove the COCs. Aquifer restoration has been found to be infeasible where non-aqueous-phase liquid (NAPL) or heavy residuals were present above or below the water table (such as the Ekonol Site), at older sites where diffusion has allowed contaminants to enter soil grains and rock, and where the precise distribution of sources was not known. Therefore, in these conditions groundwater pump and treat systems are used only to contain Site groundwater. This would reduce chemical loading to the remainder of the aquifer, such that natural processes can attenuate COCs located downgradient of the containment area.

The conceptual design for overburden groundwater remediation would be a series of extraction wells installed to provide hydraulic containment. The number of wells is determined by the area to be covered and the area of containment provided by each well. The hydraulic radius of influence (for the purposes of containment) of a single well is calculated to be approximately 30 feet. If extraction wells were placed to enclose the area from monitoring well 4S northward to the south wall of Building No. 4, then eastward to MW-10S, approximately 10 groundwater extraction wells would be needed.

The hydraulic area of influence (30 feet) was calculated using the Theis (1935) equation. The estimated pumping rate per well is approximately 0.004 gpm, based on a saturated thickness of approximately four feet, and a hydraulic conductivity of 0.03 ft/day (1×10^{-5} cm/sec).

Groundwater pump and treat would be able to provide containment in the overburden at low pumping rates. However, because it is unlikely that the pump and treatment systems would restore groundwater quality in the foreseeable future, there is no projected end date to system operations. Capital and long-term costs would be relatively higher than other alternatives. Therefore, groundwater pump and treat is not a viable alternative at this time.

Alternative 5: In situ Treatments such as Bio-enhancing Substrate, Chemical Oxidant and EZVI

Injections of *in situ* substrates such as bio-enhancing emulsions (i.e. vegetable oil), chemical oxidants and EZVI for shallow groundwater are limited by the feasibility of injecting the substrate into the low permeability soils. Additionally, each technology has other limiting factors (bio-enhancing treatments may increase the concentrations of degradation products prior to decreasing them; chemical oxidation would have to overcome the natural anaerobic environment before a reduction in COCs would occur, and EZVI is experimental and relatively high cost).

Due to these considerations, the feasibility of using an injection of an *in situ* remediation substrate is limited for shallow groundwater.

D.5 Alternative Identification for Deep Groundwater

The following alternatives were identified for the deep groundwater.

- Alternative 1: Engineering/Institutional Controls;
- Alternative 2: Monitored Natural Attenuation (MNA);
- Alternative 3: Groundwater Extraction;
- Alternative 4: Bio-enhancing *in situ* Treatment;
- Alternative 5: Chemical Oxidation *in situ* Treatments; and
- Alternative 6: EZVI *in situ* Treatments.

Other technologies exist, but these were identified for consideration because they are either common remedial solutions or are potentially feasible. The alternatives are evaluated below.

D.6 Alternative Evaluations for Deep Groundwater

Alternative 1: Engineering/Institutional Controls

The approach and evaluation of engineering/institutional control for deep groundwater is similar to for shallow groundwater (see Section D.4, 1).

Alternative 2: Monitored Natural Attenuation (MNA)

The evaluation of MNA in bedrock is similar that in shallow groundwater (see Section E 4, 3). MNA is a final step in the groundwater remediation option.

Alternative 3: Groundwater Extraction

The conceptual design for a groundwater extraction system in bedrock consists of two to three groundwater extraction wells, installed to provide hydraulic containment of the source area. The number of wells is based on an estimate that the area to be contained is a roughly triangular area bounded by wells MW-4D, MW-2D and MW-3D. The hydraulic radius of influence (for the purposes of containment) of a single well was calculated to be about 60 feet.

The hydraulic area of influence was calculated using the Theis (1935) equation. The estimated pumping rate per well is approximately two gallons per minute, based on a geometric mean transmissivity of 235 ft^2/day (well transmissivities presented on Table 3 of the Hydraulic Pulse Interference Report, GeoSierra, 2005).

Groundwater pump and treat would be able to provide containment in the bedrock at relatively low pumping rates. However, because it is unlikely that the pump and treatment systems would restore groundwater quality in the foreseeable future, there is no projected end date to system operations. Capital and operational costs will be higher than other alternatives. Therefore, groundwater pump and treat is not considered a viable option at this time.

Alternative 4: Bio-enhancing in situ Treatment

Bio-enhancing substrate injections could be used in deep groundwater for source area treatment, and possibly as linear treatment zones that intersect the area outside the source zone (i.e., ‘biobarriers’). It is anticipated that treatment of the entire area of dissolved COCs in deep groundwater would be cost-prohibitive. It is further anticipated that a combined substrate of emulsified vegetable oil and a soluble substrate would be used in the source area(s) to create a longer-term treatment zone (longer than using soluble substrate alone).

The primary concern of using a bio-enhancing *in situ* treatment is temporary production of regulated intermediates during the anaerobic degradation (Parsons, 2004c). Additional challenges include obtaining sufficient distribution of the injected compound to achieve the desired treatment effectiveness. Because organic substrates are inexpensive relative to chemical reductants (e.g., EZVI) and chemical oxidants (e.g., hydrogen peroxide, permanganate), a larger mass of organic substrate can be injected into bedrock for the same cost as chemical treatment, offering the advantage of creating a larger treatment zone. This advantage may be partially offset by the fact that enhanced anaerobic bioremediation treatment methods rely on sequential reductive dechlorination of multiple regulated compounds, and may be less effective on DNAPL. However, recent studies show that vegetable oil substrates can increase the bio-availability of compounds and sequester the DNAPL. This indicates that the use of vegetable oils may be more effective than previously thought.

Alternative 5: Injection of Chemical Oxidation in situ Treatments

Chemical oxidation as a remediation technology utilizes one or more chemical oxidizing reagents to oxidize and destroy organic COCs and convert them into innocuous material such as salts and carbon dioxide. The oxidants used for *in situ* chemical oxidation may include gaseous reagents such as ozone, or liquid reagents such as Fenton's reagent (hydrogen peroxide and ferrous ion), permanganate (sodium permanganate or potassium permanganate) and sodium persulfate solution, and activating compounds such as ferrous ion, heat or hydrogen peroxide.

Chemical oxidation technology could work, based on the COCs present at the Site. However, the reagents mentioned above are non-specific oxidizers and would oxidize all organic carbon, including those associated with native soils and bedrock reduce the ability of the natural attenuation processes. Due to the current anaerobic and pH of the deep groundwater system pH, near neutral in most areas, and large treatment area chemical oxidation has limited potential. High demands of oxidants or reagents would be required to first convert the anaerobic environment to aerobic, and then promote oxidation of almost all organic carbon, such as that associated with the native soil material, and finally oxidize the COCs.

Alternative 6: Injection of EZVI in situ Treatments

This is an innovative technology approach which injects an emulsion consisting of zero-valent metal particles, a surfactant, vegetable oil, and water into the subsurface. The metal, surfactant, and oil contribute to the dehalogenation of chlorinated, organic compounds and dense non-aqueous phase liquids (DNAPLs), such as trichloroethylene (TCE). Typically, the zero-valent metal particles consist of nanoscale and microscale zero-valent iron. The zero-valent iron is believed to degrade the DNAPL abiotically, whereas the vegetable oil and surfactant promote longer-term, anaerobic biodegradation.

It has been suggested that DNAPL compounds (e.g., TCE) diffuse through the oil membrane of the emulsion particle, and undergo reductive dechlorination in the presence of the ZVI particles in the interior aqueous phase. The target chemicals undergo dechlorination steps, with the EZVI droplets resulting in the formation of non-chlorinated hydrocarbon products (e.g., ethene, ethane). In laboratory tests, the degradation of TCE may occur primarily via the abiotic pathway, where TCE is converted to chloroacetylene, which in turn is dehalogenated to acetylene. Acetylene is subsequently degraded to ethene and ethane. In field tests, however, degradation of TCE occurs through both the abiotic and biotic pathways. This is the result of less reactivity of the iron than anticipated, leaving the vegetable oil to enhance the biodegradation of TCE.

The 2005 investigations focused on the feasibility of using EZVI, yet the results are applicable to other alternatives. Interpretation from the pulse interference tests in the deep groundwater zone indicated that the transmissivity of the bedrock may enable injection of the EZVI into this formation at low injection pressures (<1 psi). However, the effectiveness of EZVI in Site groundwater and fractured bedrock should be further evaluated, if this alternative in considered for implementation. Further work could involve bench-scale testing of the degradation processes using impacted Site groundwater and EZVI solution, as well as open-hole bedrock well(s) for discrete fracture characterization.

APPENDIX E
HYDRAULIC INTERFERENCE TEST REPORT

GeoSierra

TEST REPORT

HYDRAULIC PULSE INTEFERENCE TESTING
BP EKONOL SITE
WHEATFIELD, NEW YORK

PREPARED FOR:

PARSONS

PREPARED BY:

GEOSIERRA LLC
3560 ENGINEERING DRIVE
NORCROSS, GEORGIA 30092

October 2005

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TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

GeoSierra, LLC (GeoSierra) has prepared this Test Report to summarize the results from hydrogeological characterization testing of the source area by the hydraulic pulse interference method at the Ekonol Polyester Resins Facility (Site) in Wheatfield, New York. The location of the Wheatfield Township is shown on Figure 1. Characterization of the Site by the hydraulic pulse interference testing was completed to quantify the continuity and hydraulic connectivity within the shallow and fractured bedrock systems spatially within the source area to assist with the design of an injection system for emulsified nanoscale zero valent iron (EZVI). The design for the optimal placement of injection wells for the injection of EZVI into three (3) horizons within the defined source area at the Site will be based on the data developed during the pulse interference testing.

1.1 Site Background & Hydrogeologic Setting

The Ekonol Polyester Resins Facility site is located near the town of Wheatfield, New York and is situated on Walmore Road, which bounds the eastern boundary of the Site. The Site is underlain by a thin, variable thickness of clay of approximately 10-feet thick which overlies the dolomitic limestone bedrock. The clay/bedrock contact is a more permeable zone compared to the overlying overburden and contains gravel lenses on the top of the bedrock/clay contact. The upper portion of the bedrock has predominantly two fractured zones at approximately 20 and 30-feet below ground surface (bgs). The deeper bedrock is more competent than the shallow bedrock and has relatively few fractures and a much lower permeability than the upper bedrock. The groundwater flow gradient is directed towards the south (Parsons, 2004).

The Site has been used for the manufacture of polyester resins and from past practices, the groundwater has been contaminated by VOCs, primarily trichloroethene (TCE), and its daughter products, *cis*-1,2-dichloroethene (c-1,2-DCE) and vinyl chloride (VC). The source area is the area where the highest VOC concentrations in groundwater have been detected. The source of contamination within this area is contained in the more permeable zone at the clay/bedrock contact, and in the two (2) predominantly horizontal fractured zones in the upper bedrock. (Parsons, 2004).

1.0 HYDRAULIC PULSE INTERFERENCE TESTS

1.1 Hydraulic Pulse Interference Tests

1.1.1 General

Hydraulic pulse interference tests (HPIT) are typically conducted prior to and following the installation of a subsurface remedial system such as a permeable reactive barrier (PRB) or the injection of EZVI into subsurface fracture zones to determine whether the injected media impacts the natural groundwater flow, as well as to assess the hydraulic effectiveness of the subsurface remedial system. The pulse test is highly sensitive and defines the degrees of hydraulic continuity between the source and receiver wells. The pulse interference test is a transient test, and hydraulic properties, such as transmissivity and storativity, of the formation can be quantified as illustrated on Figure 2.

The point source hydraulic pulse interference test can be modeled from the solution of a continuous point source in an infinite isotropic homogeneous medium (Carslaw and Jaeger, 1986) as given by equation (1). This fundamental solution can be modified to incorporate finite aquifer systems, confined and unconfined conditions, anisotropic and heterogeneous conditions in a similar manner as the line source solution has been modified in the petroleum literature. This line source solution for continuous injection is the exponential integral, whereas the point source solution is the complimentary error function. The pressure response in a receiver well is given by the following equation:

$$\Delta p(t) = \frac{q}{4 \cdot \pi \cdot K \cdot r_w \cdot r_d} erfc\left({r_D} \middle/ {\sqrt{4 \cdot t_d}} \right) \tag{1}$$

where $\Delta p(t)$ is the pressure response at a given time, q is the injection flow rate, K is the formation hydraulic conductivity, S_s is the formation specific storage, r_w is the well bore radius of a source well, t_d is dimensionless time defined in equation (3), and r_D is the dimensionless distance defined by the following equation:

$$r_D = \frac{r}{r_W} \tag{2}$$

where r is the distance from the receiver well to the source well. The dimensionless time is defined as:

$$t_D = \frac{K \cdot t}{r_w^2 \cdot S_s} \tag{3}$$

where t is the elapsed time since the start of the injection.

Groundwater flow in rock masses can occur through the intact material (porous-media flow) or through the discontinuities (fissure flow). In many fractured bedrock systems, with the exception of highly weathered zones, the hydraulic conductivity of the intact material is low and the fissures within the bedrock form the main passages for fluid flow.

Fluid flow through fractured rock masses is primarily governed by: (a) fracture aperture, (b) fracture spacing, (c) fracture orientation, (d) hydraulic continuity of a fracture or a set, and (e) boundary conditions. While (a), (b), and (c) can be estimated, it is very difficult or almost impossible to establish (d) and (e) with any degree of confidence. A variety of techniques exist for estimating fracture aperture by direct logging of oriented core (Rocha, 1973), photographic methods (Bianchi, 1968), borehole seisviewer (Zemanek et al., 1969), impression packers (Harper and Hinds, 1977), etc. The average aperture of fractures can be estimated by an injection test provided the number of fractures present is known (Louis, 1969). Fracture spacing and orientation can also be measured with the above methods.

The study of flow through fissures has been based primarily on the application of classical hydrodynamic theories relating to incompressible viscous flow between parallel plates. The majority of studies have assumed a Darcy type of flow law, where v is the fluid velocity in the fracture, k_f is the fracture hydraulic conductivity, and i is the hydraulic gradient:

$$v = k_f i \tag{4}$$

If it can be assumed that the fracture can be represented by a parallel-plate system of fracture aperture e, the proportionality constant k_f is given exactly by Lamb (1932).

$$k_f = \frac{ge^2}{12\nu} \tag{5}$$

where g is the acceleration due to gravity and ν is the kinematic viscosity of the fluid in the fracture.

A very limited amount of laboratory data on the permeability of fractures exists. Extensive tests on simulated fractures (Louis, 1969) have quantified the transition from laminar to turbulent flow in a simulated fracture. The majority of laboratory experimental data has been restricted to fractures whose aperture is greater than 0.001 centimeters (cms). It is likely that at apertures that are smaller than this value, the fracture walls will have some form of an adhesive layer due to absorption. It is estimated that the critical aperture below which no fluid flow is possible is around 5 x 10^{-4} cms (Louis, 1969). Due to experimental limitations, field and laboratory measurements are lacking at low fissure apertures (<0.001 cms).

For laminar flow in a single set of parallel fissures of apertures e and spacing Δ, the hydraulic conductivity of an equivalent porous medium is related to the fissure aperture from equation (5) by the following:

$$k = \frac{ge^3}{12v\Delta} \tag{6}$$

Thus if the transmissivity of the fractured bedrock system can be quantified in situ then the equivalent parallel plate aperture of the fractures can be estimated from equation (6). These calculations are discussed in Section 2.1.3 - Results.

Fifteen (15) monitoring wells at the Site were monitored for hydraulic pulse interference testing in the shallow and bedrock saturated zones. The HPITs were conducted across select monitoring wells to provide detailed hydrogeological characterization of the Site by cross hole paths, both parallel and perpendicular to the proposed area of treatment.

1.1.2 Field Procedures

The source well injection system consists of an inflatable packer to isolate the injection horizon, and a pressure transducer that is placed in the source well to monitor injection pressures as shown on Figure 2. The receiver well system also consists of an inflatable packer isolating the high precision pressure transducer from wellbore storage effects. The injection flow rate is controlled by a constant flow rate direct drive pump with solenoid adjustable time interval switching values to modulate the periodic timed injection and shut-in of the source well.

During the pulse interference test, the source well’s flow rate and pressure are monitored along with all of the receiver pressure transducers. The receiver well pressure transducers must be of high precision and need to be continuously monitored and recorded at high data acquisition rates.

To ensure the tests are repeatable, the pulse switching mechanism needs to be automatically controlled and recorded on the data acquisition system. To optimize the resolution of the test, the injection/shut-in time interval and/or injection flow rate needs to be varied depending on site conditions and the distances between source and receiver wells.

1.1.3 Results

The interpretation of the point source hydraulic pulse interference test follows similar procedures to line source interpretation procedures using type curves as detailed in Hocking (2001). The hydraulic pulse interference test arrangement, typical data, and type curve matching are shown on Figure 2. From a match of the type curves, the HPIT data quantifies the hydraulic conductivity between well pairs as either a transmissivity or hydraulic conductivity. The degree of hydraulic conductivity is determined from these data either directly for porous media as in the case of fractured bedrock systems in terms of hydraulic conductivity or fracture flow aperture. The value of the hydraulic conductivity for the porous medium or fractured system quantifies the ease with which water will flow from one well to another. Also the pulse interference test provides a measure of the tortuosity of the major flow path between well pairs by the time delay of the pressure response in the receiver wells. A short time delay indicates a direct and well connected hydraulic system while a long delay indicates a tortuous path and less well connected well pairs.

The hydraulic conductivity between well pairs provides a measure of the ability to inject and distribute EZVI emulsion throughout the zone of interest and quantify the spacing between injection and pull well pairs. A well connected system enables the push-pull injection method to distribute the injected EZVI material evenly throughout the subsurface whereas a poorly connected system requires both a greater density of injection and push-pull points. A well connected system enables the push-pull injection method to distribute the injected EZVI material evenly throughout the subsurface whereas a poorly connected system requires both a greater density of injection and pull well points at lower injection flow rates resulting in greater cost and less certainty of even coverage of the injected EZVI material.

The hydraulic pulse interference test arrangement, typical data and type curve matching are shown on Figure 2. The hydraulic pulse interference tests at the Site were conducted across the monitoring well pairs as follows: source well MW-2S with receiver wells MW-3S, MW-4S, and MW9S; source well MW-3S with receiver wells MW-4S, MW-6S, and MW-7S; source well MW-4S with receiver wells MW-7S, and MW-9S; source well MW-2D with receiver wells MW-

3D, MW-4D, and MW-10D; source well MW-3D with receiver wells MW-4D and MW-11D and source well MW-4D with receiver well MW-10D (Figure 3). Groundwater elevations were recorded prior to beginning the pulse testing and are provided in Table 1. No hydraulic pulse interference testing was conducted on source well MW-4S with receiver well MW-8S because the water table in the receiver well, MW-8S, was below the top of the well screen and therefore the receiver well packer could not be set.

In addition to the well pairs outlined above hydraulic pulse interference tests were also conducted to determine the hydraulic connection between the shallow clay/bedrock zone and the deeper fractured bedrock zone by pulse testing in the following monitoring well pairs: source well MW-2D with receiver well MW-2S; source well MW-3D with receiver well MW-3S; and source well MW-4D with receiver well MW-4S. The locations of the monitoring wells used are shown on Figure 3.

Response data from source receiver well pairs and type curve matching for all of the source receiver well pairs are contained in Appendix A. The type curve match assumed a confined aquifer from a depth of 7-feet down to a total depth of 12-feet below ground surface (bgs) for the shallow monitoring wells in the clay/bedrock zone and a confined aquifer from a depth of 17-feet down to a total depth of 27-feet bgs for the bedrock monitoring wells.

The hydraulic conductivity and storativity values computed for each well pair are detailed in Table 2. No detectable receiver pressure response was recorded between the pulse source wells in the fractured bedrock and the receiver wells in the shallow saturated zone therefore quantifying that these zones are not hydraulically connected in the area tested.

The hydraulic conductivity calculated for the shallow monitoring wells ranged from a low of 0.0002 feet per day (ft/day) to a high of 135 ft/day. No detectable was recorded in well pairs MW3S/MW-4S and MW-3S/MW-7S. The calculated storativity values from the shallow monitoring well test data ranged from a low of 5.85E-11 1/ft to a high of 5.08E10-05 1/ft. The field data and best fit type curves are contained in Appendix A for all of the hydraulic pulse interference test data. Based on these field data it appears that poor hydraulic connection exists between the shallow monitoring wells tested with the exception of well pairs MW-4S/MW-7S and MW-4S/MW-9S. The measured injection pressures during the pulse interference tests conclude that EZVI injection into this zone will need to be at low flow rate, e.g., 1-2 gallons per minute to limit injection pressures below 5 pounds per square inch (psi).

The equivalent porous medium hydraulic conductivity calculated for the bedrock wells ranges from a low of 5.57 ft/day to a high of 117 ft/day. The calculated storativity values derived from the bedrock well test data range from a low 4.58E-08 1/ft to a high of 6.79E-07 1/ft. The field data and best fit type curves are contained in Appendix A for all of the hydraulic pulse interference test data. Based on these field data it appears that good hydraulic connection exists between all of the bedrock well pairs tested.

Transmissivity values were also calculated for the bedrock fractured media and are presented in Table 2. Transmissivity values ranged from a low 5.60E+01 square feet per day (ft^2/day) to a high of 1.17E+03 ft^2/day. As discussed above, the transmissivity of the fractured bedrock system quantified in situ can be used to estimate the equivalent parallel plate aperture of the fractures using equation (6). From a review of the cores for the deeper bedrock wells it appears that generally 3 to 5 water transmissive fractures are present in this zone. Assuming three uniform continuous fractures being present in the subsurface at the Site the equivalent parallel fracture apertures were quantified as detailed in Table 3. The fracture apertures calculated ranged from 0.29 to 0.8 millimeters (mm) assuming three (3) continuous transmissive fractures in the deeper bedrock zone. If five (5) continuous transmissive fractures were assumed present in the deeper bedrock zone then the fracture apertures would range from 0.2 to 0.6 mm in width resulting in only slightly lower apertures than if three (3) fractures were present. In both cases the fractures hydraulic conductivity is sufficiently high to allow injection of the EZVI under very low pressure of the order of 1 psi, based on measured injection pressures during the pulse interference tests.

3.0 CONCLUSIONS

The hydraulic pulse interference tests quantified the hydraulic connectivity between 1) the shallow clay/upper bedrock wells, 2) the deeper fractured bedrock wells, and 3) from the shallow (clay/upper bedrock) wells to the deeper fractured bedrock wells. Based on these test data the shallow (clay/upper bedrock wells) are poorly connected hydraulically (i.e., very low hydraulic conductivity between well pairs) except for well pairs MW-4S/MW-7S and MW-4S/MW-9S. All of the deeper fractured bedrock well pairs are well connected hydraulically through a series of well connected transmissive fractures resulting in moderate to high hydraulic conductivity and direct (non-tortuous) flow paths. The shallow (clay/upper bedrock) wells and the deeper fractured bedrock wells are not hydraulically connected in the area of the monitoring wells MW-2S/MW-2D, MW-3S/MW-3D, and MW-4S/MW-4D.

The low injection pressures recorded during the pulse interference tests in the deeper fractured bedrock and the highly transmissive fractures in this zone will enable injection of the EZVI into this formation at very low injection pressures (<1 psi) and at large injection/pull well spacing on the order of 150-feet. The shallow clay/upper bedrock zone will require a close spacing of injection/pull well pairs and extremely low injection flow rates to distribute the EZVI within this zone. From a review of contaminant levels in the shallow and deeper zones, the extent of coverage for EZVI injection in the shallow zone is immediately around MW-2S while in the deeper zone the extent of EZVI coverage extends from the source area near MW-2D to the edge of the main administration building, i.e., near MW-7D. The quantification of injection/pull well pair spacing , EZVI injection quantities and flow rates, and required EZVI injection coverage will be made in the 30% Design Report.

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TABLES

TABLE 1

WATER LEVEL ELEVATION DATA
EKONOL POLYESTER RESINS SITE
WHEATFIELD, NEW YORK

Monitoring Well ID	Depth to Water (ft bgs)	Date
MW-2S	6.98	9/13/2005
MW-3S	5.91	9/13/2005
MW-4S	8.21	9/13/2005
MW-6S	8.93	9/13/2005
MW-7S	7.41	9/13/2005
MW-8S	10.80	9/13/2005
MW-9S	9.49	9/13/2005
RMW-2D	9.05	9/13/2005
RMW-3D	9.39	9/13/2005
RMW-4D	9.30	9/13/2005
MW-10D	9.13	9/13/2005
MW-11D	12.30	9/13/2005

TABLE 2

HYDRAULIC PULSE INTERFERENCE TEST DATA
EKONOL POLYESTER RESINS SITE
WHEATFIELD, NEW YORK

Hydraulic Pulse Interference Test Results				Fractured Media
Source Well	Receiver Well	K (ft/day)	S_s (1/ft)	T (ft^2/day)
MW-2S	MW-3S	8.16E-02	1.17E-07	NC
MW-2S	MW-4S	5.30E-02	1.27E-07	NC
MW-2S	MW-9S	6.43E-01	6.95E-07	NC
MW-3S	MW-4S	NR	NR	NR
MW-3S	MW-6S	1.60E-04	5.85E-11	NC
MW-3S	MW-7S	NR	NR	NR
MW-4S	MW-7S	2.69E+01	4.68E-05	NC
MW-4S	MW-8S	ND	ND	ND
MW-4S	MW-9S	1.35E+02	5.08E-05	NC
RMW-2D	RMW-3D	1.10E+01	3.52E-07	1.10E+02
RMW-2D	RMW-4D	1.37E+01	2.28E-07	1.37E+02
RMW-2D	MW-10D	1.17E+02	6.79E-07	1.17E+03
RMW-3D	RMW-4D	5.57E+00	4.58E-08	5.60E+01
RMW-3D	MW-11D	2.44E+01	3.24E-07	2.44E+02
RMW-4D	MW-10D	7.07E+01	1.28E-07	7.07E+02

NC = Value not calculated
NR = No response recorded
ND = No data collected, screen out of water

TABLE 3

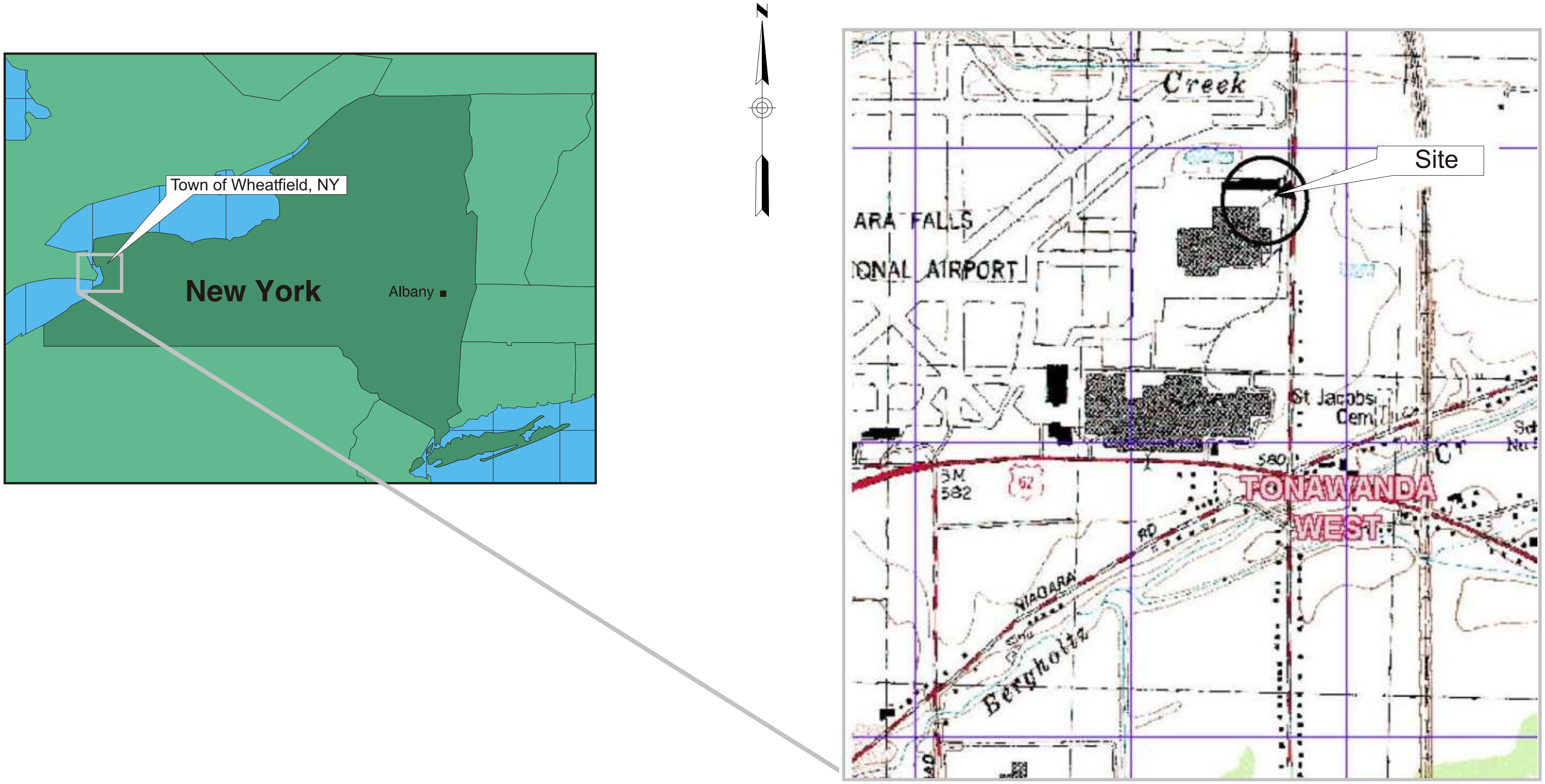
FRACTURE DATA FROM BEDROCK WELLS PULSE TESTING
EKONOLO POLYESTER RESINS SITE
WHEATFIELD, NEW YORK

Source Well	Receiver Well	Transmissivity of Fractured Media (ft^2/day)	Transmissivity of Fractured Media (ft^2/sec)	Equivalent Parallel Fracture Aperture (ft/fracture)*	Equivalent Parallel Fracture Aperture (mm/fracture)*
RMW-2D	RMW-3D	110	0.000424	0.001188	0.362086
RMW-2D	RMW-4D	137	0.000529	0.001278	0.389572
RMW-2D	MW-10D	1171	0.004518	0.002613	0.796525
RMW-3D	MW-4D	56	0.000216	0.000949	0.289119
RMW-3D	MW-11D	244	0.000941	0.001549	0.472219
RMW-4D	MW-10D	707	0.002728	0.002209	0.673215

* -- Assumes three (3) transmissive fractures in bedrock zone.

Kinematic Viscosity of Water @ 70°F = 1.06E-05 ft^2/sec

FIGURES



LOCATION MAP

CLIENT/PROJECT EKONOL POLYESTER RESINS FACILITY WHEATFIELD, NEW YORK	GeoSierra Atlanta, Georgia	TITLE TOWN OF WHEATFIELD LOCATION MAP

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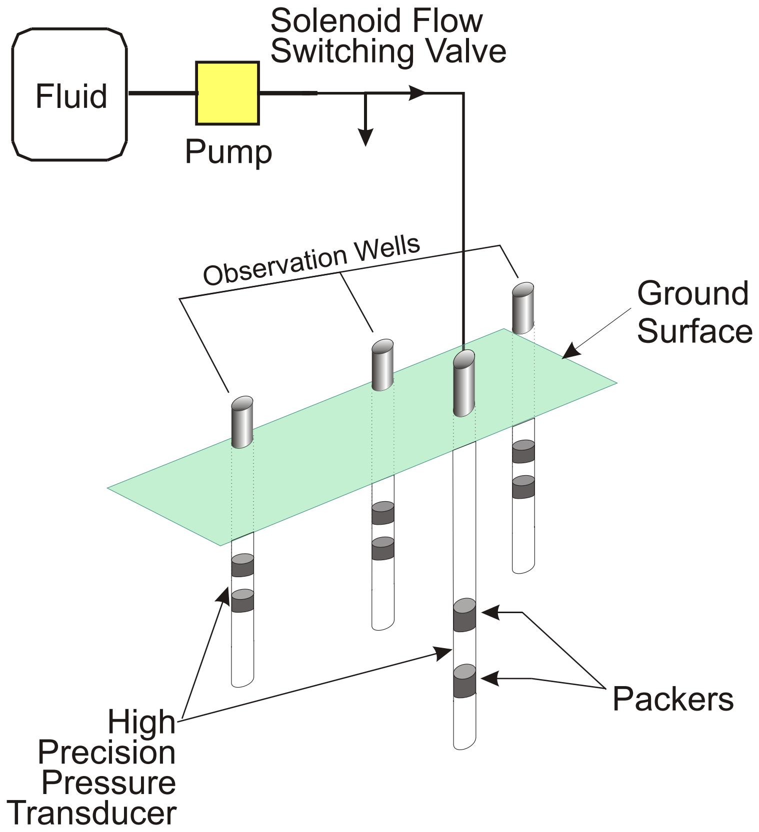

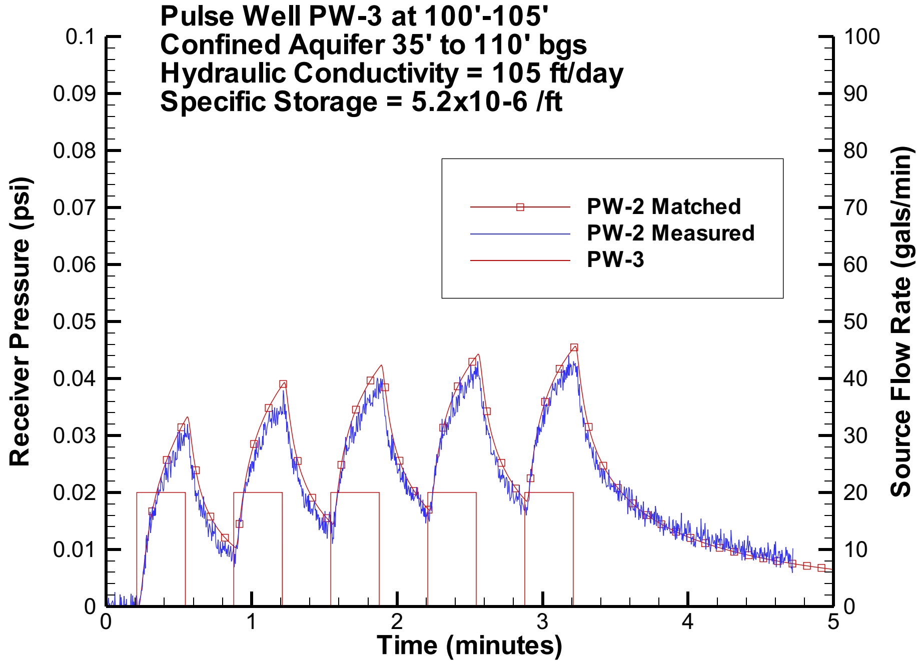

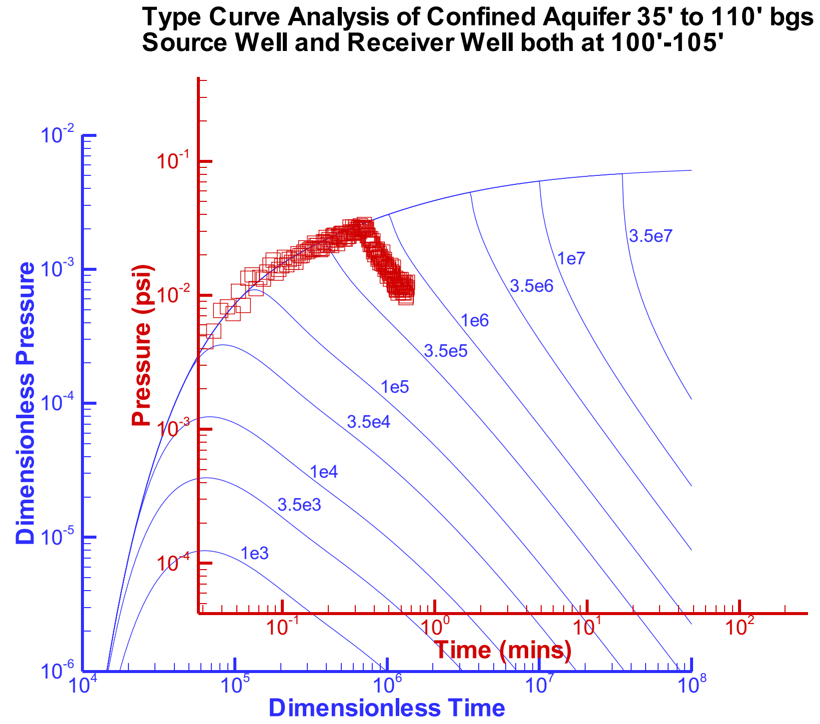

GeoSierra

Atlanta, Georgia

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REV. NO.
JOB NO. 6022
DATE 9/28/05
DRAWN MAT
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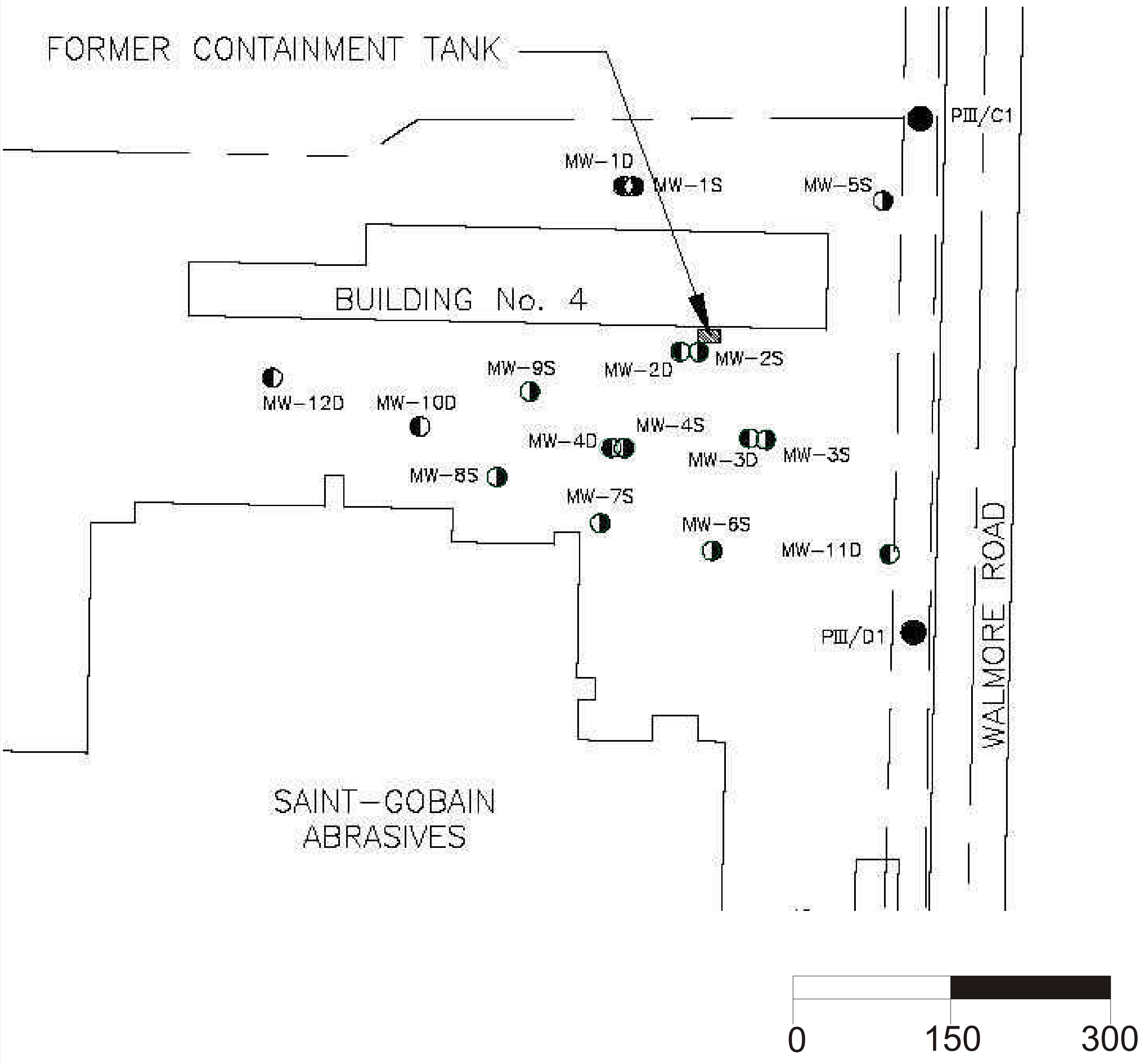
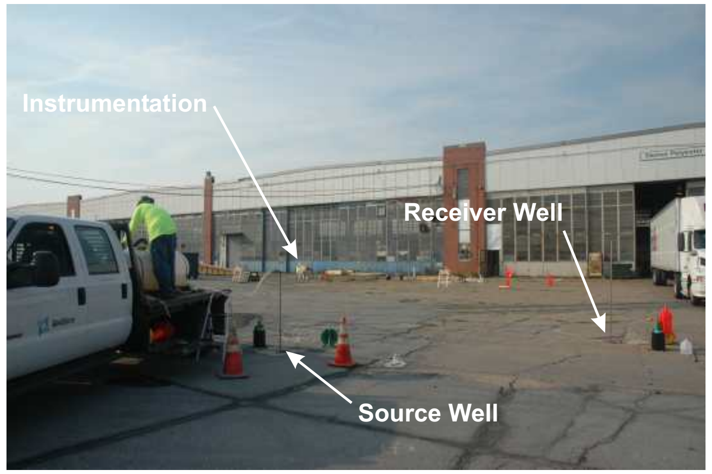
FILE NO. 6602-d02.cdr
REVIEWED

CLIENT/PROJECT
EKONOL POLYESTER
RESINS FACILITY
WHEATFIELD, NEW YORK

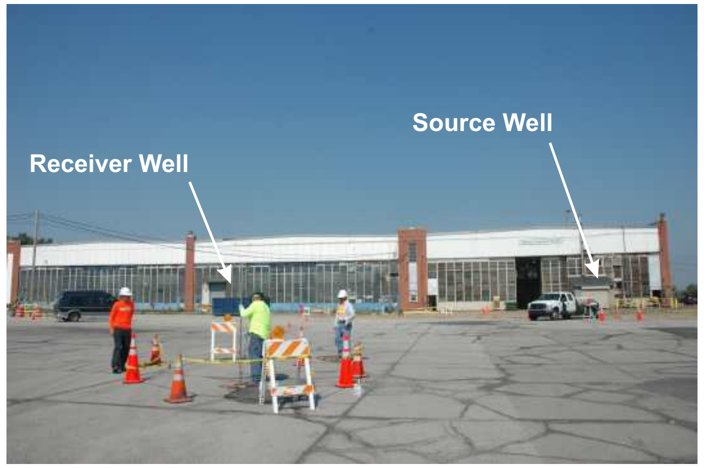
TITLE
**TYPICAL HYDRAULIC PULSE
INTERFERENCE TEST DATA
FOR SITE CHARACTERIZATION**

FIGURE NO.
2





Hydraulic Pulse Interference Testing



Installation of Pulse Receiver Equipment

Installation of Hydraulic Pulse Interference Test Equipment

Typical Set-Up of Hydraulic Pulse Equipment

LEGEND

◐ MW-1D	EXISTING BEDROCK MONITORING WELL
◑ MW-1S	EXISTING OVERBURDEN MONITORING WELL
● PⅢ/A1	GROUNDWATER SCREENING/ BEDROCK BORING LOCATION
—— — — ——	PROPERTY LINE
—— —— —— ——	RIGHT-OF-WAY

GeoSierra

Atlanta, Georgia

DWG NO. 6022-D01	
REV. NO.	JOB NO. 6020
DATE 9/18/05	DRAWN MAT
SCALE NTS	CHECKED
FILE NO. 6022-D01.cdr	REVIEWED

CLIENT/PROJECT
Former Ekonol Polyester Resin Facility
Wheatfield, NY

TITLE

PRE HYDRAULIC PULSE TEST LAYOUT

FIGURE NO.
3

APPENDIX A

Hydraulic Pulse Interference Testing Data

APPENDIX A-1	Hydraulic Pulse Interference Test Plots
APPENDIX A-2	Pressure Pulse Profiles

APPENDIX A-1

Hydraulic Pulse Interference Test Data

HYDRAULIC PULSE INTERFERENCE TEST
SOURCE WELL: MW-2S RECEIVER WELL: MW-3S

$$K = \frac{q p_D}{4 \pi r_w \Delta p}$$

K = formation hydraulic conductivity

$$S_s = \frac{K t}{r_w^{2} t_D}$$

S_s = formation specific storage

where:

q = flow rate
p_D = dimensionless pressure
r_w = well bore radius of source well
Δp = pressure
t = time
t_D = dimensionless time

PULSE TEST DATA

q =	5.00	gpm
r_w =	0.34	ft

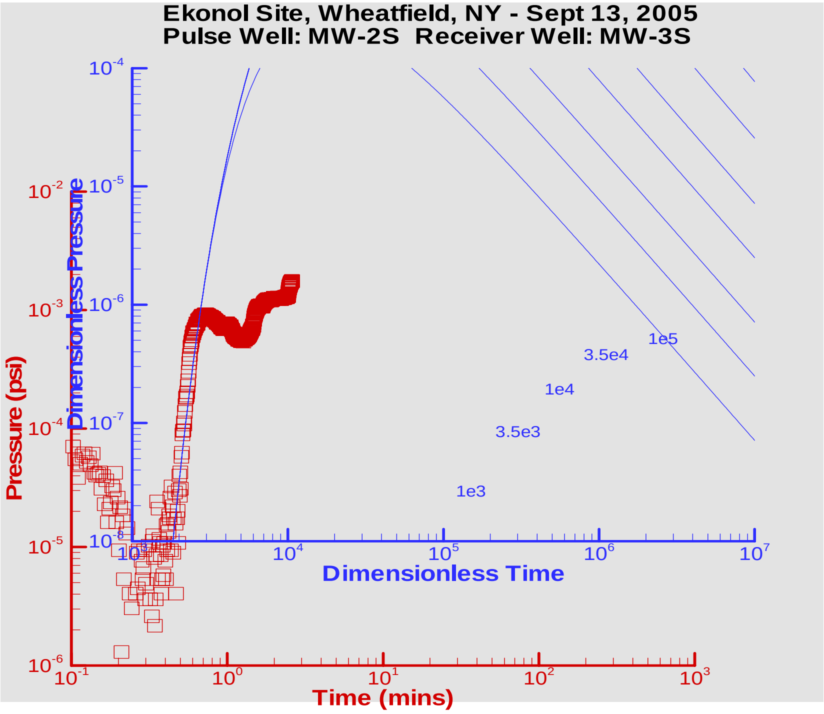
TYPE CURVE MATCH PARAMETERS

Δp =	0.0003326	psi
pD =	2.81E-07	
t =	0.59	mins
t_D =	2398.00	

RESULTS

Porous Media

K =	8.16E-02	ft/day
S_s =	1.17E-07	1/ft



Project Name: BP-Ekenol
Project No.: 6022
Test Date: 9/13/2005

Analysis By: BAF
Checked By: GH
Reference: Hocking (2001)

GEOSIERRA

HYDRAULIC PULSE INTERFERENCE TEST
SOURCE WELL: MW-2S RECEIVER WELL: MW-4S

$$K = \frac{qp_D}{4\pi r_w \Delta p}$$

K = formation hydraulic conductivity

$$S_s = \frac{Kt}{r_w{}^2 t_D}$$

S_s = formation specific storage

where:

q = flow rate
p_D = dimensionless pressure
r_w = well bore radius of source well
Δp = pressure
t = time
t_D = dimensionless time

PULSE TEST DATA

q =	**5.00**	**gpm**
r_w =	**0.34**	**ft**

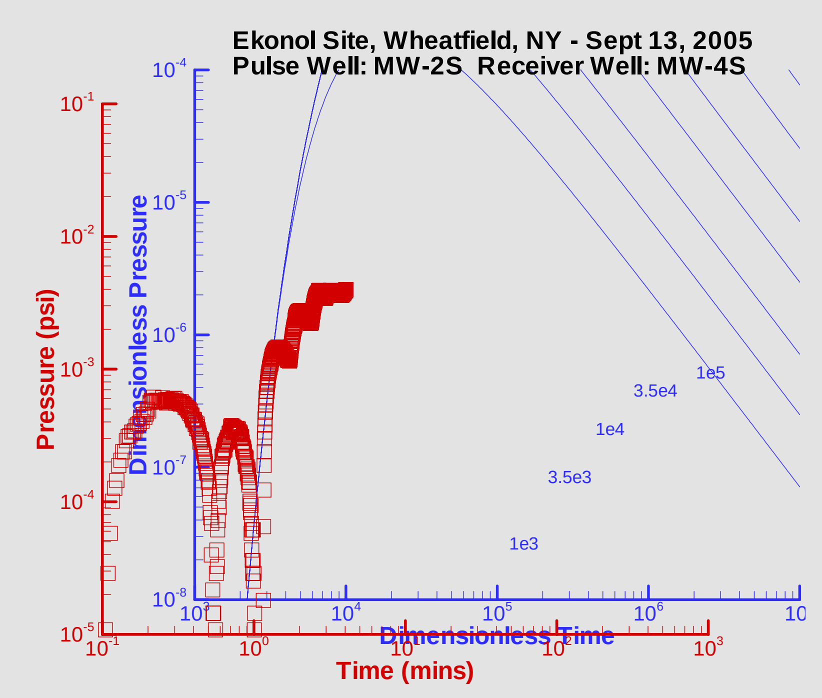
TYPE CURVE MATCH PARAMETERS

Δp =	**0.00182**	**psi**
pD =	**1.00E-06**	
t =	**4.09**	**mins**
t_D =	**10000.00**	

RESULTS

Porous Media

K =	**5.30E-02**	**ft/day**
S_s =	**1.27E-07**	**1/ft**



Project Name: BP-Ekenol
Project No.: 6022
Test Date: 9/13/2005

Analysis By: BAF
Checked By: GH
Reference: Hocking (2001)

GEOSIERRA

HYDRAULIC PULSE INTERFERENCE TEST
SOURCE WELL: MW-2S RECEIVER WELL: MW-9S

$$K = \frac{qp_D}{4\pi r_w \Delta p}$$

K = formation hydraulic conductivity

$$S_s = \frac{Kt}{r_w{}^2 t_D}$$

S_s = formation specific storage

where:

q = flow rate
p_D = dimensionless pressure
r_w = well bore radius of source well
Δp = pressure
t = time
t_D = dimensionless time

PULSE TEST DATA

q = 5.00 gpm
r_w = 0.34 ft

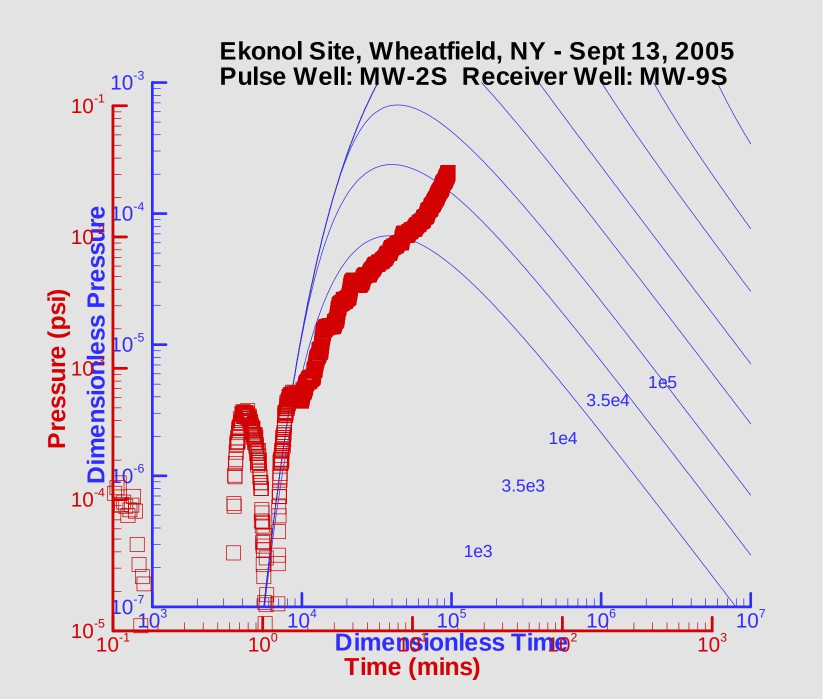
TYPE CURVE MATCH PARAMETERS

Δp = 0.0015 psi
pD = 1.00E-05
t = 1.84 mins
t_D = 10000.00

RESULTS

Porous Media

K = 6.43E-01 ft/day
S_s = 6.95E-07 1/ft



Project Name: BP-Ekenol
Project No.: 6022
Test Date: 9/13/2005

Analysis By: BAF
Checked By: GH
Reference: Hocking (2001)

GEOSIERRA

HYDRAULIC PULSE INTERFERENCE TEST
SOURCE WELL: MW-3S RECEIVER WELL: MW-6S

$$K = \frac{qp_D}{4\pi r_w \Delta p}$$

K = formation hydraulic conductivity

$$S_s = \frac{Kt}{r_w^{\,2} t_D}$$

S_s = formation specific storage

where:

q = flow rate
p_D = dimensionless pressure
r_w = well bore radius of source well
Δp = pressure
t = time
t_D = dimensionless time

PULSE TEST DATA

q =	**5.00**	**gpm**
r_w =	**0.34**	**ft**

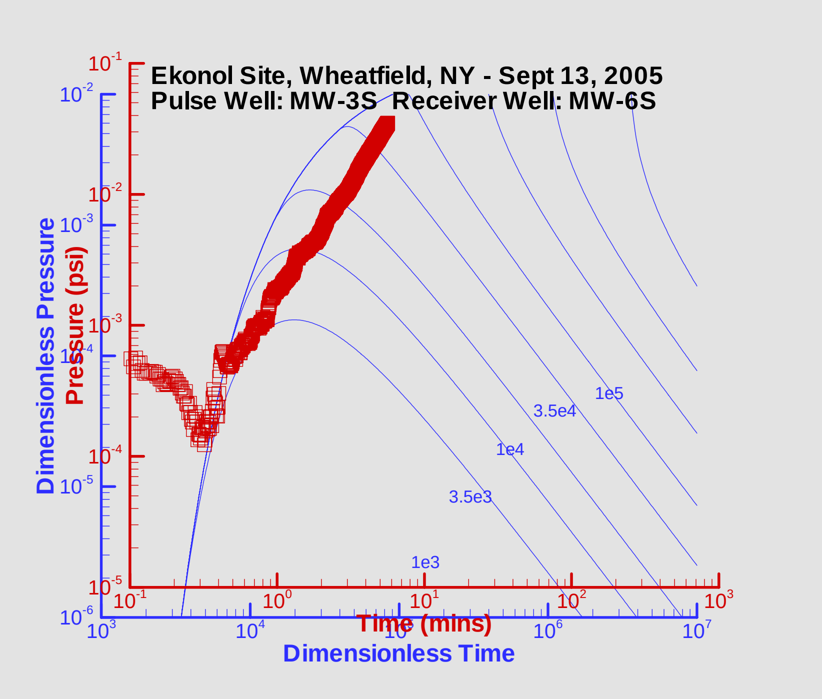
TYPE CURVE MATCH PARAMETERS

Δp =	**6.02**	**psi**
pD =	**1.00E-05**	
t =	**0.62**	**mins**
t_D =	**10000.00**	

RESULTS

Porous Media

K =	**1.60E-04**	**ft/day**
S_s =	**5.85E-11**	**1/ft**



Project Name: BP-Ekenol
Project No.: 6022
Test Date: 9/13/2005

Analysis By: BAF
Checked By: GH
Reference: Hocking (2001)

GEOSIERRA

HYDRAULIC PULSE INTERFERENCE TEST
SOURCE WELL: MW-4S RECEIVER WELL: MW-7S

$$K = \frac{q p_D}{4\pi r_w \Delta p}$$

K = formation hydraulic conductivity

$$S_s = \frac{Kt}{r_w^{\,2} t_D}$$

S_s = formation specific storage

where:
q = flow rate
p_D = dimensionless pressure
r_w = well bore radius of source well
Δp = pressure
t = time
t_D = dimensionless time

PULSE TEST DATA

q =	5.00	gpm
r_w =	0.34	ft

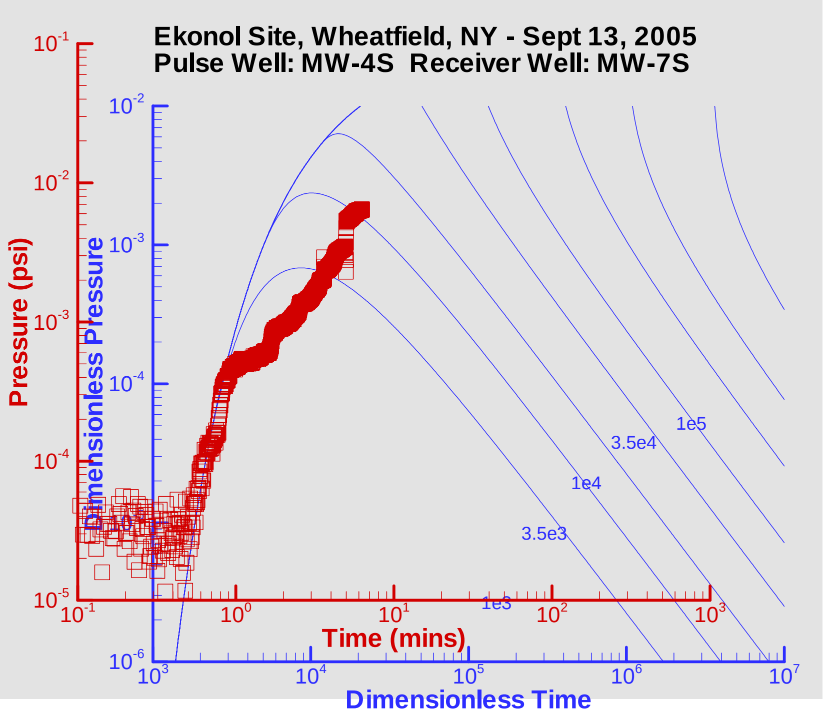
TYPE CURVE MATCH PARAMETERS

Δp =	0.000373	psi
pD =	1.04E-04	
t =	0.82	mins
t_D =	2750.09	

RESULTS

Porous Media

K =	2.69E+01	ft/day
S_s =	4.68E-05	1/ft



Project Name: BP-Ekenol
Project No.: 6022
Test Date: 9/13/2005

Analysis By: BAF
Checked By: GH
Reference: Hocking (2001)

HYDRAULIC PULSE INTERFERENCE TEST
SOURCE WELL: MW-4S RECEIVER WELL: MW-9S

$$\boxed{K = \frac{qp_D}{4\pi r_w \Delta p}}$$

K = formation hydraulic conductivity

$$\boxed{S_s = \frac{Kt}{r_w^{\ 2} t_D}}$$

S_s = formation specific storage

where:

q = flow rate
p_D = dimensionless pressure
r_w = well bore radius of source well
Δp = pressure
t = time
t_D = dimensionless time

PULSE TEST DATA

q = 5.00 gpm
r_w = 0.34 ft

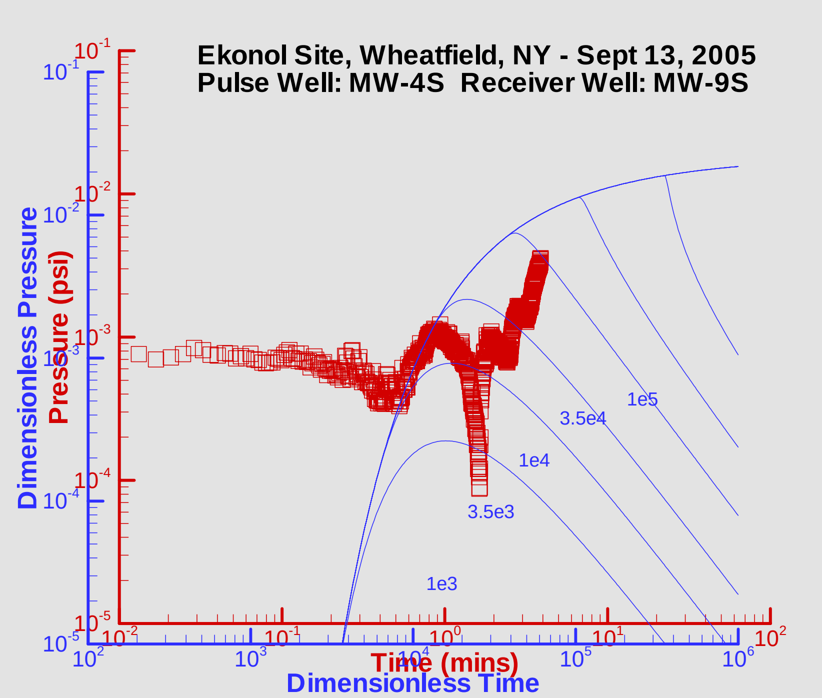
TYPE CURVE MATCH PARAMETERS

Δp = 0.001019 psi
pD = 1.43E-03
t = 0.80 mins
t_D = 12464.00

RESULTS

Porous Media

K = 1.35E+02 ft/day
S_s = 5.08E-05 1/ft



Project Name: BP-Ekenol
Project No.: 6022
Test Date: 9/13/2005

Analysis By: BAF
Checked By: GH
Reference: Hocking (2001)

GEOSIERRA

HYDRAULIC PULSE INTERFERENCE TEST
SOURCE WELL: RMW-2D RECEIVER WELL: RMW-3D

$$K = \frac{qp_D}{4\pi r_w \Delta p}$$

K = formation hydraulic conductivity
(Equivalent porous media of 10 ft. thick layer)

$$S_s = \frac{Kt}{r_w^{\,2} t_D}$$

S_s = formation specific storage

where:

q = flow rate
p_D = dimensionless pressure
r_w = well bore radius of source well
Δp = pressure
t = time
t_D = dimensionless time

PULSE TEST DATA

q = 10.00 gpm
r_w = 0.25 ft

TYPE CURVE MATCH PARAMETERS

Δp = 0.009905 psi
pD = 0.0004036
t = 0.05 mins
t_D = 17198.00

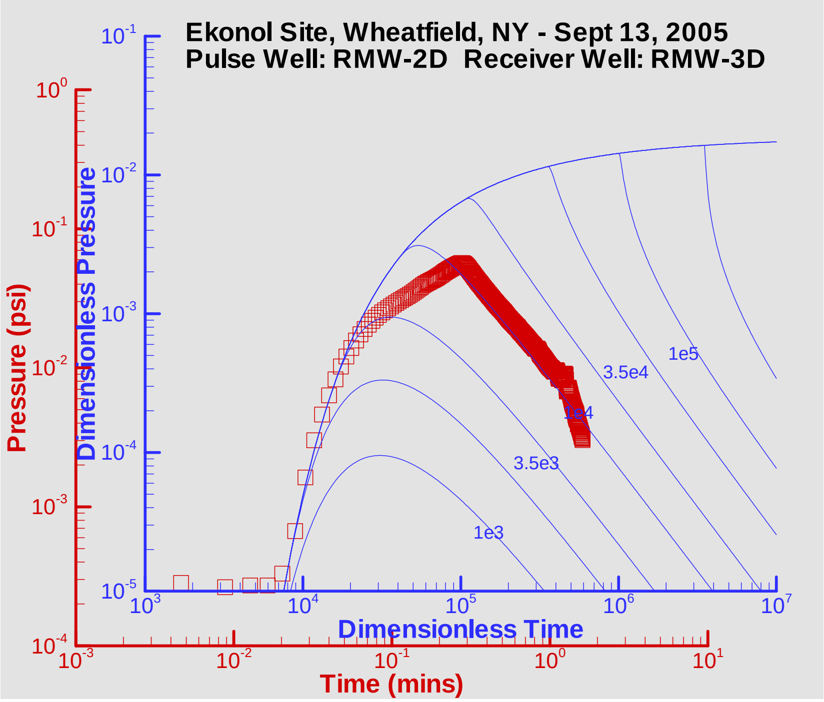
RESULTS

Porous Media

K = 1.10E+01 ft/day
S_s = 3.52E-07 1/ft

Fractured Media

T = 110 ft^2/day



Project Name: BP-Ekenol
Project No.: 6022
Test Date: 9/13/2005

Analysis By: BAF
Checked By: GH
Reference: Hocking (2001)

GEOSIERRA

HYDRAULIC PULSE INTERFERENCE TEST
SOURCE WELL: RMW-2D RECEIVER WELL: RMW-4D

$$K = \frac{q p_D}{4 \pi r_w \Delta p}$$

K = formation hydraulic conductivity
(Equivalent porous media of 10 ft. thick layer)

$$S_s = \frac{K t}{r_w^{\ 2} t_D}$$

S_s = formation specific storage

where:
q = flow rate
p_D = dimensionless pressure
r_w = well bore radius of source well
Δp = pressure
t = time
t_D = dimensionless time

PULSE TEST DATA

q =	**10.00**	**gpm**
r_w =	**0.25**	**ft**

TYPE CURVE MATCH PARAMETERS

Δp =	**0.02023**	**psi**
pD =	**0.00102**	
t =	**0.04**	**mins**
t_D =	**28613.30**	

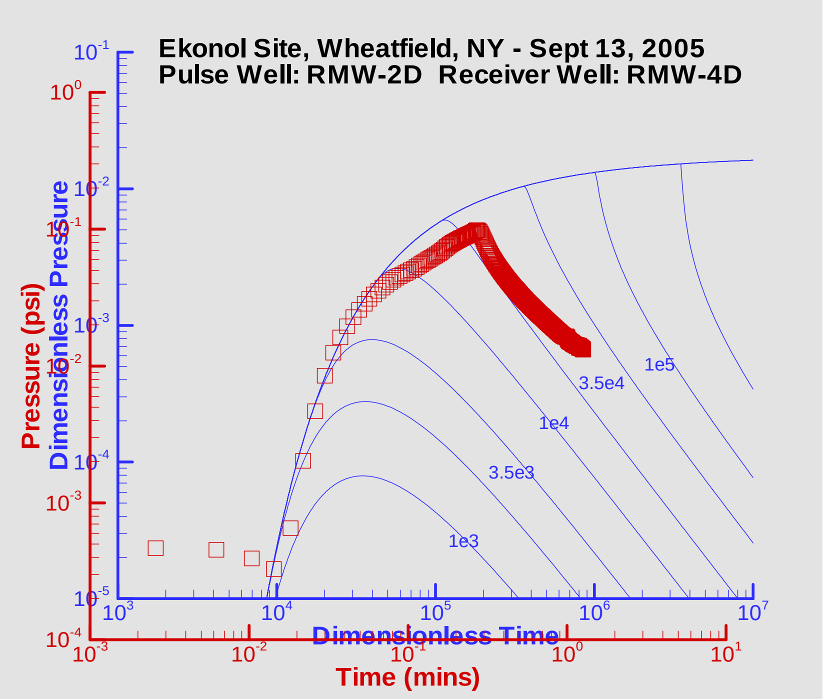
RESULTS

Porous Media

K =	**1.37E+01**	**ft/day**
S_s =	**2.28E-07**	**1/ft**

Fractured Media

T =	**137**	**ft^2/day**



Project Name: BP-Ekenol
Project No.: 6022
Test Date: 9/13/2005

Analysis By: BAF
Checked By: GH
Reference: Hocking (2001)

GEOSIERRA

HYDRAULIC PULSE INTERFERENCE TEST
SOURCE WELL: RMW-2D RECEIVER WELL: MW-10D

$$K = \frac{q p_D}{4 \pi r_w \Delta p}$$

K = formation hydraulic conductivity
(Equivalent porous media of 10 ft. thick layer)

$$S_s = \frac{K t}{r_w^2 t_D}$$

S_s = formation specific storage

where:

q = flow rate
p_D = dimensionless pressure
r_w = well bore radius of source well
Δp = pressure
t = time
t_D = dimensionless time

PULSE TEST DATA

q =	10.00	gpm
r_w =	0.25	ft

TYPE CURVE MATCH PARAMETERS

Δp =	0.00236	psi
pD =	0.00102	
t =	0.11	mins
t_D =	229112.00	

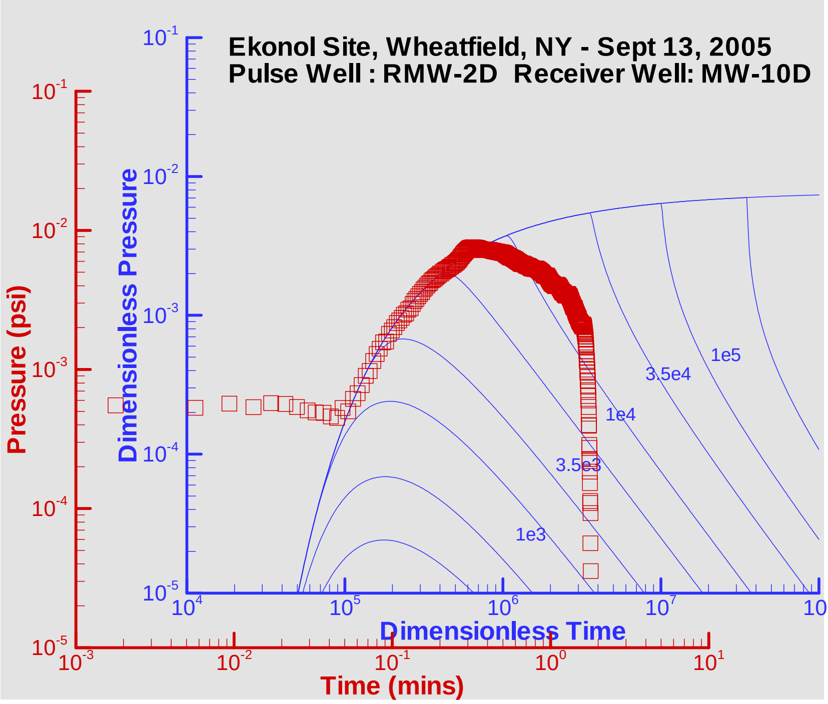
RESULTS

Porous Media

K =	1.17E+02	ft/day
S_s =	6.79E-07	1/ft

Fractured Media

T =	1171	ft^2/day



Project Name: BP-Ekenol
Project No.: 6022
Test Date: 9/13/2005

Analysis By: BAF
Checked By: GH
Reference: Hocking (2001)

HYDRAULIC PULSE INTERFERENCE TEST
SOURCE WELL: RMW-3D RECEIVER WELL: RMW-4D

$$K = \frac{q p_D}{4 \pi r_w \Delta p}$$

K = formation hydraulic conductivity
(Equivalent porous media of 10 ft. thick layer)

$$S_s = \frac{K t}{r_w^{\,2} t_D}$$

S_s = formation specific storage

where:
q = flow rate
p_D = dimensionless pressure
r_w = well bore radius of source well
Δp = pressure
t = time
t_D = dimensionless time

PULSE TEST DATA

q = **10.00** **gpm**
r_w = **0.25** **ft**

TYPE CURVE MATCH PARAMETERS

Δp = **0.02023** **psi**
pD = **0.0004156**
t = **0.02** **mins**
t_D = **30859.10**

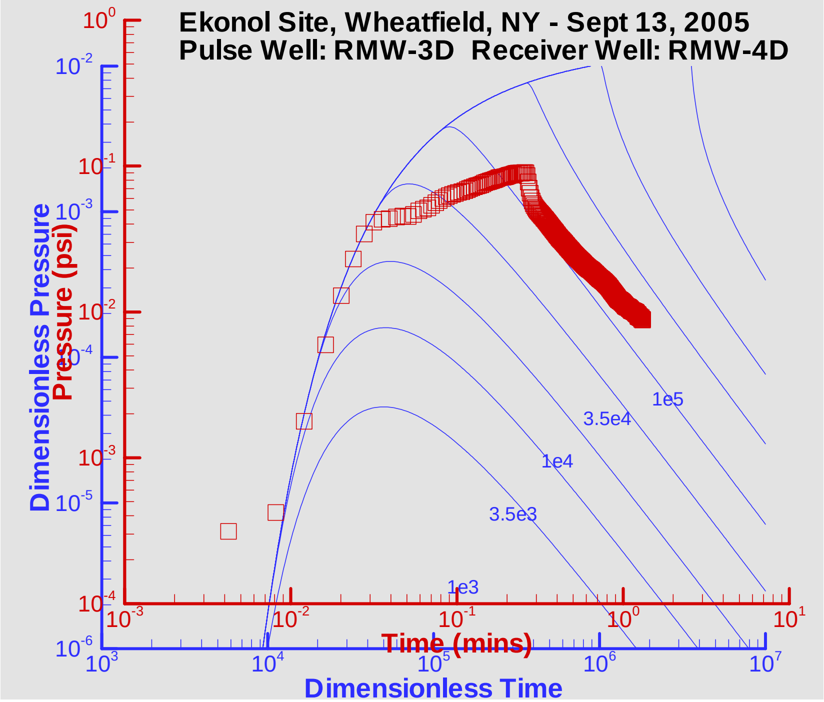
RESULTS

Porous Media

K = 5.57E+00 ft/day
S_s = 4.58E-08 1/ft

Fractured Media

T = 56 ft^2/day



Project Name: BP-Ekenol
Project No.: 6022
Test Date: 9/13/2005

Analysis By: BAF
Checked By: GH
Reference: Hocking (2001)

HYDRAULIC PULSE INTERFERENCE TEST
SOURCE WELL: RMW-3D RECEIVER WELL: MW-11D

$$K = \frac{qp_D}{4\pi r_w \Delta p}$$

K = formation hydraulic conductivity
(Equivalent porous media of 10 ft. thick layer)

$$S_s = \frac{Kt}{r_w^{\,2} t_D}$$

S_s = formation specific storage

where:

q = flow rate
p_D = dimensionless pressure
r_w = well bore radius of source well
Δp = pressure
t = time
t_D = dimensionless time

PULSE TEST DATA

q =	10.00	gpm
r_w =	0.25	ft

TYPE CURVE MATCH PARAMETERS

Δp =	0.001162	psi
pD =	0.0001048	
t =	0.04	mins
t_D =	32711.20	

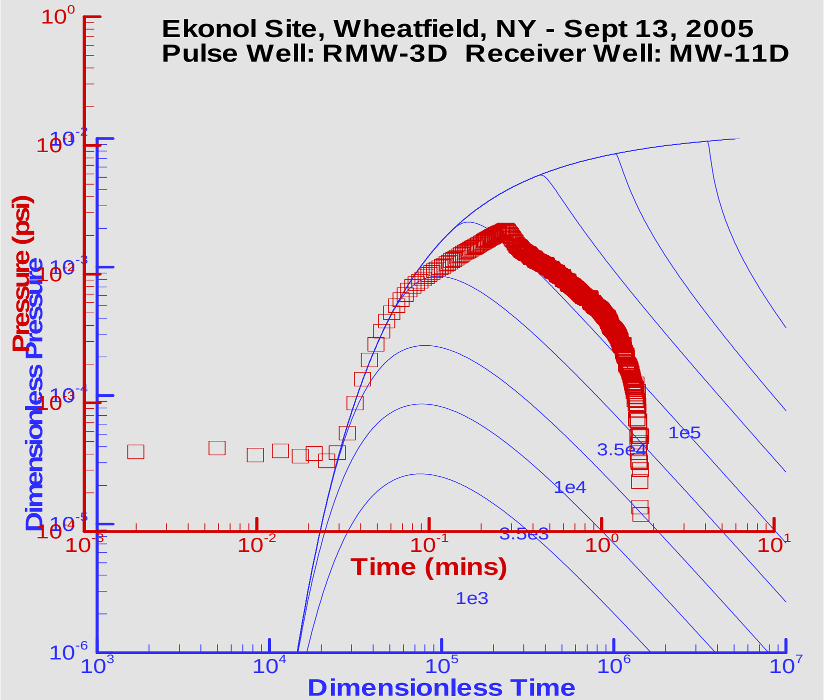
RESULTS

Porous Media

K =	2.44E+01	ft/day
S_s =	3.24E-07	1/ft

Fractured Media

T =	244	ft^2/day



Project Name: BP-Ekenol
Project No.: 6022
Test Date: 9/13/2005

Analysis By: BAF
Checked By: GH
Reference: Hocking (2001)

HYDRAULIC PULSE INTERFERENCE TEST
SOURCE WELL: RMW-4D RECEIVER WELL: MW-10D

$$K = \frac{qp_D}{4\pi r_w \Delta p}$$

K = formation hydraulic conductivity
(Equivalent porous media of 10 ft. thick layer)

$$S_s = \frac{Kt}{r_w{}^2 t_D}$$

S_s = formation specific storage

where:
q = flow rate
p_D = dimensionless pressure
r_w = well bore radius of source well
Δp = pressure
t = time
t_D = dimensionless time

PULSE TEST DATA

q = 10.00 gpm
r_w = 0.25 ft

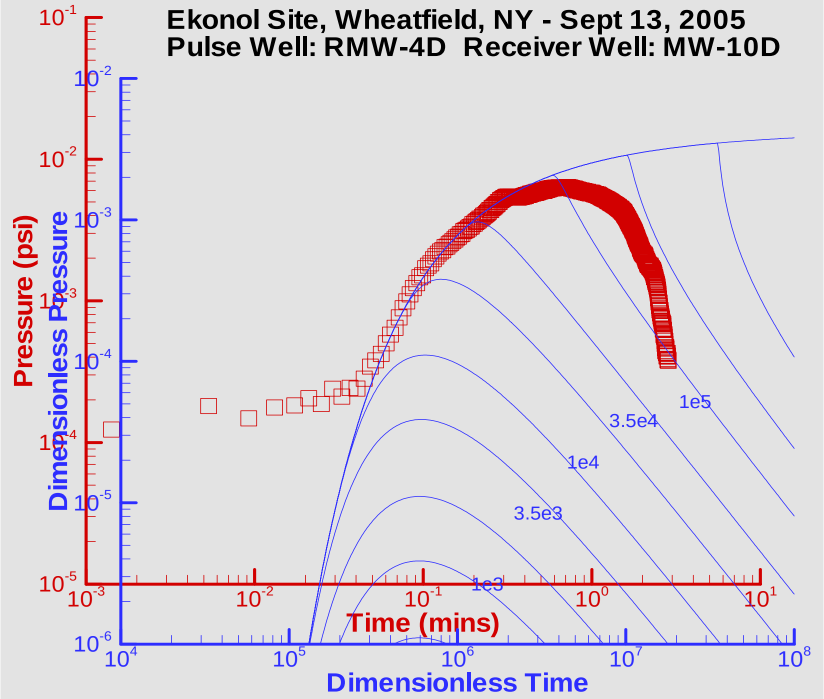
TYPE CURVE MATCH PARAMETERS

Δp = 0.003818 psi
pD = 0.0009964
t = 0.20 mins
t_D = 1257000.00

RESULTS

Porous Media
K = 7.07E+01 ft/day
S_s = 1.28E-07 1/ft

Fractured Media
T = 707 ft^2/day



Project Name: BP-Ekenol
Project No.: 6022
Test Date: 9/13/2005

Analysis By: BAF
Checked By: GH
Reference: Hocking (2001)

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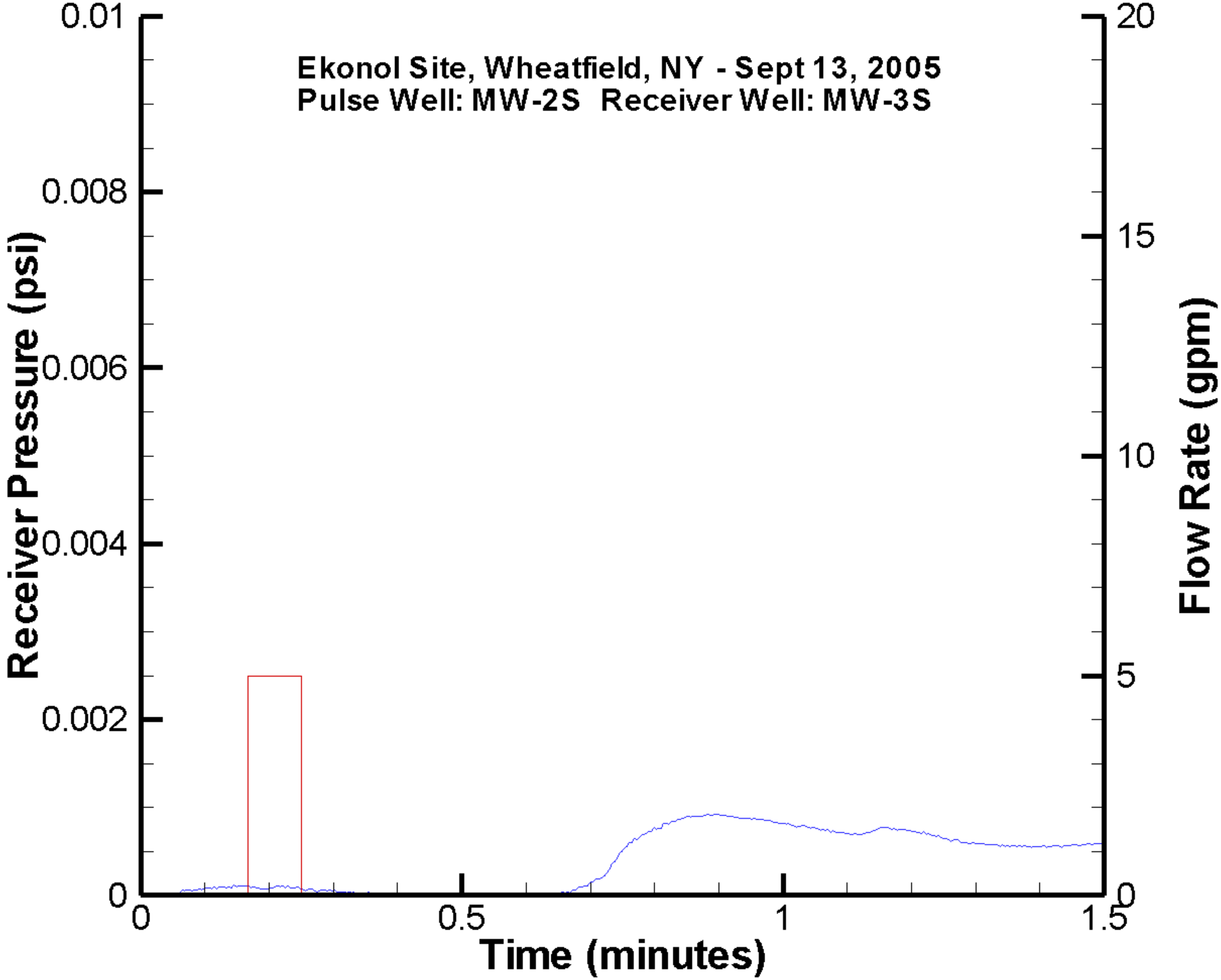
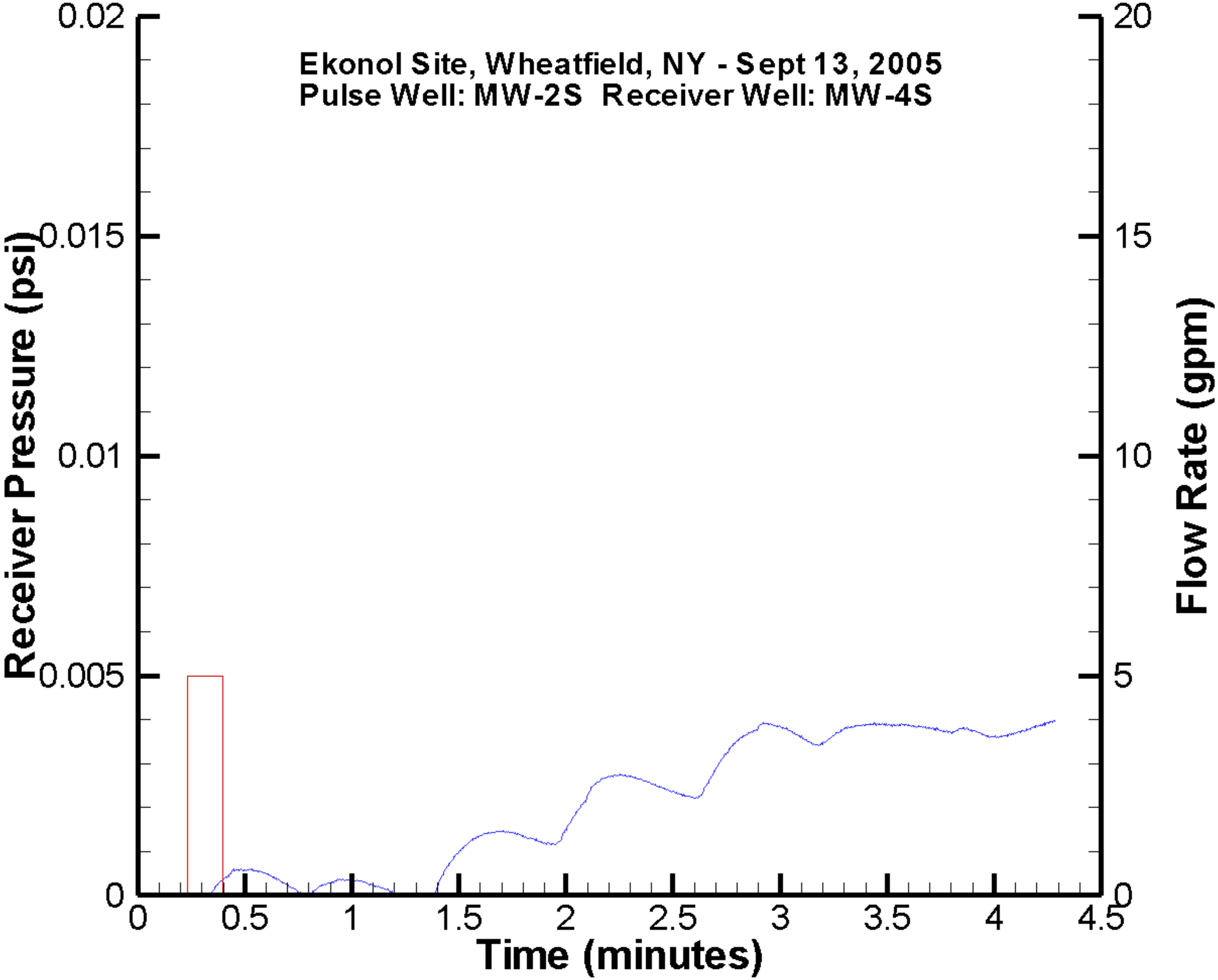
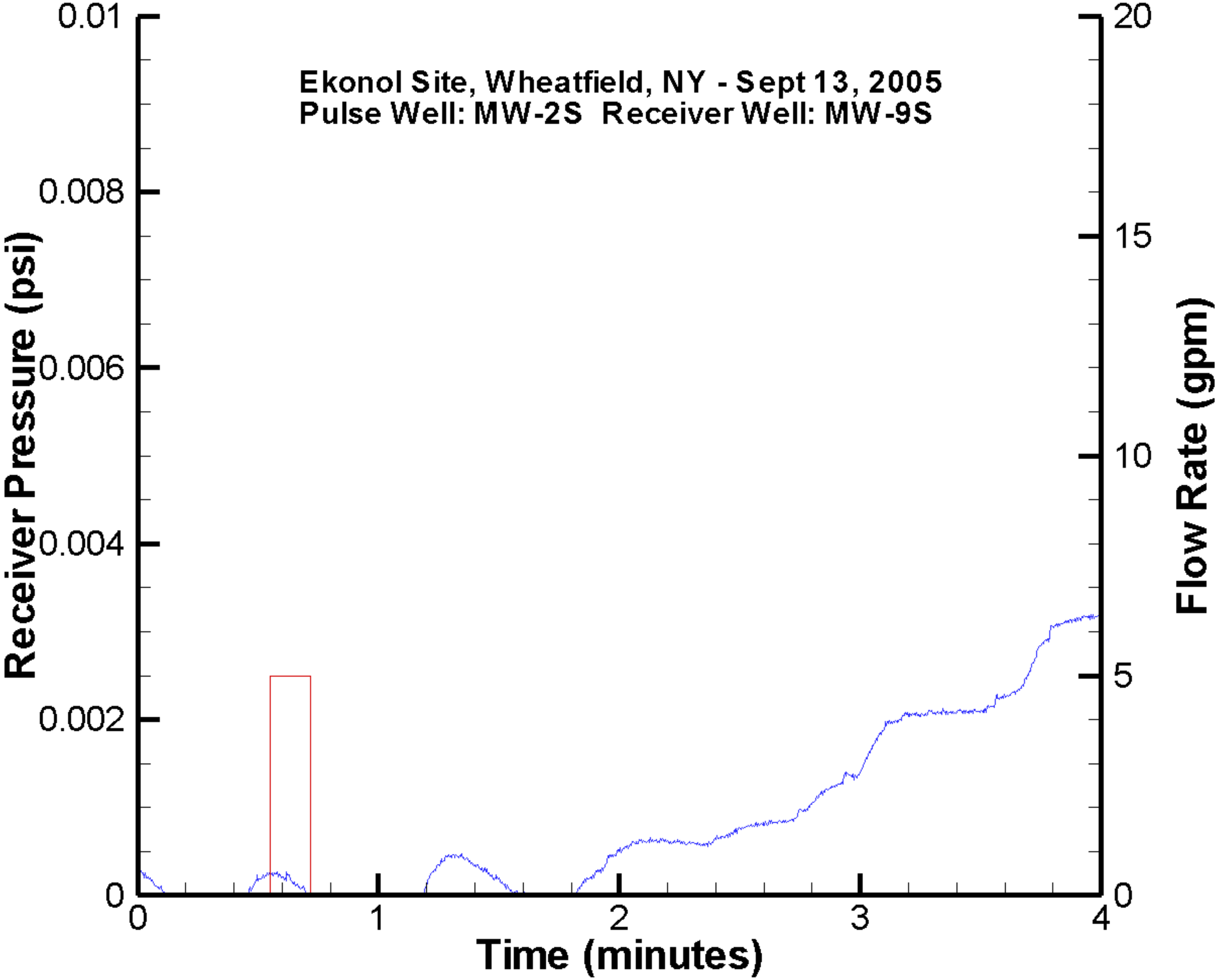
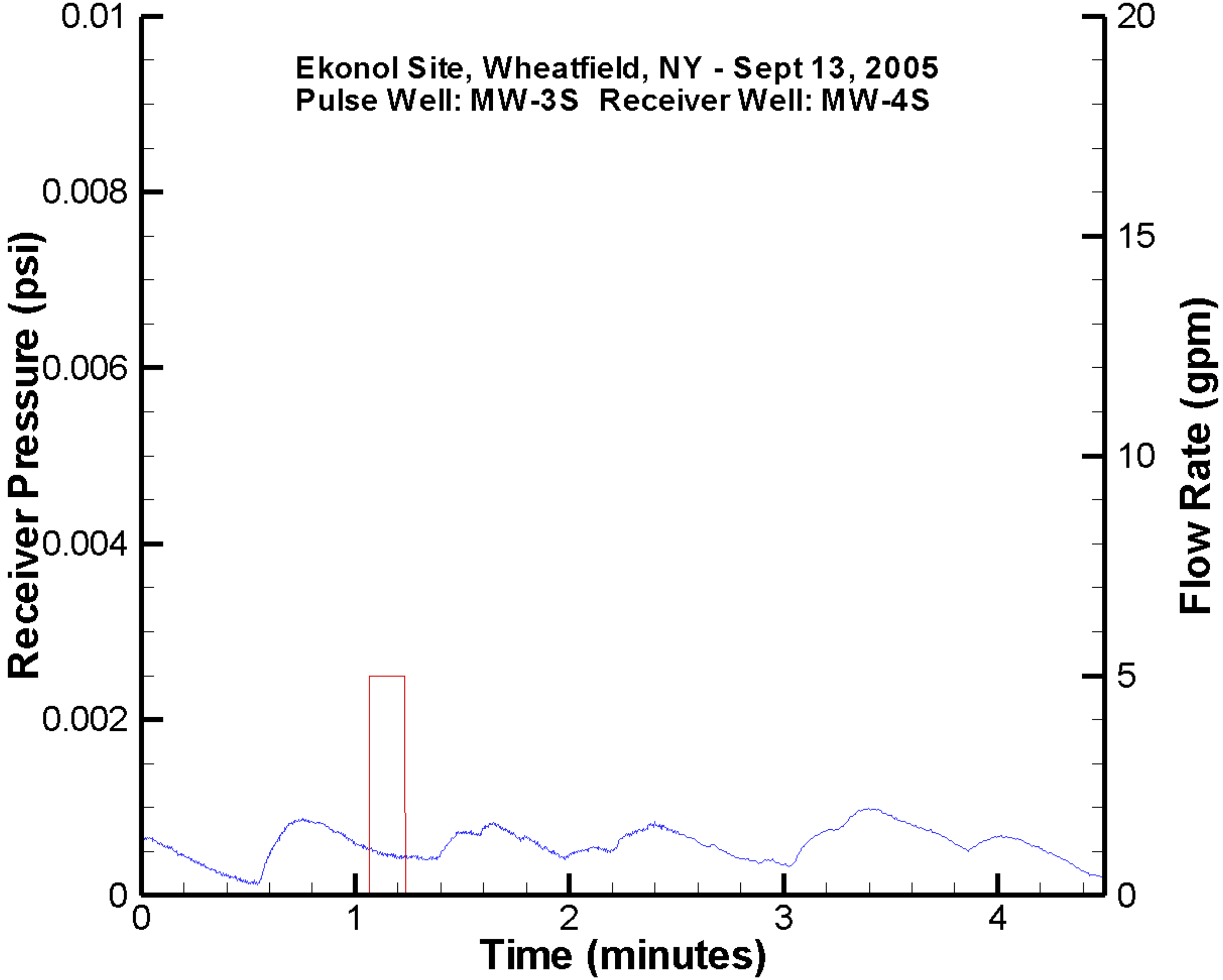
APPENDIX A-2

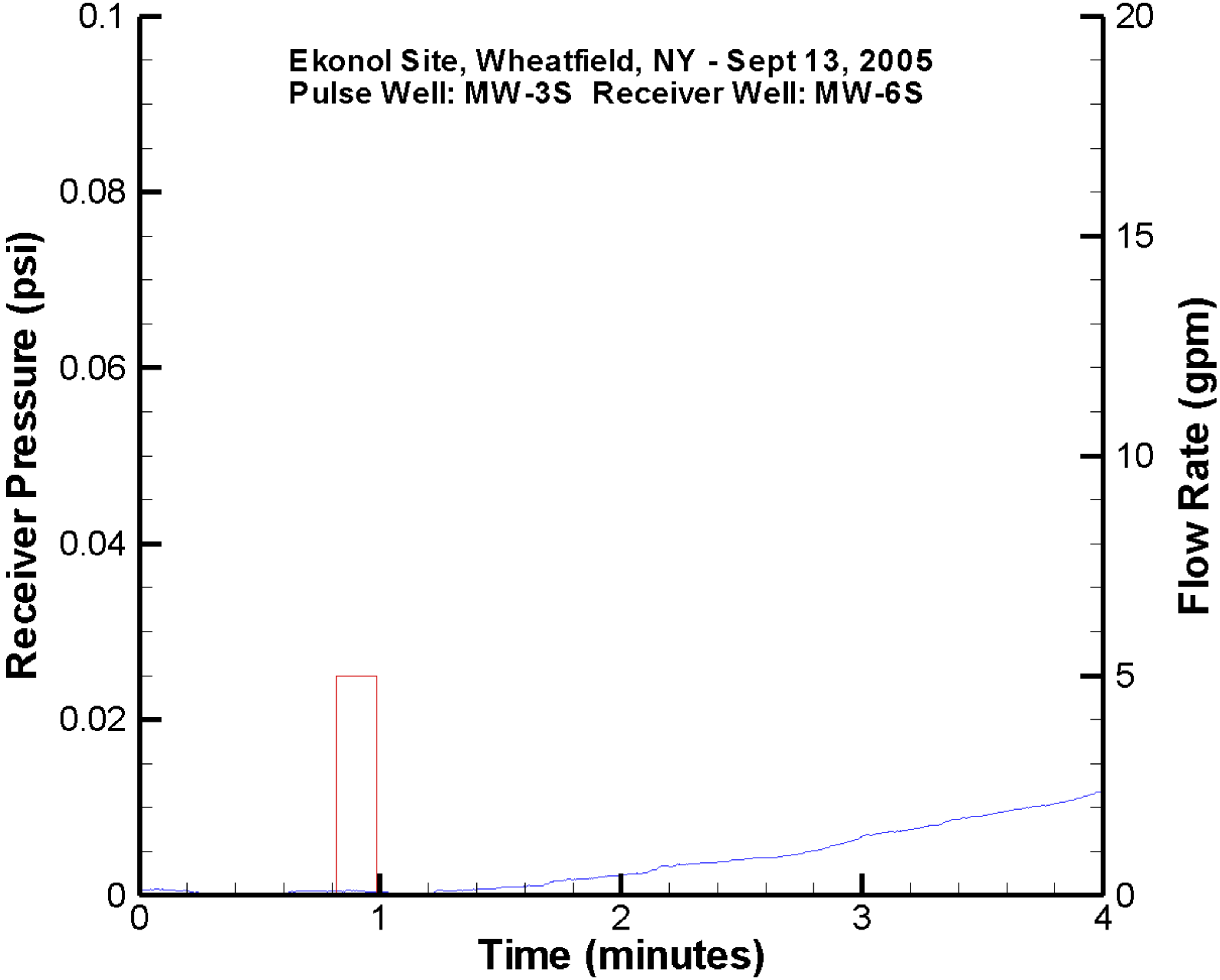
Pressure Pulse Profiles

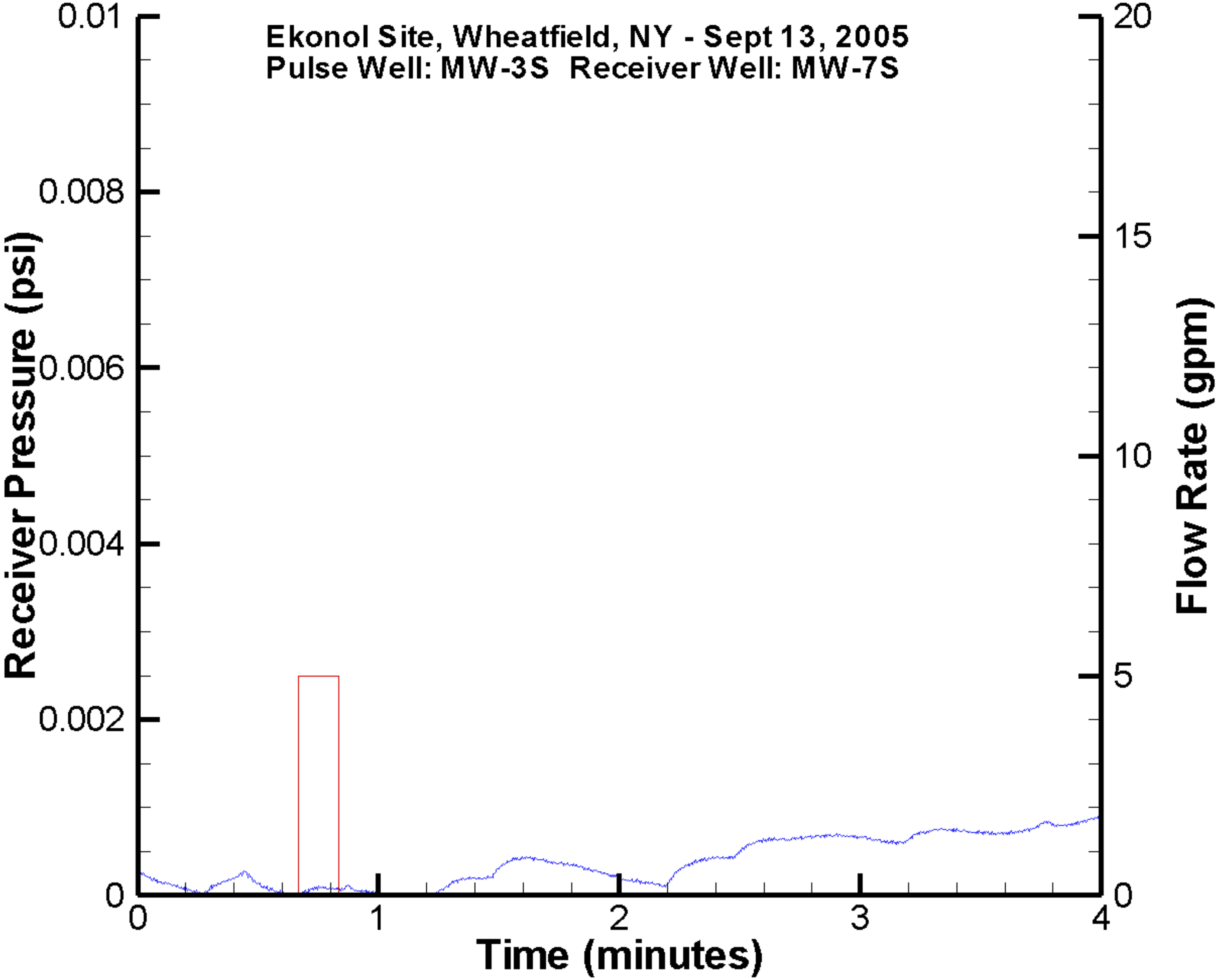

Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-2S Receiver Well: MW-3S
Receiver Pressure (psi)
0.01
0.008
0.006
0.004
0.002
0
Flow Rate (gpm)
20
15
10
5
0
Time (minutes)
0
0.5
1
1.5

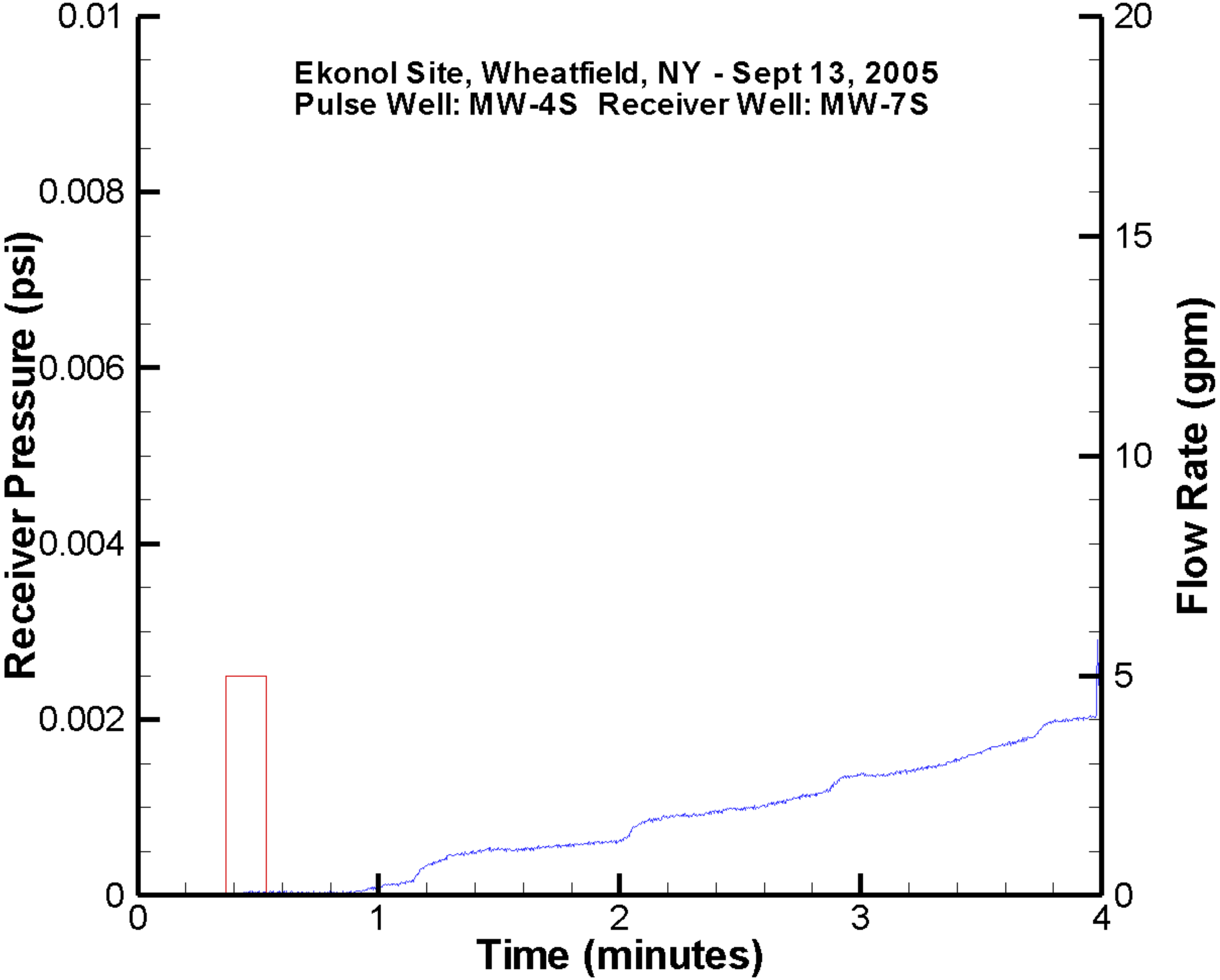

Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-2S Receiver Well: MW-4S
Receiver Pressure (psi)
0.02
0.015
0.01
0.005
0
Flow Rate (gpm)
20
15
10
5
0
Time (minutes)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5

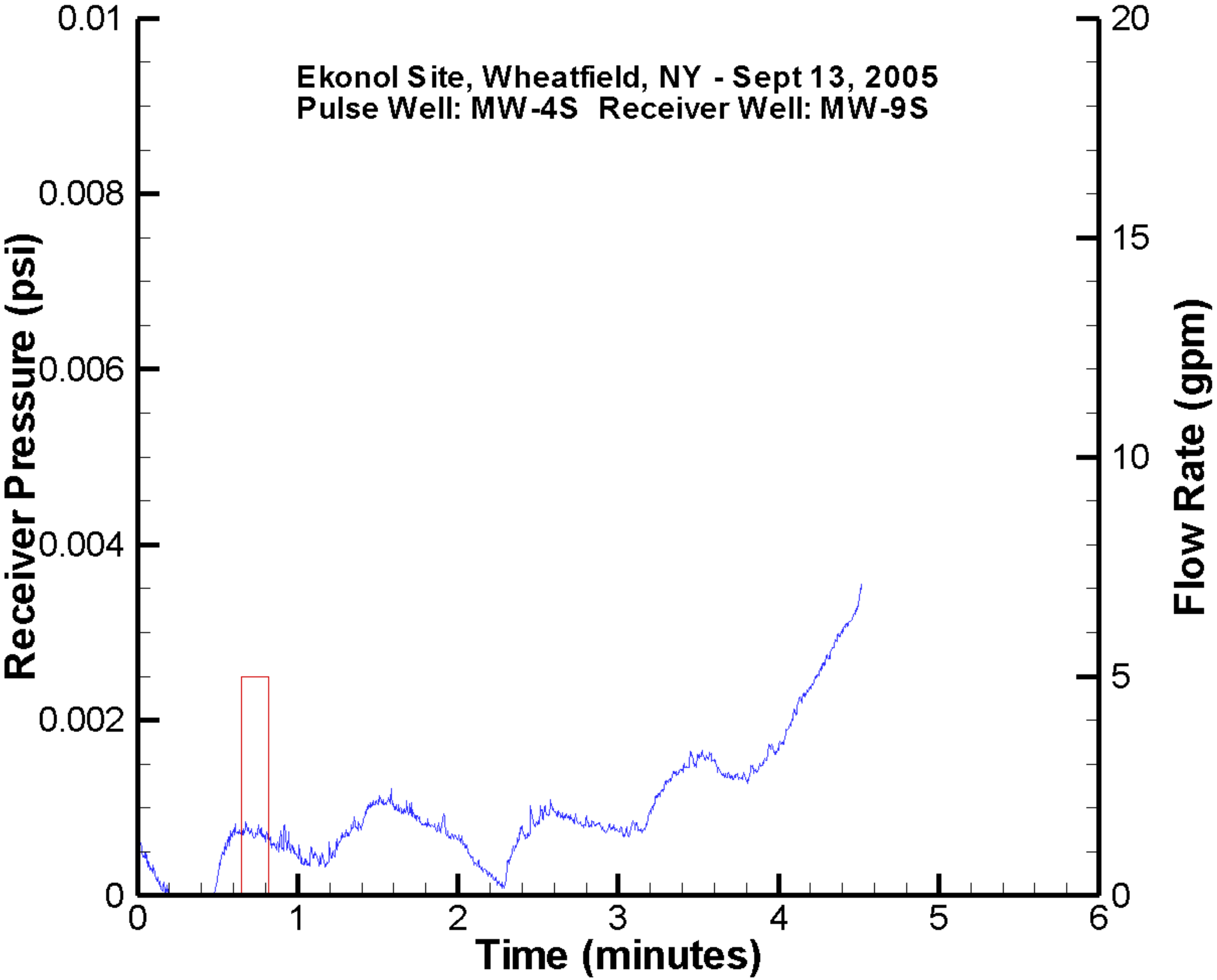

Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-2S Receiver Well: MW-9S
Receiver Pressure (psi)
0.01
0.008
0.006
0.004
0.002
0
Flow Rate (gpm)
20
15
10
5
0
Time (minutes)
0
1
2
3
4

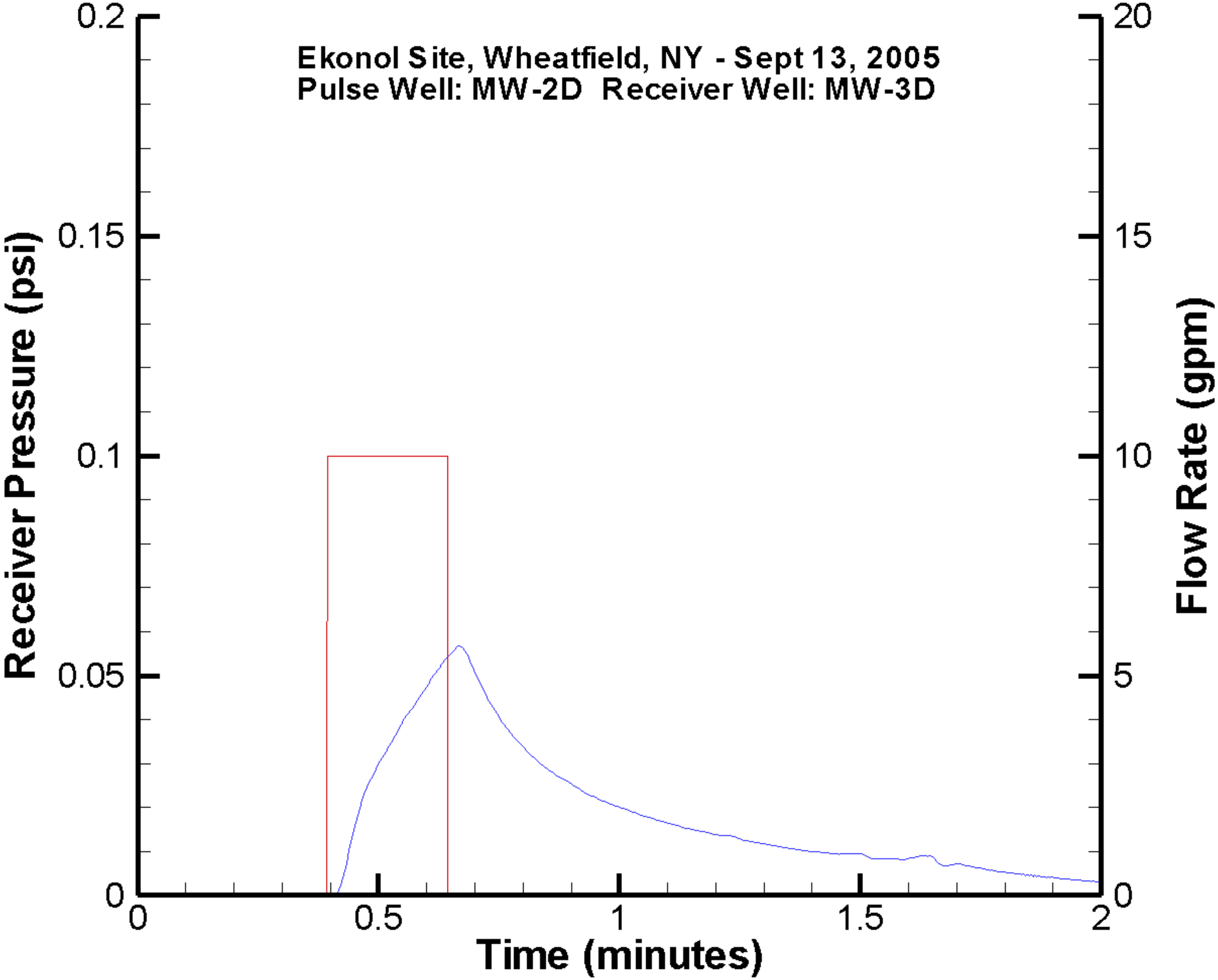

Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-3S Receiver Well: MW-4S
Receiver Pressure (psi)
0.01
0.008
0.006
0.004
0.002
0
Flow Rate (gpm)
20
15
10
5
0
Time (minutes)
0
1
2
3
4

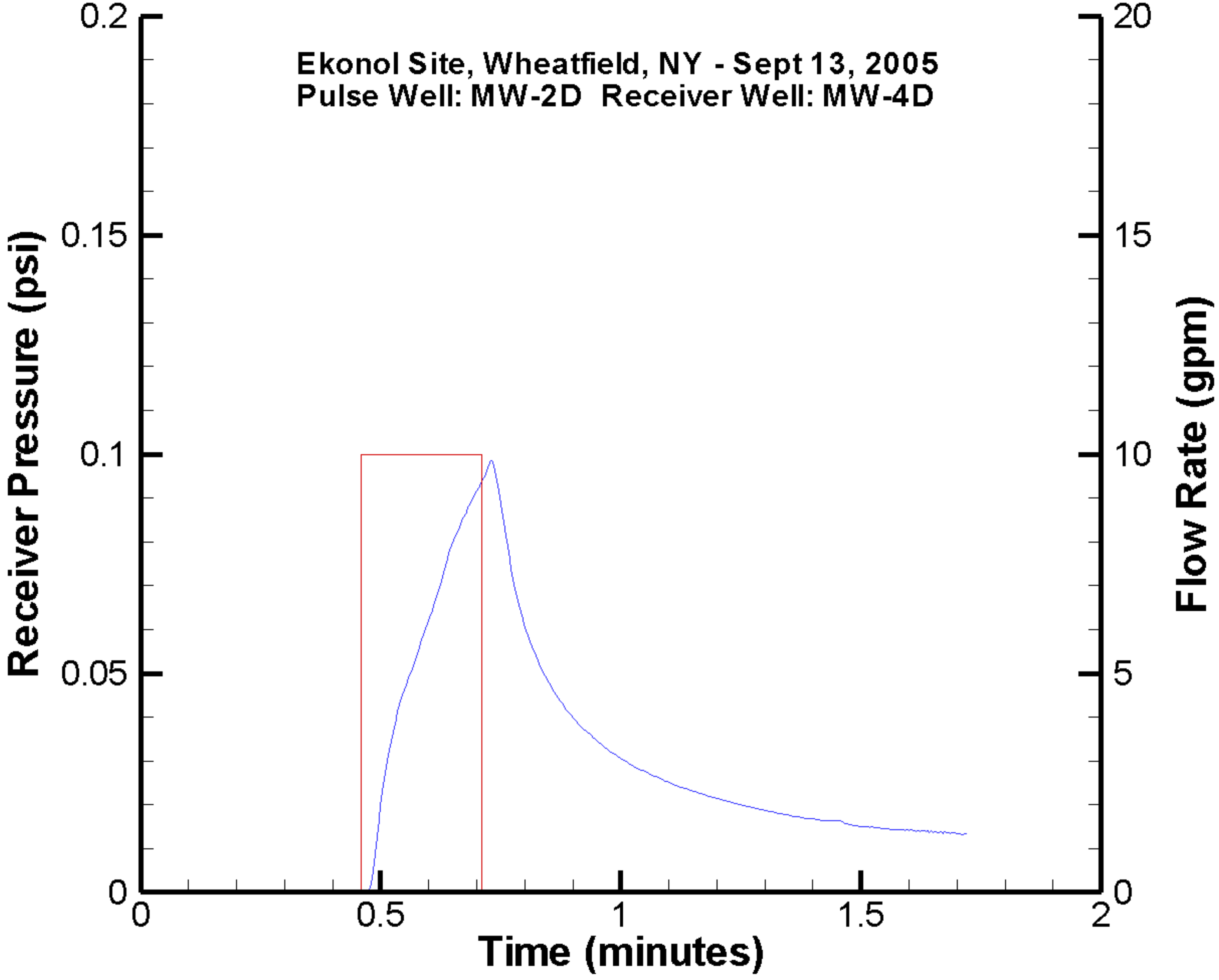

Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-3S Receiver Well: MW-6S
Receiver Pressure (psi)
0.1
0.08
0.06
0.04
0.02
0
Flow Rate (gpm)
20
15
10
5
0
Time (minutes)
0
1
2
3
4

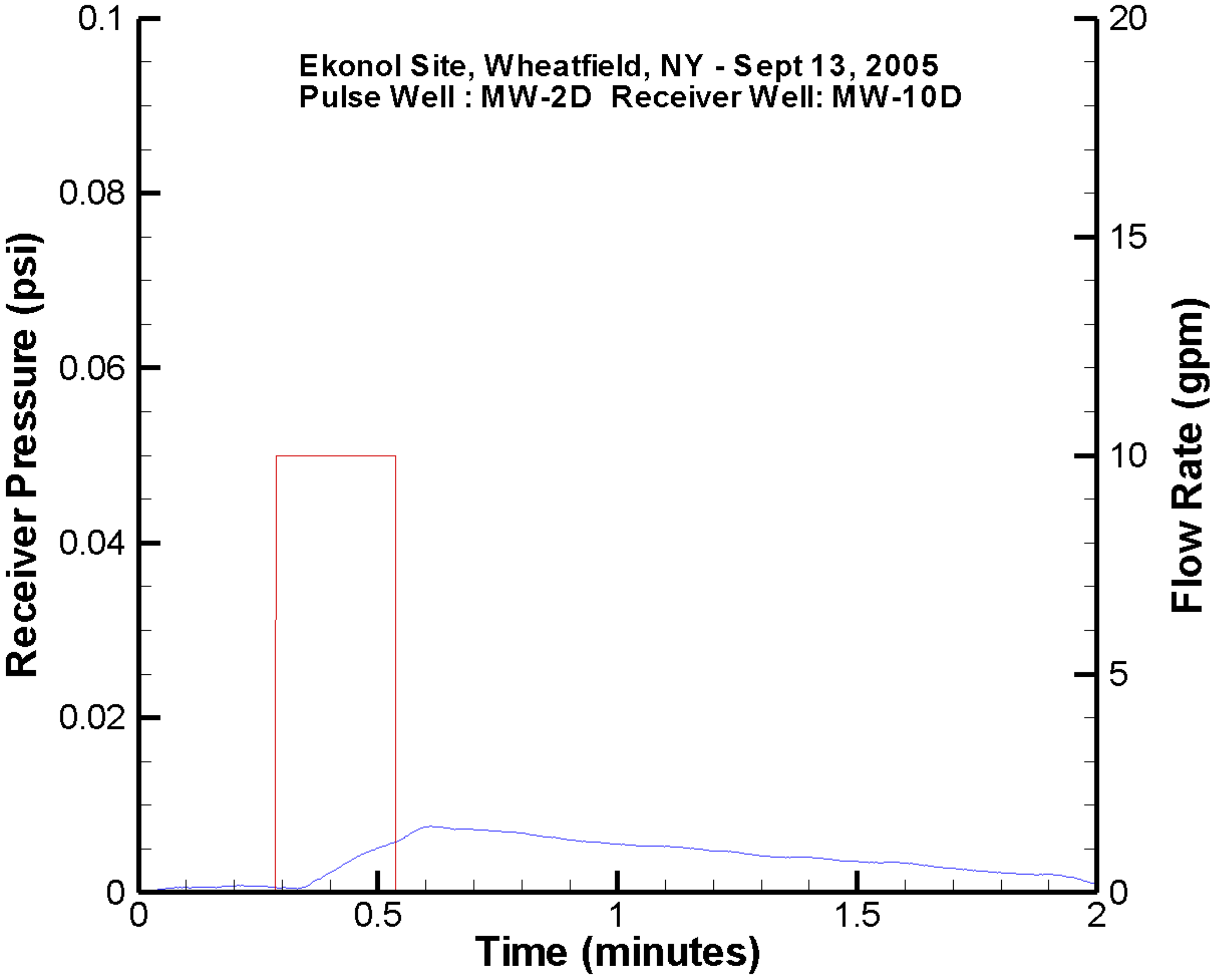

Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-3S Receiver Well: MW-7S
Receiver Pressure (psi)
0.01
0.008
0.006
0.004
0.002
0
Flow Rate (gpm)
20
15
10
5
0
Time (minutes)
0
1
2
3
4

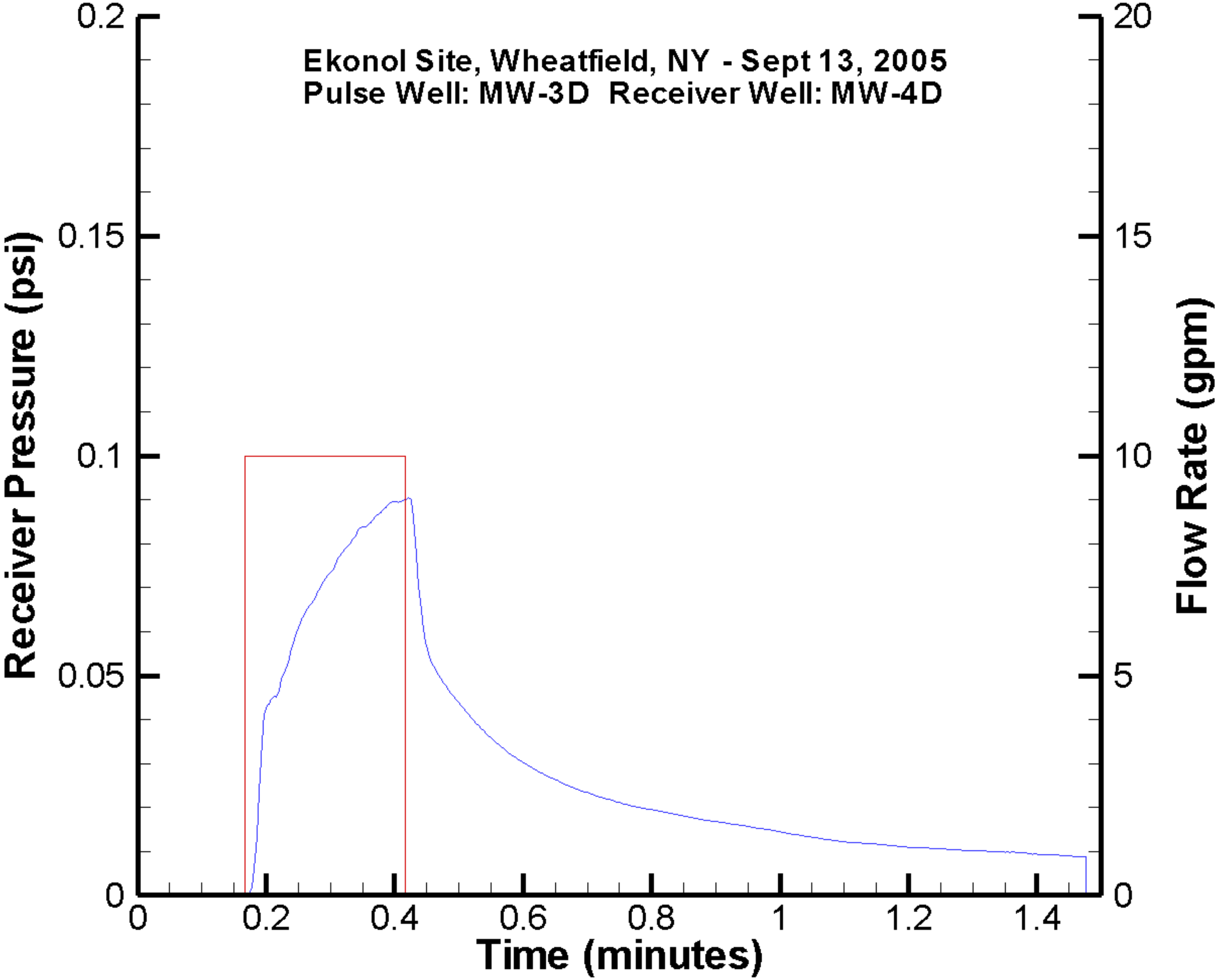

Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-4S Receiver Well: MW-7S
Receiver Pressure (psi)
0.01
0.008
0.006
0.004
0.002
0
Flow Rate (gpm)
20
15
10
5
0
Time (minutes)
0
1
2
3
4

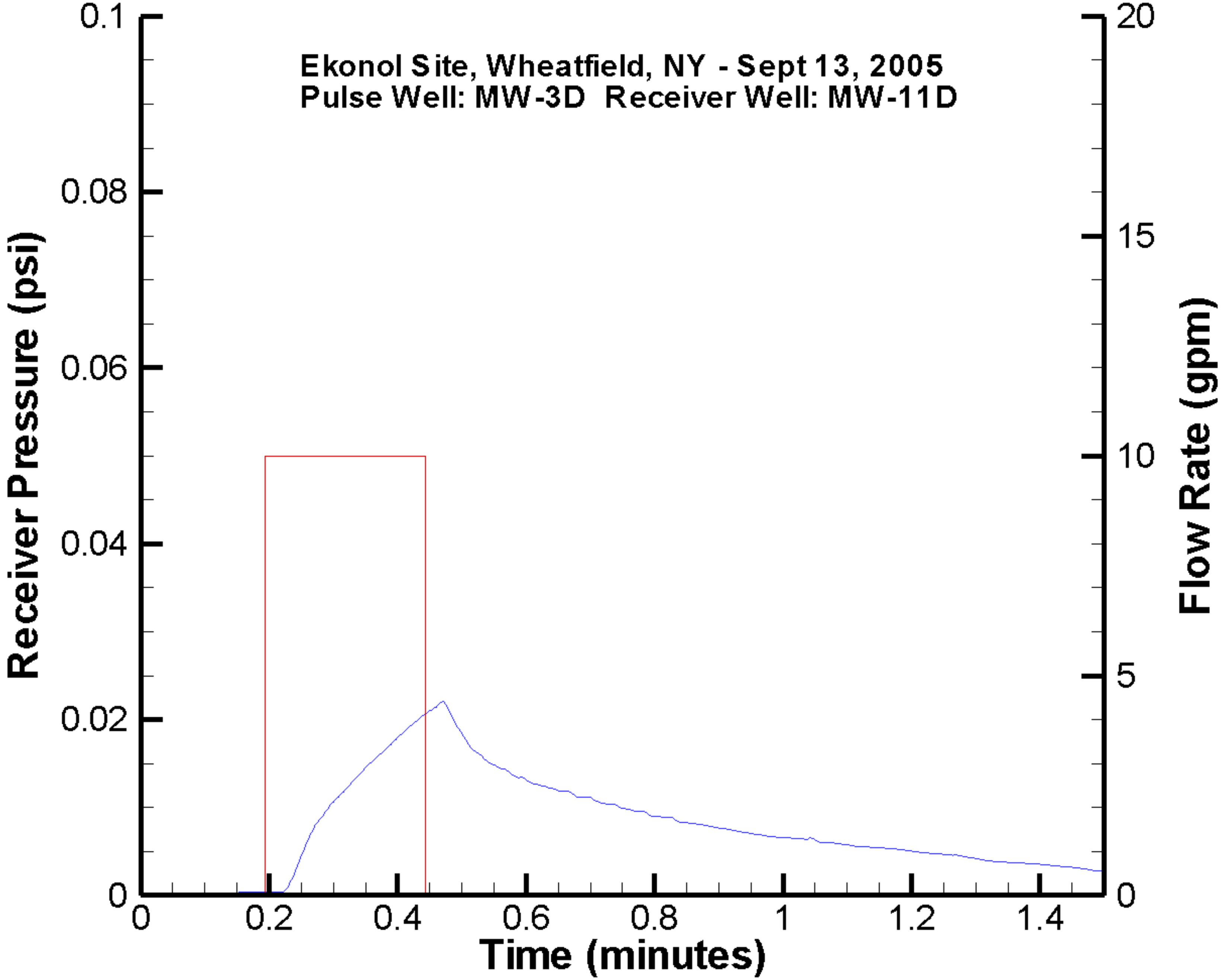

Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-4S Receiver Well: MW-9S
Receiver Pressure (psi)
Flow Rate (gpm)
Time (minutes)
0.01
0.008
0.006
0.004
0.002
0
20
15
10
5
0
0
1
2
3
4
5
6

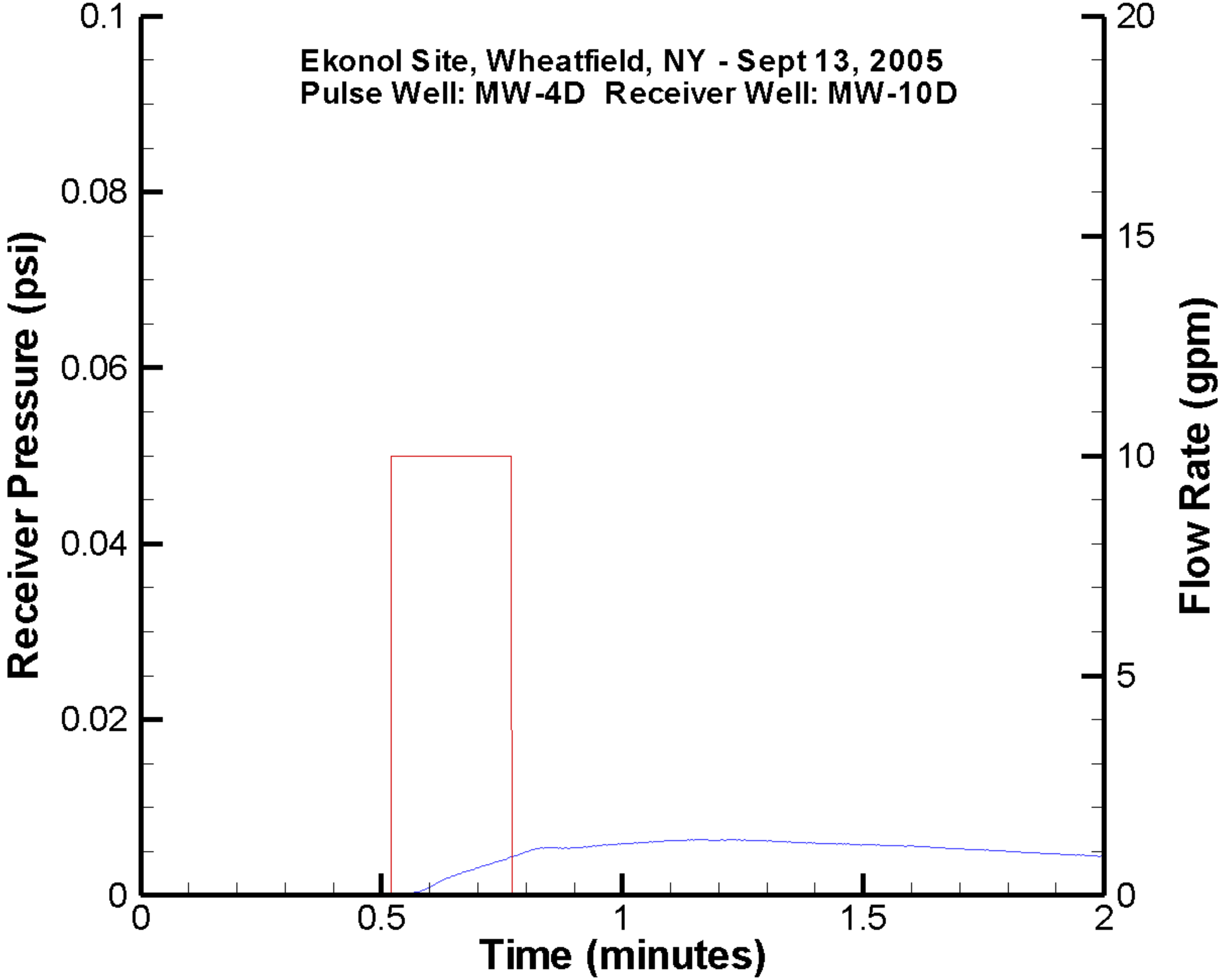

Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-2D Receiver Well: MW-3D
Receiver Pressure (psi)
Flow Rate (gpm)
Time (minutes)
0.2
0.15
0.1
0.05
0
20
15
10
5
0
0
0.5
1
1.5
2


Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-2D Receiver Well: MW-4D
Receiver Pressure (psi)
0.2
0.15
0.1
0.05
0
Flow Rate (gpm)
20
15
10
5
0
Time (minutes)
0
0.5
1
1.5
2


Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well : MW-2D Receiver Well: MW-10D
Receiver Pressure (psi)
0.1
0.08
0.06
0.04
0.02
0
Flow Rate (gpm)
20
15
10
5
0
Time (minutes)
0
0.5
1
1.5
2


Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-3D Receiver Well: MW-4D
Receiver Pressure (psi)
0.2
0.15
0.1
0.05
0
Flow Rate (gpm)
20
15
10
5
0
Time (minutes)
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-3D Receiver Well: MW-11D
Receiver Pressure (psi)
0.1
0.08
0.06
0.04
0.02
0
Flow Rate (gpm)
20
15
10
5
0
Time (minutes)
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Ekonol Site, Wheatfield, NY - Sept 13, 2005
Pulse Well: MW-4D Receiver Well: MW-10D
Receiver Pressure (psi)
Flow Rate (gpm)
Time (minutes)
0.1
0.08
0.06
0.04
0.02
0
20
15
10
5
0
0
0.5
1
1.5
2

APPENDIX B

Technical Paper - Hydraulic Pulse Interference Tests for Integrity Testing of Containment and Reactive Barrier Systems

Hydraulic Pulse Interference Tests for Integrity Testing of Containment and Reactive Barrier Systems

by

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(submitted to 2001 International Containment & Remediation Technology Conference,
to be held June 10-13 at Orlando, FL)

ABSTRACT: Hydraulic pulse interference tests involve a cyclic injection of fluid into the source well, and by high precision measurement of the pressure pulse in a neighboring well, detailed hydraulic characterization between wells can be made. The pulse interference test is highly sensitive to hydrogeological properties between the pulse source and receiver wells. The transient nature of the test, involving the time delay and attenuation of the hydraulic pulse, enables the formation's complete hydraulic properties to be computed. The advantages of the pulse interference test are the short duration of the test, the high resolution and directional characterization data obtained, and the lack of any generated contaminated groundwater. To maximize the pulse test's resolution, a small section of the injector well is isolated by packers, the flow rate into the source injector well is rate controlled and set at a constant flow rate depending on the site hydraulic conditions. High precision pressure transducers are located in receiver wells and isolated from receiver borehole storage effects by straddle packers. Thus the pulse is basically a point source, and borehole storage effects are eliminated from both the injector and receiver wells. The injector well is pulsed for a set time, shut in for the same time period, and the cycle repeated. The pulse source and receivers can be located at differing depth locations in their respective wells and a detailed image of the site's hydraulic conditions can be determined. The hydraulic pulse interference test is ideal to test the integrity of a hydraulic containment system or to determine whether a permeable reactive barrier (PRB) impacts groundwater flow. Pulse interference tests are presented pre and post PRB installation for integrity testing of an iron PRB constructed in a confined aquifer from a depth of 45 feet down to a total depth of 110 feet.

INTRODUCTION

Hydraulic pulse interference tests have been utilized in the petroleum industry since the mid sixities, Johnson et. al. (1966), Earlougher (1977), Lee (1982), Kamal (1983) and Horne (1995), primarily as full penetrating aquifer tests, but in some cases as vertical pulse interference tests, Burns (1969) and Hirasaki (1974). The test involves a cyclic injection or withdrawal of fluid from the source well followed by a shut in period, and by high precision measurement of the pressure pulse in a neighboring well, detailed hydraulic characterization between wells can be made, see Figure 1. The hydraulic pulse interference test is highly sensitive to hydrogeological properties between the pulse source and receiver wells. The time delay and attenuation of the hydraulic pulse enable the formation hydraulic properties to be computed. Since the test is a transient test, both the formation transmissivity and storativity can be calculated for a full aquifer penetrating test. Type curves are available for interpreting pulse interference tests, either as a fully penetrating wellbore, with and without borehole storage effects, or partially penetrating wellbore system.

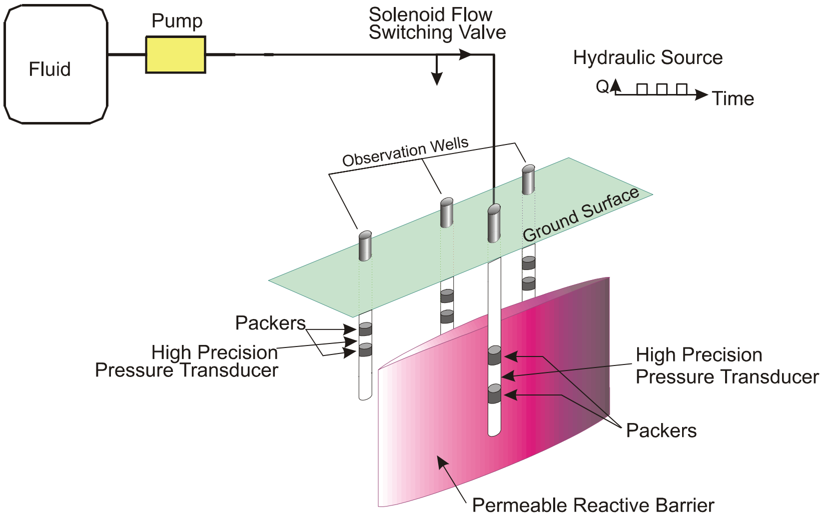

FIGURE 1. Point Source Hydraulic Pulse Interference Test.

Pulse interference testing has not been used extensively in the groundwater or environmental fields. However, considering the advantages of the test; namely, it's short duration, high resolution and directional characterization data obtained, and the lack of any generated contaminated groundwater, the test has considerable merit for both groundwater and environmental applications. To obtain maximum hydraulic property resolution (Hocking and Wells, 1997), the pulse interference test can be constructed as a point source utilizing straddle packers in the injector well. The flow rate into the source injector well is rate controlled and set at a constant flow rate, which will depend on the site hydrogeological conditions. High precision pressure transducers are located in receiver wells and isolated from receiver borehole storage effects by straddle packers. Thus the pulse is basically a point source, and borehole storage effects are eliminated from both the injector and receiver wells. The injector well is pulsed for a set time, shut in for the same time period, and the cycle repeated. The pulse source and receivers can be located at differing depth locations in their respective wells yielding a detailed quantification of the site's hydrogeological properties.

Point source hydraulic pulse interference tests are presented for both the hydrogeological characterization of a site and also for integrity testing of groundwater containment systems, such as slurry or cutoff walls, and permeable reactive barriers (PRB). The mathematical solution of the point source pulse interference test is presented along with a generated type curve for a point source pulse test in a finite confined aquifer system. Quantification of a site hydrogeological parameters both from type curves and non-linear regression analysis are presented. Hydraulic pulse integrity testing of an iron PRB system is presented by comparing pulse interference tests conducted across the proposed PRB alignment both before and after PRB construction. The objective of these tests was to quantify that the PRB had minimal impact on the site's groundwater flow.

MATHEMATICAL MODEL

The point source hydraulic pulse interference test can be modeled from the solution of a continuous point source in an infinite isotropic homogeneous medium (Carslaw and Jaeger, 1986) as given by equation (1). This fundamental solution can be modified to incorporate finite aquifer systems, confined and unconfined conditions, anisotropic and heterogeneous conditions in a similar manner as the line source solution has been modified in the petroleum literature. The line source solution for continuous injection is the exponential integral, whereas the point source solution is the complimentary error function. The pressure response in a receiver well, denoted as Δp(t) for a continuous flow rate injection of q in the injection/source well, is given by equation (1).

$$\Delta p(t) = \frac{q}{4\pi K r_w r_D} erfc(r_D / \sqrt{4t_D}) \tag{1}$$

where K is the formation hydraulic conductivity, S_s is the formation specific storage, r_w is the wellbore radius of the source well, r_D is the dimensionless distance being equal to r/r_w, in which r is the distance from the receiver well to the source well, and t_D is denoted as dimensionless time as defined in equation (2).

$$t_D = \frac{Kt}{r_w{}^2 S_s} \tag{2}$$

where t is the elapsed time since start of injection and p_D is denoted as the dimensionless pressure as defined in equation (3).

$$p_D = \frac{4\pi K r_w \Delta p(t)}{q} \tag{3}$$

For the solution of the pulse interference test, equation (1) needs to account for the periodic nature of the injection flow rate in the source well. The time intervals of injection and shut in do not need to be the same, but account for their periodic nature needs to be included. The dimensionless time interval for injection and shut in have been assumed to be the same in this paper with the dimensionless time interval for injection tp_D as defined in equation (4).

$$tp_D = \frac{Ktp}{r_w{}^2 S_s} \tag{4}$$

where tp is the pulsed injection time interval.

PULSE TEST PROCEDURE

The source well injection system consists of inflatable straddle packers to isolate the injection horizon, and a pressure transducer is placed in the source well to monitor injection pressures. The receiver well system also consists of straddle packers isolating the high precision pressure transducer from wellbore storage effects. The injection flow rate is controlled by a constant flow rate direct drive pump with solenoid adjustable time interval switching values to modulate the periodic timed injection and shut in of the source well. A typical hydraulic pulse interference test system is shown in photographs on Figure 2.

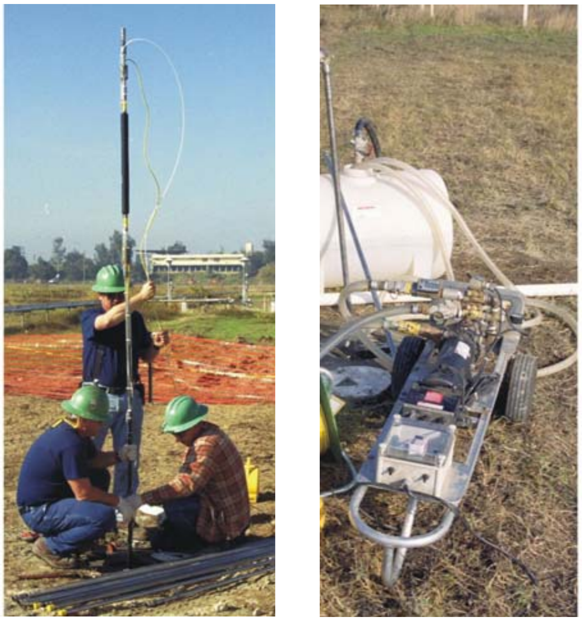

FIGURE 2. Typical Hydraulic Pulse Interference Test Setup.

During the pulse interference test, the source well’s flow rate and pressure are monitored along with all of the receiver pressure transducers. It is essential that the pressure transducers are of high precision and that the flow rates and pressures are all continuously monitored and recorded at high data acquisition rates. To ensure the tests are repeatable, the pulse switching mechanism needs to be automatically controlled and recorded on the data acquisition system. To optimize the resolution of the test, the injection/shut in time interval and/or injection flow rate will need to be varied depending on site conditions and the distances between source and receiver wells.

A series of hydraulic pulse interference tests were conducted in a confined aquifer overlain by an upper confining layer from ground surface down to 35 feet below ground surface (bgs) and underlain by a lower confining layer at a depth of 110 feet bgs. Both the source and receiver wells were straddled packed in a screened well section of 2” diameter from a depth of 100 feet down to 105 feet bgs. The receiver well was located 50 feet from the source well. The injection flow rate into the packed off section of the source well was 20 gpm with a pulsed injected time interval of 20 seconds and a shut in time interval also of 20 seconds. The receiver well response is shown on Figure 3 for a series of five (5) pulsed intervals. The maximum receiver pressure response during the first pulsed period is approximately 0.03 psi, with an extremely small time delay between the receiver well response from the source well flow rate change. The injection pressure in the source well was typically less than 5 psi throughout the test. It is imperative that the source well is well developed to enable high injection flow rates to maximize the pulse test resolution, and also minimize source well skin effects. This pulse interference test for the evaluation of formation hydrogeological properties highlights the advantages of the method; namely, its short duration, a single pulse plus shut in period of 40 seconds, and the injection of only seven (7) gallons of water into the formation.

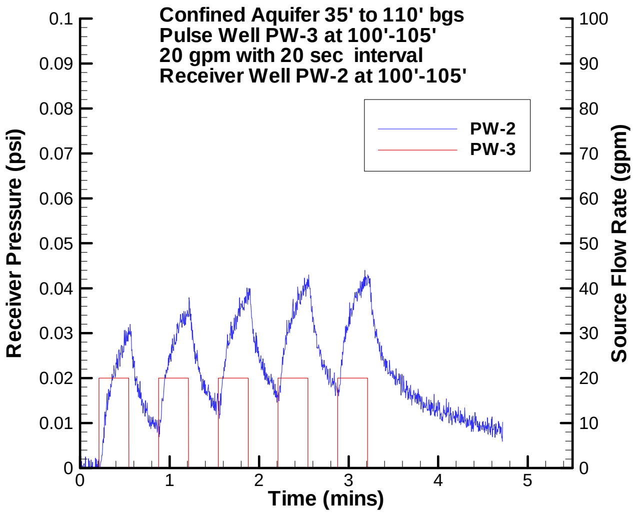

FIGURE 3. Receiver Well Pressure Response during Pulse Test.

PULSE TEST INTERPRETATION

The interpretation of the point source hydraulic pulse interference test follows similar procedures to line source interpretation procedures such as type curves and non-linear regression analysis. The type curve for the confined aquifer test described above was generated using equation (1) modified by the method of images to incorporate the periodic nature of the injections and also the confined nature and finite thickness of the aquifer system. The type curve generated is shown on Figure 4 as a plot of dimensionless pressure versus dimensionless time. The dimensionless pulsed time interval is labeled on the type curves for the respective shut in time periods as seen on the pressure descending portion of the curve. The receiver well pressure response in the pulse interference test is overlain on the type curve and matched in response as shown on Figure 4. The receiver well pressure is plotted as pressure in psi versus time in minutes.

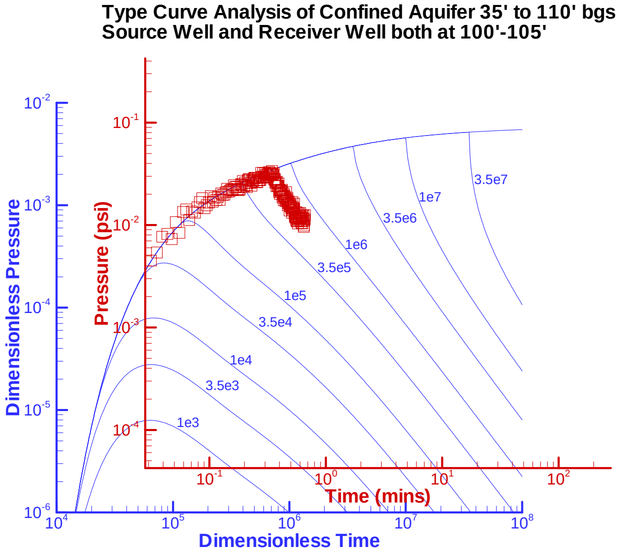

FIGURE 4. Type Curve Match for Hydraulic Pulse Interference Test.

The match point in pressure from Figure 4 is $\Delta p=1x10^{-2}$ psi with $p_D=7.6x10^{-4}$. Rearranging equation (3), the formation hydraulic conductivity is given by the following:

$$K = \frac{qp_D}{4\pi r_w \Delta p} \tag{5}$$

yielding a formation hydraulic conductivity of 105 feet per day.

The match point in time from Figure 4 is t=1 min with $t_D=2.04x10^6$. Rearranging equation (2), the formation specific storage is given by the following:

$$S_s = \frac{Kt}{r_w^2 t_D} \tag{6}$$

yielding a formation specific storage of $5.2x10^{-6}$ 1/foot.

The receiver well response for the interpreted values of hydraulic conductivity of 105 feet per day and a specific storage of $5.2x10^{-6}$ 1/foot generated from equation (1) modified to incorporate the correct image conditions for the confined aquifer geometry is shown as predicted on Figure 5 along with the measured receiver well response. As can be seen from this figure the predicted or matched response is in close agreement with the recorded data. Non-linear regression analysis of the pulse test data yielded similar hydrogeological properties for the formation as quantified by the type curve analysis. The type curve analysis though is significantly less sensitive to noise in the receiver well response compared to the non-linear regression analysis method.

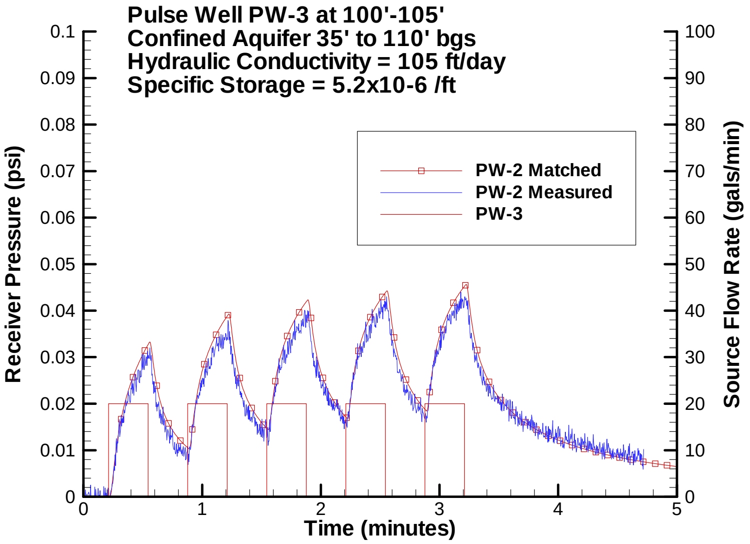

FIGURE 5. Predicted/Matched and Measured Receiver Well Response.

PULSE INTERFERENCE INTEGRITY TESTS

The hydraulic pulse interference test is an ideal test for the integrity testing of hydraulic containment systems such as cut off or slurry walls. The test can determined the extent and location of any holes or deficiencies in the wall's hydraulic containment and provided such integrity testing is carried out concurrent with wall construction can enable these deficiencies to be corrected immediately in the field. The pulse interference test requires monitoring wells installed on both sides of the wall; however, such monitoring wells are generally required as part of the verification and long term performance monitoring of the system.

Permeable reactive barrier systems are being installed as an alternative method to remediate contaminated groundwater. The most significant difference between a permeable reactive barrier and a containment system is the need to ensure the barrier's permeability does not impede or modify the groundwater flow regimes. The issues such as fines, smearing, filter cake clogging, etc. that benefit slurry wall systems as containment structures have major detrimental impacts on a PRB hydraulic performance. In general, such reductions in PRB permeability can not be retroactively removed and in certain construction techniques are difficult to avoid. Since any impediment to flow by a PRB system can have serious consequences to overall system performance, it is imperative to conduct hydraulic integrity testing of such a system to ensure it is constructed as planned.

Hydraulic pulse interference tests conducted across a barrier's alignment prior, during and after construction provide a simple means of quantifying the barrier's hydraulic characteristics and enable detailed quality assurance of the barrier during construction. An iron PRB was constructed within the confined aquifer system described earlier, from a depth of approximately 45 feet bgs down to a total depth of 110 feet bgs. The PRB was installed by the azimuth controlled vertical hydraulic fracturing technology and as a part of the quality assurance program on barrier hydraulic performance, pre and post construction pulse interference tests were conducted across the PRB alignment from pulse wells located 25 feet up and down gradient from the PRB. Pre and post PRB construction pulse interference test results are shown on Figure 6. The receiver well pressure response, amplitude, signature and time delay, shows no attenuation when comparing pre- and post- construction tests. These tests confirm that the PRB has an in placed hydraulic conductivity of at least that of the formation's highest conductive horizon. Since the hydraulic pulse interference test, utilizing pre and post test data is a high precision transient test, even minor impediments to flow by the PRB can be quantified.

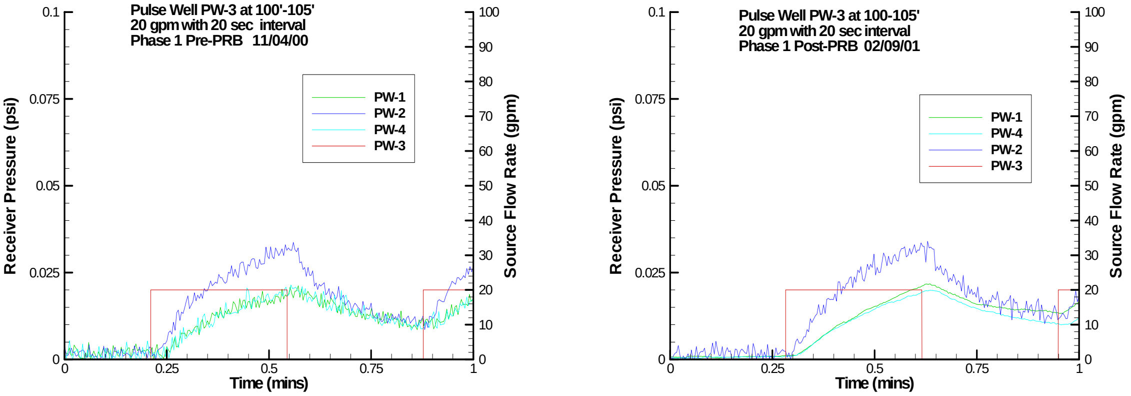

FIGURE 6. Pre and Post PRB Construction Pulse Interference Tests.

CONCLUSIONS

The hydraulic pulse interference test is an ideal test for the quantification of a site's hydrogeological properties. The pulse interference test is highly sensitive to hydrogeological properties between the pulse source and receiver wells. The transient nature of the test, involving the time delay and attenuation of the hydraulic pulse, enables the formation's complete hydraulic properties to be computed. The method is equally applicable to porous media and fractured bedrock systems. The advantages of the pulse interference test are the short duration of the test, the high resolution and directional characterization data obtained, and the lack of any generated contaminated groundwater during the test.

The pulse test has considerable merit as an integrity test for quantification of the hydraulic performance of containment and permeable reactive barrier systems. Considering the cost implications of poor performance of either a containment system, such as a slurry wall, or a permeable reactive barrier system, then using the pulse interference test as a quality assurance hydraulic test during construction can ensure the system is constructed as designed. Pre and post PRB construction pulse interference tests quantified that the azimuth controlled vertical hydraulic fracturing technology installed the PRB with an in placed permeability equivalent to or greater than the formation's highest hydraulic conductive horizon.

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