URS

Zero-Valent Iron Permeable Reactive Barrier (PRB)

Pilot Test REPORT-DRAFT

Essex/Hope Site
Jamestown, New York

Prepared for:
Essex Specialty Products, Inc.
Auburn Hills, Michigan

URS Project No. 804041.81

July, 2003

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Construction Services

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Prepared for:
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Executive Summary

Introduction and Objectives

This report describes the results of the Pilot Test for an injected Permeable Reactive Barrier (PRB) at the former Essex Specialty Products (ESP) facility in Jamestown, New York. The test period was July, 2000 through December, 2002. The reactive material injected into the subsurface consisted of fine-grained iron particles, also referred to as zero-valent iron (ZVI). The pilot test was conducted at two (2) locations on site as follows:

- **NPL Area shallow and deep groundwater zones**, around active recovery well RW-2D,
- **Plant No. 5 deep groundwater zone** (approximately 50 ft. southeast of the RW-2D test area, beneath Custom Production Manufacturing [CPM] building)

The **objectives** of the PRB Pilot Tests were as follows:

- Verify injected PRB effectiveness in treating VOCs in site groundwater over a range of expected concentrations and hydrogeologic conditions, and
- Provide data for full-scale PRB design and installation as an alternative or supplemental remedial action

Pilot Test Basis of Design

The pilot test design was based on the hydrogeologic conditions and VOC distributions at the site, the treatability of the site VOCs by ZVI and the physical features on the surface. Subsurface groundwater flow conditions and VOC distributions have been established by site investigations and ongoing site monitoring (Appendix A). The treatability of the VOCs by zero-valent iron (ZVI) has been demonstrated in the literature, and was confirmed in the bench-scale testing (Appendix B). Physical site features such as property lines, buildings, utilities and active work areas affected the accessibility of the injection equipment and the availability of test locations. The pilot test plan was designed to accommodate the site constraints and still provide for a suitable test configuration.

Samples of site aquifer materials and groundwater were used in the **bench-scale testing** to simulate site conditions. In the bench-scale testing, VOCs were reduced from approximately 8000 ug/l to below 200 ug/l after 4 hours, and below detectable limits after 12 hours of residence time in the ZVI column. The bench-scale degradation rates, with the flow conditions of the water-bearing zones and URS' experience with injected PRB's, were used to estimate the quantities of iron for use in the pilot tests.

Pilot Test Configurations

ZVI injections were initiated in the NPL Area on July 13, 2000. Three injection borings, INJ-1 through INJ-3, were completed from July 13 through July 16. Four ZVI injection borings, INJ-4 through INJ-7, were completed in the Plant #5 Test Area from July 17 through July 19, 2000.

NPL Area

- ZVI injections continuously through the **shallow and deep groundwater zones** at a depth interval of 6 to 45 feet below the ground surface, not including the clay confining layer.
- ZVI injection borings (three) on approximate 10 ft spacings, at a 5-7 ft distance from RW-2D (INJ-1 through INJ-3). This would allow the installation of a continuous ZVI zone around and upgradient of RW-2D.

Plant #5 Test Area

- ZVI injections continuously through the **deep groundwater zone only**, at a depth of approximately 20 to 45 feet below the ground surface.
- ZVI injection borings (four) on an approximate 10 ft square grid spacing (INJ4 through INJ7) around GP-1D. This would allow the installation of ZVI injections directly within the high VOC zone beneath Plant #5.

Performance Monitoring

The PRB Pilot Test performance was evaluated mainly by the changes in groundwater quality after injection of the ZVI. Groundwater analyses was performed for inorganic and volatile organic compounds and dissolved gases. Vapor-phase samples were taken throughout the pilot test area primarily to monitor gas migration from the injection zones and to provide data for recovery of the gases. Vapor phase monitoring included analyses of VOC degradation by-product compounds that were indicative of dechlorination of the VOCs.

NPL Area Pilot Test, Shallow Zone

Piezometer PZ-1S is the primary shallow zone monitoring point for the pilot test since it lies within and hydraulically downgradient of the ZVI injections.

General Water Quality - Water quality data indicated a significant change in shallow groundwater chemistry after injection of the ZVI. Most notably the PZ-1S and MW-7S **ORP** levels have been lowered significantly to –64.0 and –82 mV, resp., (July, 2001) indicating that the shallow groundwater is under reducing conditions. The average shallow zone ORP was +69.3 mV prior to the ZVI injections. ORP levels changed rapidly after injection of the ZVI, and have consistently stayed negative for at least one year, up to July, 2001, when the last OPR measurement was taken.

Consistent with the change to reducing conditions is the reduction in levels of **nitrate, sulfate and TOC** in the shallow monitoring points, all indications that increased anaerobic activity is occurring in the shallow zone. This increase in bioactivity is likely a result of the reducing conditions created by the ZVI, including the production of hydrogen gas.

Volatile Organics - VOC levels in the shallow zone varied with time after injection of the ZVI. VOCs increased approximately one order of magnitude in **PZ-1S and MW-7S** after injection of the ZVI, and remained above baseline levels for up to 9 months after the start of the pilot test. The dominant VOCs were TCE and cis-1,2 DCE. The VOC increase after ZVI injection is expected to be a local VOC "spike effect" caused by the increase in hydraulic pressures and fluid flow around the injection borings. **The VOC levels in both monitoring points decreased to below baseline VOC levels, and less than 50 ppb total VOCs, by July, 2001, one year after the start of the test. TCE reduction was 96.3% in PZ-1S.** TCE reduction was less in MW-7S (39%), however, the baseline TCE level was 14 ug/l and the July, 2001 level was 8.5 ug/l.

Recovery wells **RW-1S and RW-2S** were less affected by the ZVI injections. VOC levels in these wells generally were the same before and after the ZVI injections. Total VOC levels increased in each well, and the percentage of by-products compounds (vinyl chloride and cis-1,2 DCE) increased significantly above pre-test levels. This effect is similar to the "VOC spike" effect noted for MW-7S and PZ-1D. It is expected that the VOC spike at RW-1S is a combination of the radial VOC migration from the ZVI injection, enhanced by the flat and periodically reversed gradient towards RW-1S. Because of the variable hydraulic gradient in the area of RW-1S, the radius of the injection effect could not be confirmed to extend to RW-1S (55 feet), although it is expected to be significantly greater than the minimum 5 feet radius estimated from MW-7S. **Preliminary estimates based on the pilot test results are that the radius of influence of the VOC spike effect is 10-50 feet.**

Monitoring data at RW-1S and 2S through year 2002 indicates that the VOC levels have continually reduced to near or below pre-test levels (April, 2000 data) prior to the start of the pilot test. **The VOC levels in RW-2S decreased to below pre-test VOC levels, and less than 50 ppb total VOCs, by December, 2002, two and one-half years after the start of the test. TCE reduction was 98.5% in RW-2S.** TCE levels were reduced less at RW-1S, and were still above pre-test levels, however, the VOC levels were reduced over 90% from the highest levels detected as a result of the VOC spike effect. These VOC reductions are expected to be a result of the ongoing pumping of the shallow groundwater zone and flushing of the VOC spike. The most recent RW-1S samples also included by-product compounds, which were not present in this well prior to the pilot test. These results indicate that residual VOC spike effects have not yet been flushed from the RW-1S pumping zone.

NPL Area Pilot Test, Deep Zone

Active recovery well RW-2D is at the center of the ZVI injection boring grid and produces the hydraulic cone of depression maintained throughout the pilot test. PZ-1D was installed between the injection boring INJ 3 and RW-2D. PZ-2D was installed within INJ 3. Existing monitoring well MW-7D, approximately 6 feet "upgradient" of INJ 3, was also monitored.

General Water Quality - Water quality data indicated a significant change in deep groundwater chemistry after injection of the ZVI. Most notably the **ORP** levels in all of the monitoring points have been lowered significantly (July, 2001) indicating that the deep groundwater has been further chemically reduced. The average deep zone ORP was -44.8 mV prior to the ZVI injections, which indicated that the deep zone was already slightly reduced and was likely undergoing anaerobic biodegradation. **ORP levels changed rapidly after injection of the ZVI, and have consistently stayed negative for at least one year, up to July, 2001. Average ORP levels in the deep zone were –184 mV for July, 2001.**

Consistent with the change to reducing conditions is the reduction in the level of **sulfate** in all of the deep zone monitoring points, an indication that increased anaerobic activity is occurring. **Nitrate** levels were low prior to the start of the test and on average did not change. This increase in bioactivity, as also seen in the shallow zone, is likely a result of the reducing conditions created by the ZVI, including the production of hydrogen gas. It is noted that **TOC** levels did not decrease in the deep zone as found in the shallow zone. Mean TOC levels in the NPL Area actually increased over 300% above historic mean levels. This increase was highest in PZ-1D and PZ-2D, and is expected to be attributable to the guar compounds contained in the ZVI slurry.

Chloride levels on average increased to 108.5 mg/l in the NPL Area relative to the pre-test mean levels of 33.8 mg/l. This increase is expected to be directly related to the dechlorination of the VOCs by both the ZVI reactions and the enhanced biological degradation. The chloride level of 108.5 mg/l has an equivalent TCE concentration of 134 mg/l based on stoichiometric equivalence, assuming complete TCE degradation to chloride ions. All of the chloride cannot be assumed to be a result of VOC breakdown since background chloride (16.7 mg/l) is present onsite. This relatively high TCE level is not typical of historic TCE concentrations found in the NPL Area, although MW-7D has had a TCE level of 340 mg/l. This concentration is similar to the TCE concentrations found in the Plant No. 5 hot spot area, and suggest the historic presence of NAPL in the NPL Area. NAPL, if present in and upgradient of the NPL Area, such as in the Plant No. 5 test area, could explain the elevated chloride levels found in July, 2001.

Volatile Organics - VOC levels in the deep zone varied with time after injection of the ZVI. The three monitoring points within and downgradient of the injection borings: PZ-1D, PZ-2D and RW-2D, all responded similarly. After ZVI injection, TCE levels increased initially (August, 2000) from 56 to 63% above baseline levels. TCE levels remained above baseline levels for up to 7 months after the start of the pilot test, similar to the same spike effect noted for the shallow zone. **The TCE levels in these three monitoring points decreased significantly from the initial elevated levels, and were below the baseline levels, by July, 2001, one year after the start of the test. TCE reductions from the initial (Aug, 2000) high levels were 70% in PZ-1D, 94% in PZ-2D and 86% in RW-2D. The July, 2001 TCE levels in these monitoring points were 18 mg/l, 11 mg/l and 0.7 mg/l, respectively.** RW-2D has been sampled quarterly as part of the ongoing monitoring program at the site, in addition to the pilot test monitoring. **TCE level in RW-2D reduced to 110 ug/l in December, 2002. This was the lowest TCE concentration found in RW-2D since the start of the historical monitoring in 1997.**

MW-7D, upgradient of the injection boring, had a similar initial TCE increase (24%) after the ZVI injection. TCE levels remained above baseline levels for up to 16 months after the start of the pilot test. TCE reduction below the baseline level was observed in July, 2001 (<250 ug/l. **The MW-7D TCE level reduced to 38 ug/l in December, 2002 as determined from the annual monitoring.**

Plant No. 5 Test Area

ZVI was injected into the deep water-bearing zone VOC "hot spot" in the western area of Plant No. 5. This area was found to have the highest VOC levels at the site and was suspected to contain NAPLs. Deep zone groundwater in this test area is within the influence of RW-2D and the flow direction is generally to the northwest.

ZVI was injected on a rectangular grid around monitoring point GP-1D on an approximately 8 feet spacing. The pilot test in this area was intended to evaluate ZVI as an insitu treatment method for VOC hot spot, or direct source area reduction. Monitoring points were installed within injection boring INJ 4 (**PZ-4D**) and at the center of the injection grid (**PZ-3D**). PZ-4D was hydraulically downgradient of the general hot spot injection area.

General Water Quality - The only pre-pilot water quality obtained in the hot spot test area (GP-1D, now PZ-3D) indicates that the groundwater in this area was under reducing conditions and was undergoing biological VOC degradation. ORP was –289 mV and nitrate was 0.37 mg/l, indicative of anaerobic biological activity. Water quality data obtained during the pilot test period indicated minor changes in deep groundwater chemistry after injection of the ZVI. The ORP levels in all of the monitoring points continued to be negative (July, 2001) and did not change significantly after the ZVI injections. **The ORP levels have consistently stayed negative for at least one year in the Hot Spot area, up to July, 2001. The average deep zone ORP in the hot spot area was -130 mV after the ZVI injections.**

Nitrate and sulfate levels in the Hot Spot area were reduced to at or below detection limits after the ZVI injections. Nitrate levels were low prior to the start of the test and on average did not change. The low sulfate and nitrates are an indication of increased bioactivity, which was also seen in the NPL Area in both water-bearing zones. In addition, the **TOC** levels increased to an average level of 120 mg/l in PZ-3D and PZ-4D, relative to the TOC level of 27.5 mg/l in GP-1D prior to the pilot test. This TOC increase, also found in the NPL Area deep zone, is expected to be attributable to the guar compounds contained in the ZVI slurry.

Chloride level increased in the Hot Spot Area relative to the pre-test mean levels of 33.8 mg/l in the deep zone, and 80.4 mg/l in GP-1D. Chloride in PZ-4D was 210 mg/l (July, 2001).. This increase is expected to be directly related to the dechlorination of the VOCs by both the ZVI reactions and the enhanced biological degradation. The chloride level of 210 mg/l has an equivalent TCE concentration of 259 mg/l based on stoichiometric equivalence. This relatively high TCE level is typical of historic TCE concentrations found in the Plant No. 5 Test Area and suggests that an equal amount of TCE has been degraded.

The chloride-equivalent TCE concentration does not account for the TCE and by-product compounds still present in the July, 2001 samples. It is evident that this chloride level is much higher than the chloride level predicted for degradation of the pre-test VOC levels. This could indicate that the Plant No. 5 Test Area is not a steady state system, and VOCs continue to be generated in the test area. These VOCs are expected to migrate into the test area from upgradient locations. In addition, the data also suggests that the ZVI injections enhance the desorption of VOCs from the groundwater formation, and possibly from NAPL dissolution.

Volatile Organics - VOC levels in the deep zone varied with time after injection of the ZVI. The two monitoring points within and downgradient of the injection borings: PZ-3D and PZ-4D, responded similarly. The average pre-pilot test TCE concentration at GP-1D (PZ-3D) was 210.5 mg/l, based on samples taken in February and July, 2000. All other VOCs were reported as below detection limits, which were 5 mg/l or less. This is the only historic and baseline data available for the Plant No. 5 Test area.

Initially after ZVI injection (August, 2000), TCE levels increased to 367 mg/l in PZ-4D, and decreased to 76 mg/l in PZ-3D. TCE levels dropped significantly in both points following the initial increase. **The November, 2000 TCE levels were 5.3 mg/l in PZ-4D and 30 mg/l in PZ-3D, approximately 3 months after the start of the pilot test. These are TCE reductions of 97% and 86%, respectively, relative to the pre-test mean TCE level of 210.5 mg/l in the Plant No. 5 Area. After November, 2000, the TCE levels started to increase to levels approaching the pre-test mean levels as demonstrated in samples taken from February through July, 2001.** This TCE increase represents a unique condition not found in the NPL Area pilot test, and is expected to be caused by the differing groundwater hydraulic conditions in the Hot Spot test area. Specifically, upgradient VOCs (to the southeast of the Plant #5 Test Area) have migrated into the test area over time. In addition, NAPL desorption in the test area is expected to cause a further increase in the VOCs.

By-Product VOC Generation

Byproduct compounds cis- 1,2 DCE and vinyl chloride (VC) increased in concentration initially after ZVI injection, and continued to increase as TCE levels reduced in the injection zone. Prior to the pilot test, the ratio of by-product compounds (DCE and VC) to TCE was 0.75 at RW-2D, 0.34 at PZ-1D and <0.1 at PZ-3D. The July, 2001 by-product/TCE ratios were 20.8 at RW-2D, 4.6 at PZ-1D and 0.8 at PZ-3D. These ratios are at least one order of magnitude increases above the pre-pilot test ratios for these monitoring points.

RW-2D quarterly monitoring indicates that cis-1,2 DCE and VC levels continue on an increasing trend as TCE levels reduce. Trans 1,2 DCE was typically reported as below detection limits or it was found at levels less than 1 mg/l. The compound cis-1,2 DCE is reported in the literature to be the most common DCE isomer produced during anaerobic degradation of TCE. **The VOC by-product data, with the water quality data, indicate that VOC dechlorination is continuing, although at a much lower rate than predicted for the ZVI reduction reaction alone. It is suspected that the ongoing VOC reduction is primarily biological dechlorination enhanced by the reducing conditions produced by the ZVI.**

Vapor Generation and Characterization

Vapor phase compounds of most interest included hydrogen, methane, ethane/ethene, propane/propylene and butanes. These compounds are indicators of ZVI reactions and the breakdown of chlorinated VOCs. At high concentrations, and in the presence of oxygen, these compounds are potentially explosive. A major concern during the pilot test was the potential for vapor migration into the Plant #5 building. Existing monitoring points were sampled for vapors and new vapor probes (VPs) were installed throughout the site, including beneath the Plant #5 floor, to check for vapor presence beyond the pilot test area. A vapor control system was installed in September, 2000, to contain vapor migration from the test area, especially in the area of Plant #5.

Field Vapor Monitoring - Field vapor monitoring (LEL, PID and FID) conducted during the pilot test indicated that significant levels of potentially explosive vapors were being generated in the shallow and deep water-bearing zones after injection of the ZVI. "Significant levels" are defined herein as LELs > 10% and PID/FID readings > 50 ppm each.

Note: The vapor readings have all been taken from within the casing headspace of the monitoring point and do not represent vapor levels in the work zones.

Generally, significant vapor levels have been found only in the deep water-bearing zone, with the exception of elevated FID readings in the NPL Area shallow zone at MW-7S. The MW-7S levels were high only during the 2 month period after ZVI injection, after which they reduced to near or below the "action level". **Vapor readings have been consistently below action levels in the shallow zone throughout the entire monitoring period, including all of the floor probes (VP1S-4S) beneath Plant #5.** The shutdown of the vapor recovery system in November, 2000 had no noticeable effect on the shallow vapor levels.

Vapor readings above action levels were found in the deep zone throughout all areas of the site, however, these vapors were confined to within the site property in all directions, with the exception of the UST Area to the southeast of the ZVI injections. The UST Area vapors were found to be primarily methane and TEX compounds and they do not appear to be related to the Pilot Test.

The deep zone PZ's in the injection area (PZs 1D, 2D, 3D and 4D) have shown a decline in vapor levels that appear to have started in January, 2001, after the vapor recovery system was shutdown. This decline is most evident in the NPL Area, and indicate that vapor generation is declining in the pilot test area.

Vapor Analyses – Vapor samples were taken for offsite laboratory analyses to characterize individual compounds and determine their concentrations. Samples were taken from the well headspace vapor and dissolved groundwater phases. **The vapor analyses indicate that excess hydrogen gas and TCE/DCE degradation by-products ethylene and propylene were generated during the pilot test. The vapor data indicates that hydrogen is the dominant compound in the vapor phase, followed by ethane and ethylene.** Methane has been found at high levels in the UST Area (VP-7D @ 11.7 – 43.3 % by vol.), but vapors in this area are not expected to be from the pilot test area since the hydrogen and ethylene levels were found to be very low. The data also confirmed that pilot test-generated vapors (hydrogen and organic gases) have not been found beyond the immediate areas of the ZVI injections in the NPL and Hot Spot areas.

The Plant #5 Area **deep zone** had the highest by-product vapor levels found at the site. At **PZ-3D** the hydrogen levels ranged from 1.22 to 590,000 ppmv. The low levels were present primarily during the period when the vapor recovery system was in operation and the well headspace was under vacuum extraction. For the period when the vapor recovery system was not in operation, the **mean hydrogen levels in PZ-3D were 281,730 ppmv (28.2%).** Similar high hydrogen levels were found at PZ-4D. Over time, the hydrogen levels have fluctuated, mainly in response to the vapor recovery system. **After the vacuum recovery system was shutdown in November, 2000, the hydrogen levels have increased to the high levels found at the start of the vapor sampling in August, 2000.**

Organic vapors (ethane, ethylene, propane, propylene, butane) were also at their highest levels in the hot spot area. Ethylene and ethane were the dominant organic compounds found in the vapor phase. At PZ-3D, ethylene levels were less than hydrogen and ranged from 2 to 17% of the hydrogen concentrations. Ethane ranged from 1 to 20% of the hydrogen levels. **After the vacuum recovery system was shutdown in November, 2000, the ethylene and ethane levels have increased to above the high levels found at the start of the vapor sampling in August, 2000. The ratios of hydrogen/ethane and hydrogen/ethene show a general reducing trend which is indicative of hydrogen utilization and TCE degradation. It is noted that the last vapor samples taken from PZ-3D and PZ-4D, in July, 2001, had the highest organic vapor levels found to-date.**

The **NPL Area** had relatively low by-product vapor levels compared to the Hot Spot Area. **PZ-1D and PZ-2D** hydrogen levels were 21,000 and 4800 ppmv, 3.5 and 0.8%, respectively, of the levels found at PZ-3D (Plant No. 5) in July, 2001. Hydrogen levels at RW-2D were relatively low and ranged from 0.84 to 39 ppmv during the monitoring period. Organic vapors (ethane, ethylene, propane, propylene, butane) were also at relatively low levels in the NPL Area. Ethylene and ethane were also the dominant organic compounds found in the vapor phase in the NPL Area. Ratios of H_2/ethane and H_2/ethene were at similar levels as found in the Plant #5 Test Area.

1.0 Introduction and Objectives

On behalf of Essex Specialty Products, Inc. (ESP), URS has prepared this report to describe the results of the Pilot Test for a Zero-Valent Iron Permeable Reactive Barrier (PRB) at the former ESP facility in Jamestown, New York. The permeable reactive material injected into the subsurface consisted of fine-grained iron particles, also referred to as zero-valent iron (ZVI). The pilot test was conducted at two (2) locations on site, each with a different injection configuration as follows:

- ZVI barrier injected in the NPL Area shallow and deep groundwater zones, around active recovery well RW-2D,
- ZVI injections into the deep groundwater zone beneath the CPM Plant #5 building (approximately 50 ft. southeast of the RW-2D test area)

The conventional approach for in situ use of ZVI has been for PRB walls located at or near a plume front or property line, installed using trenching methods. Trench installation techniques for ZVI PRBs limit the depths to which PRBs can be constructed and are a significant component of the costs for PRBs. ZVI injection methods reduce costs and increase the applications for this remedial technique. The injection technique also affords the ability to inject ZVI closer to or into source areas.

URS conducted PRB bench-scale testing in April, 2000 and submitted a Pilot Test Work Plan to NYDEC on May 19, 2000. NYDEC approved the Work Plan on June 23 and the ZVI injections were performed in July, 2000. Pilot test monitoring was conducted on an approximate monthly basis from August, 2000 through July, 2001. Follow-on monitoring was conducted as part of the routine site groundwater monitoring conducted on a quarterly basis. An Interim Report containing the results of the first four rounds of monitoring was submitted to NYDEC in February, 2001.This Pilot Test report contains quarterly monitoring results through the end of 2002.

The PRB Pilot Tests were conducted at the ESP Site within the area of the existing operating remedial actions. A detailed description of the site conditions, historical water quality and the operating remedial action is contained in Appendix A. A general plan of the site conditions is shown on Figure 1.

Objectives

The objectives of the PRB Pilot Tests are as follows:

- Evaluate PRB effectiveness in treating VOCs in site groundwater over a range of expected concentrations and hydrogeologic conditions, and
- Provide data for full-scale PRB design and installation as an alternative or supplemental remedial action at the site.

2.0 PRB Pilot Test Installation

The PRB Pilot Test was developed based on the results of bench-scale testing and an evaluation of site conditions. A detailed description of site hydrogeologic conditions as applicable to the pilot testing is contained in Appendix A. The PRB Bench Testing is summarized in Appendix B.

A Work Plan for the Pilot Test was submitted to NYDEC on May 19, 2000. NYDEC approval to proceed was provided in a June 23, 2000 letter to URS. Equipment and materials were mobilized to the site during the week of July 10, 2000, and pilot test monitoring point installation started later that week.

URS roles and responsibilities for the work are as follows:

- Bench-Scale Testing -- Planned and performed by URS ROS Milwaukee, WI, James Imbrie - Task Manager
- Pilot Test Work Plan – Prepared by URS Milwaukee, James Imbrie - Task Manager
- Pilot Test Installation -- Managed by URS Milwaukee, James Imbrie, Drilling Manager - Tom Reed,
- Pilot Test Monitoring – Plan prepared by URS Milwaukee, James Imbrie, monitoring performed by URS Pittsburgh, PA, Mark Dowiak - Project Manager, Keith Dodrill- Task Manager
- Final Report – Prepared by URS Pittsburgh, Mark Dowiak- Project Manager

2.1 Pilot Test Basis of Design

The pilot test design was based on the hydrogeologic conditions and VOC distributions at the site, the treatability of the site VOCs by ZVI, and the physical features and obstructions on the surface. Subsurface groundwater flow conditions and VOC distributions have been established by site investigations and ongoing site monitoring (Appendix A). The treatability of the VOCs by zero-valent iron (ZVI) has been demonstrated in the literature, and was confirmed in the bench-scale testing (Appendix B). Physical features at the site determined the constraints for equipment access and installation of the test injections and monitoring systems.

A brief summary of each component of the pilot test design basis follows:

2.1.1 VOC Treatability By Zero-Valent Iron

ZVI is a technology that has been demonstrated to be successful in the treatment of chlorinated VOCs. Numerous case studies have been reported in the literature for both pilot and full-scale applications of ZVI in various configurations for insitu groundwater remediation. The following references provide a good summary of ZVI applications:

Field Applications of In Situ Remediation Technologies: Permeable Reactive Barriers, USEPA, EPA 542-R-99-002, June, 1999.

Permeable Reactive Barrier Technologies for Contaminant Remediation, USEPA, EPA/600/R-98/125, September, 1998.

The mechanism for "treatment" of the chlorinated VOCs by ZVI is considered to be abiotic reductive dehalogenation that involves corrosion of the Fe(0) by the VOCs. The reaction pathways have been determined to be sequential as the halogens are removed from the organic compound, for example : TCE $\rightarrow$ DCE $\rightarrow$ VC $\rightarrow$ ethene $\rightarrow$ ethane. The VOC degradation rates have been shown to be pseudo-first order, with the rate constant relatively insensitive to the initial VOC concentration. Less halogenated intermediate products generally are reduced at a lower rate than their parent compound.

The anodic reaction for corrosion of ZVI by aqueous phase TCE in anoxic solutions is

$$Fe \rightarrow Fe^{2+} + 2e^-$$

While the subsequent cathodic reactions when ethene[1] is the end product may be expressed as:

$$2H_2O + H^+ + 2e^- \rightarrow H_2 + 2OH^-$$

$$C_2HCl_3\ [TCE] + 3H^+ + 6e^- \rightarrow C_2H_4 + 3\ Cl^-$$

The rate of these reactions is dependent upon the rate at which oxidants are able to accept electrons and the rate at which the iron is able to release electrons. Since the reduction of TCE is a cathodic reaction, cathodic control on the reaction will be dependent upon the amount of TCE to be reduced.

Stoichiometric relationships indicate that 3 moles of H_2 are needed to degrade 1 mole of TCE. In addition, 1 mole of Fe(0) (ZVI) produces 1 mole of H_2.

[1] Other end products are ethane and acetylene

Assuming the ZVI in the form of magnetite (Fe_3O_4), one ton (909 kg) represents 3,928 moles of iron. From Section 2.1.1, one mole of iron produces one mole of H_2 gas. Therefore, 3,928 moles H_2 = 87,976 liters (3,079 ft^3) H_2(at standard temperature and pressure) could be produced over time from this reaction. Section 2.1.1 also indicates that three moles of hydrogen are required to convert one mole TCE to ethene. These reactions allow an estimate of the quantity of VOCs that could theoretically be degraded in a dehalogenation reaction based strictly on H_2 as the electron acceptor.

Table 1 summarizes the theoretical quantities of hydrogen and ZVI required for total VOC degradation based on a range of TCE quantities in the injection areas. It is noted that these values of ZVI and hydrogen represent the quantities equivalent to 100% efficient reactions in a "completely mixed" system. The reaction efficiencies in the subsurface are limited by various factors, primarily the distribution of the ZVI in the contamination zone and the groundwater seepage velocity, and are expected to be reduced significantly from 100%. Therefore, the ZVI quantities calculated in Table 1 are the theoretical minimum amounts necessary for TCE degradation. These quantities are used as a baseline value and are increased by site-specific safety factors for the pilot test injections.

The proprietary injection technique used by URS involves the use of guar gum ($C_3H_3O_3$, plus hydration spheres) with proprietary enzymes to act as a carrier for the iron. With the aid of the enzymes, the guar degrades, adding a source of organic carbon to the groundwater. It is believed that this also enhances the intrinsic biodegradation of the chlorinated VOCs. The metabolism of guar is believed to be represented by the following half reaction:

$$C_3H_3O_3 + 6H_2O \rightarrow 3HCO_3 + 6H_2$$

This would then represent a significant source of hydrogen that would contribute to the reductive dehalogenation of TCE. With the cathodic reactions producing hydrogen, the guar and hydrogen combined has the potential to produce excess hydrogen for the dehalogenation reaction.

According to Bokermann, et al., 2000, there are additional compounds in groundwater that result in generation of H_2. These are carbon dioxide and bicarbonate.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

$$H_2CO_3 + e^- \rightarrow H + HCO_3^-$$

$$HCO_3^- + e^- \rightarrow H + CO_3^{2-}$$

These reactions have not been quantified at the site, however, they are expected to be a minor contributor to the hydrogen production relative to the ZVI and guar reactions.

It is believed that there are three factors controlling the generation of hydrogen: 1) the cathodically driven corrosion of iron resulting from the high concentrations of TCE in the subsurface; 2) the metabolism of guar to form bicarbonate; and, 3) the breakdown of bicarbonate to form carbonate.

Other factors have also been shown to affect the VOC degradation rates, including the distribution of the VOC contamination, the presence of NAPLs, and the groundwater temperature. The latter factor is significant when using bench test results to predict field performance.

2.1.2 Bench-Scale Testing

Column tests were performed in the laboratory to obtain data on VOC degradation rates by ZVI. Samples of site aquifer materials and groundwater were used in the bench-scale testing to simulate site conditions. See Appendix B for a summary of the tests. In the bench-scale testing, VOCs were reduced from approximately 8000 ug/l to below 200 ug/l after 4 hours, and below detectable limits after 12 hours of residence time in the ZVI column. The column tests provided data to estimate degradation rates for the two primary VOC constituents in groundwater: trichloroethylene (TCE) and cis 1,2–dichloroethylene (cis 1,2 DCE). The estimated degradation rates, k_1, for each compound are as follows:

k_1 TCE = 2.04

k_1 cis 1,2 DCE = 0.57

The site-specific degradation rates determined in the bench-scale testing were compared to values reported in the literature. For six similar projects, TCE k_1 ranged from 0.15 to 1.14, and cis - DCE k_1 ranged from 0.07 to 0.27. The bench test results for TCE and cis 1,2 DCE are higher than the range reported in the literature. It is not known from this limited data comparison whether these high k values are a statistical outlier or if they represent site-specific conditions exhibited in the bench testing. Tables B-1 and B-2, PRB Pilot Test Designs for 5 ug/l and 100 ug/l target VOC cleanup levels, respectively, summarize the estimates for ZVI quantities for use in the pilot tests based on the VOC degradation rates obtained from the bench test. Note that NYDEC groundwater cleanup objectives (RAOs) for the site are 5 ppb for individual VOCs.

The bench-scale degradation rates, with the grain size and porosities of the water-bearing zones, and URS' experience with injected PRB's, were used to estimate the quantities of iron for use in the pilot tests.

2.1.3 VOC Distribution in Groundwater

Historic groundwater monitoring data generated from the start of remedial actions in 1997, up to the start of the PRW pilot testing, in July, 2000, was used to identify the most suitable locations for the pilot tests. The evaluation of the data indicated two dominant features of VOC contamination in groundwater.

Plant No. 5 Test Area- A high VOC concentration zone exists in the deep groundwater zone beneath the western end of the Plant #5 building as found in test borings GP-1D through GP-3D. This zone had soil TCE levels from 66 to 160 mg/kg, which is equivalent to groundwater concentrations of 118 to 286 mg/l based on equilibrium partitioning estimates (see Appendix A, Table A-2). These hot spot TCE levels were generally 1 to 2 orders of magnitude greater than the mean TCE concentrations found in the deep groundwater zone of the NPL Area, and are historically the highest TCE levels found at the site. See Appendix A for a detailed summary of the historic groundwater VOC data.

Note: *The groundwater samples taken from the GP deep wells, prior to the start of the pilot test had relatively low VOC levels that were not in equilibrium with the corresponding soil samples from the same wells. This inconsistency in VOC concentrations in co-located soil and groundwater samples is considered a sampling error. Pilot test groundwater monitoring in the hot spot area indicated high VOC levels, consistent with the theoretical equilibrium groundwater levels expected for the previously detected high soil VOCs. The hot spot groundater monitoring during the pilot test confirmed the initial assumptions of high VOCs in groundwater.*

The elevated TCE found in the deep zone soil samples beneath Plant #5, and expected to be present in groundwater, were the basis for selecting this area for the PRW bulk injection hot spot pilot test. This test was intended to evaluate the effectiveness of ZVI injections for direct reduction of high VOCs in groundwater hot spots.

NPL TCE Plume Area- Historically, the NPL Area has had the highest levels of chlorinated VOC contamination in groundwater and is the location for the original primary source of VOCs, the NPL sump. The sump and surrounding soils contaminated with VOCs, and PCBs, were removed in 1997 as part of the site remedial action. The remnant VOC plume, containing primarily TCE, is concentrated in the deep groundwater zone in the northern NPL Area and extends under the Plant #5 building. See Appendix A, Figures A-7 and A-8. This plume has been the focus of the groundwater pump and treat system that has been operating since 1997. Recovery well RW-2D is the only pumping well operating in the NPL Area since

RW-1D was shutdown in 1999. The NPL Area VOC plume would also be the primary area for application of a full-scale PRB.

The area around RW-2D was selected as the location for the PRB pilot test because it best represents the NPL TCE plume conditions and the groundwater flow direction is radially towards the pumping well. The pilot test configuration presented some unique conditions since the VOC plume was under pumping conditions. Ideally, a PRB pilot test wall would be downgradient of the plume leading edge to best simulate a full-scale PRB. In this scenario, the area downgradient of the test wall would be relatively uncontaminated and would not cause interference with the performance monitoring results. Under the existing pumping conditions, however, the VOC plume is migrating towards the pumping well, and the area "downgradient" of the ZVI injection area, including RW-2D, contains VOCs. The presence of these "baseline" VOCs in the downgradient test area was taken into account in the performance monitoring.

2.1.4 Site Physical Features

The physical conditions in the pilot test areas presented constraints for equipment access, drilling and well installation, mainly in the hot spot test area beneath the Plant #5 building, however, none of these physical limitations prevented injection of the ZVI or installation of the monitoring systems.

The PRB test area around RW-2D is within a concrete-paved parking lot with easy access. Approval was obtained from the City of Jamestown for installation of some of the injection borings in the right-of-way for Hopkins Avenue, to the north of the NPL area. All of the injection borings and monitoring points were constructed as flush-mounts to allow vehicular traffic over the test area.

The hot spot test area was beneath the existing Plant #5 building. CPM manufacturing operations were active during the test installation and the performance monitoring period. Injection borings and monitoring wells were installed inside of the building through the concrete floor slab. All of the injection borings and monitoring points were constructed as flush-mounts to allow manufacturing operations and equipment traffic over the test area.

2.1.5 Pilot Test Configurations

The layouts of the two PRB pilot tests are shown on Figure 2. Basic criteria for the test configurations are as follows:

NPL Area-

- ZVI injections were performed continuously through the shallow and deep groundwater zones at a depth interval of 6 to 45 feet below the ground surface, except across the confining clay layer from approximately 17 to 21 ft BGS.

- ZVI injection borings (three) were on approximate 10 ft spacings, at a 5-7 ft distance from RW-2D (INJ-1 through INJ-3). The boring spacing is based on a minimum effective injection radius of 5 feet. This would alow the installation of a continuous PRB around and upgradient of RW-2D.

- Injection of ZVI was performed using radial (lateral) jet nozzles (three equally spaced at 120 deg angles) on the injector pipe to achieve a vertical ZVI panel.

Plant #5 Test Area-

- ZVI injections were performed continuously through the deep groundwater zone only, at a depth of approximately 20 to 45 feet below the ground surface.

- ZVI injection borings (four) were on an approximate 10 ft square grid spacing (INJ4 through INJ7) around GP-1D. The boring spacing is based on an effective injection radius of 5 feet. This would allow the installation of ZVI injections directly into the VOC hot spot.

- Injection of ZVI was performed using a single vertical (axial) jet on the injector pipe to achieve a vertical ZVI column

2.1.6 Recovery Well (RW) Operations and Historical VOC Flushing

The existing groundwater remediation system was in operation during performance of the pilot test. See Appendix A for description of the system. The primary effect on the pilot test was the pumping of recovery wells RW-1D and RW-2D, which created groundwater cones of hydraulic depression around the pumping wells, and throughout the areas of the pilot tests. Figure 2 shows the groundwater flow lines for the shallow (S) and deep (D) water-bearing zones.

Since the NPL Area deep zone pilot test was centered around RW-2D, a concern was the presence and persistence of pre-pilot test VOCs between the injection borings and RW-2D which may not have been initially degraded by the ZVI injections. These historic VOCs may persist in this annular zone and be present in the performance monitoring samples, thus providing misleading data on the actual degradation of the VOCs within and upgradient of the ZVI zone.

The retardation and flushing of the historical VOCs were evaluated as part of the pilot test. VOC retardation factors were used to estimate the travel time of the VOC contaminants from the ZVI injection zone to the recovery well. This calculation provided the "VOC flushing time" which is defined as the time after which the effects on of historical VOC migration from the annular zone on performance monitoring samples would be minimized, and the pilot test VOC transport conditions would be near "steady state". It is noted that the VOC retardation estimates are based on the assumption that the VOCs are dissolved in the groundwater phase. The presence of NAPLs is not considered in the calculation, although they may be present in the pilot test areas, however they are mainly suspected to be present in the Plant #5 Test Area.

Estimated flushing times for site VOCs at 10 and 25 foot radii from RW-2D are presented on Table 2. The worst-case flushing times are for TCE, at 23.5-58.6 days. These times were considered acceptable for minimizing interference from historic VOC contamination since the length of the pilot test monitoring was planned at a minimum of one year.

2.2 ZVI Injection System, Equipment and Materials

URS injected the ZVI using a proprietary in-house system that used a specialty-built high pressure pump unit and a modified Direct Push Technology (DPT) drilling rig. All of the equipment is owned and was operated by URS. The ZVI injection system is summarized on Figure 3. Photos of the system are contained in Appendix D.

The primary components of the injection system are as follows:

- AMS PowerProbe 9600 Direct Push System mounted on a 1 ton pickup truck- The rig was modified to add an injection header connection and injection nozzles for the end of the drill rods. Injection rods were 2.0 in dia.

- BioCl Amendment Pump (BAP) Unit housed on an open-top trailer- The BAP Unit includes a high-pressure positive displacement pump powered by a diesel engine, a 350-gallon mixing hopper for the ZVI/guar solution, and ZVI dry feed conveyor. The pump is capable of injection up to 3200 psi.

- Slurry mix tank – A 20,000 gallon steel storage tank equipped with 4 mixers for blending the water/guar slurry mixture.

Materials used in the ZVI injection process included the following:

- Zero-Valent Iron (ZVI) – Cast iron aggregate, Peerless Metal Powders, Detroit, MI. The iron was delivered and stored onsite in 1 CY bulk bags, 3000 pounds each. Specific surface area = 1.0 m2/g.

- Guar Gum - Granular, bagged, mixed onsite with a proprietary enzyme breaker.

- Water – City of Jamestown public water obtained onsite.

URS also installed monitoring wells (referred to as piezometers, PZ's) near and within some of the injection points to monitor groundwater quality. The PZs were prepacked screened wells manufactured by Geoprobe Systems, Salina, KS. The well screens are approximately 1.4 in. O.D. SS with ½ in. Schedule 80 PVC riser pipe. A typical PZ monitoring point is shown on Figure 4. A summary of the PZ well construction for the pilot test is contained on Table 3.

2.3 ZVI Injection Operations

ZVI injections were initiated in the NPL Area on July 13, 2000. Three injection borings, INJ-1 through INJ-3, were completed from July 13 through July 16. Four ZVI injection borings, INJ-4 through INJ-7, were completed in the Plant #5 Test Area from July 17 through July 19, 2000. Monitoring piezometers (PZ's 1S, 1D, 2D, 3D and 4D) were installed in the pilot test areas after completion of the injection borings. PZ-2D and PZ-4D were installed within injection borings INJ-3 and INJ-4, respectively. The other NPL Area PZ's were installed downgradient of the injection borings and the other Plant #5 PZ (PZ-3D) was installed in the center of the injection boring cluster. A summary of the ZVI injections is contained on Table 4.

2.4 Injection Verification

The extent of the ZVI migration was assessed by drilling test borings into the injection zones and taking continuous samples through the shallow and deep zone formations. Surface electromagnetic (EM) surveys were also performed using EM-31 equipment. The EM surveys were found to have considerable interference, especially in the areas of INJ 1 and INJ 3, in the parking lot. Concrete pad reinforcing steel and steel monitoring well casings in the EM area were suspected to have caused the interference. The EM data was judged to be inconclusive and is not reported herein.

In August, 2000, three Geoprobe test borings were drilled in the NPL Area in the vicinity of injection boring INJ 2. No borings were drilled in the Plant #5 Test Area. See Appendix D for the boring layout and logs. Boring 2A was vertical, to a depth of 40 feet BGS, and borings 2B and 2C were drilled on an angle to evaluate the ZVI configuration. Borings were logged by visual inspection. ZVI layers were visibly evident based on their dark brown color and texture. A rare-earth magnet was used to verify the iron detections. A summary of each test boring is as follows:

Test Boring 2A - Located 2.5 ft. north of INJ 2

Shallow zone, 0-12 ft BGS, No iron was found in this zone

Deep zone, 20-40 ft BGS, Iron was found in the interval from 21 to 30 ft in varying thin layers. A 0.5 ft layer of iron was found at a depth of 34.2 ft and 39.4 ft. The iron layers were a composite of formation material (silty fine sand) and iron at an iron fraction of approximately 50%, by volume. The iron composite layers totaled 5.05 feet in thickness, which comprised approximately 25% of the deep zone interval. At 50% iron in the composite layer, the total iron by volume in the deep zone at this boring is estimated at 12.5%.

Test Boring 2B - Located 3.5 ft. east of INJ 2, with a NW drilling direction and a boring angle 12 deg. off vertical

Shallow zone, 0-12 ft BGS, No iron was found in this zone

Deep zone, 20-32 ft BGS, Iron was found in the deep zone interval in varying thin layers, less than detected in test boring 2A. The iron layers were a composite of formation material (silty fine sand) and iron at an iron fraction of approximately 50%, by volume. The iron composite layers totaled 0.70 feet in thickness, which comprised approximately 5.8% of the deep zone interval. At 50% iron in the composite layer, the total iron by volume in the deep zone at this boring is estimated at 2.9%.

Test Boring 2C - Located approx. 8 ft. NW of INJ 2, with a SW drilling direction and a boring angle 12 deg. off vertical

Shallow zone, 0-12 ft BGS, No iron was found in this zone

Deep zone, 20-36 ft BGS, Iron was found in the deep zone interval in varying thin layers, more than detected in test boring 2B. The iron layers were a composite of formation material (silty fine sand) and iron at an iron fraction of approximately 50%, by volume. The iron composite layers totaled 4.65 feet in thickness, which comprised approximately 29% of the deep zone interval. At 50% iron in the composite layer, the total iron by volume in the deep zone at this boring is estimated at 14.5%.

The test borings provide an indication of the ZVI distribution around injection boring 2A. The following general observations can be made from the boring logs:

1. Average iron in the deep zone is 10%, by volume of the formation material. **At a ZVI density of 110 pcf, the average iron content in the injection zone is 176 pounds per square foot of projected water-bearing zone.**

2. The ZVI distribution in the deep zone appears to be radial from the injection boring, and generally uniform on a vertical basis.

3. The horizontal extent of the ZVI injection is 5 ft or greater.

2.5 Performance Monitoring Plan

The PRB Pilot Test included a performance monitoring plan designed to evaluate the effects of the ZVI injections on groundwater quality. Specifically, the new piezometers (PZs) installed for the pilot test, and selected existing monitoring wells (MWs), Geoprobe monitoring points (GPs) and recovery wells (RWs) were used for collection of groundwater samples.

The monitoring was conducted in three general phases:

Baseline (pre-pilot test) monitoring - July 13-20, 2000

Performance Monitoring - Comprehensive - August 2000 through July, 2001

Performance Monitoring – Limited – August, 2001 through December, 2002

The primary monitoring points used for the pilot test and those sampled most frequently during the comprehensive monitoring phase are as follows:

NPL Area

Shallow Water-Bearing Zone- PZ-1S, MW-7S

Deep Water-Bearing Zone- PZ-1D, PZ-2D (INJ 3), MW-7D, RW-2D

Plant #5 Test Area

Deep Water Bearing Zone- PZ-3D (GP-1D), PZ- 4D (INJ 4)

Analytical parameters for the monitoring varied by phase, and by monitoring points. Generally, all groundwater samples were analyzed for VOCs (by EPA Methods 8021 or 8260). Some of the comprehensive phase samples included analyses for chemical indicator parameters, including inorganics, metals and dissolved gases. Field instrumentation and offsite laboratory analytical methods were used to obtain monitoring data. Generally, field measurements for dissolved oxygen (DO), pH, oxidation potential (ORP) and conductivity were performed on all groundwater samples. All other analyses was performed in an offsite laboratory. Table 5 summarizes the monitoring plan. The results of the performance monitoring are described in Section 3.0.

3.0 Pilot Test Performance Results

The PRB Pilot Test performance was evaluated mainly by the changes in groundwater quality after injection of the ZVI. These changes included both groundwater chemistry and the generation of dissolved gases in groundwater. Gas-phase (vapor) samples were taken throughout the pilot test area primarily to monitor their migration from the injection zones and to provide data for recovery of the gases. Gas recovery was initiated in the Plant #5 area since some of the by-product gases were potentially explosive, depending on their atmospheric concentrations and the presence of oxygen (air). Vapor phase monitoring also provided data on the degradation of the VOCs since the analyses included by-product compounds that were indicative of complete dechlorination of the VOCs. Vapor monitoring is summarized in Appendix C of this report and is described in this section as applicable to the ZVI performance.

Since the ZVI was injected into each of the two distinct water-bearing zones at the site: shallow and deep, the pilot test performance is described for each zone. It is noted that the emphasis of the pilot test is on the deep water-bearing zone since this zone contains the highest VOC levels at the site.

Pilot test data has been tabulated and presented in figure formats as follows:

Table 6- Water Quality Analyses in the NPL Area (Post ZVI Injections)- July, 2001

Table 7- Comparison of Pre- and Post-Pilot Test VOCs in NPL Area Recovery Wells and Monitoring Wells

Table 8- ORP Monitoring Results- Pilot Test

Table 9- pH Monitoring Results- Pilot Test

Tables 10 – 17, Pilot Test VOC results for Monitoring Points

Figure 5- PRB Pilot Test Report Performance Monitoring Summary

Figures 6- 21, Field Monitoring and VOC Data at Monitoring Points

Figures 22-24, Headspace Vapor Analyses for PZ-3d and RW-2D

Appendix A provides a summary of historic groundwater chemical characteristics, prior to the PRB Pilot Test. Note that historical data is not available for the monitoring points constructed specifically for the pilot test: PZs 1S, 1D, 2D, 3D, and 4D. Historic water quality was estimated from monitoring wells constructed in the NPL Area, in the general vicinity of the ZVI injections.

3.1 NPL Area Pilot Test Results

3.1.1 Shallow Water-Bearing Zone

The NPL Area is the only area onsite that ZVI was injected into the shallow water-bearing zone zone (see Table 2). ***Specifically, piezometer PZ-1S is the primary shallow zone monitoring point for the pilot test since it lies within and hydraulically downgradient of the ZVI injections.*** Other shallow monitoring points sampled during the test, including RW-2S, RW-1S and MW-7S, are either hydraulically upgradient of the ZVI injections (RW-1S and MW-7S), or they are downgradient, but outside of the ZVI injection area (RW-2S). RW-2S is limited as a monitoring point since it collects a portion of it's groundwater from the NPL Area that is outside and unaffected by the ZVI injections. These other points were monitored to provide data on groundwater chemistry upgradient of the ZVI injections and to assess the extent of the radial migration of the ZVI and it's effects on the groundwater.

3.1.1.1 General Groundwater Quality

General groundwater quality data obtained during the pilot test was compared to pre-pilot test water quality data, and the data was also evaluated over the pilot test period to examine water quality changes and trends after injection of the ZVI. The primary shallow monitoring points in the NPL Area for general groundwater quality are:

> **PZ-1S** (downgradient of ZVI injections) and **MW-7S** (approx. 5 ft upgradient of INJ 3)– Reference Tables 6 and 7 and Figures 6 through 9 for analytical data. See Figure 2 for a site plan of the pilot test area.

Water quality data obtained during the pilot test period indicated a significant change in shallow groundwater chemistry after injection of the ZVI. Most notably the PZ-1S and MW-7S ORP levels have been lowered significantly to –64.0 and –82 mV, resp., (July, 2001) indicating that the shallow groundwater is under reducing conditions. The average shallow zone ORP was +69.3 mV prior to the ZVI injections. See Table 6. Figure 6 shows that the ORP levels changed rapidly after injection of the ZVI, and have consistently stayed negative for at least one year, up to July, 2001, when the last OPR measurement was taken.

Consistent with the change to reducing conditions is the reduction in levels of nitrate, sulfate and TOC in both monitoring points, all indications that increased anaerobic activity is occurring in the shallow zone. This increase in bioactivity is likely a result of the reducing conditions created by the ZVI, including the production of hydrogen gas, which is an established electron donor for anaerobic degradation of chlorinated VOCs.

Hydrogen generation during the Pilot Test is discussed in Section 3.4 and Appendix C. correlate with monitoring wells vs time?

Water quality in MW-7S was affected by the ZVI in a very similar manner to PZ-1S. Although MW-7S was slightly upgradient of the injection boring (INJ 3), the well is within the influence of the ZVI injection, and provides a good indication that the area of influence of the shallow zone injections is at least a 5 feet radius.

3.1.1.2 Volatile Organics

Groundwater VOC data obtained during the pilot test was compared to pre-pilot test VOC data, and the data was also evaluated over the pilot test period to examine VOC changes and trends after injection of the ZVI. The primary shallow monitoring points for VOCs in the NPL Area are:

> **PZ-1S** (downgradient of ZVI injections), **MW-7S** (approx. 5 ft upgradient of INJ 3), **RW-2S** (outside of and downgradient of ZVI injections) and **RW-1S** (approx. 55 ft upgradient of the injection area) – Reference Tables 7 through 17 and Figures 10 through 21 for analytical data. See Figure 2 for a site plan of the pilot test area.

VOC levels in the shallow zone varied with time after injection of the ZVI. VOCs increased approximately one order of magnitude in **PZ-1S and MW-7S** after injection of the ZVI, and remained above baseline levels for up to 9 months after the start of the pilot test. The dominant VOCs were TCE and cis-1,2 DCE. ***The VOC levels in both monitoring points decreased to below baseline VOC levels, and less than 50 ppb total VOCs, by July, 2001, one year after the start of the test. TCE reduction was 96.3% in PZ-1S.*** TCE reduction was less in MW-7S (39%), however, the baseline TCE level was 14 ug/l and the July, 2001 level was 8.5 ug/l. Byproduct compounds cis- 1,2 DCE and VC were present in the monitoring points at low levels (< 20 ug/l) indicating that residual VOCs remained in the groundwater from the post-injection VOC increase. It is noted that these byproduct compounds were not detected in the baseline samples in either monitoring point.

The VOC increase after ZVI injection is expected to be a local VOC "spike effect" caused by the increase in hydraulic pressures and fluid flow around the injection borings. This effect appears to increase the VOC desorption from the groundwater zone and temporarily increase the dissolved VOC levels in the area of the injection boring. The injected fluid flow and increased hydraulic gradients around the injection borings are also expected to cause an increase in VOC migration radially from the injection borings by physical displacement of the pore space fluids. In both monitoring points the distribution of the VOC compounds also changed over time. The percentages of cis-1,2 DCE and vinyl chloride increased relative to TCE, indicating that VOC dechlorination was proceeding along it's expected pathway.

Recovery wells **RW-1S and RW-2S** were less affected by the ZVI injections. VOC levels in these wells generally were the same before and after the ZVI injections. See Table 7 and Figures 18 and 19. RW-1S and RW-2S appear to have been affected by the ZVI injections based on the changes in VOC levels and distribution after the start of the pilot test. Generally, total VOC levels increased in each well, and the percentage of by-products compounds (vinyl chloride and cis-1,2 DCE) increased significantly above pre-test levels. This effect is similar to the "VOC spike" effect noted for MW-7S and PZ-1D, This was expected for RW-2S since it is 10 feet downgradient of the ZVI injections. It was less expected for RW-1S since it is 55 feet upgradient of the injection area.

The "VOC spike" at RW-1S could possibly be caused by an upgradient VOC migration, however, this condition was not found in local upgradient wells over this same period, and it is not likely to occur based on the historic decreasing VOC trends in the shallow groundwater. The VOC spike at RW-1S appears to be a result of the ZVI injections. Although the recovery well is indicated as upgradient in the NPL Area, the historic hydrologic data show that this shallow zone gradient is relatively flat, and is variable throughout the year in the NPL Area. It is expected that the VOC spike at RW-1S is a combination of the radial VOC migration from the ZVI injection, enhanced by the flat and periodically reversed gradient towards RW-1S. Because of the variable hydraulic gradient in the area of RW-1S, the radius of the injection effect could not be confirmed to extend to RW-1S (55 feet), although it is expected to be significantly greater than the minimum 5 feet radius estimated from MW-7S. The radius of the spike effect has not been firmly established, and is expected to vary with each injection boring, and with depth. ***Preliminary estimates based on the pilot test results are that the radius of influence of the VOC spike effect is 10-50 feet.***

Monitoring data at RW-1S and 2S through year 2002 indicates that the VOC levels have continually reduced to near or below pre-test levels (April, 2000 data) prior to the start of the pilot test. ***The VOC levels in RW-2S decreased to below pre-test VOC levels, and less than 50 ppb total VOCs, by December, 2002, two and one-half years after the start of the test. TCE reduction was 98.5% in RW-2S.*** TCE levels were reduced less at RW-1S, and were still above pre-test levels, however, the VOC levels were reduced over 90% from the highest levels detected as a result of the VOC spike effect. These VOC reductions are expected to be a result of the ongoing pumping of the shallow groundwater zone and flushing of the VOC spike. The most recent RW-1S samples also included by-product compounds, which were not present in this well prior to the pilot test. These results indicate that residual VOC spike effects have not yet been flushed from the RW-1S pumping zone. It is noted that RW-2S recovered to baseline VOC levels faster than RW-1S, and it also had a significantly higher fraction of TCE by-product compounds (cis 1,2 DCE and VC) relative to RW-1S. This difference is attributed to the effects of the ZVI injections upgradient and near the ZVI injections (RW-2S is approx. 12 ft from INJ 1).

3.1.2 Deep Water-Bearing Zone

The deep water-bearing zone is the primary focus of the pilot test in the NPL Area. Active recovery well RW-2D is at the center of the injection boring grid and produces the hydraulic cone of depression maintained throughout the pilot test. PZ-1D was installed between the injection boring INJ 3 and RW-2D. PZ-2D was installed within INJ 3. Existing monitoring well MW-7D, approximately 6 feet "upgradient" of INJ 3, was also monitored to provide data on groundwater chemistry upgradient of the ZVI injections and to assess the extent of the radial migration of the ZVI and it's effects on the groundwater.

3.1.2.1 General Groundwater Quality

General groundwater quality data obtained during the pilot test was compared to pre-pilot test water quality data, and the data was also evaluated over the pilot test period to examine water quality changes and trends after injection of the ZVI. The primary deep zone monitoring points in the NPL Area for general groundwater quality are:

PZ-1D (downgradient of ZVI injections), **PZ-2D** (within injection boring INJ 3), **RW-2D** (active recovery well in center of injection grid) and **MW-7D** (approx. 6 ft upgradient of INJ 3)– Reference Tables 6, 8 and 9 and Figures 6 through 9 for analytical data. See Figure 2 for a site plan of the pilot test area.

Water quality data obtained during the pilot test period indicated a significant change in deep groundwater chemistry after injection of the ZVI. Most notably the ORP levels in all of the monitoring points have been lowered significantly (July, 2001) indicating that the deep groundwater has been further chemically reduced. The average deep zone ORP was -44.8 mV prior to the ZVI injections, which indicated that the deep zone was already slightly reduced and was likely undergoing anaerobic biodegradation. See Table 6. ***Table 8 and Figure 6 show that the ORP levels changed rapidly after injection of the ZVI, and have consistently stayed negative for at least one year, up to July, 2001. Average ORP levels in the deep zone were –184 mV for July, 2001.***

Consistent with the change to reducing conditions is the reduction in the level of sulfate in all of the deep zone monitoring points, an indication that increased anaerobic activity is occurring. Nitrate levels were low prior to the start of the test and on average did not change.

This increase in bioactivity, as also seen in the shallow zone, is likely a result of the reducing conditions created by the ZVI, including the production of hydrogen gas, which is an established electron donor for anaerobic degradation of chlorinated VOCs. Hydrogen generation during the Pilot Test is discussed in Section 3.4 and Appendix C. It is noted that TOC levels did not decrease in the deep zone as found in the shallow zone. Mean TOC levels in the NPL Area actually increased over 300% above historic mean levels. This increase was highest in PZ-1D and PZ-2D, and is expected to be attributable to the guar compounds contained in the ZVI slurry.

Chloride levels on average increased to 108.5 mg/l in the NPL Area relative to the pre-test mean levels of 33.8 mg/l. See Table 4. This increase is expected to be directly related to the dechlorination of the VOCs by both the ZVI reactions and the enhanced biological degradation. The chloride level of 108.5 mg/l has an equivalent TCE concentration of 134 mg/l based on stoichiometric equivalence, assuming complete TCE degradation to chloride ions. All of the chloride cannot be assumed to be a result of VOC breakdown since background chloride is present onsite. Although background chloride data was not available for the deep zone, an estimate of background chloride was made based on the mean background levels in the shallow zone (16.7 mg/l), assuming they were the same for the deep zone. By taking the background chloride into account, the adjusted chloride level attributed to theoretical VOC degradation is 91.8 mg/l, which has an equivalent TCE level of 113.3 mg/l. This relatively high TCE level is not typical of historic TCE concentrations found in the NPL Area, although MW-7D has had a TCE level of 340 mg/l. This concentration is similar to the TCE concentrations found in the Plant No. 5 hot spot area, and suggest the historic presence of NAPL in the NPL Area. A current presence of NAPL in and upgradient of the NPL Area, such as in the hot spot area, could explain the elevated chloride levels found in July, 2001. ***Since the chloride data is limited by infrequent sampling and lack of background levels, definite conclusions cannot be made on the relative contributions of the potential sources of elevated chloride in the NPL Area. A significant portion of the elevated chloride is expected to be attributed to the dechlorination of VOCs.***

Water quality differences among the NPL Area monitoring points were most evident with piezometers PZ-1D and PZ-2D. Chemical parameter concentrations were practically identical for these points, and they were both significantly different from RW-2D and MW-7D. Specifically, mean chloride levels were 180 mg/l, and mean sulfate levels were <1.5 mg/l. These chloride levels were the highest values in the NPL Area, and the sulfate levels were the lowest found in the NPL Area. This confirms that the ZVI effects were greatest in the immediate area of the ZVI injections, which was expected.

MW-7D (7 ft upgradient of ZVI injection boring) was affected by the ZVI in a very similar manner to PZ-2D (INJ 3), with some notable differences. Although MW-7D was slightly upgradient of the injection boring (INJ 3), the ORP level of –202 mV indicates that the well is within the influence of the ZVI injection radius. It is noted that the chloride and TOC levels in MW-7D were significantly lower than the levels found in PZ-1D and PZ-2D, and the sulfate level (48 mg/l) was the highest found in the NPL Area. This data suggests that the VOC reduction is proceeding at a lower rate in the MW-7D area, despite the reducing conditions. VOC data in the NPL Area (next section) provide further confirmation on the water quality findings.

3.1.2.2 Volatile Organics

Groundwater VOC data obtained during the pilot test was compared to pre-pilot test VOC data, and the data was also evaluated over the pilot test period to examine VOC changes and trends after injection of the ZVI. The primary deep zone monitoring points for VOCs in the NPL Area are:

PZ-1D (downgradient of ZVI injections), **PZ-2D** (within injection boring INJ 3), **RW-2D** (active recovery well in center of injection grid) and **MW-7D** (approx. 6 ft upgradient of INJ 3)– Reference Tables 6 and 7 and Figures 10 through 21 for analytical data. See Figure 2 for a site plan of the pilot test area.

VOC levels in the deep zone varied with time after injection of the ZVI. The three monitoring points within and downgradient of the injection borings: PZ-1D, PZ-2D and RW-2D, all responded similarly. After ZVI injection, TCE levels increased initially (August, 2000) from 56-63% above baseline levels. TCE levels remained above baseline levels for up to 7 months after the start of the pilot test, similar to the same effect noted for the shallow zone. The dominant VOCs were TCE, cis-1,2 DCE and vinyl chloride. ***The TCE levels in these three monitoring points decreased significantly from the initial elevated levels, and were below the baseline levels, by July, 2001, one year after the start of the test. TCE reductions from the initial (Aug, 2000) high levels were 70% in PZ-1D, 94% in PZ-2D and 86% in RW-2D. The July, 2001 TCE levels in these monitoring points were 18 mg/l, 11 mg/l and 0.7 mg/l, respectively.*** PZ-1D and PZ-2D were not sampled after July, 2001. See Figures 5, 11 and 12 for tabulated data summaries and graphical depictions of VOC levels over time.

RW-2D has been sampled quarterly as part of the ongoing monitoring program at the site, in addition to the pilot test monitoring (Phase II). VOC data was available up to December, 2002 and is shown on Figure 21. ***TCE level in RW-2D reduced to 110 ug/l in December, 2002. This was the lowest TCE concentration found in RW-2D since the start of the historical monitoring in 1997.***

MW-7D, upgradient of the injection boring, had a similar initial TCE increase (24%) after the ZVI injection. TCE levels remained above baseline levels for up to 16 months after the start of the pilot test. TCE reduction below the baseline level was observed in July, 2001, and beyond as part of the annual monitoring. The July, 2001 analytical result was reported as below detection limits (<250 ug/l), so a TCE reduction compared to the other deep zone monitoring points over this period is not determinable. ***The MW-7D TCE level reduced to 38 ug/l in December, 2002 as determined from the annual monitoring.*** See Figure 17 for a plot of MW-7D VOC levels over time.

The VOC increase after ZVI injection is expected to be from the local VOC "spike effect" as observed in the shallow water-bearing and discussed previously in Section 3.1.1.2.

By-Product VOC Generation- Byproduct compounds cis- 1,2 DCE and vinyl chloride (VC) were expected to be present in the monitoring points as a result of the reductive dechlorination of TCE. A review of the NPL deep zone monitoring data indicates that these compounds increased in concentration initially after ZVI injection, and continued to increase as TCE levels reduced in the injection zone. RW-2D quarterly monitoring indicates that cis-1,2 DCE and VC levels continue on an increasing trend as TCE levels reduce. Trans 1,2 DCE was typically reported as below detection limits or it was found at levels less than 1 mg/l. The compound cis-1,2 DCE is reported in the literature to be the most common DCE isomer produced during anaerobic degradation of TCE. ***The VOC by-product data, with the water quality data, indicate that VOC dechlorination is continuing, although at a much lower rate than predicted for the ZVI reduction reaction alone. It is suspected that the ongoing VOC reduction is primarily a biological dechlorination enhanced by the reducing conditions produced by the ZVI.***

Recovery well **RW-1D** was less affected by the ZVI injections. VOC levels in this well generally were the same before and after the ZVI injections, but with some notable differences. RW-1D appears to have been affected by the ZVI injections based on the changes in VOC levels and distribution after the start of the pilot test. Generally, total VOC levels increased initially after injections, and the percentage of by-product compounds (vinyl chloride and cis-1,2 DCE) also increased significantly above pre-test levels. This effect is similar to the "VOC spike" effect noted for RW-1S. It is noted that RW-1D is approximately 65 feet from the nearest injection boring, and it has not been operating throughout the monitoring period. Also, the VOC levels fluctuated considerably in RW-1D after the start of the pilot test and throughout the monitoring period compared to the relatively smooth VOC concentration trends observed prior to the ZVI injections.

3.2 Plant No. 5 Test Area Pilot Test Results

ZVI was injected into the deep water-bearing zone only in the Plant No. 5 Test Area. The deep zone in the western area of Plant No. 5 was found to have the highest VOC levels at the site and was suspected to contain NAPLs. Geoprobe borings and groundwater monitoring points (GP's) installed in year 2000 provided the VOC data for the deep zone groundwater in the Plant No. 5 area. Deep zone groundwater in this test area is within the influence of RW-2D and the flow direction is generally to the northwest. See Appendix A for a summary of subsurface conditions and water quality in the Plant No. 5 area.

3.2.1 Deep Water-Bearing Zone

ZVI was injected on a rectangular grid around monitoring point GP-1D, on the west side of the Plant No. 5 building. Injection boring spacing was approximately 8 feet. See Figure 2. The pilot test in this area was intended to evaluate ZVI as an insitu treatment method for VOC hot spot, or direct source area reduction. Monitoring points were installed within injection boring INJ 4 (**PZ-4D**) and at the center of the injection grid (**PZ-3D**). PZ4D was hydraulically downgradient of the general hot spot injection area.

3.2.1.1 General Groundwater Quality

General groundwater quality data obtained during the pilot test was compared to pre-pilot test water quality data, and the data was also evaluated over the pilot test period to examine water quality changes and trends after injection of the ZVI. The primary deep zone monitoring points in the Plant No. 5 Area for general groundwater quality are:

PZ-3D (in center of injection grid and at location of former point GP-1D), **PZ-4D** (within injection boring INJ 4 and downgradient of ZVI injections), **GP-1D** (Geoprobe monitoring point pre-pilot test)– Reference Table 6 for water quality analytical data. See Figure 2 for a site plan of the pilot test area.

The only pre-pilot water quality obtained in the Plant #5 Test Area was from GP-1D (now PZ-3D). See Appendix A, Table A-3. The data indicates that the groundwater in this area was under reducing conditions and was undergoing biological VOC degradation. ORP was–289 mV and nitrate was 0.37 mg/l, indicative of anaerobic biological activity. It is noted that the pre-test sulfate concentration was at 46 mg/l, which is consistent with other deep zone sulfate levels found prior to the pilot test. Although nitrate and sulfate reduction is expected under anaerobic, reducing conditions, the data indicates that sulfate reduction was not significant under pre-test conditions. The literature indicates that sulfate is a less favored microbial electron acceptor than nitrate, and typically is deleted after nitrate and iron (III), which indicates that anaerobic activity was limited during the pre-test period.

Water quality data obtained during the pilot test period indicated some changes in deep groundwater chemistry after injection of the ZVI. The ORP levels in all of the monitoring points continued to be negative (July, 2001) and did not change significantly after the ZVI injections. ***The ORP levels have consistently stayed negative for at least one year in the Plant #5 Area, up to July, 2001. The average deep zone ORP in the hot spot area was-130 mV after the ZVI injections.***

Nitrate and sulfate levels in the Hot Spot area were reduced to at or below detection limits after the ZVI injections. Nitrate levels were low prior to the start of the test and on average did not change. The low sulfate and nitrates are an indication of increased bioactivity, which was also seen in the NPL Area in both water-bearing zones. This increased bioactivity is likely a result of the enhanced reducing conditions created by the ZVI injections, including the production of hydrogen gas, which is an established electron donor for anaerobic degradation of chlorinated VOCs. Hydrogen generation during the Pilot Test is discussed in Section 3.4 and Appendix C.

In addition, the TOC levels increased to an average level of 120 mg/l in PZ-3D and PZ-4D, relative to the TOC level of 27.5 mg/l in GP-1D prior to the pilot test. This TOC increase, also found in the NPL Area deep zone, is expected to be attributable to the guar compounds contained in the ZVI slurry.

Chloride level increased in the Hot Spot Area relative to the pre-test mean levels of 33.8 mg/l in the deep zone, and 80.4 mg/l in GP-1D. Chloride in PZ-4D was 210 mg/l (July, 2001). See Table 4. This increase is expected to be directly related to the dechlorination of the VOCs by both the ZVI reactions and the enhanced biological degradation. The chloride level of 210 mg/l has an equivalent TCE concentration of 259 mg/l based on stoichiometric equivalence. All of the chloride cannot be assumed to be a result of VOC breakdown since background chloride is present onsite. Although background chloride data was not available for the deep zone, an estimate of background chloride was made based on the mean background levels in the shallow zone (16.7 mg/l), assuming they were the same for the deep zone. **By taking the background chloride into account, the adjusted chloride level in PZ-4D attributed to theoretical VOC degradation is 193.3 mg/l, which has an equivalent TCE level of 238.6 mg/l.** This relatively high TCE level is typical of historic TCE concentrations found in the Hot Spot Area. GP-1D had an estimated pre-test TCE concentration in groundwater of 286 mg/l based on "soil" TCE levels found in the February, 2000 samples. See Table A-2 in Appendix A. The elevated chloride level suggests that an equal amount of TCE has been degraded.

The chloride-equivalent TCE concentration of 238.6 mg/l based on complete degradation does not account for the TCE and by-product compounds still present in the July, 2001 samples. Specifically, for PZ-4D, the equivalent chloride level for 74.5 mg/l TCE and 31 mg/l cis-1,2 DCE found in the July, 2001 samples is 134.4 mg/l. With the adjusted chloride level of 193.3 mg/l as previously estimated from the actual sample data, the total theoretical chloride level in PZ-4D would be 327 mg/l (134.4 plus 193.3) for complete VOC degradation. It is evident that this chloride level is much higher than the chloride level predicted for degradation of the pre-test VOC levels. This chloride difference indicates that the Hot Spot Area is not a steady state system, and VOCs continue to be generated in the test area. These VOCs are expected to migrate into the test area from upgradient locations to the east/southeast. In addition, the data also suggests that the ZVI injections enhance the desorption of VOCs from the groundwater formation, and possibly from NAPL dissolution.

3.2.1.2 Volatile Organics

Groundwater VOC data obtained during the pilot test was compared to pre-pilot test VOC data, and the data was also evaluated over the pilot test period to examine VOC changes and trends after injection of the ZVI. The primary deep zone monitoring points for VOCs in the Hot Spot Area are:

PZ-3D (in center of injection grid and at location of former point GP-1D), **PZ-4D** (within injection boring INJ 4 and downgradient of ZVI injections), **GP-1D** (Geoprobe monitoring point, pre-pilot test only)– Reference Figure 5 for water quality analytical data. See Figure 2 for a site plan of the pilot test area.

VOC levels in the deep zone varied with time after injection of the ZVI. The two monitoring points within and downgradient of the injection borings: PZ-3D and PZ-4D, responded similarly. The average pre-pilot test TCE concentration at GP-1D (PZ-3D) was 210.5 mg/l, based on samples taken in February and July, 2000. All other VOCs were reported as below detection limits, which were 5 mg/l or less. This is the only historic and baseline data available for the Hot Spot test area.

Initially after ZVI injection (August, 2000), TCE levels increased to 367 mg/l in PZ-4D, and decreased to 76 mg/l in PZ-3D. TCE levels dropped significantly in both points following the initial increase. ***The November, 2000 TCE levels were 5.3 mg/l in PZ-4D and 30 mg/l in PZ-3D, approximately 3 months after the start of the pilot test. These are TCE reductions of 97% and 86%, respectively, relative to the pre-test mean TCE level of 210.5 mg/l in the Plant No. 5 Area. After November, 2000, the TCE levels started to increase to levels approaching the pre-test mean levels as demonstrated in samples taken from February through July, 2001.*** PZ-3D and PZ-4D were not sampled after July, 2001. This TCE increase represents a unique condition not found in the NPL Area pilot test, and is expected to be caused by the differing groundwater hydraulic conditions in the Plant #5 Test Area. Specifically, upgradient VOCs (to the southeast of the "hot spot") have migrated into the test area over time. In addition, NAPL desorption in the test area is expected to cause a further increase in the VOCs. This effect is further described in the following section. See Figures 5, 11, 12, 13 and 14 for tabulated data summaries and graphical depictions of VOC levels over time in the Plant #5 Pilot Test Area.

By-Product VOC Generation- Byproduct compounds cis-1,2 DCE and vinyl chloride (VC) were expected to be present in the monitoring points as a result of the reductive dechlorination of TCE. Prior to the pilot test, the ratio of by-product compounds (DCE and VC) to TCE was 0.75 at RW-2D, 0.34 at PZ-1D and <0.1 at PZ-3D. The performance monitoring data indicates that by-product compounds increased in concentration initially after ZVI injection, and continued to increase over time in the injection zone. The July, 2001 by-product/TCE ratios were 20.8 at RW-2D, 4.6 at PZ-1D and 0.8 at PZ-3D. These ratios are at least one order of magnitude increases above the pre-pilot test ratios for these monitoring points.

The degree of biodegradation can be evaluated by assessing the ratio of the number of moles of TCE relative to the number of moles of the by-product daughter compounds (TCE:DCE). As biodegradation progresses, TCE concentrations decrease relative to the daughter compounds and as a result, this ratio decreases. For all of the monitoring points there is a reduction in this ratio from the initial conditions.

3.3 Vapor Generation and Characterization

Generation of vapor-phase by-product compounds in the pilot test was anticipated as a result of the ZVI reactions in groundwater and the degradation of TCE, both by ZVI and biological reactions. Guar degradation was also expected to generate vapor phase compounds, including hydrogen and possibly methane. Vapor phase compounds of most interest included hydrogen, methane, ethane/ethene, propane/propylene and butanes. See Section 2.1.1 for estimates of theoretical quantities of vapor phase compounds that could be generated in the pilot test.

Monitoring of vapor compounds was not originally part of the performance monitoring plan, however, vapor migration into the CPM Plant No. 5 building from piezometers during the pilot test emphasized the need for determining the characteristics and migration of the vapors. Most of the vapor compounds generated by the ZVI/TCE reactions are potentially explosive, depending on their concentrations and the presence of oxygen. Lower explosive limits (LELs) for the compounds of interest are as follows:

Compound	LEL, % by Volume
Butane	1.8
Ethane	3.0
Ethylene	2.7
Hydrogen	4.0
Methane	5.0
Propane	2.1
Propylene	2.4

A major concern during the pilot test was the potential for vapor migration into the Plant #5 building. Although ZVI was not injected in the shallow zone beneath the building, URS investigated the potential for migration of vapors from the NPL Area shallow zone into the Plant #5 and surrounding areas, and from the deep zone into the shallow zone. Existing monitoring points were sampled for vapors and new vapor probes (VPs) were installed throughout the site, including beneath the Plant #5 floor, to check for vapor presence beyond the pilot test area. A vapor vacuum recovery system was installed in September, 2000, to contain vapor migration from the test area, especially in the area of Plant #5. Detailed information on the vapor monitoring, analyses and recovery operations is contained in Appendix C. This section provides a summary of vapor characteristics and distribution.

3.3.1 Field Vapor Monitoring

Field vapor monitoring (LEL, PID and FID) conducted during the pilot test indicated that significant levels of potentially explosive vapors were being generated in the shallow and deep water-bearing zones after injection of the ZVI. "Significant levels" are defined herein as LELs > 10% and PID/FID readings > 50 ppm each. These values are equivalent to the standard safety action levels used for onsite monitoring in work zones and were selected as a general reference criteria and an indicator of potential safety risk. ***It is noted that the vapor readings have all been taken from within the casing headspace of the monitoring point and do not represent vapor levels in the work zones.***

Generally, significant vapor levels have been found only in the deep water-bearing zone, with the exception of elevated FID readings in the NPL Area shallow zone at MW-7S. The MW-7S levels were high only during the 2 month period after ZVI injection, after which they reduced to near or below the "action level". **Vapor readings have been consistently below action levels in the shallow zone throughout the entire monitoring period, including all of the floor probes (VP1S-4S) beneath Plant #5.** The shutdown of the vapor recovery system in November, 2000 had no noticeable effect on the shallow vapor levels.

In the UST Area MW-13 and TW-01 exhibited vapor readings significantly above the "action levels". The UST Area vapors were found to be primarily methane and TEX compounds and do not appear to be related to the Pilot Test-generated gases.

Vapor readings above action levels were found in the deep zone throughout all areas of the site. The elevated levels were confined to within the site property in all directions, with the exception of the UST Area to the southeast of the ZVI injections. As described previously these vapors were found to be primarily methane and TEX compounds and they do not appear to be related to the Pilot Test.

The deep zone PZ's in the injection area (PZs 1D, 2D, 3D and 4D) have shown a decline in vapor levels that appear to have started in January, 2001, after the vapor recovery system was shutdown. This decline is most evident in the NPL Area, and indicate that vapor generation is declining in the pilot test area.

3.3.2 Vapor Analyses

Samples were taken for offsite laboratory analyses to characterize individual compounds and determine their concentrations in the well headspace vapor and dissolved groundwater phases. Vapor samples were taken from selected monitoring points by extracting headspace gases from the well casings with a syringe. Vapor samples from the groundwater phase were also taken by the field gas stripping method (Microseeps). Gas stripping sampling procedures are described in Appendix C. Analytical results are summarized on the tables in Appendix C. Figures 22-24 summarize vapor analyses of headspace samples from PZ-3D and RW-2D.

All vapor analyses was done for the following suite of compounds:

-Carbon dioxide

-Oxygen

-Nitrogen

-Hydrogen

-Methane

-Ethane

-Ethylene

-Propane

-Propylene

-Butanes

Vapor sampling was initiated in August, 2000 at selected monitoring points, and continued until July, 2001. No vapor samples have been taken after July, 2001.

Groundwater gas strip sampling was performed less frequently, and was limited to monitoring points with a 2 inch diameter or greater casing. Smaller size casings did not permit insertion of pump tubing and generally did not have sufficient discharge to conduct the test.

The vapor analyses indicate that excess hydrogen gas and TCE/DCE degradation by-products ethylene and propylene were generated during the pilot test. The vapor data indicates that hydrogen is the dominant compound in the vapor phase, followed by ethane and ethylene. Methane has been found at high levels in the UST Area (VP-7D @ 11.7 – 43.3 % by vol.), but vapors in this area are not expected to be from the pilot test area since the hydrogen and ethylene levels were found to be very low. The data also indicates that pilot test-generated vapors (hydrogen and organic gases) have not been found beyond the immediate areas of the ZVI injections in the NPL and Plant No. 5 Test Areas.

Monitoring points RW-2D and PZ-3D were sampled the most frequently and are the most representative indicators of vapor characteristics and trends over time. Vapor analytical data for RW-2D and PZ-3D are plotted graphically on Figures 22, 23 and 24. Vapor analyses is contained in Appendix C.

Plant #5 Test Area

The Plant No. 5 area deep zone had the highest by-product vapor levels found at the site. At **PZ-3D** the hydrogen levels ranged from 1.22 to 590,000 ppmv. The low levels were present primarily during the period when the vapor recovery system was in operation and the well headspace was under vacuum extraction. For the period when the vapor recovery system was not in operation, the **mean hydrogen levels in PZ-3D were 281,730 ppmv (28.2%).** This mean level includes a 380 ppmv result that is expected to be a diluted sample. Similar high hydrogen levels were found at PZ-4D. Over time, the hydrogen levels have fluctuated, mainly in response to the vapor recovery system. **After the vacuum recovery system was shutdown in November, 2000, the hydrogen levels have increased to the high levels found at the start of the vapor sampling in August, 2000.**

Organic vapors (ethane, ethylene, propane, propylene, butane) were also at their highest levels in the hot spot area. Ethylene and ethane were the dominant organic compounds found in the vapor phase. At PZ-3D, ethylene levels were less than hydrogen and ranged from 2 to 17% of the hydrogen concentrations. Ethane ranged from 1 to 20% of the hydrogen levels. Over time, the ethene and ethane levels have fluctuated, mainly in response to the vapor recovery system. It is noted that TCA/DCA by-products ethane and propane are also being produced at nearly the same levels as the TCE/DCE by-products, although TCA/DCA compounds have not been detected at significant levels in the subsurface relative to the TCE/DCE compounds. **After the vacuum recovery system was shutdown in November, 2000, the ethylene and ethane levels have increased to above the high levels found at the start of the vapor sampling in August, 2000. The ratios of hydrogen/ethane and hydrogen/ethene show a general reducing trend which is indicative of hydrogen utilization and TCE degradation. It is noted that the last vapor samples taken from PZ-3D and PZ-4D, in July, 2001, had the highest organic vapor levels found to-date.**

NPL Area

The NPL Area had relatively low by-product vapor levels compared to the Plant No. 5 Test Area. **PZ-1D and PZ-2D** hydrogen levels were 21,000 and 4800 ppmv, 3.5 and 0.8%, respectively, of the levels found at PZ-3D in July, 2001. Hydrogen levels at RW-2D were relatively low and ranged from 0.84 to 39 ppmv during the monitoring period. The vapor recovery system operation had no apparent effect on the RW-2D hydrogen levels.

Organic vapors (ethane, ethylene, propane, propylene, butane) were also at relatively low levels in the NPL Area. Ethylene and ethane were also the dominant organic compounds found in the vapor phase in the NPL Area. Ratios of H_2/ethane and H_2/ethene were at similar levels as found in the Plant No. 5 Test Area.

Table 1
Theoretical ZVI and Hydrogen Quantities for TCE Degradation

Site Area	Historical Mean VOC (1)		Quantity of VOCs, kg (2)		Equivalent ZVI and Hydrogen for TCE Degradation (3)					
	compound	mg/l	Radius, ft		10 ft radius			25 ft radius		
			10	25	ZVI		H_2	ZVI		H_2
					kg	lbs	liters	kg	lbs	liters
NPL Area										
Shallow zone	**TCE**	0.881	0.014	0.088	0.07462	0.164	7.20	0.466	1.027	45.03
	DCE (total)	0.153	0.002	0.0153						
	VC	0.0069	0.000	0.0007						
Deep zone	**TCE**	33.405	1.960	12.250	10.37	22.85	1001.60	64.84	142.81	6260.03
	DCE (total)	0.050	0.003	0.018						
	VC	0.137	0.008	0.050						
Total Quantity			1.99	12.42						
Plant #5 Hot Spot										
Deep zone	**TCE**	286	16.8	104.88	88.82	195.63	8575.33	555.10	1222.69	53595.8
	DCE (total)	0.0	0.0	0.00						
	VC	0.085	0.005	0.03						
Total Quantity			16.79	104.91						

Notes:

1. See Appendix A, Table A-1. "Historical mean" VOCs for the NPL Area calculated as the average of all mean values for the monitoring points in each water-bearing zone. Plant No. 5 Hot Spot data represented by GP-1D only.
2. Radius of VOC contamination zone based on center points @ RW-2D for the NPL Area and PZ-3D for the Hot Spot Area.The quantity of VOCs was estimated based on a unifrom distribution of the mean VOCs across the thickness (t) of each water-bearing zone: NPL Area SZ= 6 ft, DZ= 22 ft, Hot Spot DZ= 22 ft.

Saturated Volume = n (3.14 r^2) t (7.48) 3.785 = liters, where n=porosity (0.3), r=radius and t=thickness of formation

VOC Quantity = VOC mg/l (Sat Vol)/10^6 mg/kg = kg

3. 3 moles H2 = 1 mole TCE for degradation to ethene, 1 mole Fe = 1 mole H2 (mw TCE = 131.5g, mw Fe3O4 = 232g)

Table 2

Estimated VOC Flushing Times at NPL Area Pilot Test - Deep Zone

Essex Jamestown Site

Compound	Solubility, S, (1)	Organic Carbon Partition Coefficient, Koc (1)		Soil-Water Distribution Ratio, Kd (2)	Retardation coeficient (3)	Solute Velocity, Vt, ft/day (4)	VOC Flushing Time, days radius from RW-2D, ft	
	mg/l	L/kg					10	25
	average	range	average					
TCE	1100	87-150	120	0.37	2.98	0.43	**23.5**	**58.6**
cis- 1,2 DCE	3500	49-80.2	65	0.20	2.07	0.62	**16.2**	**40.6**
VC	1932	0.4- 56	19.6	0.06	1.32	0.96	**10.4**	**26.0**

Notes:

1. Ref: USEPA Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater, EPA/600/R-98/128, Sept., 1998, Tables B.2.1 and B.2.2
2. Kd = Koc x Foc, where Foc is the total organic carbon content of the aquifer soil sample = 3087 mg/kg average conc. (0.0031), Ref: Essex Jamestown SMAART Submittals, Table 9 Soil Sample Analytical Results, 2/00
3. R = 1 + [p*Kd/n], where R=retardation coefficient, p= bulk density (1.6 kg/l), Kd=soil-water dist. ratio, n=porosity (0.3)
4. Vt= (Vs*n)/R, where Vs=seepage velocity (4.24 ft/day), n=porosity, R=Retardation

Table 3

PRB Pilot Test Piezometer (PZ) Construction Data

Piezometer (PZ)	Groundwater Zone	Screened Interval	Screen Data	Riser Data
NPL Area				
PZ-1S	shallow	7-17 ft BGS	1.4 in. OD prepack- 10 slot?	1/2 in. dia Sch. 80 PVC
PZ-1D	deep	25-45 ft BGS	1.4 in. OD prepack- 10 slot?	1/2 in. dia Sch. 80 PVC
PZ-2D	deep	25-45 ft BGS	1.4 in. OD prepack- 10 slot?	1/2 in. dia Sch. 80 PVC
Plant #5 Hot Spot				
PZ-3D	deep	25-45 ft BGS	1.4 in. OD prepack- 10 slot?	1/2 in. dia Sch. 80 PVC
PZ-4D	deep	25-45 ft BGS	1.4 in. OD prepack- 10 slot?	1/2 in. dia Sch. 80 PVC

See Figure 2 for PZ locations.

Table 4
ZVI Injection Data

Site Area	Boring	Completion Date	Injection Interval	Injected Quantity	ZVI Estimate, tons (1)			Notes
					TCE	cis 1,2 DCE	total	
NPL Area				**tons**				
	INJ-1	July 15, 2000	6-12 ft BGS	3	0.74	1.78	2.52	7 batches injected at INJ-1
			19-41 ft BGS	6	4.48	10.86	15.34	
	INJ-2	July 16, 2000	6-14 ft BGS	3	0.99	2.37	3.36	upper formation not taking injection
			19-41? ft BGS	6	4.48	10.86	15.34	
	INJ-3	July 16, 2000	6-12 ft BGS	3	0.74	1.78	2.52	
			19-41 ft BGS	6	4.48	10.86	15.34	
Total ZVI Quantity				**27 Tons**	**15.9**	**38.5**	**54.4**	
Plant #5 Area								
	INJ-4 through INJ-7	July 17-19, 2000	20-42 ft BGS	2.25/ea	0.31	0.8	1.11	injections in deep zone only
Total ZVI Quantity				**9 Tons**	**1.23**	**3.2**	**4.43**	

Notes:
1. ZVI estimate based on bench-scale testing results, k1 = 2.04 and 0.567 for TCE and cis 1,2 DCE, resp., and target VOC clenup conc., P = 5ug/l VOC and initial VOC conc., Po = maximum levels found onsite

Reference Table B-1 (App B)

Table 5
PRB Pilot Test
Sampling and Analyses Plan

Parameter	Analytical Method	Sampling Frequency (1)	Data Use
VOCs	EPA 8021 or 8260	Baseline (Phase I) , Phases II & III	Indicators of VOC reduction by ZVI dechlorination and biodegradation
DO, pH, ORP, conductivity	Field meter	Baseline (Phase I) , Phases II & III	Indicator of aerobic or anaerobic biodegradation conditions
Total Organic Carbon (groundwater)	EPA 9060	Historic analyses (Nov/99 and Feb/00) and Phase II, July, 2001 sampling only	Determines the availabilty of carbon for anaerobic biodegradation
Chloride	ICE 300		Indicator of final reduction of chlorinated VOCs, mainly by ZVI reduction
Nitrate, Sulfate	ICE 300		Competing electron acceptors for anaerobic biodegradation
Iron & manganese (dissolved)	EPA 6010 *Filtered sample*		Same as above for chloride and NO3/SO4, plus an indicator of potential encrustation/fouling in recovery wells
Iron (+2)- ferrous (dissolved)	Hach field test *Filtered sample*		Same as above for chloride and NO3/SO4
Methane, ethane, ethene, H2, propane, propylene, butanes (groundwater)	EPA 3810 Modified	Historic analyses only (Nov/99 and Feb/00)	Indicators of VOC reduction by anaerobic biodegradation
Dissolved light HCs and H2 (bubble strip sampling)	Microseeps method	Phase II Oct and Nov/2000 only	Indicators of VOC reduction by anaerobic biodegradation, H2 generation by ZVI reactions

Notes:
1. Baseline (Phase I) - July, 2000, prior to ZVI Injections
Phase II - Comprehensive monitoring, August, 2000 - July, 2001
Phase III - Limited monitoring, August, 2001 - December, 2002

Table 6

Water Quality Analyses in NPL Area Post-ZVI Injection, July, 2001

Chemical Parameter	Shallow Zone Wells								
concentrations mg/l unless otherwise indicated	MW-7S	PZ-1S						Mean	Historic mean (1)
Chloride	32	72						52.0	16.7
Nitrate	< 0.5	< 0.5						0.0	6.4
Sulfate	28	47						37.5	64.8
Total Organic Carbon (TOC)	<1.0	1.1						0.6	5.1
Methane, ug/l, note (3)	676							676.0	8.7
Ethane, ug/l, note (3)	977							977.0	0.3
Ethene, ug/l, note (3)	2262							2262.0	<1.1
Calcium								0.0	89.8
Magnesium								0.0	24.0
Potassium								0.0	13.1
Sodium								0.0	42.2
Ferrous Iron +2 (note 2)	0 08	0.24						0.2	
ORP, mV (note 2)	-82	-64.00						-73.0	69.3
pH, S.U. (note 2)	6.38	7.40						6.9	7.5
Conductivity, mS/cm (note 2)								0.0	

Chemical Parameter	Deep Zone Wells										
concentrations mg/l unless otherwise indicated	RW-2D	GP-2D	GP-3D	GP-4D	MW-7D	PZ-1D	PZ-2D	PZ-3D	PZ-4D	Mean	Historic mean (1)
Chloride	46	4 6	16	21	28	190 0	170.0	21 0	210	78.5	33.8
Nitrate	< 0 5	0.69	< 0 5	< 0.5	< 0 5	< 0 5	< 0.5	0 67	< 0.5	0.2	0.1
Sulfate	38	3.2	15	26	48	< 1.5	< 1.5	< 0 5	2.4	14.7	39.8
Total Organic Carbon (TOC)	13	15	3.1	2 3	3.5	55.0	48.0	120.0	120	42.2	7.8
Methane, ug/l, note (3)	3569				2629					3099.0	102.3
Ethane, ug/l, note (3)	46.4				6.20					26.3	2.2
Ethene, ug/l, note (3)	155.6				47 2					101.4	<1.1
Calcium										0.0	465.8
Magnesium										0.0	191.8
Potassium										0.0	30.6
Sodium										0.0	40.9
Ferrous Iron +2 (note 2)	0.18	0.095	0.077	0.064	0 077	0 23	0.1	0.44	0 097	0.2	
ORP, mV (note 2)	-204				-202	-172	-156.0	-140.0	-138	-168.7	-44.6
pH, S.U. (note 2)	7.09				7 19	6.4	6.5	6.4	6 5	6.7	8.6
Conductivity, mS/cm (note 2)										0.0	

Notes:

1. November, 1999 samples: MW-6, MW-7S, RW-1S, RW-2S, MW-7D, RW-1D, RW-2D
   February, 2000 samples: All GP monitoring points
2. Iron (+2), oxidation-reduction potential (ORP), pH and conductivity measured in field at completion of well purging, except for iron measurements at MW-6, MW-7S, RW-1S, RW-2S, MW-7D, RW-1D, and RW-2D, which were measured during well sampling.
3 Light hydrocarbon gases measured in groundwater by method SW-3810 to obtain historical mean data Mean values used for comparison purposes are mean estimates from groundwater gas strip sampling and analyses, October and November, 2000.

Table 7
Comparison of Pre and Post-Pilot Test VOCs
in NPL Area Recovery Wells and Monitoring Wells

Key Chemical Constituent see note (1) concentrations as ug/l	Shallow Zone Wells: MW-7S Pilot Test	MW-7S Pre-Pilot Test	RW-1S Pilot Test	RW-1S Pre-Pilot Test	RW-2S Pilot Test	RW-2S Pre-Pilot Test	Deep Zone Wells: MW-7D Pilot Test	MW-7D Pre-Pilot Test	RW-1D Pilot Test	RW-1D Pre-Pilot Test	RW-2D Pilot Test	RW-2D Pre-Pilot Test
Trichloroethylene												
Number of samples	3	3	10	13	10	13	3	4	10	13	10	13
Range of concentration	7.5-900	8-160	100 -3300	<5-12,000	7.2-6400	17-3700	38-1800	8-340,000	<5-150	<1-38	<5-4400	1900-18,000
Mean concentration (note 2)	**305**	**66**	**1224.0**	**1389.0**	**1391**	**1006**	**663**	**95,752**	**38.8**	**10.2**	**989**	**4454**
Standard deviation	515	82	1186.0	3240.0	2043	1108	987	163,188	46	10.8	1497	4216
Coefficient of variation (sd/mean)	1.69	1.24	0.97	2.33	1.47	1.10	1.49	1.70	1.19	1.07	1 51	0 95
Trans- 1,2 Dichloroethylene												
Number of samples	3	1	10	13	10	13	3	3	10	13	10	13
Range of concentration	<5-7	<1	<5-77	<5-160	<5-92	<1-130	2-18	29-64	<5-52	<5-110	7.8-41	<5-320
Mean concentration	**5.7**	**1**	**13.7**	**24.7**	**19**	**32.4**	**11**	**51.3**	**18.7**	**23.9**	**23.8**	**69.3**
Standard deviation	1.2	NA	22.4	48.7	30.2	71.2	8.2	19.4	15.4	34.9	10	103.7
Coefficient of variation (sd/mean)	0.2	NA	1.63	1.97	1.59	2.20	0.74	0.38	0.82	1.46	0.42	1.50
Cis- 1,2 Dichloroethylene												
Number of samples	2	No Data	8	No Data	8	No Data	2	No Data	8	No Data	8	No Data
Range of concentration	11-23		44-1200		6.6-620		2900-3800		<180-3000		50-12000	
Mean concentration	**17**		**567**		**244**		**2200**		**1278**		**6169**	
Standard deviation	8.5		471		234		1970		985		3554	
Coefficient of variation (sd/mean)	0.5		0.83		0.96		0.90		0.77		0.58	
Vinyl Chloride												
Number of samples	3	3	10	13	10	12	3	4	10	13	10	13
Range of concentration	<5-870	<1-<10	2-407	<1-110	<2-470	<1-6	270-1600	20-51	<2-910	23-830	55-1600	<20-280
Mean concentration	**50.7**	**1.0**	**137**	**16.1**	**87.1**	**5.5**	**797**	**37.6**	**169**	**237**	**848**	**137.4**
Standard deviation	154.1	NA	137	28.8	147	6.4	707	15.3	282	231	628	84.1
Coefficient of variation (sd/mean)	3.04	NA	1.0	1.8	1.69	1.18	0.89	0.40	1.66	0.97	0.74	0.61
BTEX (note 3)												
Number of samples	3	3	10	13	10	13	3	4	10	13	10	13
Range of concentration	<5-20	<5-<10	<5-595	<1-5	<5-19	<1-20	<2-5.3	<1-2	<5-21.6	<1-23 (B)	<5-21.1	<1-38
Mean concentration	**22.1**	**BDL**	**74.7**	**BDL**	**7.7**	**BDL**	**4.1**	**BDL**	**7.8**	**6.4**	**9.9**	**BDL**
Standard deviation	46.2	NA	184.8	NA	5.3	NA	1.8	NA	5.9	6.4	5.6	NA
Coefficient of variation (sd/mean)	2.09	NA	2.47	NA	0.69	NA	0.45	NA	0.75	1.00	0 56	NA
Equivalent Chloride, mg/l (note 4)	0.3	0.1	1.5	1.2	1.4	0.8	2.6	77.6	1.1	0.2	5.8	3.7

Notes:
1. Pilot Test data from August, 2000 to December, 2002. Pre-Pilot Test data from July, 1997 to June, 2000 (see Table A-1).
2. Reported detection limit values were used in the calculation of the mean and standard deviation
3. Total BTEX inc. benzene, toluene, ethylbenzene and xylenes
4 Total equivalent chloride calculated from stoichiometric breakdown of TCE, DCEs and VC as follows: Chloride= TCE(0 81)+DCE(0.73)+VC(0.57), where the factors are the molar mass ratios of the VOC to chloride on an equivalent weight basis

Table 8

ORP Monitoring Results
Pilot Test
Essex/Hope Site, Jamestown, New York

Monitoring Point	ORP (mV)					
	7/13/2000	8/24/2000	11/8/2000	2/6/2001	4/26/2001[(1)]	7/12/2001
NPL Area Pilot - Deep	**Baseline**					
MW-7D	111.8	4.8	-184	-165	65	-202
PZ-2D/INJ-3		7.1	-152	-139	88	-156
PZ-1D	148	1.9	-150	-126	119	-172
RW-2D	73.7	35.6	-168	-175	4	-204
NPL Area Pilot - Shallow						
MW-7S	311.5	1.2	-172	-106	134	-82
PZ-1S	155.9	-4.9	-126	-108	114	-64
Hot Spot Area Pilot						
PZ-3D	-84.3		-128	-144	142	-140
PZ-4D/INJ-4			-94	-137	138	-138
Upgradient Well						
MW-11D				56		

Notes:

1. ORP data for 4/26/01 is anomalous and is suspected to be the result of instrument error. Data is not plotted on graph.

Table 9

pH Monitoring Results
Pilot Test
Essex/Hope Site, Jamestown, New York

Monitoring Point	pH						
	7/13/2000	8/24/2000	10/2/2000	11/8/2000	2/6/2001	4/26/2001	7/12/2001
NPL Area Pilot - Deep	**Baseline**						
MW-7D	6.71	7.06	7.38	7.45	7.92	7.43	7.19
PZ-2D/INJ-3		6.88	7.31	6.76	7.16	7.13	6.46
PZ-1D	6.86	7.23	7.09	6.77	7.60	6.75	6.40
RW-2D	5.47	7.67	7.41	7.46	7.63	7.40	7.09
NPL Area Pilot - Shallow							
MW-7S	5.51	6.90	6.89	7.07	7.65	7.32	6.38
PZ-1S	6.06	6.95	7.15	7.13	7.97	7.80	7.28
Hot Spot Area Pilot							
PZ-3D	8.27		7.35	6.86	6.91	7.12	6.38
PZ-4D/INJ-4			7.24	6.97	7.26	7.27	6.50
Upgradient Well							
MW-11D					8.36		

Table 10

PZ-1S
Pilot Test VOC Results
Essex/Hope Site, Jamestown, New York

Parameter	07/13/00 Baseline	08/24/00	10/02/00	11/08/00	02/07/01	04/26/01	07/11/01
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Trichloroethene	**186**	**2,440**	**1,300**	**5,400**	**700**	**7.5**	**6.9**
cis-1,2-Dichloroethene	<10	**2,560**	**1,300**	**2,400**	**580**	**72**	**20**
trans-1,2-Dichloroethene	<10	**14**	<100	<100	<100	<5	<1
Vinyl Chloride	<10	**80**	**370**	<200	<100	**50**	**5.1**

Note:

Non-detected values appear on graph as one-half the detection limit values.

Table 11

PZ-1D
Pilot Test VOC Results
Essex/Hope Site, Jamestown, New York

Parameter	07/13/00 Baseline ug/L	08/24/00 ug/L	10/02/00 ug/L	11/08/00 ug/L	02/07/01 ug/L	04/26/01 ug/L	07/12/01 ug/L
Trichloroethene	**36,400**	**59,400**	**58,000**	**23,000**	**2,700**	**12,000**	**18,000**
cis-1,2-Dichloroethene	**12,200**	**10,000**	**14,500**	**25,000**	**35,000**	**84,000**	**79,000**
trans-1,2-Dichloroethene	<1000	<500	<2500	<1000	<1000	<1000	<2000
Vinyl Chloride	<1000	<1000	<5000	<2000	<1000	**16,000**	**4,600**

Note:

Non-detected values appear on graph as one-half the detection limit values.

Table 12

PZ-2D
Pilot Test VOC Results
Essex/Hope Site, Jamestown, New York

Parameter	07/13/00 Baseline ug/L	08/24/00 ug/L	10/02/00 ug/L	11/08/00 ug/L	02/07/01 ug/L	04/26/01 ug/L	07/10/01 ug/L
Trichloroethene	-	**198,000**	**55,000**	**97,000**	**25,000**	**28,000**	**11,000**
cis-1,2-Dichloroethene	-	**16,500**	**8,500**	**32,500**	**65,000**	**73,500**	**72,000**
trans-1,2-Dichloroethene	-	<1000	<5000	<5000	<1000	<1000	<1000
Vinyl Chloride	-	<2000	<1000	<1000	**2,400**	**24,000**	**3,600**

Note:

Non-detected values appear on graph as one-half the detection limit values.

Table 13

PZ-3D
Pilot Test VOC Results
Essex/Hope Site, Jamestown, New York

Parameter	07/20/00						
	Baseline	08/24/00	10/02/00	11/08/00	02/07/01	04/26/01	07/10/01
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Trichloroethene	**135,500**	**76,000**	**104,000**	**30,000**	**90,000**	**141,500**	**110,000**
cis-1,2-Dichloroethene	<5000	**6,300**	**28,000**	**11,500**	**38,000**	**95,000**	**74,000**
trans-1,2-Dichloroethene	<5000	<5000	**120**	<5000	<2000	<5000	<5000
Vinyl Chloride	<5000	<10000	**2,200**	<10000	<2000	<10000	<10000

Note:

Non-detected values appear on graph as one-half the detection limit values.

Table 14

PZ-4D
Pilot Test VOC Results
Essex/Hope Site, Jamestown, New York

Parameter	07/13/00 Baseline ug/L	08/24/00 ug/L	10/02/00 ug/L	11/08/00 ug/L	02/07/01 ug/L	04/26/01 ug/L	07/10/01 ug/L
Trichloroethene	-	**367,000**	**3,200**	**5,300**	**26,500**	**214,000**	**74,500**
cis-1,2-Dichloroethene	-	**24,500**	**240**	**3,500**	**10,500**	**61,500**	**31,000**
trans-1,2-Dichloroethene	-	<500	<100	<250	<500	<5000	<5000
Vinyl Chloride	-	**2,550**	<200	<500	<500	<10000	<10000

Note:

Non-detected values appear on graph as one-half the detection limit values.

Table 15

RW-2D
Pilot Test VOC Results
Essex/Hope Site, Jamestown, New York

Parameter	07/13/00 Baseline ug/L	08/24/00 ug/L	10/02/00 ug/L	11/08/00 ug/L	02/07/01 ug/L	04/26/01 ug/L	07/11/01 ug/L
Trichloroethene	**3,210**	**5,020**	**6,000**	**4,800**	**4,000**	**600**	**700**
cis-1,2-Dichloroethene	**2,120**	**2,060**	**3,100**	**4,300**	**7,750**	**6,750**	**13,250**
trans-1,2-Dichloroethene	<100	<100	<100	<1000	<250	<250	<250
Vinyl Chloride	**290**	**350**	**920**	<1000	**600**	**4,750**	**1,300**

Note:
Non-detected values appear on graph as one-half the detection limit values.

Table 16

MW-7S
Pilot Test VOC Results
Essex/Hope Site, Jamestown, New York

Parameter	07/13/00 Baseline	08/24/00	10/02/00	11/7/00*	11/08/00	02/07/01	04/26/01	07/11/01	12/6/01*	12/3/02*
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Trichloroethene	**14**	<5	**12**	**900**	**1,850**	**228**	<250	**8.5**	**7.6**	**7.5**
cis-1,2-Dichloroethene	<5	**5,420**	**107**	NA	**9,250**	**11,000**	**6,500**	**19**	**23**	**11**
trans-1,2-Dichloroethene	<5	**44**	<5	**7**	<250	<250	<250	<1	<5	<5
Vinyl Chloride	<5	**181**	**12**	**870**	**12**	<250	**1,225**	**8.1**	**2.1**	<2

Notes:

Non-detected values appear on graph as one-half the detection limit values.

NA = Not analyzed

* = Results of Annual Sampling Events

Table 17

MW-7D
Pilot Test VOC Results
Essex/Hope Site, Jamestown, New York

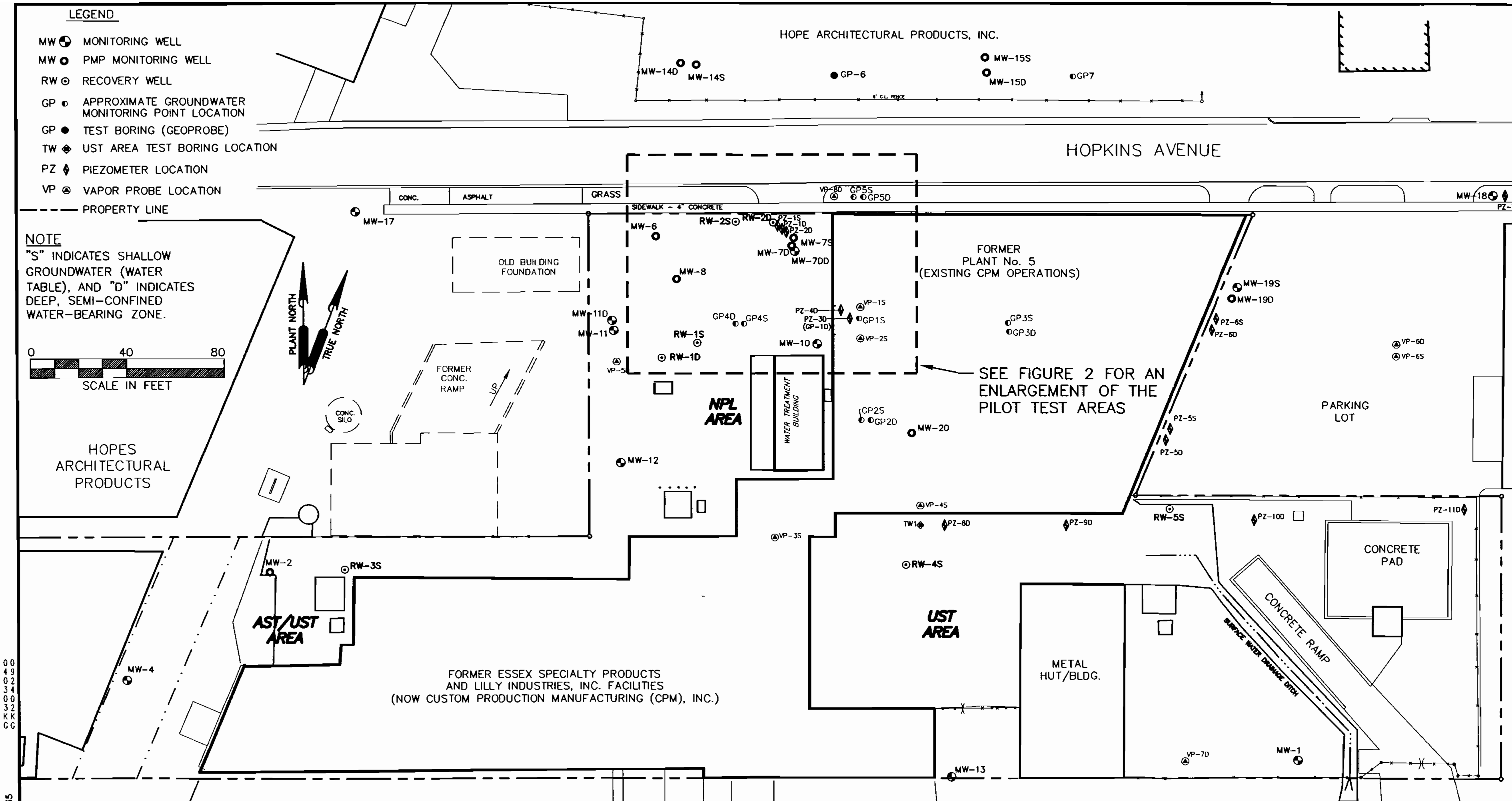
Parameter	07/13/00 Baseline	08/24/00	10/02/00	11/7/00*	11/08/00	02/07/01	04/26/01	07/10/01	12/6/01*	12/5/02*
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Trichloroethene	1,190	1,480	1,800	7,100	3,450	1,500	4,750	<250	1,800	38
cis-1,2-Dichloroethene	775	850	1,030	NA	1,600	23,500	7,500	4,500	4,100	2,900
trans-1,2-Dichloroethene	<50	<50	<50	12	<500	675	<250	<250	28	13
Vinyl Chloride	<50	390	295	270	<1000	3,500	8,400	590	540	1,600

Note:

Non-detected values appear on graph as one-half the detection limit values.

NA = Not analyzed

* = Results of Annual Sampling Events



MAP REFERENCE AND CONTROL:

BASE MAPPING INCLUDING THE LOCATIONS OF SOME OF THE BUILDINGS, ROADS, CURBS/SIDEWALKS, FENCING, PAVED AREAS, ALL UTILITIES (UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE), AND PROPERTY BOUNDARY WAS PROVIDED BY MICHAEL J. RODGERS AND ASSOCIATES, LAND SURVEYORS, BEMUS POINT, NEW YORK, N.Y.S. LICENSE No. 49232. THE BASE MAP WAS A SEPIA HARD COPY AT A SCALE OF 1"=20', DATED APRIL 15, 1992, LAST REVISION DATE MARCH 10, 1993. RECOVERY WELLS AND MONITORING WELLS IN THE VICINITY OF THE REMEDIAL ACTION CONSTRUCTION WERE SURVEYED AUGUST, 1997. OTHER MONITORING WELLS WERE EITHER PART OF THE APRIL, 1992 MAP/SURVEY OR NOT SURVEYED AT ALL. SOME OF THE BUILDING CORNERS ARE FROM THE MICHAEL J. ROGERS SURVEY DONE ON JANUARY 9, 1998. ALL OTHER BUILDING CORNERS ARE APPROXIMATE.

VERTICAL BENCH MARK INFORMATION CAME FROM U.S.G.S. PLAQUE U-88-S.E. ABUTT. ERIE R.R. BRIDGE OVER BUFFALO ST., ELEV.=1296.034 (NATIONAL GEODETIC VERTICAL DATUM, 1929).
HORIZONTAL COORDINATES PROVIDED FOR THE MONITORING WELLS AND THE PROPERTY CORNERS ARE BASED ON A LOCAL GRID ESTABLISHED BY THE SURVEYOR. N10000, E10000 IS A PK NAIL SET IN THE CONCRETE CURB/GUTTER AND IS PART OF THE ORIGINAL TRAVERSE. IRON STAKES WERE SET AT THE PROPERTY CORNERS.

URS

PITTSBURGH, PENNSYLVANIA 15205

PERMEABLE REACTIVE BARRIER (PRB) PILOT TEST REPORT
GENERAL SITE CONDITIONS

ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.		JOB NUMBER: 804041.81	
SCALE: AS SHOWN	FIGURE NUMBER 1		REV 0

FILE: ESSEXHOP\804041\80404135

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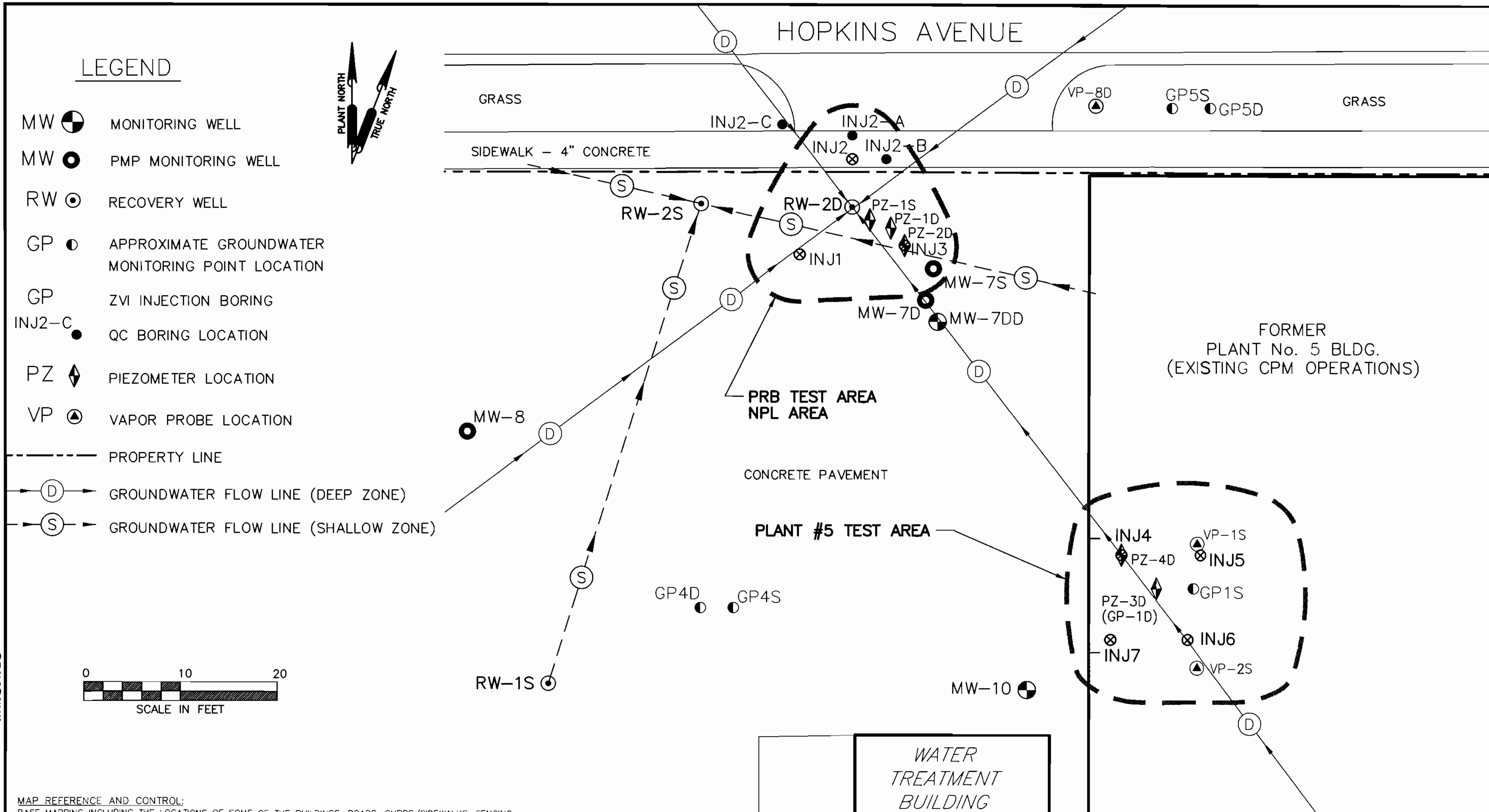

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BASE MAPPING INCLUDING THE LOCATIONS OF SOME OF THE BUILDINGS, ROADS, CURBS/SIDEWALKS, FENCING, PAVED AREAS, ALL UTILITIES (UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE), AND PROPERTY BOUNDARY WAS PROVIDED BY MICHAEL J. RODGERS AND ASSOCIATES, LAND SURVEYORS, BEMUS POINT, NEW YORK, N.Y.S. LICENSE No. 49232. THE BASE MAP WAS A SEPIA HARD COPY AT A SCALE OF 1"=20', DATED APRIL 15, 1992, LAST REVISION DATE MARCH 10, 1993. RECOVERY WELLS AND MONITORING WELLS IN THE VICINITY OF THE REMEDIAL ACTION CONSTRUCTION WERE SURVEYED AUGUST, 1997, OTHER MONITORING WELLS WERE EITHER PART OF THE APRIL, 1992 MAP/SURVEY OR NOT SURVEYED AT ALL. SOME OF THE BUILDING CORNERS ARE FROM THE MICHAEL J. ROGERS SURVEY DONE ON JANUARY 9, 1998. ALL OTHER BUILDING CORNERS ARE APPROXIMATE.

VERTICAL BENCH MARK INFORMATION CAME FROM U.S.G.S. PLAQUE U–88–S.E. ABUTT. ERIE R.R. BRIDGE OVER BUFFALO ST., ELEV.=1296.034 (NATIONAL GEODETIC VERTICAL DATUM, 1929).
HORIZONTAL COORDINATES PROVIDED FOR THE MONITORING WELLS AND THE PROPERTY CORNERS ARE BASED ON A LOCAL GRID ESTABLISHED BY THE SURVEYOR. N10000, E10000 IS A PK NAIL SET IN THE CONCRETE CURB/GUTTER AND IS PART OF THE ORIGINAL TRAVERSE. IRON STAKES WERE SET AT THE PROPERTY CORNERS.

URS

PITTSBURGH, PENNSYLVANIA 15205

PERMEABLE REACTIVE BARRIER (PRB) PILOT TEST REPORT
PILOT TEST AREAS

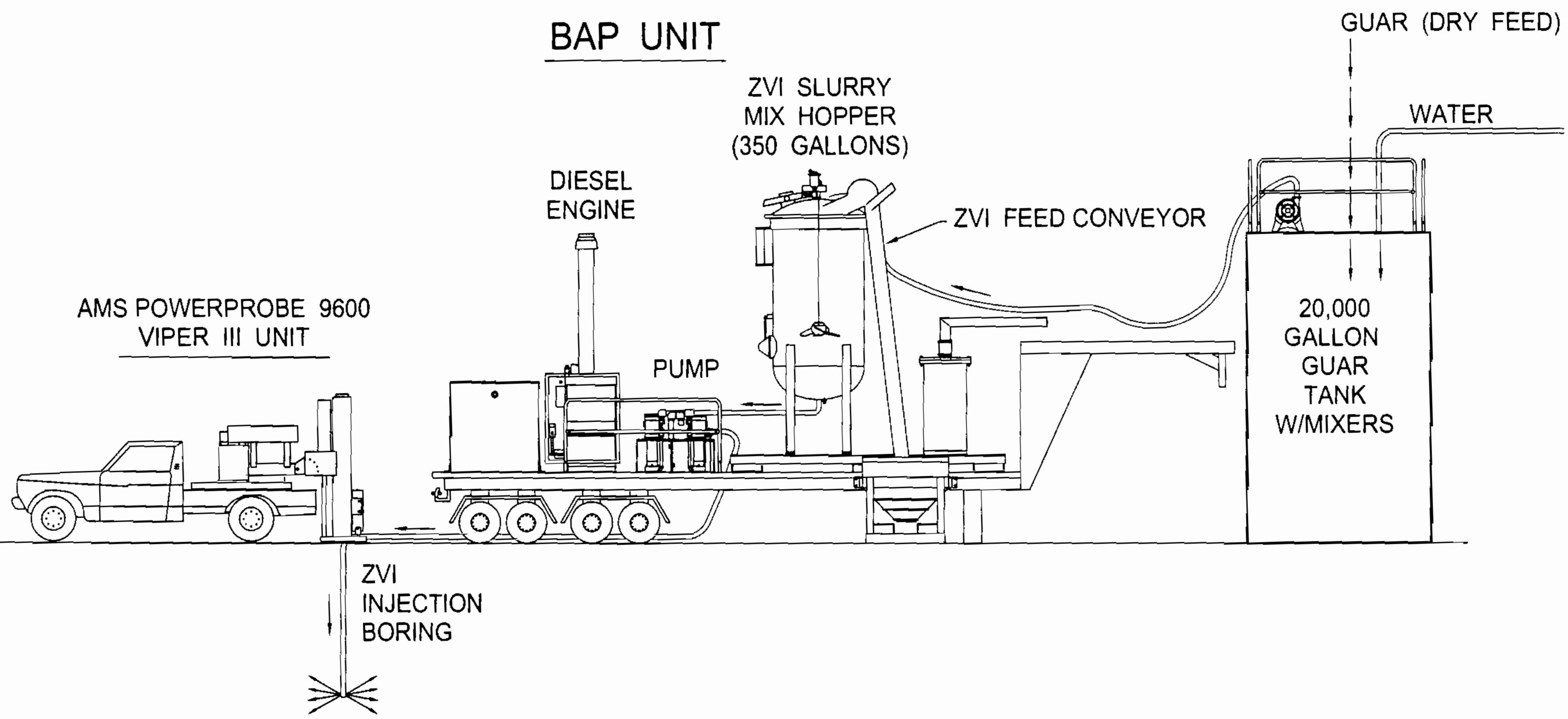
ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC. JOB NUMBER: 804041.81

SCALE: AS SHOWN FIGURE NUMBER 2 REV 0

FILE: \ESSEXHOP\7138\804041\INJECT

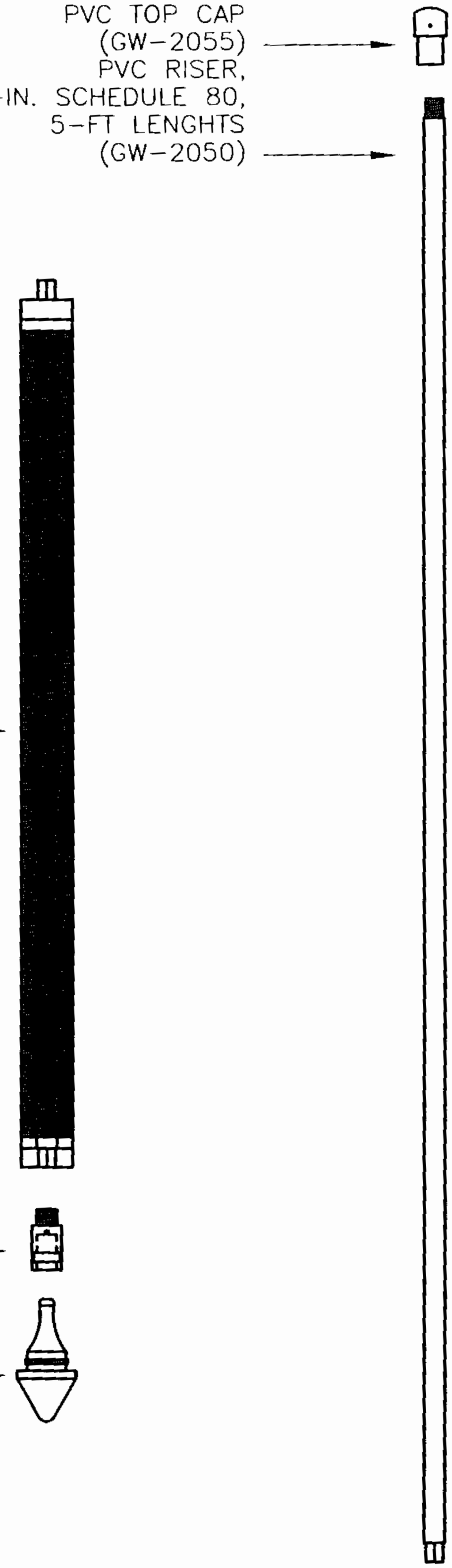
ZVI INJECTION SYSTEM



URS

PITTSBURGH, PENNSYLVANIA 15205

PERMEABLE REACTIVE BARRIER (PRB) PILOT TEST REPORT ZVI INJECTION SYSTEM	
ESSEX/HOPE	JAMESTOWN, NY
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.	JOB NUMBER: 804041
SCALE: AS SHOWN	FIGURE NUMBER 3 — REV 0



FILE: \ESSEXHOP\804041\GEO WELL

URS

PITTSBURGH, PENNSYLVANIA

PERMEABLE REACTIVE BARRIER (PRB) PILOT TEST REPORT
GEOPROBE MONITORING WELL (PZ)

ESSEX/HOPE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.		JOB NUMBER: 804041.81	
SCALE: NONE	FIGURE NUMBER 4		REV 0

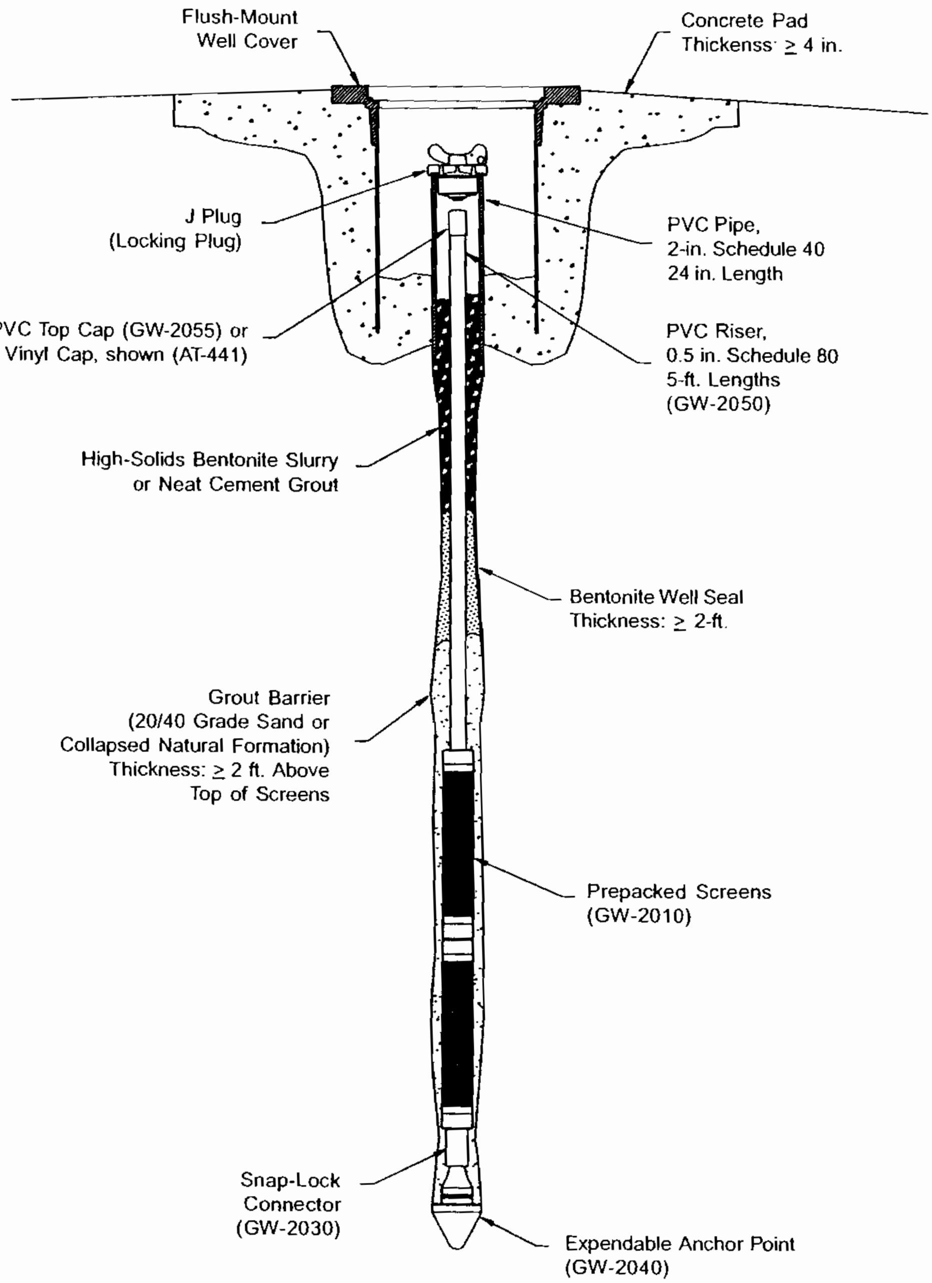


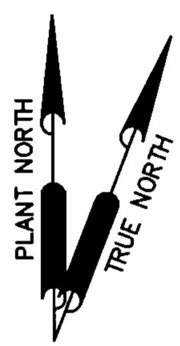
FIGURE 4.11

A Properly Installed Geoprobe Prepacked Screen Monitoring Well

LEGEND

- MONITORING WELL
- PMP MONITORING WELL
- RECOVERY WELL
- APPROXIMATE PROPERTY LINE
- APPROXIMATE GROUNDWATER MONITORING POINT LOCATION
- TEST BORING (GEOPROBE)
- UST AREA TEST BORING LOCATION
- PIEZOMETER LOCATION (PZ-1D)
- PRW INJECTION WELL (INJ3)

TCE Trichloroethene
DCE,c cis-1,2 Dichlorethene
DCE,t trans-1,2 Dichlorethene
VC Vinyl Chloride

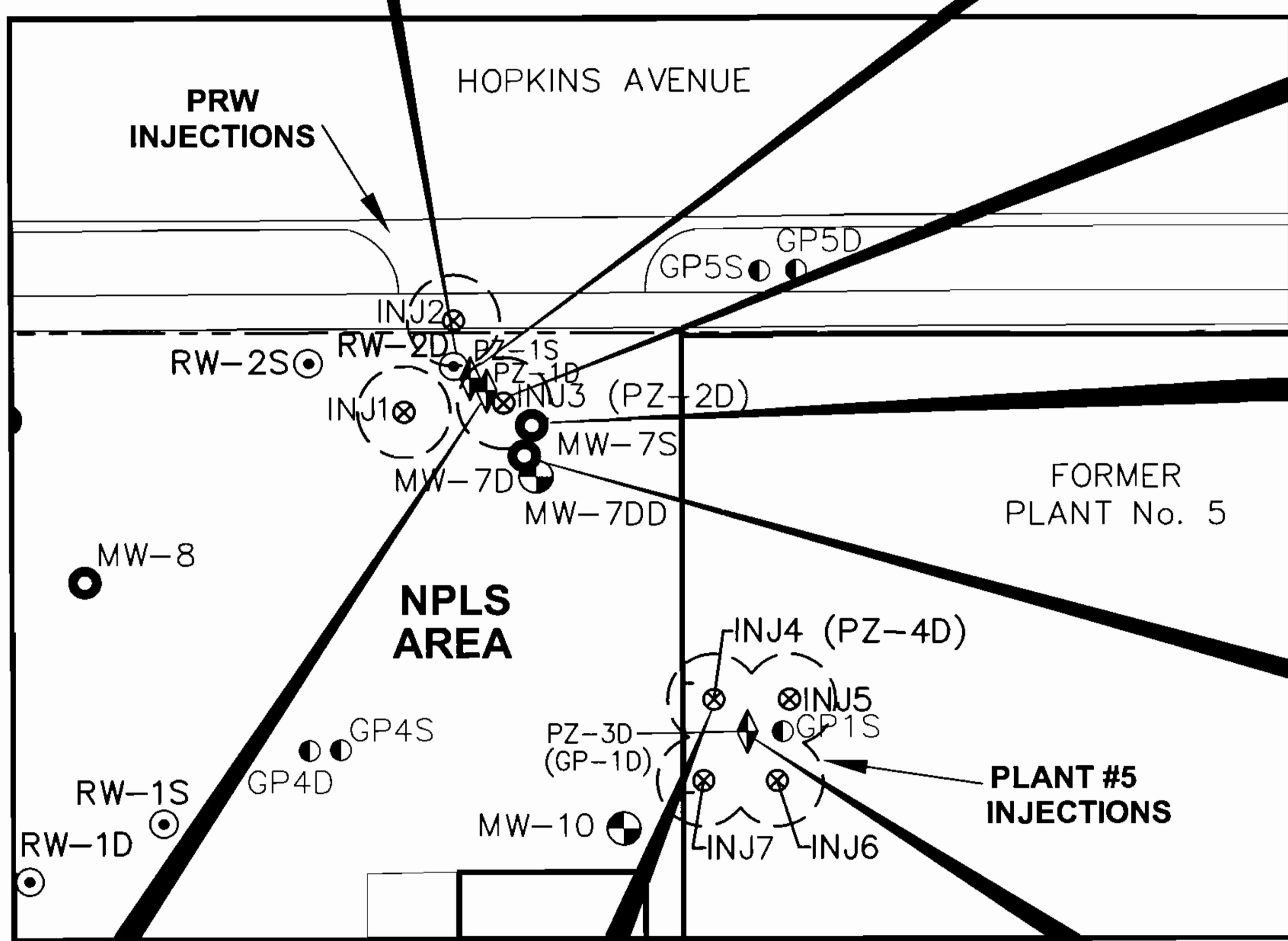


NOTE:
1. ALL VOC ANALYTICAL RESULTS REPORTED AS ug/L

Analyte	BASELINE 7/13/00	BASELINE 7/20/00	RW-2D 8/24/00	RW-2D 10/2/00	RW-2D 11/8/00	RW-2D 2/7/01	RW-2D 4/26/01	RW-2D 7/11/01
TCE	3210	–	5020	6000	4800	4000	600	700
DCE,c	2120	–	2060	3100	4300	7750	6750	13250
DCE,t	<100	–	<100	<100	<1000	<250	<250	<250
VC	290	–	350	920	<1000	600	4750	1300

Analyte	BASELINE 7/13/00	BASELINE 7/20/00	PZ-1S 8/24/00	PZ-1S 10/2/00	PZ-1S 11/8/00	PZ-1S 2/7/01	PZ-1S 4/26/01	PZ-1S 7/11/01
TCE	186	–	2440	1300	5400	700	7.5	6.9
DCE,c	<10	–	2560	1300	2400	580	72	20
DCE,t	<10	–	14	<100	<100	<100	<5	<1
VC	<10	–	80	370	<200	<100	50	5.1

Analyte	BASELINE 7/13/00	BASELINE 7/20/00	PZ-2D/INJ3 8/24/00	PZ-2D/INJ3 10/2/00	PZ-2D/INJ3 11/8/00	PZ-2D/INJ3 2/7/01	PZ-2D/INJ3 4/26/01	PZ-2D/INJ3 7/10/01
TCE	–	–	198000	55000	97000	25000	28000	11000
DCE,c	–	–	16500	8500	32500	65000	73500	72000
DCE,t	–	–	<1000	<5000	<5000	<1000	<1000	<1000
VC	–	–	<2000	<1000	<1000	2400	24000	3600



Analyte	BASELINE 7/13/00	BASELINE 7/20/00	MW-7S 8/24/00	MW-7S 10/2/00	MW-7S 11/8/00	MW-7S 2/7/01	MW-7S 4/26/01	MW-7S 7/11/01
TCE	14	–	<5	12	1850	228	<250	8.5
DCE,c	<5	–	5420	107	9250	11000	6500	19
DCE,t	<5	–	44	<5	<250	<250	<250	<1
VC	<5	–	181	12	12	<250	1225	8.1

Analyte	BASELINE 7/13/00	BASELINE 7/20/00	MW-7D 8/24/00	MW-7D 10/2/00	MW-7D 11/8/00	MW-7D 2/7/01	MW-7D 4/26/01	MW-7D 7/10/01
TCE	1190	–	1480	1800	3450	1500	4750	<250
DCE,c	775	–	850	1030	1600	23500	7500	4500
DCE,t	<50	–	<50	<50	<500	675	<250	<250
VC	<50	–	390	295	<1000	3500	8400	590

Analyte	BASELINE 7/13/00	BASELINE 7/20/00	PZ-1D 8/24/00	PZ-1D 10/2/00	PZ-1D 11/8/00	PZ-1D 2/7/01	PZ-1D 4/26/01	PZ-1D 7/12/01
TCE	36400	–	59400	58000	23000	2700	12000	18000
DCE,c	12200	–	10000	14500	25000	35000	84000	79000
DCE,t	<1000	–	<500	<2500	<1000	<1000	<1000	<2000
VC	<1000	–	<1000	<5000	<2000	<1000	16000	4600

Analyte	BASELINE 7/13/00	BASELINE 7/20/00	PZ-4D/INJ4 8/24/00	PZ-4D/INJ4 10/2/00	PZ-4D/INJ4 11/8/00	PZ-4D/INJ4 2/7/01	PZ-4D/INJ4 4/26/01	PZ-4D/INJ4 7/10/01
TCE	–	–	367000	3200	5300	26500	214000	74500
DCE,c	–	–	24500	240	3500	10500	61500	31000
DCE,t	–	–	<500	<100	<250	<500	<5000	<5000
VC	–	–	2550	<200	<500	<500	<10000	<10000

Analyte	BASELINE 7/13/00	BASELINE 7/20/00	PZ-3D/GPID 8/24/00	PZ-3D/GPID 10/2/00	PZ-3D/GPID 11/8/00	PZ-3D/GPID 2/7/01	PZ-3D/GPID 4/26/01	PZ-3D/GPID 7/10/01
TCE	–	135500	76000	104000	30000	90000	141500	110000
DCE,c	–	<5000	6300	28000	11500	38000	95000	74000
DCE,t	–	<5000	<5000	120	<5000	<2000	<5000	<5000
VC	–	<5000	<10000	2200	<10000	<2000	<10000	<10000

0 20 40
SCALE IN FEET

URS

PITTSBURGH, PENNSYLVANIA 15205

PERMEABLE REACTIVE BARRIER (PRB) PILOT TEST REPORT PERFORMANCE MONITORING SUMMARY

ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC. JOB NUMBER: 804041.81

SCALE: AS SHOWN FIGURE NUMBER 5 REV 0

FILE: ESSEXHOP\804041\80404133

Figure 6
ORP Trends - Deep Groundwater Zone
Essex/Hope Site, Jamestown, NY

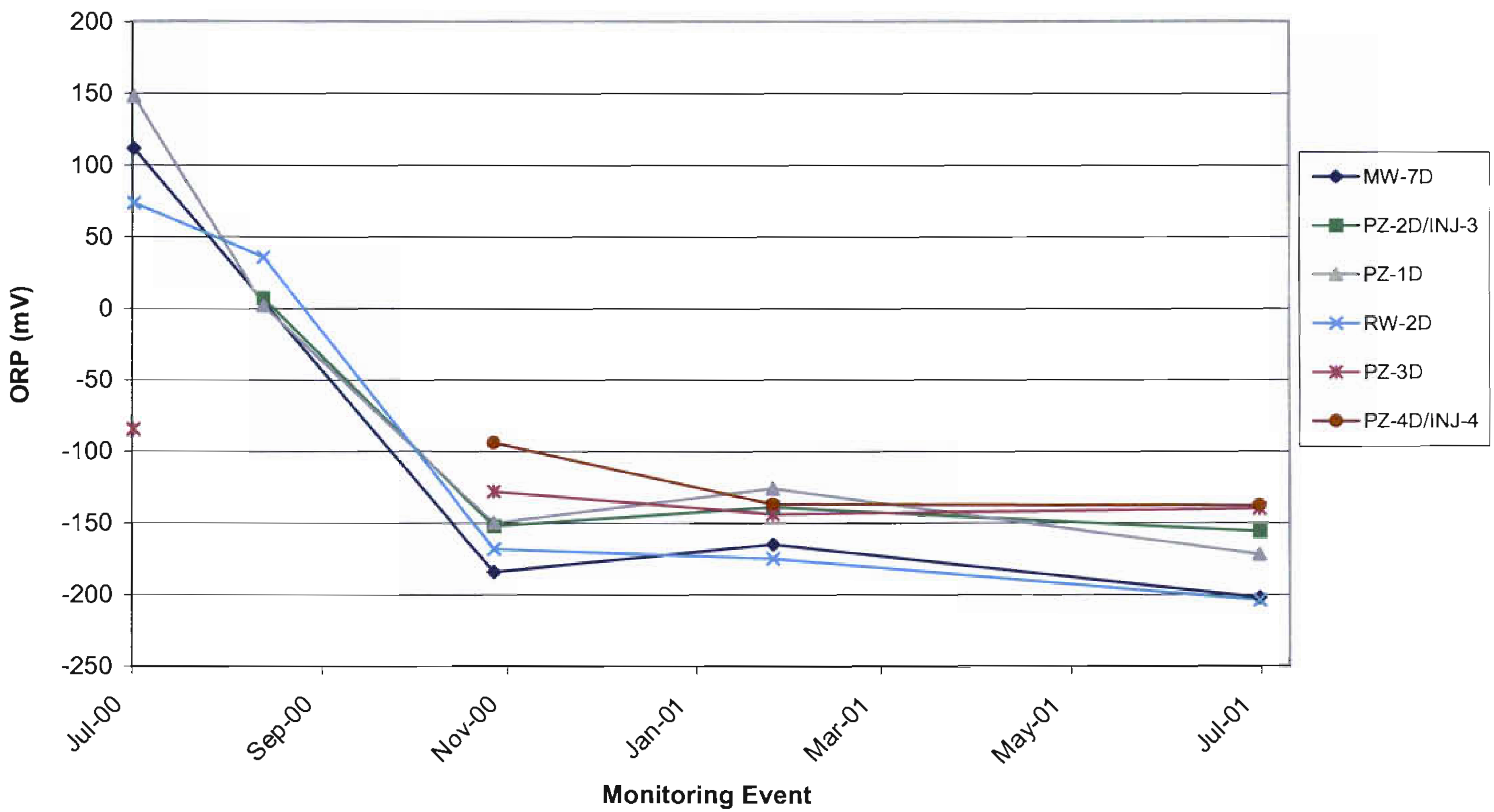


Figure 7
ORP Trends - Shallow Groundwater Zone
Essex/Hope Site, Jamestown, NY

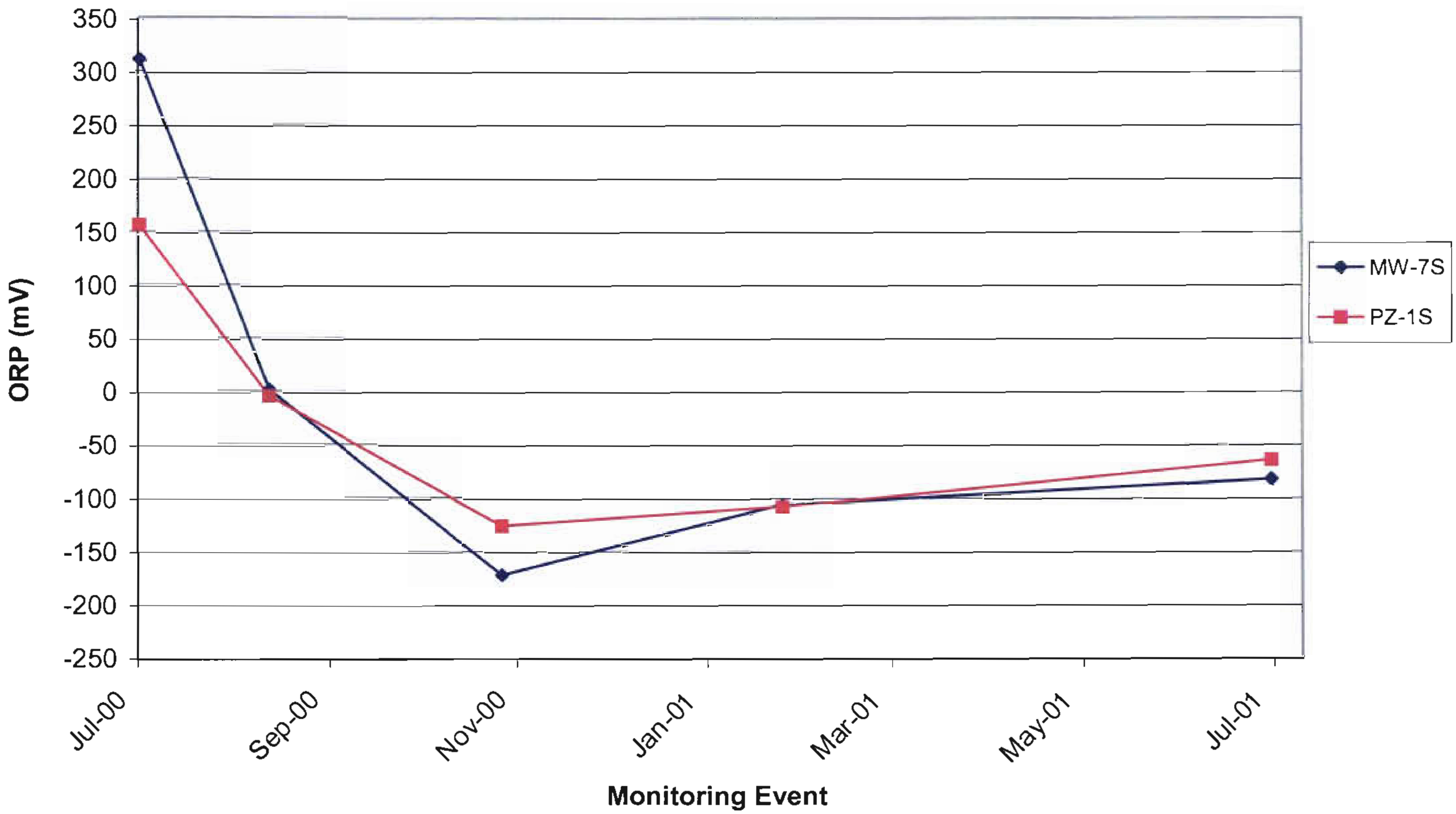


Figure 8
pH Trends - Deep Groundwater Zone
Essex/Hope Site, Jamestown, NY

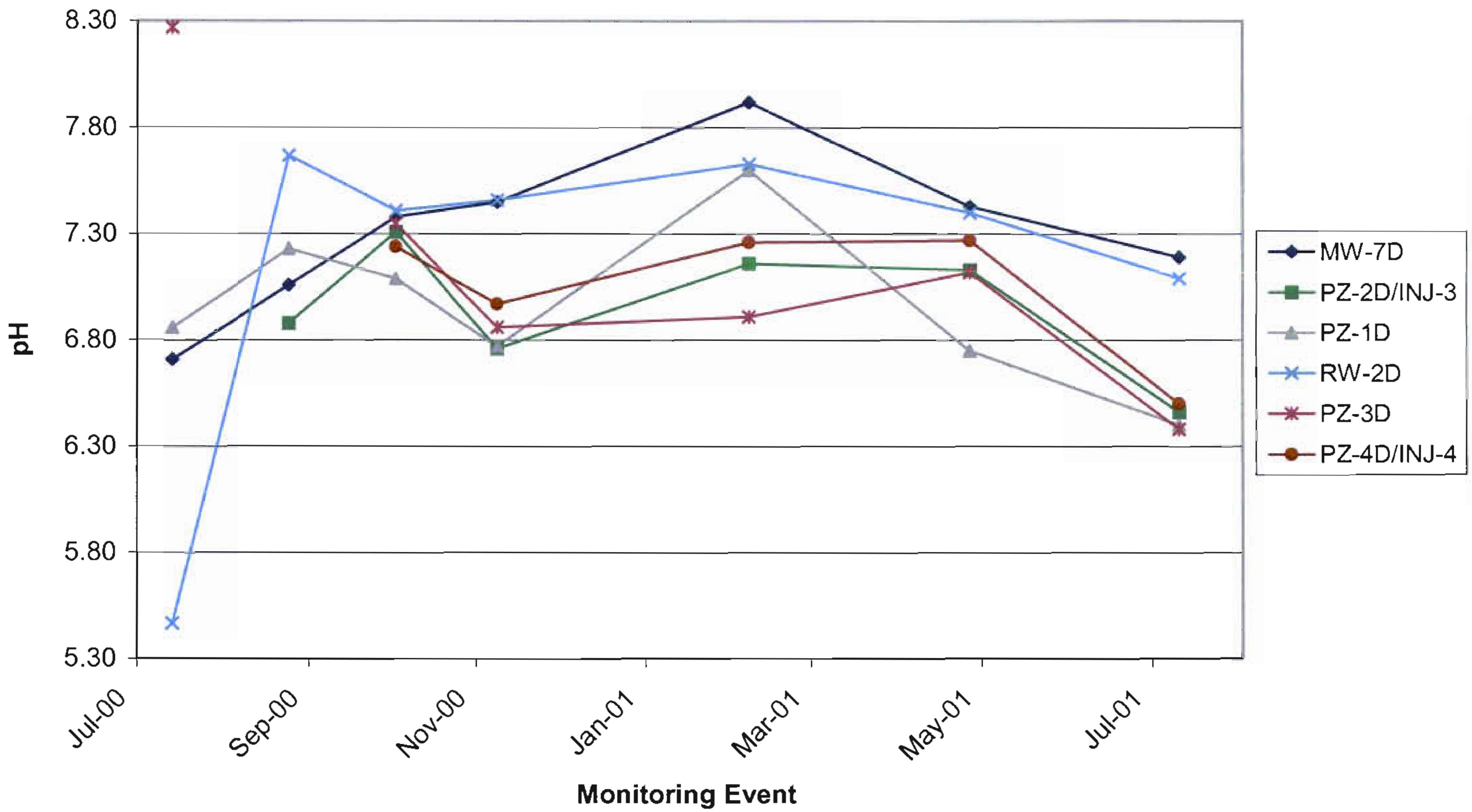


Figure 9
pH Trends - Shallow Groundwater Zone
Essex/Hope Site, Jamestown, NY

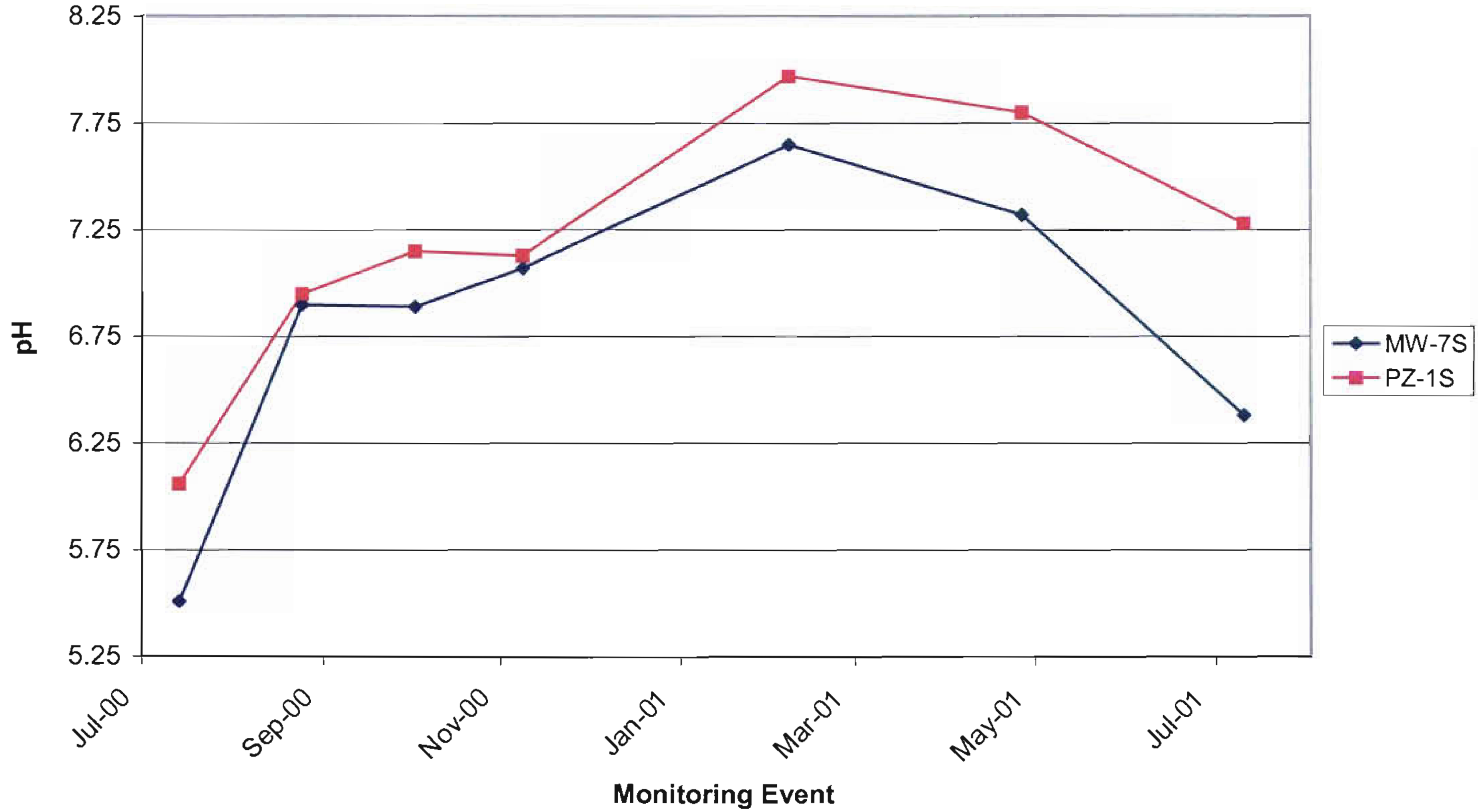


Figure 10
Pilot Test Monitoring Point PZ-1S (NPL Area)
Concentration vs. Time

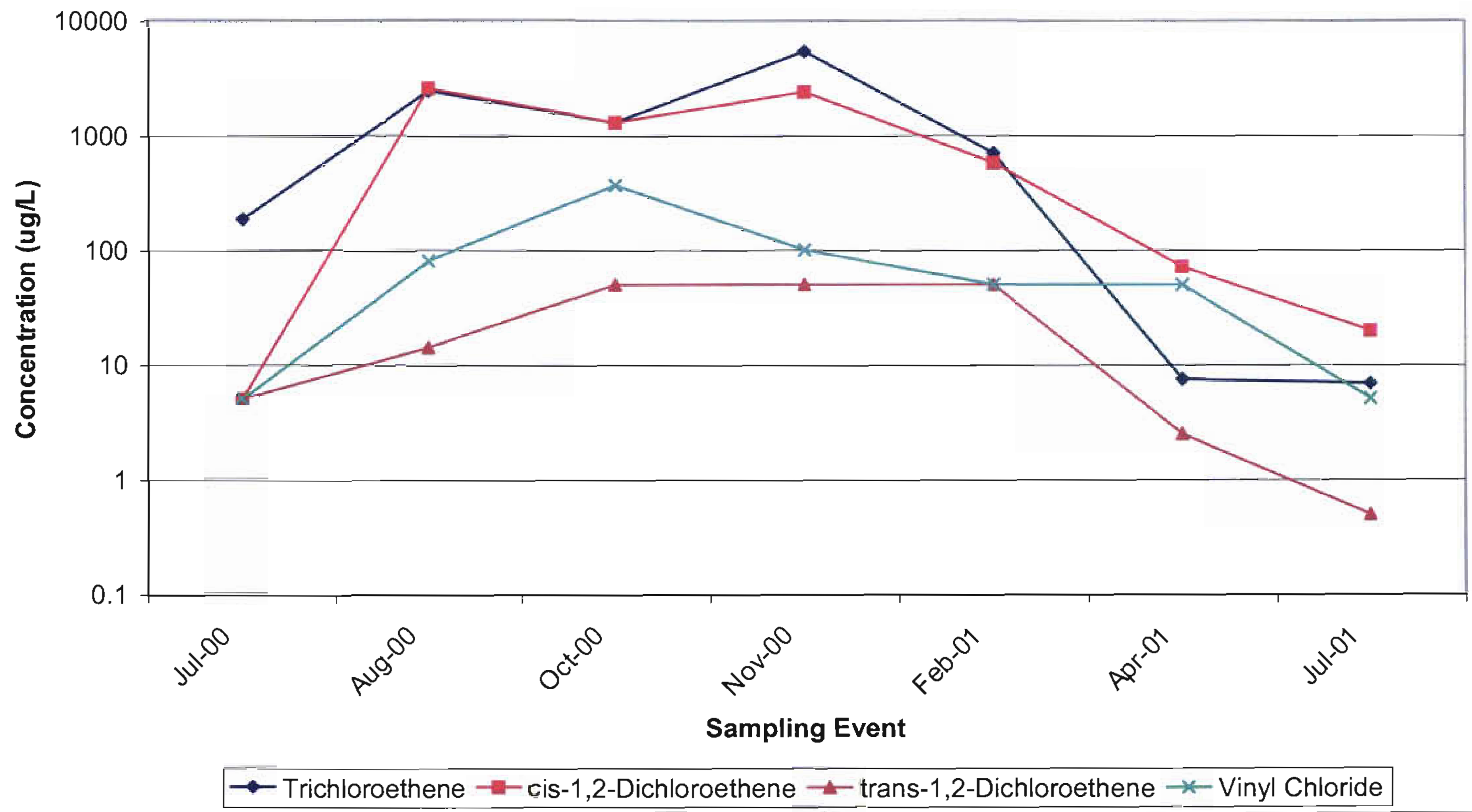


Figure 11
Pilot Test Monitoring Point PZ-1D (NPL Area)
Concentration vs. Time

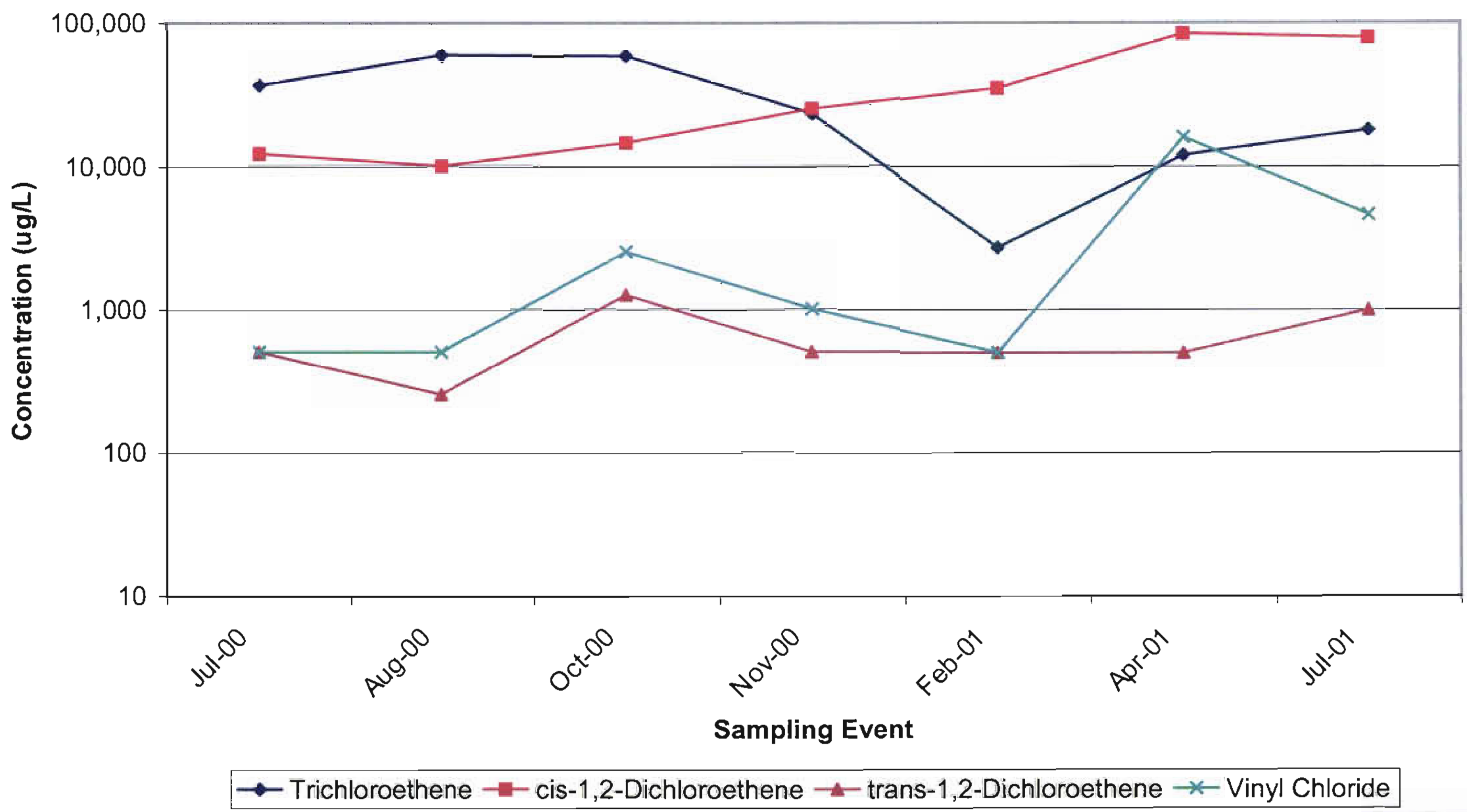


Figure 12
Pilot Test Monitoring Point PZ-2D (NPL Area)
Concentration vs. Time

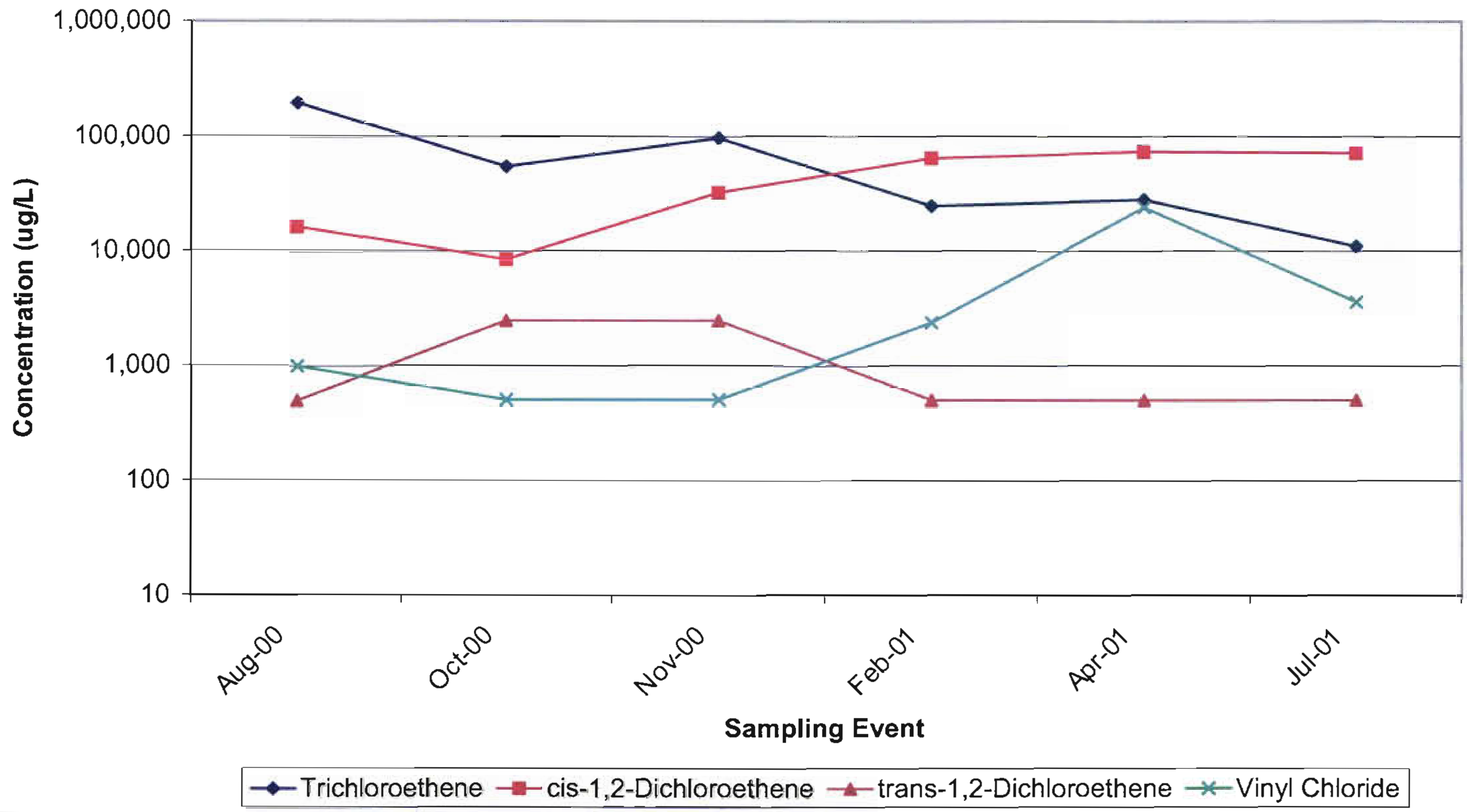


Figure 13
Pilot Test Monitoring Point PZ-3D (Hot Spot Area)
Concentration vs. Time

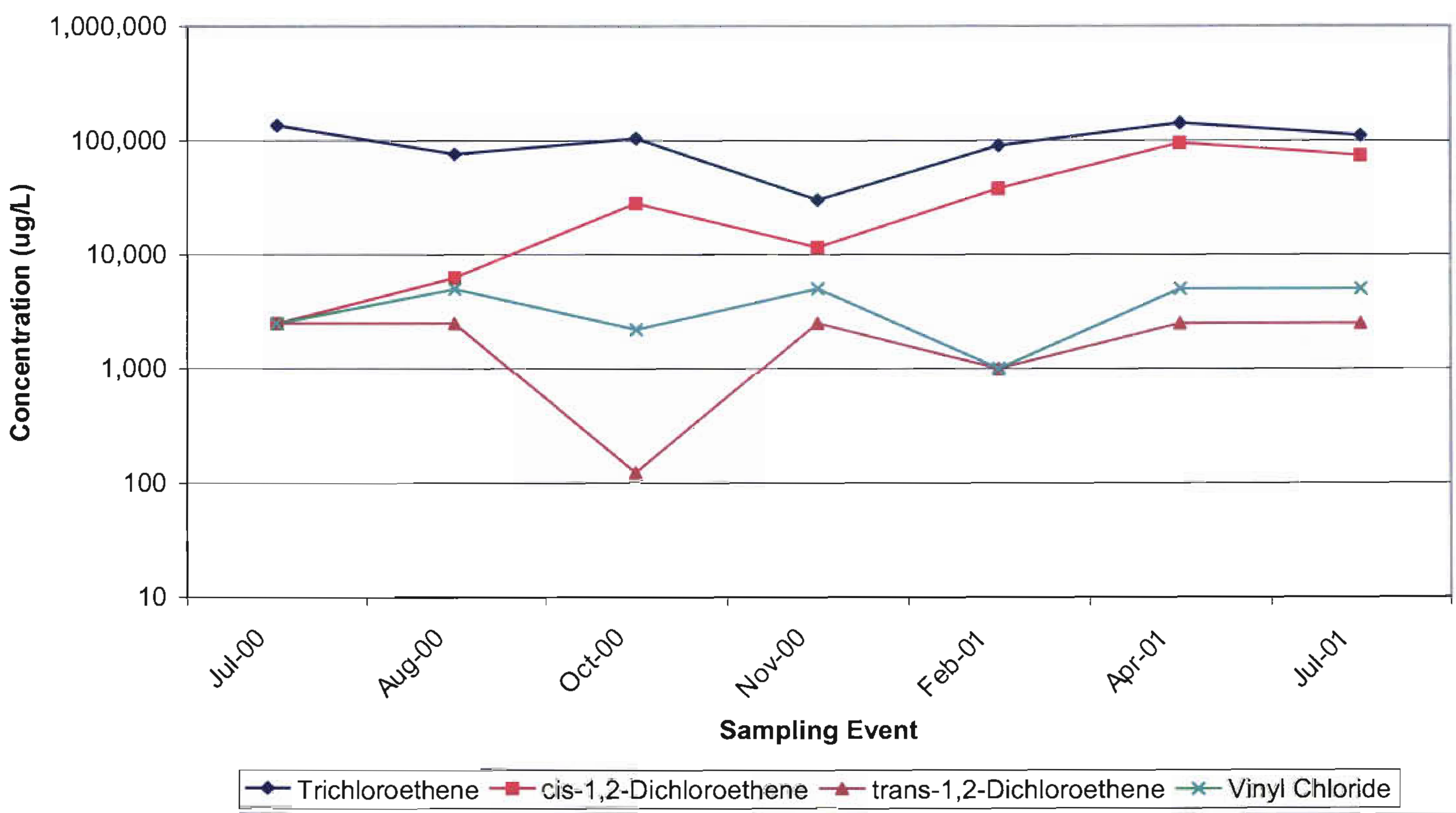


Figure 14
Pilot Test Monitoring Point PZ-4D (Hot Spot Area)
Concentration vs. Time

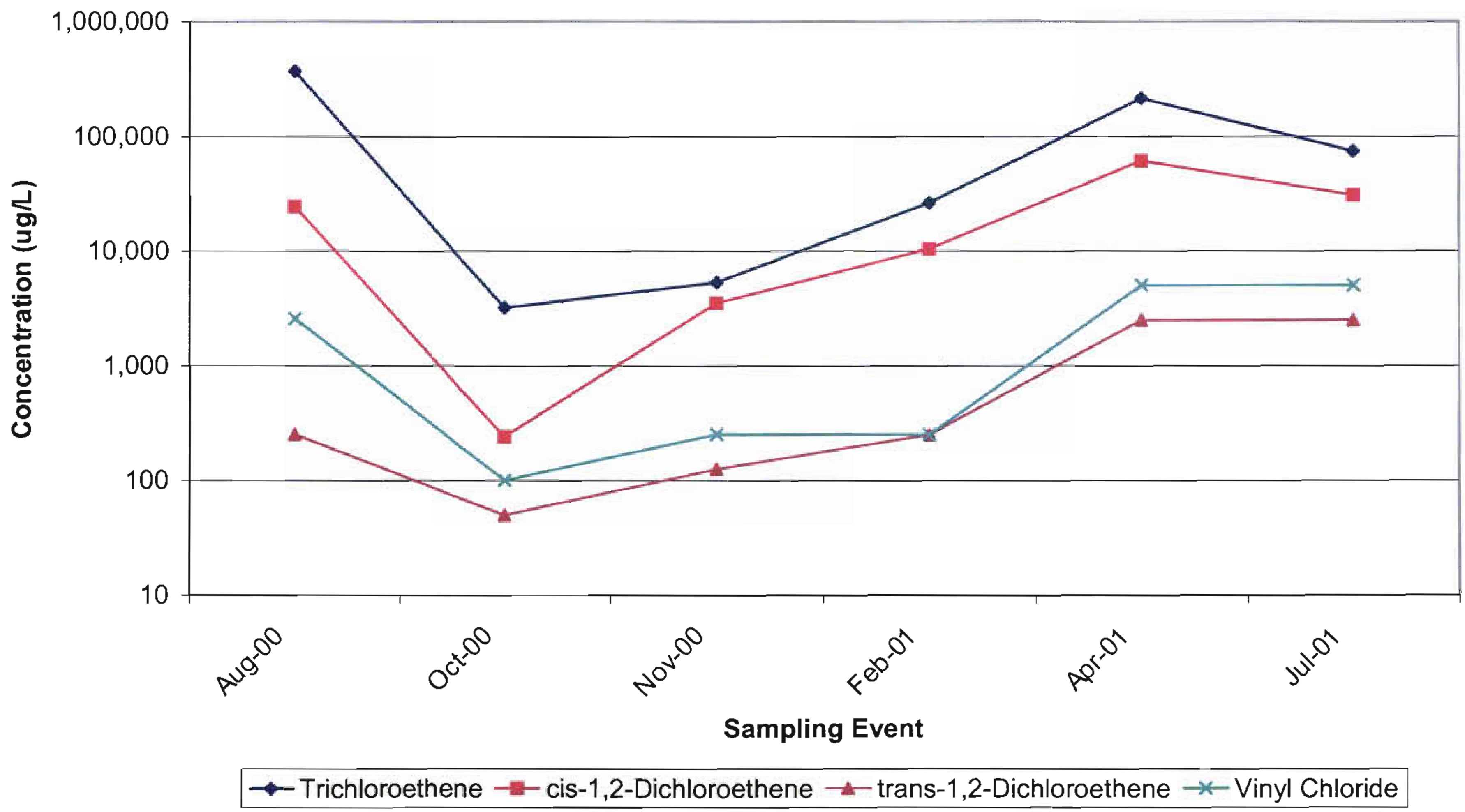


Figure 15
Pilot Test Monitoring Point RW-2D (NPL Area)
Concentration vs. Time

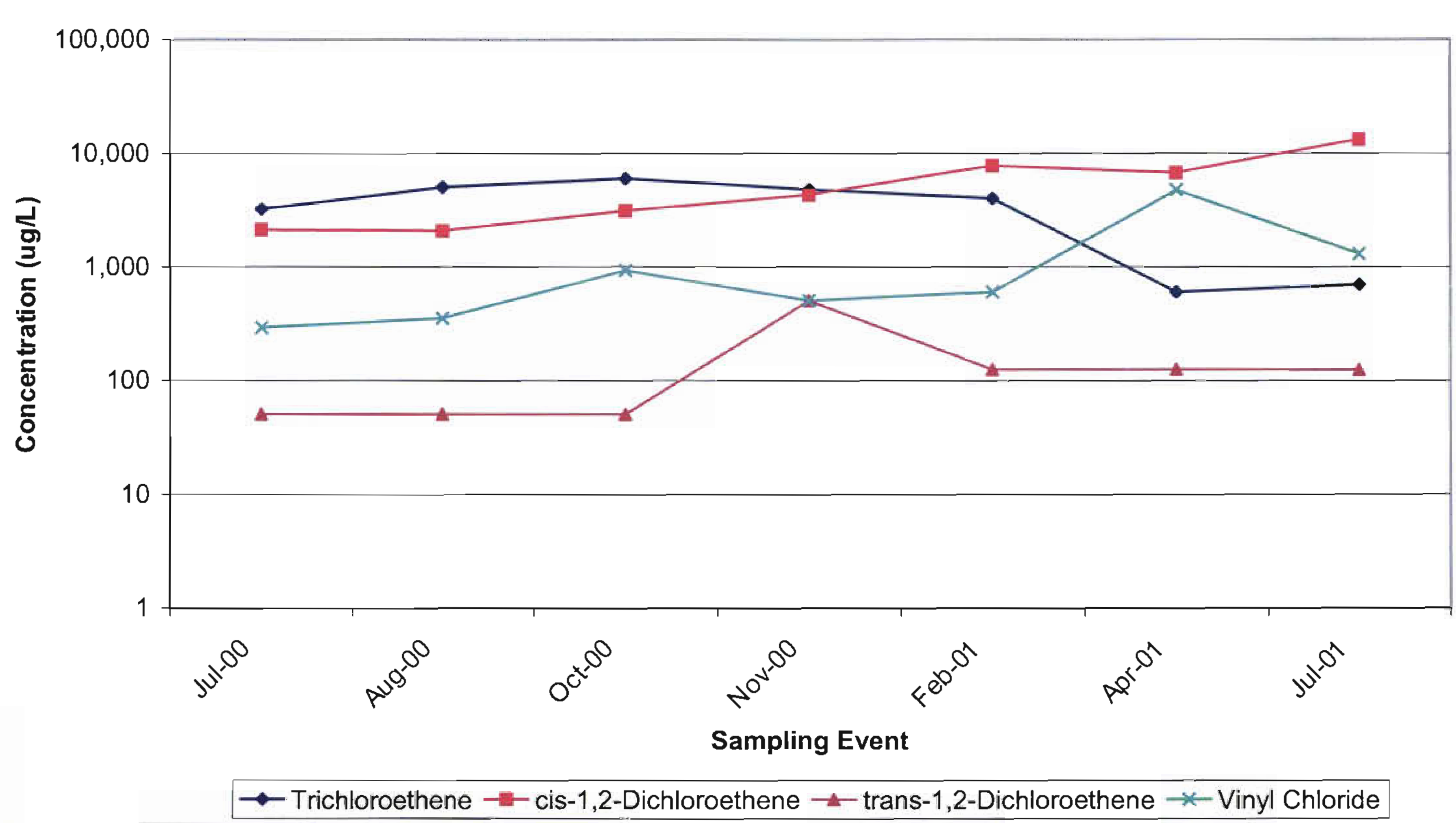


Figure 16
Pilot Test Monitoring Point MW-7S (NPL Area)
Concentration vs. Time

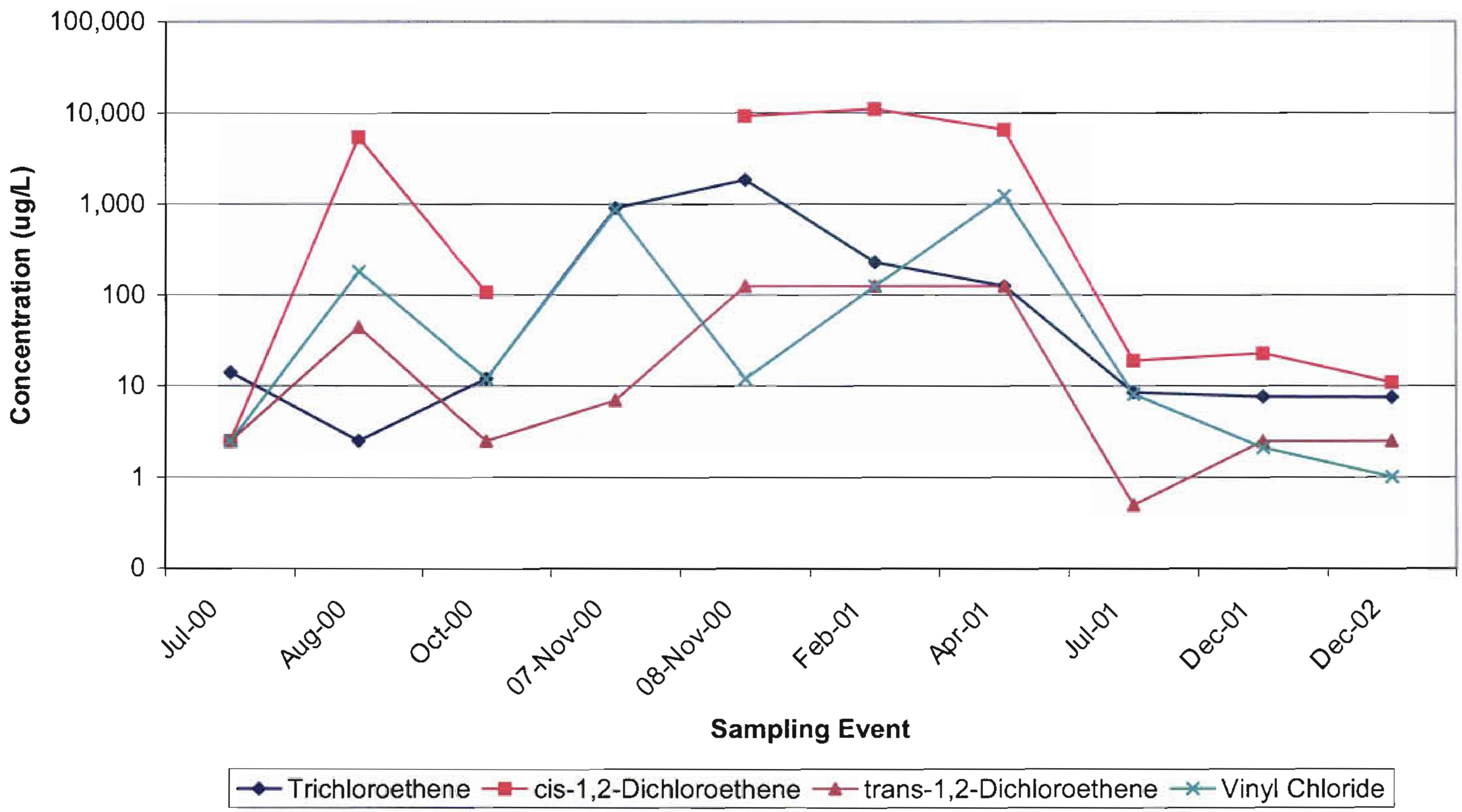


Figure 17
Pilot Test Monitoring Point MW-7D (NPL Area)
Concentration vs. Time

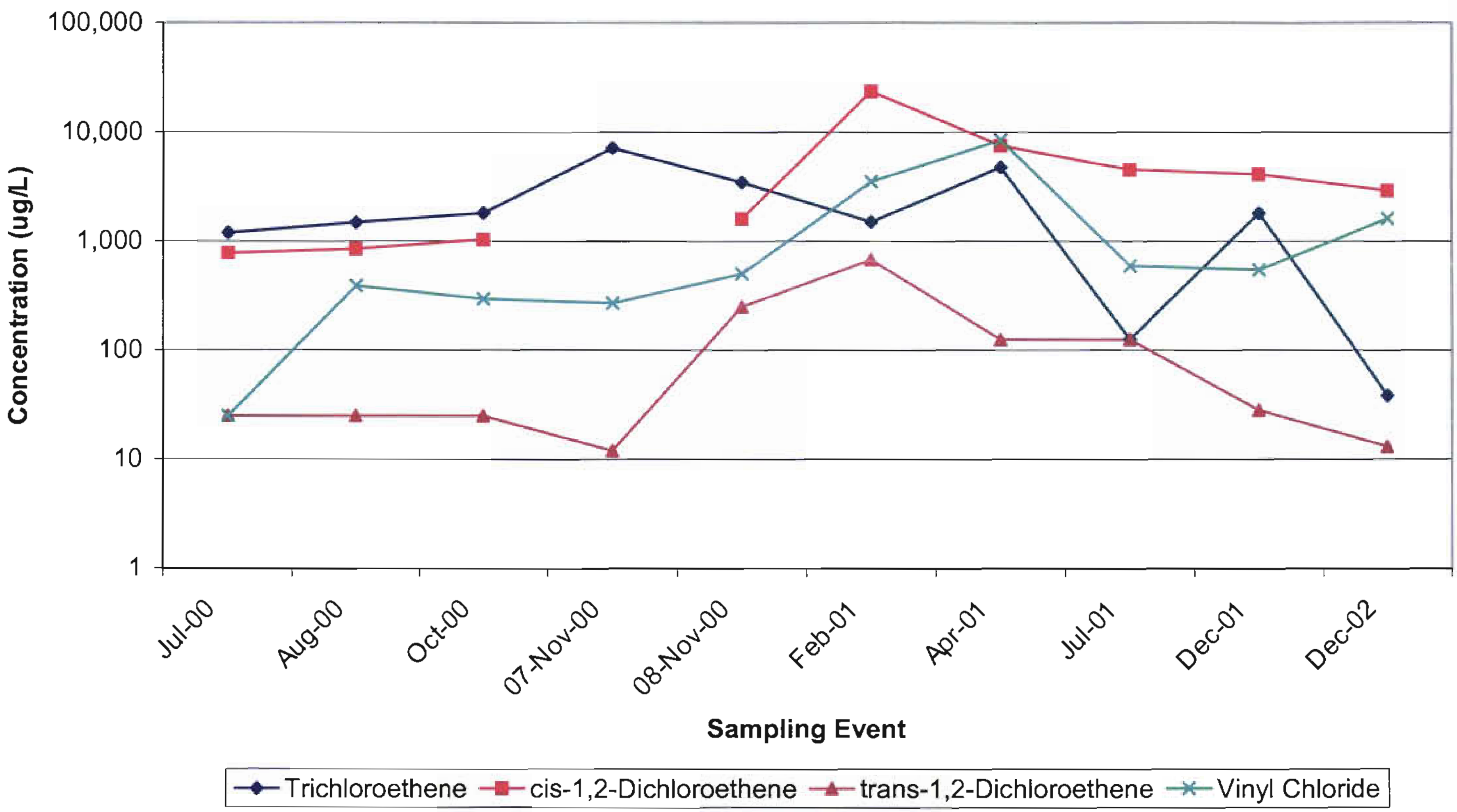


Figure 18
RW-1S Quarterly Monitoring Results
Concentration vs. Time

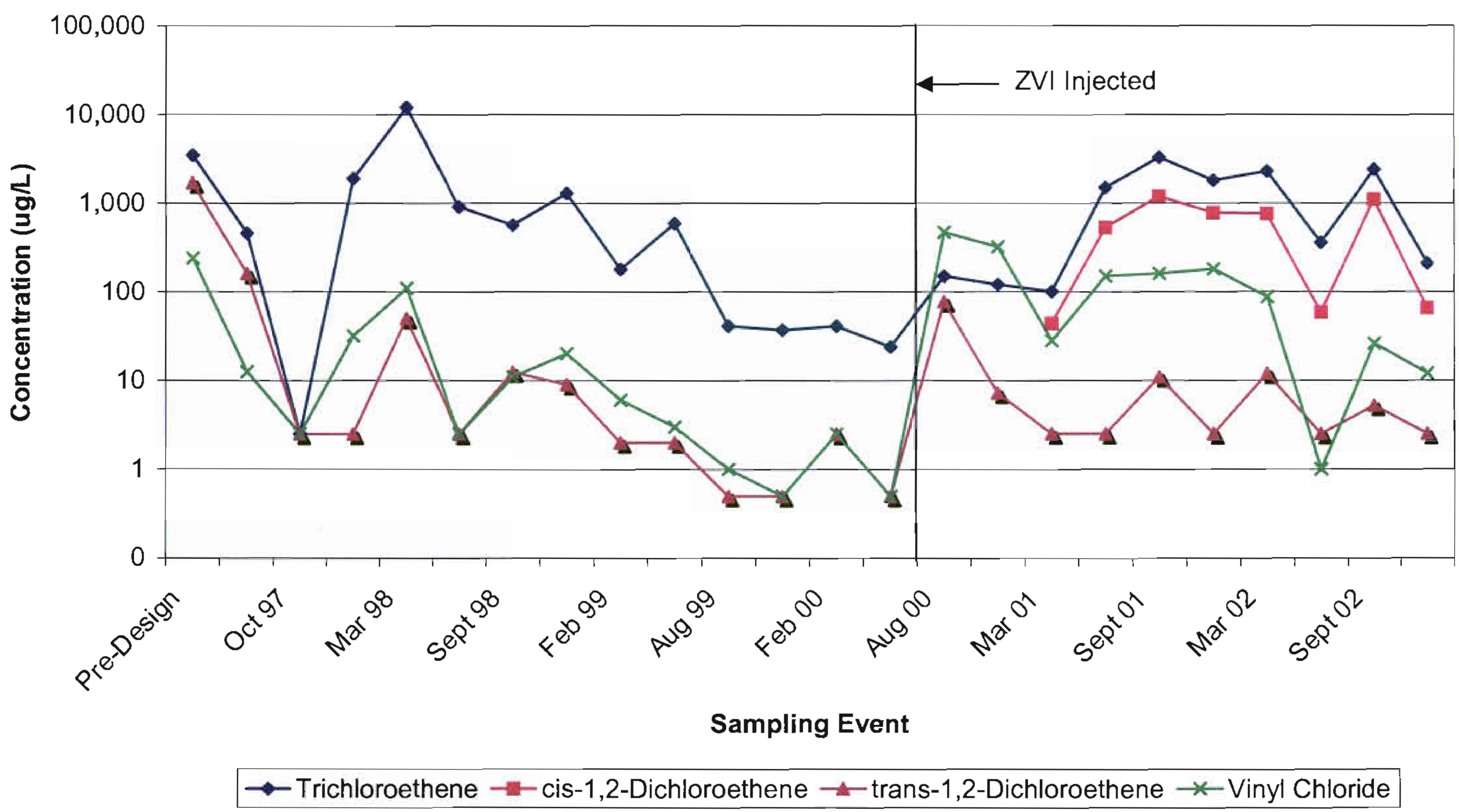


Figure 19
RW-2S Quarterly Monitoring Results
Concentration vs. Time

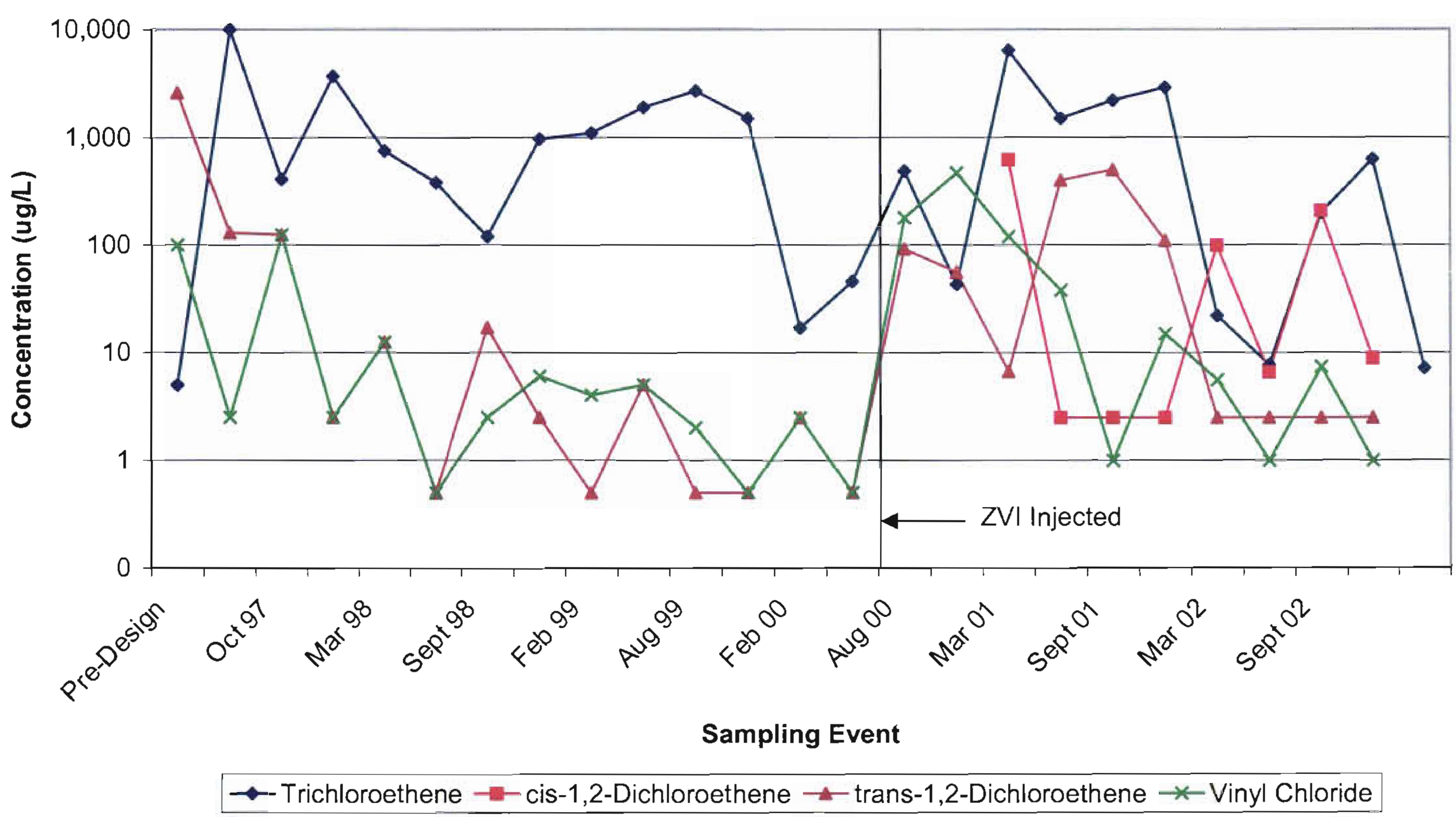


Figure 20
RW-1D Quarterly Sampling Results
Concentration vs. Time

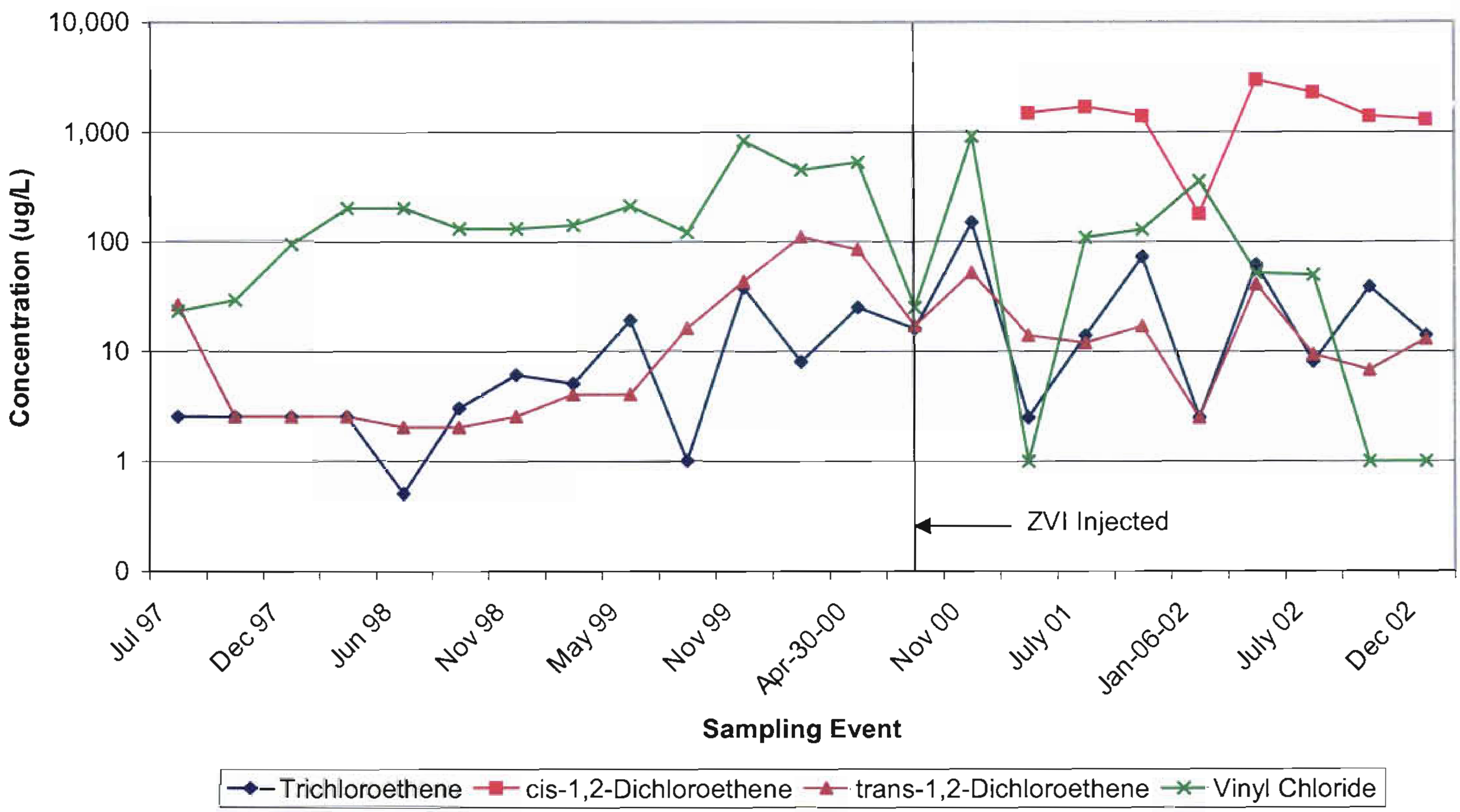


Figure 21
RW-2D Quarterly Sampling Results
Concentration vs. Time

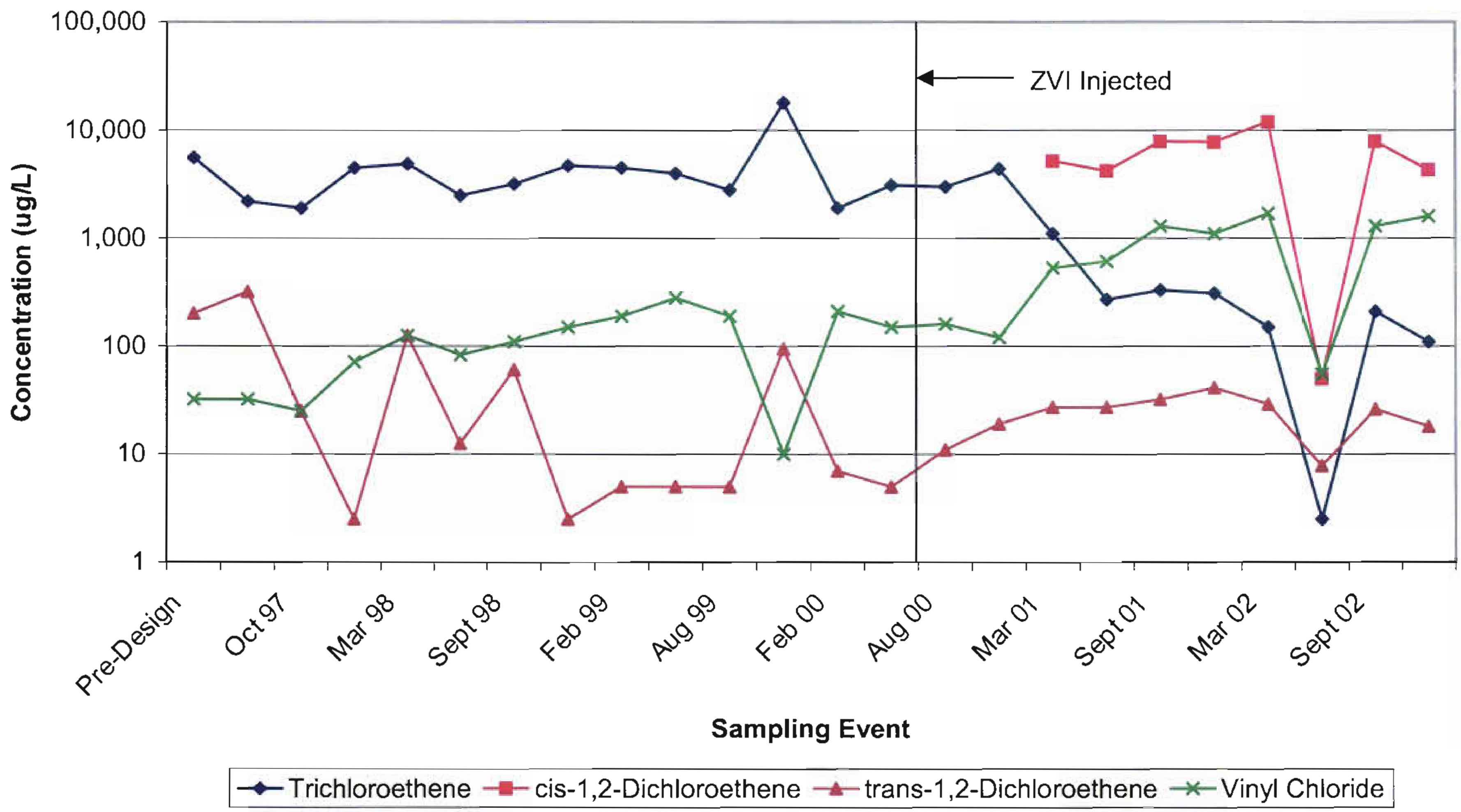


Figure 22
PZ-3D Headspace Vapor
CH4, H2, Ethylene

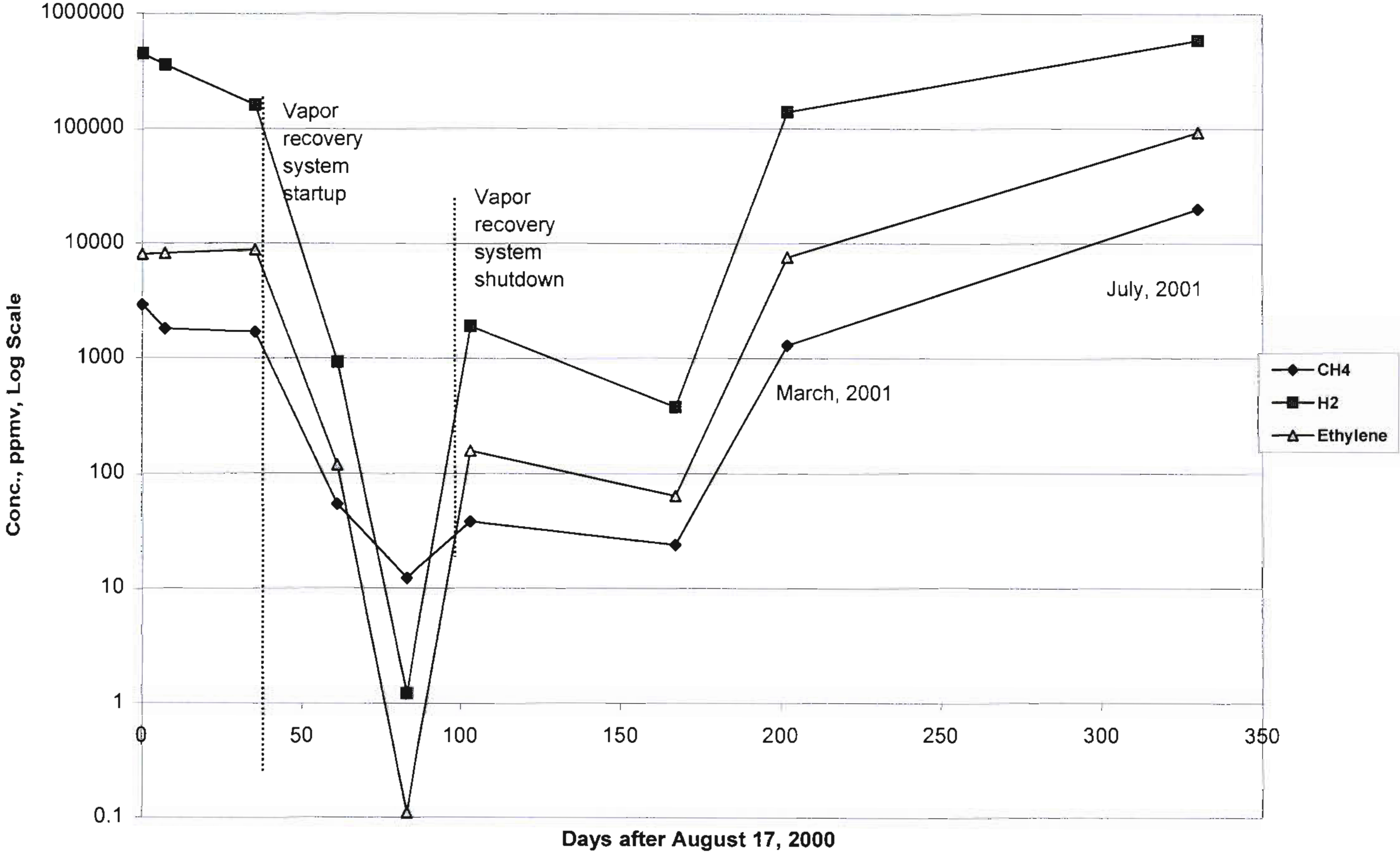


Figure 23
RW-2D Headspace Vapor
CH4, H2, Ethylene

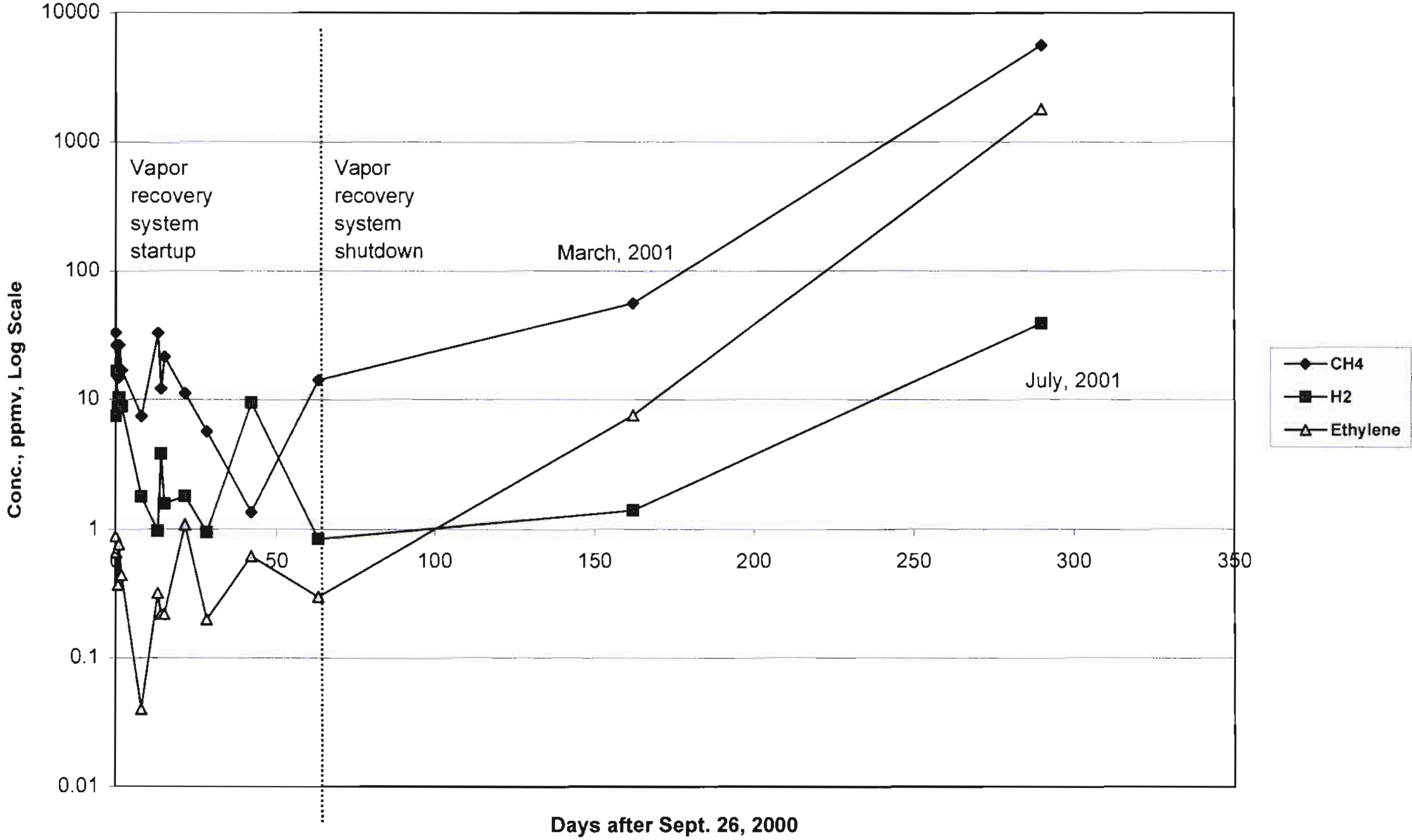
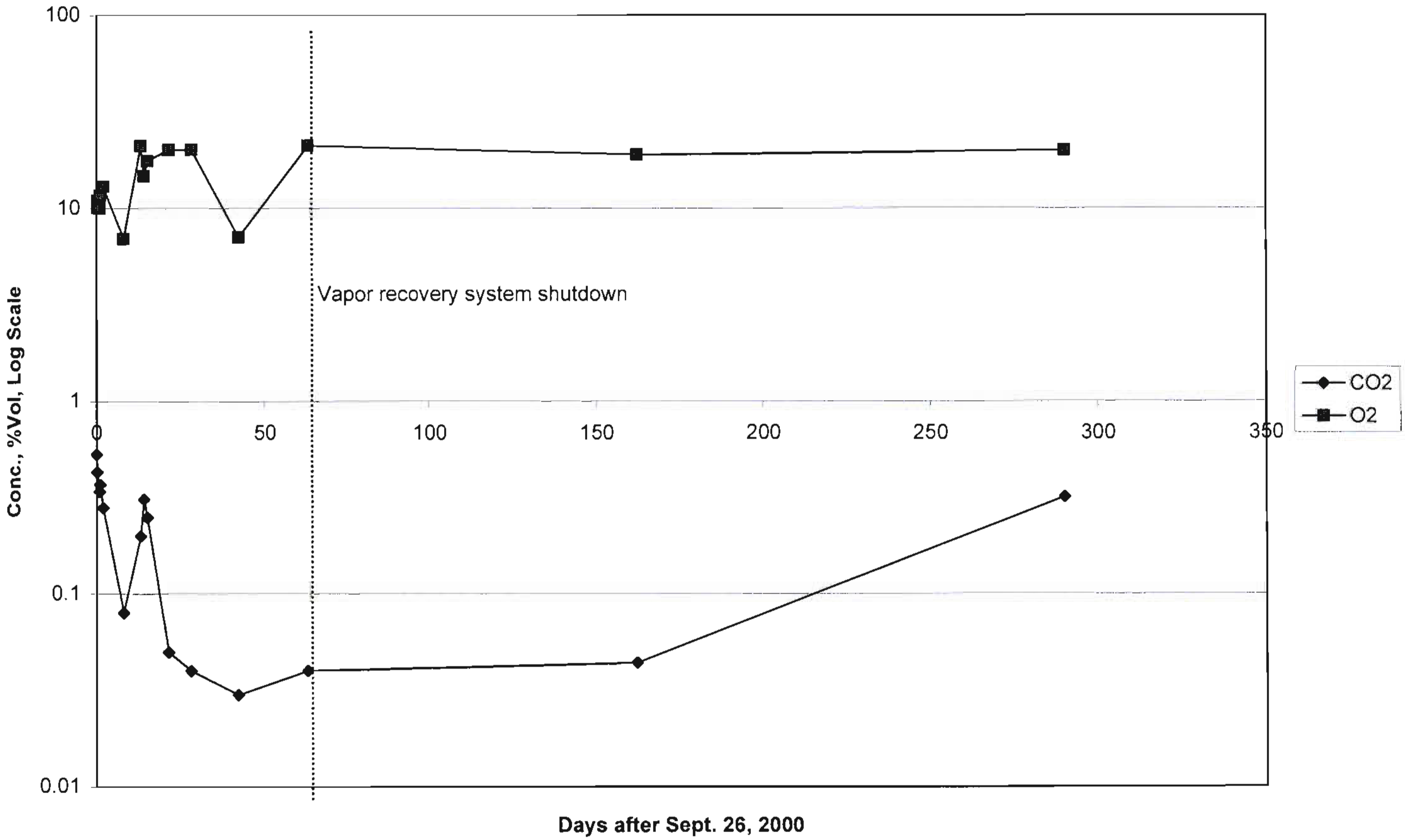


Figure 24
RW-2D Headspace Vapor
CO2, O2



Appendix A
Site Background and Subsurface Conditions

APPENDIX A
SITE BACKGROUND AND SUBSURFACE CONDITIONS

Remedial actions were initiated at the Essex/Hope Inactive Hazardous Waste Site in 1997 as required under a NYDEC Record of Decision (ROD) and subsequent Consent Order. These actions include groundwater pumping and air sparging, soil vapor extraction, and onsite groundwater and vapor treatment. The primary contaminants of concern are volatile organic compounds (VOCs). The site is currently in the operations stage of the remedial action. The site has been divided into three subareas based on the physical conditions of the area and the type of contaminant source (See Figure 1). These include the following:

- North Parking Lot Sump (NPLS) Area
- Aboveground Storage Tank (AST) Area
- Underground Storage Tank (UST) Area

The PRB Pilot Test was conducted in the NPLS Area of the site. An interim report on the pilot testing, *PRW Pilot Test Results for First Four Sample Rounds, February, 2001*, summarized the initial results of the testing and was submitted to NYDEC.

Considerable data has been generated on the performance of the remedial action and it's effectiveness in treating groundwater and soil contamination. URS has performed quarterly and annual groundwater monitoring and a series of supplemental site investigations have also been performed. The most recent monitoring report was the *2001 Annual Performance Monitoring Report* submitted to NYDEC in March, 2002. The annual reports are not summarized herein but some of the data collected within and adjoining the pilot test areas is included in this report. All background data is included in Appendix A.

The two recent supplemental investigations that provided further data on the site are briefly summarized in the following sections.

SUPPLEMENTAL SITE INVESTIGATIONS, NOVEMBER, 1999 THROUGH FEBRUARY, 2000, AND JUNE, 200 MEETING WITH NYDEC

URS (as Radian International) conducted a supplemental site investigation from November, 1999 through February, 2000 to obtain additional data for the evaluation of alternative technologies that may be considered as cost-effective upgrades or modifications to the existing remedial actions. The work included the installation of temporary groundwater monitoring points (GPs) in the NPL Area and within Building No. 5, collection and laboratory analysis of subsurface soil samples in and around the NPL Area, and groundwater sampling and analysis of select existing groundwater monitoring wells as well as new temporary monitoring points. The data is summarized in the report: *Supplemental Investigations for Systematic Application of Advanced Remedial Technologies (SMAART) Evaluations, May, 2000*. URS reviewed the investigation findings and identified a potential alternative approach to the existing remedial action that included natural attenuation and a passive PRB barrier for groundwater treatment. The alternative action was proposed as a more cost-efficient approach that would also improve containment and treatment of the groundwater contaminants.

The May, 2000 report presented site data on natural attenuation (NA) parameters throughout the site and provided more data on groundwater conditions in the proposed area for the Permeable Reactive Barrier (PRB) Pilot Test. URS met with NYDEC on June 13, 2000 to review the report findings and outline proposed site actions. Four major areas were discussed at the meeting, including:

- Additional investigations around the area of MW-19D (east of Plant Building #5) to delineate the source and extent of vinyl chloride in the deep groundwater zone,
- Implementation of the PRB Pilot Test in the NPL Area.

The first item was addressed in the subsequent investigations conducted from July through October, 2000. The PRB Pilot Testing was initiated in July 2000.

PLANT #5 EAST AREA AND UST AREA INVESTIGATIONS, JULY THROUGH OCTOBER, 2000

URS implemented further investigations at the site as a result of the June, 2000 meeting with NYDEC. Test borings and groundwater piezometers were installed in the east and southeast area of Plant # 5 to evaluate potential sources for the vinyl chloride detected in MW-19D. The borings were located to evaluate chemical and hydrogeologic conditions within the Lower Water Bearing Zone (LWBZ) along the eastern and southern perimeter of Plant # 5, the former above ground storage tank (AST) area at the east portion of the site, and the eastern downgradient location near shallow Monitoring Well MW-18 along Hopkins Avenue.

URS also installed vapor probes (VPs) in the deep water-bearing zone as part of the ongoing PRB Pilot Testing, which started in July 2000. These probes were placed at the site perimeter to monitor potential migration of gases generated from the ZVI injections. Two of the probes were installed in the UST and Plant # 5 East Areas, VP-6S/6D and VP-7D. Groundwater samples were taken from the probes to provide additional data for the UST/Plant # 5 Area Investigations.

The test boring and piezometer installations were performed from July 31 through August 7, 2000. The deep vapor probes were installed in October 2000. The results of the these investigations are contained in the *Plant #5 East Area and UST Area Investigations Report, March, 2001.*

GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS

This section presents a summary of the hydrogeologic and groundwater contamination conditions at the site to provide a background for the descriptions of the pilot testing, and present the groundwater contamination conditions prior to the start of the pilot testing (baseline conditions). Detailed descriptions of the site subsurface conditions, including test boring and monitoring well construction logs, can be found in the reports referenced in Sections 2.1 and 2.2. Monitoring wells, recovery wells, piezometers and deep vapor probe locations are shown on Figure 1.

Hydrogeologic Conditions

The site geologic profile of interest ranges from approximately 0-50 ft below ground surface. This interval, as defined by the previous Remedial Investigations (O'Brien & Gere, 1992 and 1993) and the Basis of Design Investigation (Radian 1995), consists of two separate water-bearing zones, an upper unconfined water-bearing zone and a lower semi-confined water-bearing zone. These have also generally been referred to as the "shallow" and "deep" water-bearing zones. An upper semi-confining layer, generally described as a clayey silt, separates the two water-bearing zones. A thick clayey confining layer occurs at the base of the lower water-bearing confined zone. The geology of the upper water-bearing zone is composed of silty, sandy gravel with occasional clayey fine sand and ranging in thickness between 11 and 16 feet. The upper semi-confining layer ranges in thickness between less than 2 to 9.5 feet across the site. The lower semi-confined water-bearing zone occurs within a fine sandy silt to silty fine sand unit with a thickness between approximately 17 and 28.5 feet.

The upper semi-confining layer, generally consisting of silt grading to clay, was encountered at all test boring locations and ranged in thickness between less than 2 to 9.5 feet. This layer is thickest beneath Plant #5 and the UST Area and thins towards the north, east and south of this area. The structure formed by the top of the upper clay consists of a trough and ridge across the site area. The trough occurs within the NPL Area and extends toward the east. The trough is generally oriented northwest by southeast and dips toward the southeast. A ridge occurs within the UST Area oriented east to west. The top of the upper clay surface dips toward the northeast, east, and southeast from the crest of the ridge in this area. A contour map of the top of the upper semi-confining layer across the site is presented as Figure A-1. An isopach map illustrating the thickness of the layer is provided as Figure A-2.

The lower water-bearing zone is consistent across the site and is composed of fine sandy silt to silty fine sand with occasional clay laminations. The thickness of this unit ranged between approximately 16 to 23 feet in the UST Area and the area east of Plant #5.

Groundwater contour maps of the shallow water-bearing zone and deep water-bearing zone are provided as Figures A-3 through A-6. Figures A-3 and A-4 illustrate groundwater contours under static (non-pumping) conditions measured in January 2001. Groundwater contours representing normal pumping conditions in September 2000 within the upper and lower water bearing zones are provided as Figures A-5 and A-6. Static flow conditions occurred up to July 1997, when the remedial actions started and the recovery wells began operation. The recovery wells have been operating continuously, with only intermittent short shutdowns of less than 1 week, since their startup in 1997. The site has been under pumping conditions since late 1997 up to the issuance of this report. Pumping is expected to continue indefinitely until groundwater cleanup objectives are met.

Groundwater within the shallow zone generally is encountered at approximately 7 feet in depth below ground surface. As depicted in Figure A-3, groundwater flow direction from the AST/UST and NPL Areas is toward the northeast under static conditions. A groundwater divide exists within the UST Area, with groundwater flowing toward the northeast, east and southeast directions from this area under static conditions. Groundwater flow under pumping conditions within the shallow water-bearing zone is illustrated in Figure A-5. In the NPL Area, the effects of hydraulic leakage through the upper semi-confining layer by pumping in the lower semi-confined zone is evident by the cone of depression surrounding MW-11.

Groundwater flow direction within the deep water-bearing zone under static condtions is toward the northeast across the site area (Figure A-4). The cone of depression under normal pumping conditions is shown on Figure A-6. Groundwater flow lines indicate groundwater capture throughout the NPL Area extending beneath Plant #5 to the east and southeast to the UST Area.

The permeability of the water bearing zones has been estimated from previous investigations by the means of pumping tests and monitoring well slug tests. The permeabilities (k) of the groundwater zones have been estimated to be as follows:

- Shallow water-bearing zone- **k= 9.4 x EE-4 cm/sec = 2.66 ft/day**

- Deep water-bearing zone- T= 400 gal/ft/day and m=30 ft (**k=1.82 ft/day**)

Groundwater zone seepage velocity under pumping conditions

Groundwater seepage velocities (Vs) based on pumping conditions and hydraulic gradients at various time periods, with an assumed formation porosity of 0.30, are as follows:

Shallow Groundwater Zone-

September, 2000

- GP2S to GP1S (hot spot pilot test area, i=0.032)– **Vs = 2.79 ft/day**
- MW-7 to RW-2S (PRW pilot test area) -Data insufficient

December, 2000

- GP2S to GP1S (hot spot pilot test area, i=0.029)– **Vs = 2.55 ft/day**
- MW-7 to RW-2S (PRW pilot test area) –Data insufficient

April, 2001

- GP2S to GP1S (hot spot pilot test area, i=0.026)– **Vs = 2.29 ft/day**
- MW-7 to RW-2S (PRW pilot test area, i=0.206) –**Vs = 18.17 ft/day**

Deep Groundwater Zone-

September, 2000

- GP2D to MW-7D (hot spot pilot test area, i=0.042) – **Vs = 0.25 ft/day**
- MW-7D to RW-2D (PRW pilot test area, I=0.397)– **Vs = 2.41 ft/day**

December, 2000

- GP2D to MW-7D (hot spot pilot test area, i=0.08)– **Vs = 0.49 ft/day**
- MW-7D to RW-2D (PRW pilot test area, I=0.923)– **Vs = 5.60 ft/day**

April, 2001

- GP2D to MW-7D (hot spot pilot test area, i=0.031) – **Vs = 0.19 ft/day**
- MW-7D to RW-2D (PRW pilot test area, I=0.767)– **Vs = 4.7 ft/day**

Plant No. 5 Pilot Test Area- The data shows that the seepage velocities in each groundwater zone vary both at the pilot test locations and over the time period of the pilot tests. For the pilot test area in Plant #5, the **shallow zone mean seepage velocity is 2.54 ft/day** and is relatively constant over time. The **deep zone mean seepage velocity is 0.31 ft/day** and varies considerably more than the shallow zone, likely a result of the variations in the RW-2D pumping rates.

PRB Pilot Test Area- The shallow zone mean seepage velocity in the PRB pilot test area cannot be estimated because of insufficient data on recovery well water levels. One data point in April, 2001 has a velocity of 18.17 ft/day. The site-wide **deep zone mean seepage velocity is 4.24 ft/day** and varies similar to the deep zone in the hot spot test area. Of significant note is that the seepage velocities in the PRB pilot test area are approximately one order of magnitude greater than the velocities in the hot spot test area as a result of the proximity of the PRB test area to the recovery wells (RW-1D and RW-2D) and the steeper groundwater gradients.

Groundwater Chemical Characteristics –Historic Pre-Pilot Conditions

Site groundwater has been sampled for various chemical constituents since the initial Remedial Investigations were started in 1991. Groundwater is currently sampled quarterly and annually as part of the remedial action performance monitoring program. This section describes the pre-pilot test groundwater conditions that existed prior to July, 2000. It is noted that the initial sampling of groundwater monitoring points for the pilot test was conducted in July, 2000, prior to ZVI injection. This sampling has been referred to as the "baseline" sampling, and is distinguished from the historic pre-pilot conditions described herein.

Volatile Organic Compounds

Site groundwater contamination has historically been characterized by the presence of volatile organic compounds (VOC), primarily trichloroethylene (TCE), dichloroethylene (DCE) compounds, vinyl chloride, and toluene, ethylbenzene and xylenes (TEX). The chlorinated compounds are generally located within and downgradient of the NPLS Area. The historical downgradient area is to the northeast based on the pre-remediation groundwater flow direction. A remnant VOC plume is present in this area, mainly beneath the Plant #5 building. TEX compounds have been found primarily in the UST and AST Areas. Since remedial actions commenced in 1996, groundwater flow has been influenced by recovery well pumping and hydraulic gradients are towards the site recovery wells.

The primary period of interest for the pre-pilot test background data is from July, 1997 through June, 2000. This is the period between the completion of the remedial action construction and the start of the PRW pilot test. A summary of groundwater monitoring data in the NPL Area over this period is contained in Table A-1. Historically, the primary detected VOCs were TCE, DCE compounds and vinyl chloride. It is noted that analytical results for DCE over this period were reported for the compounds 1,2 DCE (total) and trans-1,2 DCE only. Cis-1,2 DCE was not included in the lab analyses until after the start of the pilot testing. Figures A-7 through A-10 present TCE and vinyl chloride groundwater distributions for the most recent background sampling period, November, 1999 and February, 2000.

The data summary in Table A-1 and Figures A-7 through A-10 provides some general indications of pre-pilot test groundwater conditions:

- In the NPL Area shallow groundwater zone, TCE has the highest mean concentrations, followed by DCE compounds and VC. For the deep zone, TCE also has the highest mean concentrations, however, VC mean concentrations are higher than the DCE compounds. This relative difference in VC versus DCE concentrations indicates a greater rate of DCE breakdown (biological and chemical) in the deep zone, resulting in higher VC relative to DCE. Another consideration is the absence of cis-DCE analyses for the deep zone, which from later pilot test data has been found to be significant and indicates enhanced biological breakdown of TCE. Because of the lack of cis-DCE data , it is likely that the relative concentrations of the key VOCs are similar in both groundwater zones despite the historical differences shown in Table 1. Pilot test data reported in Section 3.0 of this report confirm the similarities in the VOC by-product ratios for each groundwater zone.

- The deep groundwater zone generally has higher mean VOC levels than the shallow zone. The highest VOC levels are in the vicinity of RW-2D and MW-7D, on the north end of the NPL Area. **This condition was used as the basis for selecting this area for the PRB injected wall pilot test.**

- Temporary groundwater monitoring points installed in 1999 by the Geoprobe drilling method (GPs), directly east of the NPL Area beneath the CPM Plant #5 building, indicated that significant TCE is present in the deep water-bearing zone. Of note is that the soil samples taken during the GP installation have TCE levels 1-2 orders of magnitude greater than the groundwater samples taken from the corresponding monitoring points at each location. For example, GP-1D TCE concentration was 1200 ug/l in groundwater and 160,000 ug/kg in soil. The relatively low TCE level in the water phase is not consistent with the typical soil-water distribution ratios for TCE. A soil TCE concentration of 160,000 ug/kg under equilibrium conditions with groundwater would equate to a groundwater concentration of 286,000 ug/l. (See Table 2 for an estimate of equilibrium groundwater concentrations based on the soil sample analyses). This TCE discrepancy at the GP wells suggests one or more of the following conditions:

1. DNAPL TCE is present in the deep water-bearing zone, likely as microspherical particles heterogeneously distributed throughout the deep zone. The GP wells, which are 1-inch diameter casings with screened intervals of 5 feet in length, are not representative of the entire thicker deep water-bearing zone and may not encounter local DNAPL zones. The GP wells were screened at depth intervals near the soil sample intervals, but not exactly at the same interval.

2. The GP's were not fully developed and the February, 2000 groundwater samples are not representative of the deep zone screened interval. A sample taken later from GP-1D (as PZ-3D) in July, 2000, prior to the start of the ZVI injections, had a TCE concentration of 135,500 ug/l. This result confirms the high levels of TCE expected in groundwater with formation soils containing high TCE levels found in the GP soil samples.

The elevated TCE found in the deep zone soil samples beneath the western area of Plant #5, and expected to be present in groundwater, were the basis for selecting this area for the PRB bulk injection pilot test.

General Water Quality Parameters

General water quality parameters include cation/anions and chemical indicators of VOC breakdown. The historic pre-pilot test groundwater quality analyses in the NPL Area is summarized on Table 3. These parameters have been analyzed only for samples taken in November, 1999 and February, 2000, much less frequently than VOC analyses over the history of the site. **It is noted that upgradient (background) water quality has not been established since upgradient wells were not sampled for the water quality parameters.** The water quality data supports the contention that NPL groundwater is undergoing VOC degradation under natural attenuation conditions.

The data summary in Table A-3 provides some indications of pre-pilot test groundwater quality:

- **Chloride-** Chloride is an indicator of natural water quality and the degree of chlorinated VOC reduction. TCE will ultimately degrade to produce chloride ions at the ratio of 1 mole of TCE to 3 moles of chloride, or a mass ratio of 106.4g TCE to 131.4g Cl (0.81:1). Similar ratios can be calculated for DCE and VC. Molar equivalent chloride concentrations have been calculated for the historic mean VOC concentrations found at each NPL Area monitoring point. The values are shown on Table A-1. The equivalent chloride concentrations are the stoichiometrically-based levels calculated from the total chlorinated VOCs in the groundwater. These values provide a general indication of the degree of VOC degradation that has occurred at the site.

  Shallow Groundwater Zone Chloride- Generally, the mean chloride levels in the shallow groundwater zone of 16.7 mg/l are one order of magnitude greater than the equivalent chloride levels for VOC reduction. This indicates that sufficient chloride is present to account for complete VOC reduction, however, the relatively low mean chloride level is likely representative of background chloride levels since equivalent VOC levels (>10 mg/l) were never present historically in the shallow zone to produce these chloride levels. Since background (upgradient) chloride levels have not been established for the site, the portion of the chloride generated from VOC reduction cannot be accurately estimated.

  Deep Groundwater Zone Chloride- The data indicates that the mean chloride level of 33.8 mg/l in the deep zone is on average about twice as high as the shallow groundwater zone. This is consistent with the higher VOC levels in the deep zone, and the potential for greater degradation of VOCs to chloride. Generally, the mean chloride levels in the deep groundwater zone are approximately 15% of the estimated equivalent chloride levels for complete VOC reduction based on the maximum VOC levels found in the deep zone (286 mg/l TCE at GP-1D). Since background (upgradient) chloride levels have not been established for the site, the portion of the chloride attributable to VOC reduction cannot be accurately estimated. If the shallow zone mean chloride level of 16.7 mg/l is assumed to be the site background level, then the remaining 17.1 mg/l of chloride in the deep zone can be estimated for the amount associated with VOC reduction. This chloride level would equate to the complete reduction of approximately 14,000 ug/l TCE. The VOC data summarized in Tables 1 and 2 indicate that historic deep zone TCE has been found at levels significantly greater than 14,000 ug/l, indicating that TCE reduction has not been completed. At a chloride level of 17.1 mg/l, TCE reduction is estimated to be approximately 5-10% complete in the deep groundwater zone.

- **Nitrate-** Nitrate analyses provides an indication of the degree of biodegradation since nitrate is a competing electron acceptor for anaerobic bioactivity if oxygen is depleted. Mean nitrate levels are near detection limits (0.01 mg/l) in the deep zone compared to an average of 6.4 mg/l in the shallow zone. Nitrate concentrations must be less than 1.0 mg/l for reductive dechlorination to occur. The data supports the indications that natural biodegradation of VOCs is occurring in the deep water-bearing zone.

- **Sulfate-** Sulfate analyses provides an indication of the degree of biodegradation since sulfate is a competing electron acceptor for anaerobic bioactivity if oxygen is depleted, similar to nitrate. Mean sulfate levels in the deep zone are about 50% of the levels in the shallow zone. This supports further the indications that natural biodegradation of VOCs is occurring in the deep water-bearing zone.

- **Ferrous Iron (Fe +2)-** Ferrous iron (Fe II) analyses provides an indication of the degree of biodegradation since it is the reduced state of ferric iron (Fe III), which is a competing electron acceptor for anaerobic bioactivity if oxygen is depleted, as are sulfate and nitrate. The presence of Fe (II) above 1 mg/l provides an indication of reducing conditions in the groundwater favorable to reductive dechlorination. The data show that Fe (II) levels are below 1 mg/l in all wells except in the area of the Plant #5 building, where Fe (II) levels are at or slightly above 1.0 mg/l.

- **Total Organic Carbon-** TOC is used as an indicator of the presence of available organic carbon necessary for anaerobic biodegradation.

- **Methane, ethane and ethene-** Methane in groundwater suggests the degradation of BTEX via methanogenesis. Methanogenesis generally occurs after oxygen, nitrate and sulfate have been depleted from the groundwater zone. Ethane and ethene are biodegradation products of PCE/TCE. In general, reductive dechlorination occurs in sequence from TCE to DCE to VC to ethene to ethane. This sequence may be modified if residual VC is oxidized. In that case, VC breaks down to carbon dioxide and ethene is not produced.

  The data indicates that mean methane levels are greater in the deep zone relative to the shallow zone. The sample for GP-4D had a methane level of 560 ug/l, which is an outlier result that skews the deep zone mean concentration much higher. Historically, BTEX has not been found in the NPL Area (see Table 1) and thus the

BTEX source of methane production is questioned. Further, sulfate is present in the deep groundwater zone at concentrations greater than 20 mg/l, which is generally indicative of methanogenic inhibition. This supports the contention that BTEX is not the methane source. At this time, the presence of methane in groundwater is suspected to be from another unknown source. Ethane and ethene levels are both low in each groundwater zone and ethane is generally slightly higher in concentration in each zone. ORP data in the deep groundwater zone confirm that reducing conditions are present and VC reduction to ethene is likely. These relatively low ethane/ethene concentrations compared to the mean VOC levels in NPL groundwaters suggest that the dechlorination process is not complete.

- **Oxidation-reduction Potential (ORP)-** ORP is a measure of the oxidative or reductive state of the groundwater. A negative ORP (reducing conditions) indicates that groundwater is either amenable to or is undergoing reductive reactions, which are generally biological. The specific reducing mechanism (nitrate, Fe (III), sulfateor methanogenic) is not discernable from the ORP measurements. The ORP data indicates that the shallow groundwater zone is in the oxidized condition, and the deep groundwater zone is generally under reducing conditions. This further supports the conclusion that the deep groundwater zone is conducive to reductive dechlorination and VOCs have been undergoing biodegradation.

OPERATING REMEDIAL ACTION

Remedial actions have been operating at the site since the fourth quarter of 1997. In the NPL Area, groundwater has been pumped from the shallow and deep zones, and air sparging/vapor extraction has been operated in the shallow zone. Details on the operations and performance can be found in the Annual Performance Monitoring Reports which are submitted to NYDEC in the first quarter after the operating year. The year 2001 report was submitted to NYDEC on March 29, 2002. The reports contain considerable data on groundwater flow conditions, water quality, and soil chemical constituents, which is not summarized in thisreport. Data most pertinent to the PRW Pilot Test performance involves the groundwater flow and pumping conditions in the NPL Area during the pilot test. A summary of the remedial operations in the NPL Area is contained on Table A-4.

The only remedial component in operation in the NPL Area during the PRW Pilot Test was the pumping of recovery wells RW-1S, RW-2S and RW-1D. RW-1D was shutdown in June, 1999 and the vapor extraction and air sparging systems in the shallow zone were shutdown in July, 2000, prior to the start of the pilot testing. The NPL vapor extraction system and a supplemental vapor recovery system were operated from September to November, 2000 to contain and remove vapors generated as part of the PRW pilot test. Details on the vapor monitoing and recovery are contained in Appendix C of this report.

The shallow and deep zone recovery wells operated almost continuously during the PRW Pilot Test. These wells were designed to contain groundwater migration and remove contaminated groundwater. The shallow and deep groundwater zones were both under pumping conditions during the pilot test, and groundwater flow was towards the pumping wells. Groundwater flow directions in the shallow and deep zones are shown on Figures A-5 and A-6, respectively.

Year 2000 Operations

Recovery wells RW-1S and RW-2S extracted a combined total of approximately 294,700 gallons of groundwater from the **shallow zone** during 2000. The highest groundwater yields occurred during the 1st and 2nd quarters of 2000 at 86,500 and 108,600 gallons extracted respectively. The lower groundwater yield during the 3rd quarter (52,400 total gallons) is related to decreased infiltration from precipitation events and recovery well down time during the installation of the PRW Pilot Test system. Groundwater yield from the NPL Area shallow zone was further decreased during the 4th quarter (46,500 total gallons) during gas monitoring and evaluation activities related to the PRW pilot testing that occurred throughout this period. The pumping rate from deep zone recovery well RW-2D was increased to between 4 and 6 gallons per minute (gpm) during this period to de-water the deep water-bearing zone in the vicinity of the pilot PRW as part of a gas extraction test. The increased groundwater extraction in the deep zone increased the leakage from the shallow unconfined aquifer and caused a resultant de-watering of the upper zone in the NPL Area. This resulted in a reduction of the saturated thickness in the shallow zone.

Groundwater was extracted from the **deep zone** in the NPL Area from RW-2D during the 2000 operational year. Pumping was discontinued at RW-1D in June of 1999 with the approval of the NYSDEC. Approximately 1,505,600 gallons of groundwater was extracted from the deep zone through RW-2D during 2000. Approximately 316,900 gallons of groundwater was extracted during the 1st quarter and 350,600 gallons during the 2nd quarter. Pumping was temporarily stopped at RW-2D between July 12, 2000 and July 29, 2000 during drilling activities related to the Pilot PRW installation in the NPL Area. Total groundwater extracted during the 3rd quarter was 284,300 gallons. The most groundwater extracted from the deep zone occurred during the 4th quarter (553,800 gallons) where the extraction rate at RW-2D was increased as part of the subsurface gas extraction test conducted as part of the PRW pilot testing. The pumping rate from RW-2D was increased from approximately 2.5 gpm to 6.5 gpm on September 26, 2000, with an average pumping rate of approximately 4 gpm over the 4th quarter.

The pumping rate from RW-2D was decreased to the normal rate of 2.8 gpm on January 17, 2001, after the completion of the gas evaluation.

Year 2001 Operations

Recovery wells RW-1S and RW-2S extracted a combined total of approximately 251,800 gallons of groundwater from the **shallow zone** during 2001. Groundwater extraction ranged between approximately 63,400 and 72,900 gallons per quarter for the first three quarters of 2001, with the highest flows occurring in the 2nd Quarter. Total groundwaterextracted during the 4th Quarter 2001 was lower at approximately 48,400 gallons primarily due to pumping down time during this period.

During 2001, groundwater was extracted from the **deep zone** in the NPL Area only from RW-2D. A total of approximately 884,900 gallons of groundwater was extracted from the deep zone through RW-2D during 2001. A lower groundwater removal rate from RW-2D was experienced during 2001 as compared to previous years due to the buildup of precipitation on the well screen and formation. This enhanced precipitation is expected to be associated with the zero-valent iron injections around the well. Approximately 341,300 gallons of groundwater was extracted during the 1st Quarter. Groundwater yield slowly diminished with approximately 213,300 gallons removed during the 2nd Quarter followed by 129,500 gallons for the 3rd Quarter. After well rehabilitation in the 3rd Quarter (discussed below), groundwater extraction increased to approximately 200,700 gallons during the 4th Quarter.

The average steady state extraction rates from the deep zone by Quarter during 2001 was as follows: 1st Quarter (2.82 gpm); 2nd Quarter (1.76 gpm); 3rd Quarter (1.03 gpm); and 4th Quarter (1.72 gpm).

Recovery Well RW-2D was rehabilitated in October 2001 to remove precipitate buildup from the well and surrounding formation as reported in the 3rd Quarter 2001 Performance Monitoring Report. Through laboratory analysis for metals and visual observation, the precipitate was identified to be primarily iron hydroxide. A pumping test conducted in August 2001 defined the extent of the precipitate buildup to be within the immediate formation surrounding the recovery well. The recovery well and surrounding formation was acidified, with approval from the NYSDEC, using a solution of phosphoric acid and NuWell NW-310 acid enhancer to remove the precipitate buildup. Results of the rehabilitation increased the pumping rate from RW-2D from less than 0.5 gpm in September 2001 to a sustainable rate of approximately 2.2 gpm through the end of the year. Subsequent observations indicate that the precipitate continues to buildup on the well and within pumping equipment. The pump and discharge piping was cleaned out with a 3% phosphoric acid solution in November and

December of 2001. To date, no further rehabilitation of the well has been required. A history of Recovery well RW-2D pumping is contained on Figure A-11.

In neither case, for the shallow or deep groundwater zones, did the variations in recovery well flowrates over years 2000-2001 alter the basic groundwater flow directions in the areas of the PRW or Hot Spot Pilot Tests as shown on Figures A-5 and A-6. The variable pumping rates did, however, affect the amount of drawdown around the pumping wells, especially at RW-2D, which resulted in increased hydraulic gradients and seepage velocity in the vicinity of the PRW Pilot Test. The seepage velocity increases were not considered significant enough to compromise the VOC treatment capabilities of the PRW Pilot Test based on the original test design. (See Section 2.1 of this report for a summary of the pilot test design basis.)

Table A-1
Historic Pre-Pilot Test VOCs in NPL Area and PLant No. 5 Area
July, 1997 to June, 2000

Key Chemical Constituent	Shallow Zone Wells:								Deep Zone Wells:						
concentrations as ug/l	MW-6	MW-7S	RW-1S	RW-2S	GP-1S	GP-2S	GP-3S	GP-4S	MW-7D	RW-1D	RW-2D	GP-1D	GP-2D	GP-3D	GP-4D
Trichloroethylene															
Number of samples	3	3	13	13	1	1	1	1	4	13	13	1	1	1	1
Range of concentration	10-3100	8-160	<5-12,000	17-3700	28	12	<5	33	8-340,000	<1-38	1900-18,000	1200	670	<5	140
Mean concentretion (note 1)	1063	66	1389	1006	NA	NA	NA	NA	95,752	10.2	4454	NA	NA	NA	NA
Standard deviation	1764	82	3240	1108	NA	NA	NA	NA	163,188	10 8	4216	NA	NA	NA	NA
Coefficient of variation (sd/mean)	1.66	1 24	2.33	1 10	NA	NA	NA	NA	1 70	1 07	0 95	NA	NA	NA	NA
Trans 1,2 Dichloroethylene															
Number of samples	1	1	13	13	1	1	1	1	3	13	13	1	1	1	1
Range of concentration	<1	<1	<5-160	<1-130	<5	<5	<5	<5	29-64	<5-110	<5-320	<5	<5	<5	<25
Mean concentration (note 1)	1	1	24.7	32.4	NA	NA	NA	NA	51.3	23 9	69.3	NA	NA	NA	NA
Standard deviation	NA	NA	48.7	71 2	NA	NA	NA	NA	19.4	34.9	103 7	NA	NA	NA	NA
Coefficient of vanation (sd/mean)	NA	NA	1.97	2 20	NA	NA	NA	NA	0 38	1.46	1 50	NA	NA	NA	NA
1,2 Dichloroethylene (note 2)															
Number of samples	2	3	No Data	No Data	No Data	No Data	No Data	No Data	1	No Data	No Data	No Data	No Data	No Data	No Data
Range of concentration	<5-1100	<1-<10							6						
Mean concentration (note 1)	552	1							6						
Standard deviation	774	NA							NA						
Coefficient of vanation (sd/mean)	1.4	NA							NA						
Vinyl Chloride															
Number of samples	3	3	13	12	1	1	1	1	4	13	13	1	1	1	1
Range of concentration	<1- 8	<1-<10	<1-110	<1-6	<5	<5	<5	6	20-51	23-830	<20-280	<25	57	<5	320
Mean concentration (note 1)	5	1	16.1	5 5	NA	NA	NA	NA	37 8	237	137 4	NA	NA	NA	NA
Standard deviation	8	NA	28 8	6 4	NA	NA	NA	NA	15.3	231	84.1	NA	NA	NA	NA
Coefficient of vanation (sd/mean)	1.60	NA	1.78	1.18	NA	NA	NA	NA	0.40	0.97	0 61	NA	NA	NA	NA
BTEX (note 3)															
Number of samples	3	3	13	13	1	1	1	1	4	13	13	1	1	1	1
Range of concentration	<1-<5	<5-<10	<1-5	<1-20	<5	<5	<5	<5	<1-2	<1-23 (B)	<1-38	<5	29 (B)	<5	<5
Mean concentration (note 1)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	6 4	BDL	NA	NA	NA	NA
Standard deviation	NA	NA	NA	NA	NA	NA	NA	NA	NA	6 4	NA	NA	NA	NA	NA
Coefficient of vanation (sd/mean)	NA	NA	NA	NA	NA	NA	NA	NA	NA	1 00	NA	NA	NA	NA	NA
Equivalent Chloride, mg/l (note 4)	1.3	0.1	1 2	0.8					77.6	0 2	3.7				

Notes.
1. Reported detection limit values were used in the calculation of the mean and standard deviation
2. Total 1,2 DCE compounds, inc. trans, cis
3. Total BTEX inc. benzene, toluene, ethylbenzene and xylenes
4. Total equivalent chloride calculated from stoichiometric breakdown of TCE, DCEs and VC as follows Chloride= TCE(0 81)+DCE(0.73)+VC(0 57), where the factors are the molar mass ratios of the VOC to chloride on an equivalent weight basis (mg/l used)

Table A-2
Geoprobe (GP) Groundwater VOCs in Plant #5 Area
February, 2000 Samples, Adjusted Concentrations

Groundwater Concentrations Adjusted Based on Equilibrium with Soil Concentrations- Deep Zone

Compound	Soil-Water Distribution Ratio, Kd	Sample Locations: GP-1D (20-24 ft)			GP-2D (24-28 ft)			GP-3D (27-31 ft)		
		Cs, (1) ug/kg	Cw, (1) ug/l	Cwa, (2) ug/l	Cs, (1) ug/kg	Cw, (1) ug/l	Cwa, (2) ug/l	Cs, (1) ug/kg	Cw, (1) ug/l	Cwa, (2) ug/l
Tetrachloroethylene	0.83	39	<25	**44**	270	<5	**306**	12	<5	**14**
Trichloroethylene	0.37	160000	1200	**286225**	86000	670	**153846**	66000	<5	**118068**
cis 1,2 Dichloroethylene	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans 1,2 Dichloroethylene	0.18	<6	<25	BDL	11	<5	**26**	7	<5	**16**
Vinyl Chloride	0.06	29	<25	**85**	10	57	**29**	23	<5	**67**

Groundwater Concentrations Adjusted Based On Equilibrium with Soil Concentrations- Shallow Zone

Compound	Soil-Water Distribution Ratio, Kd	Sample Locations: GP-1S (8.6-12 ft)			GP-2S (8-8.5 ft)			GP-3S (10-12 ft)		
		Cs, (1) ug/kg	Cw, (1) ug/l	Cwa, (2) ug/l	Cs, (1) ug/kg	Cw, (1) ug/l	Cwa, (2) ug/l	Cs, (1) ug/kg	Cw, (1) ug/l	Cwa, (2) ug/l
Tetrachloroethylene	0.83	<6	<5	BDL	<6	<5	BDL	<6	<5	BDL
Trichloroethylene	0.37	8	28	**14.3**	6	12	10.7	7	<5	**12.5**
cis 1,2 Dichloroethylene	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans 1,2 Dichloroethylene	0.18	<6	<5	BDL	<6	<5	BDL	<6	<5	BDL
Vinyl Chloride	0 06	<6	<5	BDL	<6	<5	BDL	<6	<5	BDL

Soil-Water Distribution Ratios, Kd, for Volatile Organic Compounds

Compound	Solubility, S, (3) mg/l average	Organic Carbon Partition Coefiicient, Koc (4) L/kg range	average	Kd (3)
Tetrachloroethylene	827	209-359	267	**0.83**
Trichloroethylene	1100	87-150	120	**0.37**
cis 1,2 Dichloroethylene	3500	49-80.2	64.6	**0.20**
trans 1,2 Dichloroethylene	6300	36-80.2	58.4	**0.18**
Vinyl Chloride	1932	0.4- 56	19.6	**0.06**

Notes:

1. GP monitoring points-Cs, soil concentration and Cw, groundwater concentration, from SMAART Submittals to NYDEC, Tables 3 and 9, February, 2000
2. Soil Conc., Cs = 0.7 (Csa) + 0.3 (Cwa) and
   Cwa = Csa/Kd
   where Csa = adjusted soil conc.
   Cwa = adjusted groundwater conc.
   assuming soil sample water content = 30% (0.3)
3. Ref: USEPA Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater, EPA/600/R-98/128, Sept., 1998, Tables B.2.1 and B.2.2
4. Kd = Koc x Foc, where Foc is the total organic carbon content of the aquifer soil sample = 3087 mg/kg average conc. (0.0031), Ref: Essex Jamestown SMAART Submittals, Table 9 Soil Sample Analytical Results, 2/00

Table A-3
Historic Pre-Pilot Test Water Quality Analyses in NPL Area
November, 1999 and February, 2000 (see Note 1)

Chemical Parameter	Shallow Zone Wells:								
concentrations mg/l unless otherwise indicated	MW-6	MW-7S	RW-1S	RW-2S	GP-1S	GP-2S	GP-3S	GP-4S	mean
Chloride	53.3	9 83	9 32	40.2	5.67	4.27	3.43	7 81	16.7
Nitrate	8.76	16.2	12.2	11 8	0 56	0.47	0 52	0.86	6.4
Sulfate	97.5	43.3	96 4	104	96 1	85.1	17.3	76.4	64.8
Total Organic Carbon (TOC)	2.3	1 5	1.9	3.3	2.6	6 3	16.9	6.1	5.1
Methane, ug/l	<0.6	0 6	<0.6	<0 6	2.2	41	26	<1	8.7
Ethane, ug/l	<1 2	<1.2	<1 2	<1 2	<1.2	2.00	<1.2	<1 2	0.3
Ethene, ug/l	<1.1	<1.1	<1 1	<1 1	<1.1	<1.1	<1 1	<1.1	<1.1
Calcium	ND	ND	ND	ND	36 5	89.4	134.0	99.2	89.8
Magnesium	ND	ND	ND	ND	6 6	25.2	12.5	51.8	24.0
Potassium	ND	ND	ND	ND	<5	9.4	11 5	31.3	13.1
Sodium	ND	ND	ND	ND	49 7	102 0	6.2	10.9	42.2
Ferrous Iron +2 (note 2)	0	0	0	0	0 4	1 6	0.6	0 2	
ORP, mV (note 2)	ND	28 5	56.8	28.90	147.0	63.0	88.0	73.0	69.3
[redacted]	7 51	7.9	7.83	7.40	6 7	7.6	7 2	7.9	7.5
Conductivity, mS/cm (note 2)	1382	407	6.9	9 39	0.9	0.6	0.4	0.3	

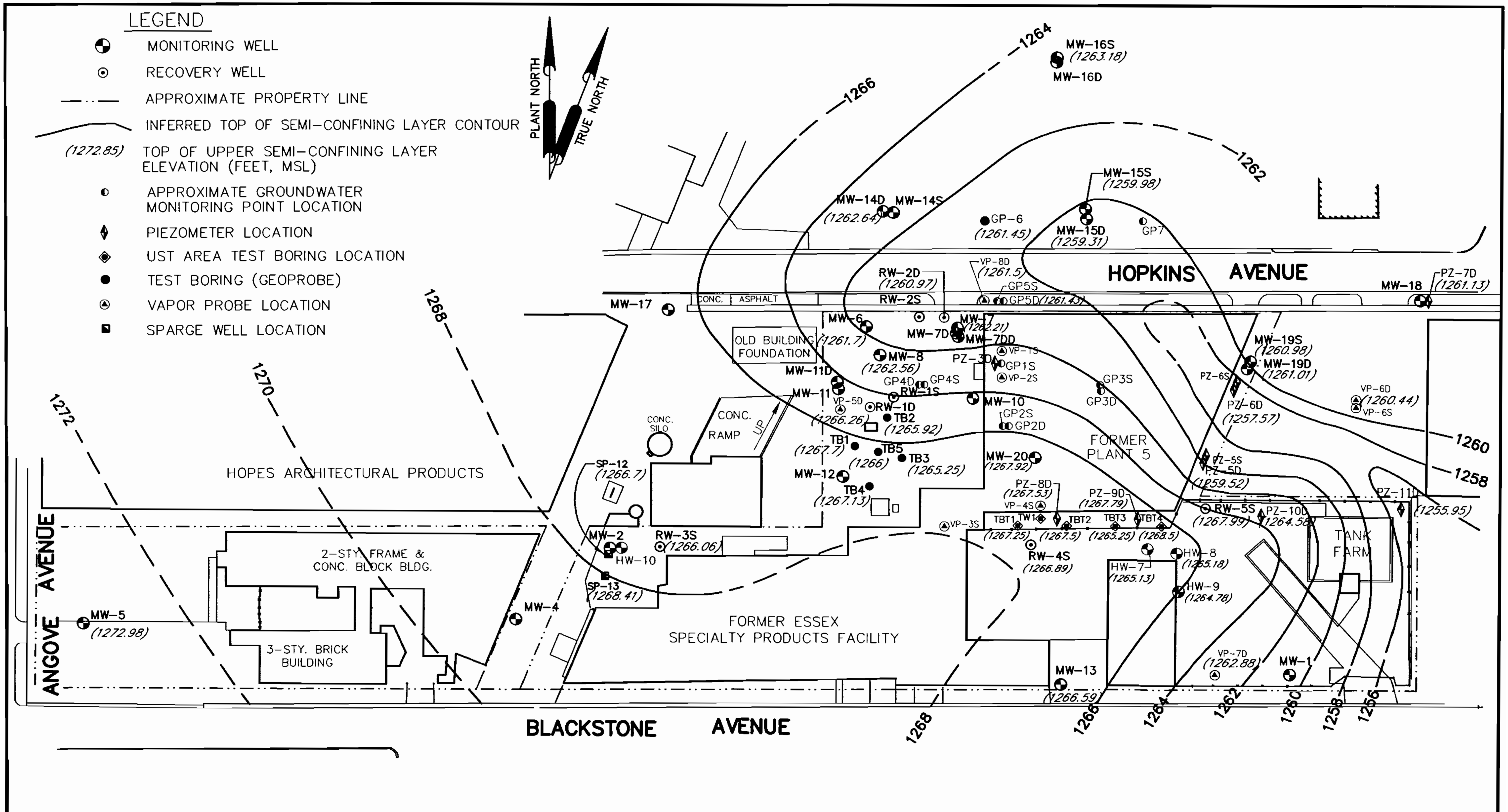
Chemical Parameter	Deep Zone Wells:							
concentrations mg/l unless otherwise indicated	MW-7D	RW-1D	RW-2D	GP-1D	GP-2D	GP-3D	GP-4D	mean
Chloride	34 6	17.4	35	80 4	27.6	24	17.9	33.8
Nitrate	0 08	<0.05	<0.05	0.37	0.17	0.22	0.16	0.1
Sulfate	57.2	31 7	60 5	46	16.9	38 5	27.9	39.8
Total Organic Carbon (TOC)	4	3	2.2	27.5	6	5.7	5 6	7.8
Methane, ug/l	31	30	2.7	3 6	68	21	560	102.3
Ethane, ug/l	<1.2	5	<1.2	<1 2	3 20	2.20	5.20	2.2
Ethene, ug/l	<1 1	<1 1	<1 1	<1 1	<1 1	<1.1	<1.1	<1.1
Calcium	ND	ND	ND	760.0	1040 0	74 6	68 4	485.8
Magnesium	ND	ND	ND	495 0	236 0	23.0	13 2	191.8
Potassium	ND	ND	ND	62.0	41 7	13.5	5 4	30.6
Sodium	ND	ND	ND	49 7	26.8	37.6	49 3	40.9
Ferrous Iron +2 (note 2)	0.2	0	0	1.0	0.4	1 2	0.2	
ORP, mV (note 2)	35.6	86 2	-109.80	-289 0	6 00	-16 0	-25 0	-44.6
[redacted]	7 93	8 13	7.60	8 5	8 97	10.5	8.7	8.6
Conductivity, mS/cm (note 2)	1138	919	11 35	0.5	0.3	0.3	0.5	

Notes: ND- No Data
1. November, 1999 samples: MW-6, MW-7S, RW-1S, RW-2S, MW-7D, RW-1D, RW-2D
February, 2000 samples: All GP monitoring points
2. Iron (+2), oxidation-reduction potential (ORP), pH and conductivity measured in field at completion of well purging, except for iron measurements at MW-6, MW-7S, RW-1S, RW-2S, MW-7D, RW-1D, and RW-2D, which were measured during well sampling

Table A-4
Remedial Operations in the NPL Area during the PRW Pilot Test
July, 2000 to current?

Groundwater Zone	Recovery Wells (1)	Vapor Extraction	Air Sparging	Notes
Shallow	RW-1S, ~220 gpd (2000) ~xxx gpd (2001) RW-2S, ~ 671 gpd (2000) ~xxx gpd (2001)	Shutdown from July, 2000-January, 2001	Shutdown in July, 2000	recovery wells pumping continuously over test period????
Deep	RW-1D, shutdown in June, 1999 RW-2D, ~ 4562 gpd (2000) ~xxx gpd (2001)	Vapor extraction system not constructed in the deep zone. Supplemental vapor extraction system operated from xx to xx at RW-2D and PZ-3D and PZ-4D for PRW pilot test vapor recovery	Air sparging system not constructed in the deep zone	see Figure A-11 for RW-2D detailed pumping history

Notes:
1. Average recovery well flowrates based on total gallons pumped per well at 330 operating days/year (avg)



0 60 120

SCALE IN FEET

VERTICAL BENCH MARK INFORMATION CAME FROM U.S.G.S. PLAQUE U-88-S.E. ABUTT. ERIE R.R. BRIDGE OVER BUFFALO ST., ELEV.=1296.034 (NATIONAL GEODETIC VERTICAL DATUM, 1929).

FILE: J:ESSEXHOP\804041\80404138.DWG

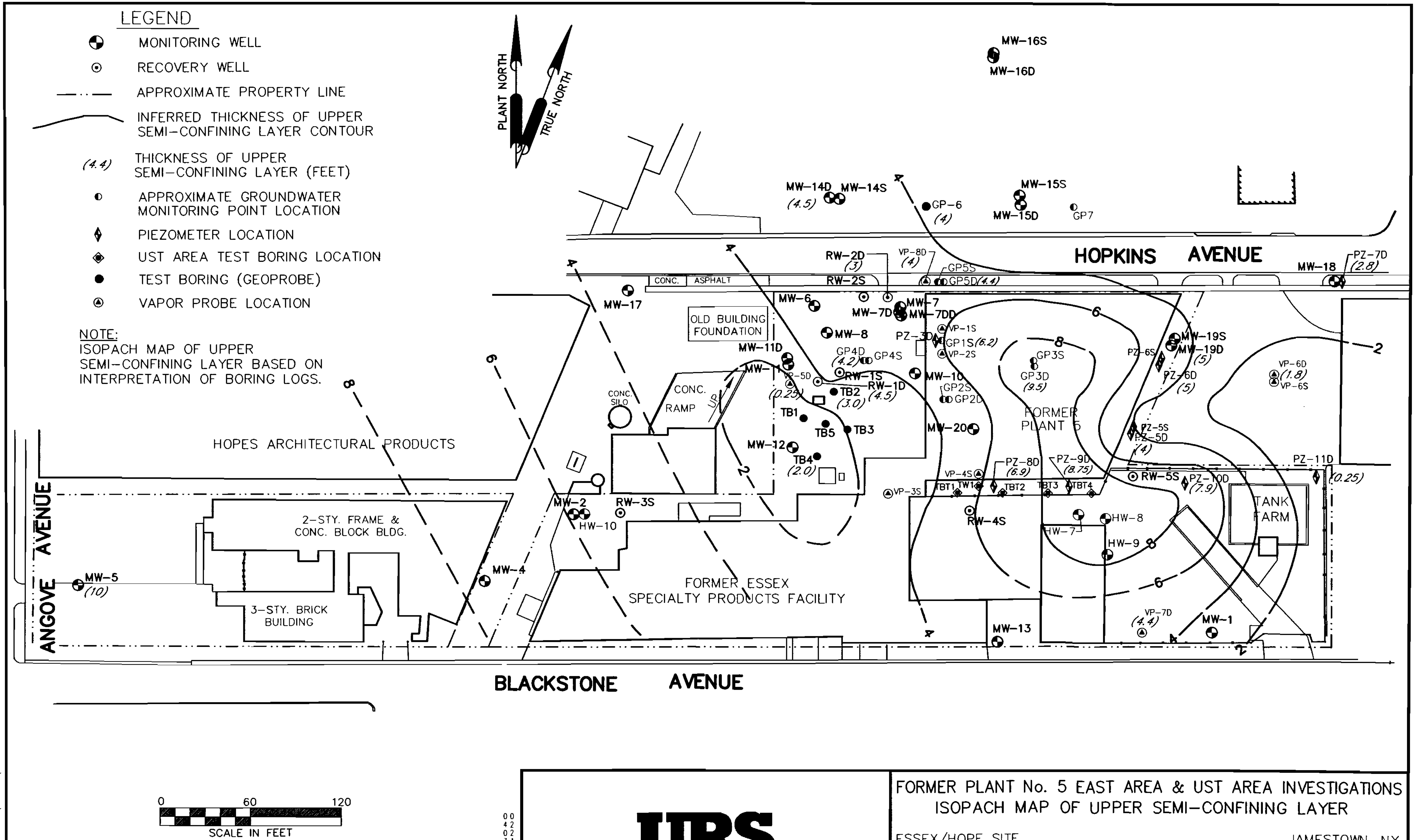
00 42 01 39 00 31 KK GG

URS

FORMER PLANT No. 5 EAST AREA & UST AREA INVESTIGATIONS
STRUCTURE CONTOUR MAP OF
TOP OF UPPER SEMI-CONFINING LAYER

ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.	JOB NUMBER: 804041.81
SCALE: AS SHOWN	FIGURE NUMBER A-1 · REV 0



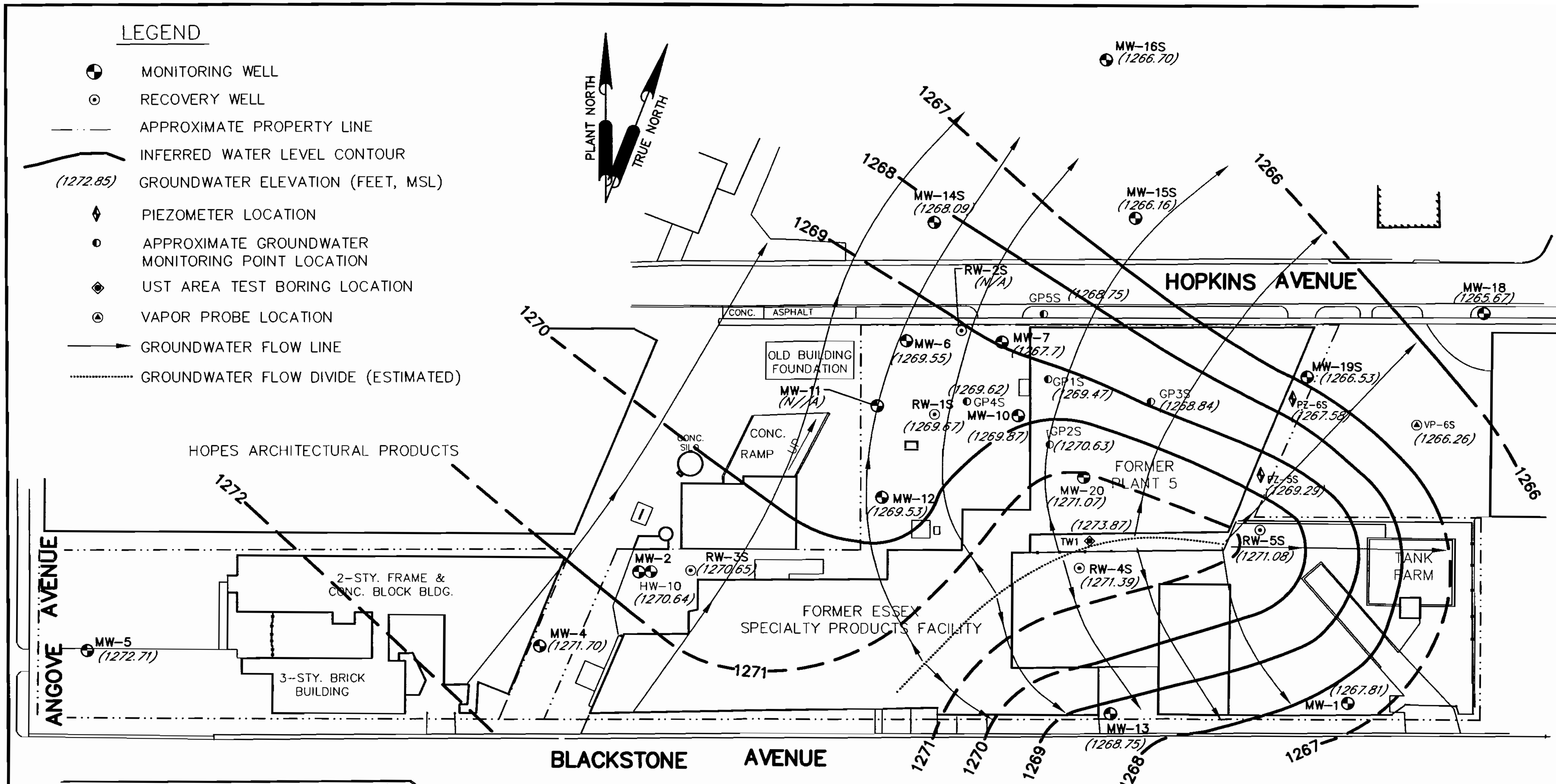
VERTICAL BENCH MARK INFORMATION CAME FROM U.S.G.S. PLAQUE U-88-S.E. ABUTT. ERIE R.R. BRIDGE OVER BUFFALO ST., ELEV.=1296.034 (NATIONAL GEODETIC VERTICAL DATUM, 1929).

FILE: J:ESSEXHOP\804041\80404139.DWG

00 42 02 31 00 31 KK GG

URS

FORMER PLANT No. 5 EAST AREA & UST AREA INVESTIGATIONS ISOPACH MAP OF UPPER SEMI-CONFINING LAYER	
ESSEX/HOPE SITE	JAMESTOWN, NY
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.	JOB NUMBER: 804041.81
SCALE: AS SHOWN	FIGURE NUMBER A-2 / REV 0



NOTE:

RECOVERY WELLS RW-3S, RW-4S AND RW-5S CYCLE BETWEEN CONTACT PROBE SETTINGS. THE WATER LEVELS DEPICTED FOR RW-3S, RW-4S AND RW-5S REPRESENT THE WATER LEVEL ELEVATION CORRESPONDING TO THE LOWER CONTACT PROBE SETTING (PUMP OFF) IN EACH WELL.

0 60 120
SCALE IN FEET

VERTICAL BENCH MARK INFORMATION CAME FROM U.S.G.S. PLAQUE U-88-S.E. ABUTT. ERIE R.R. BRIDGE OVER BUFFALO ST., ELEV.=1296.034 (NATIONAL GEODETIC VERTICAL DATUM, 1929).

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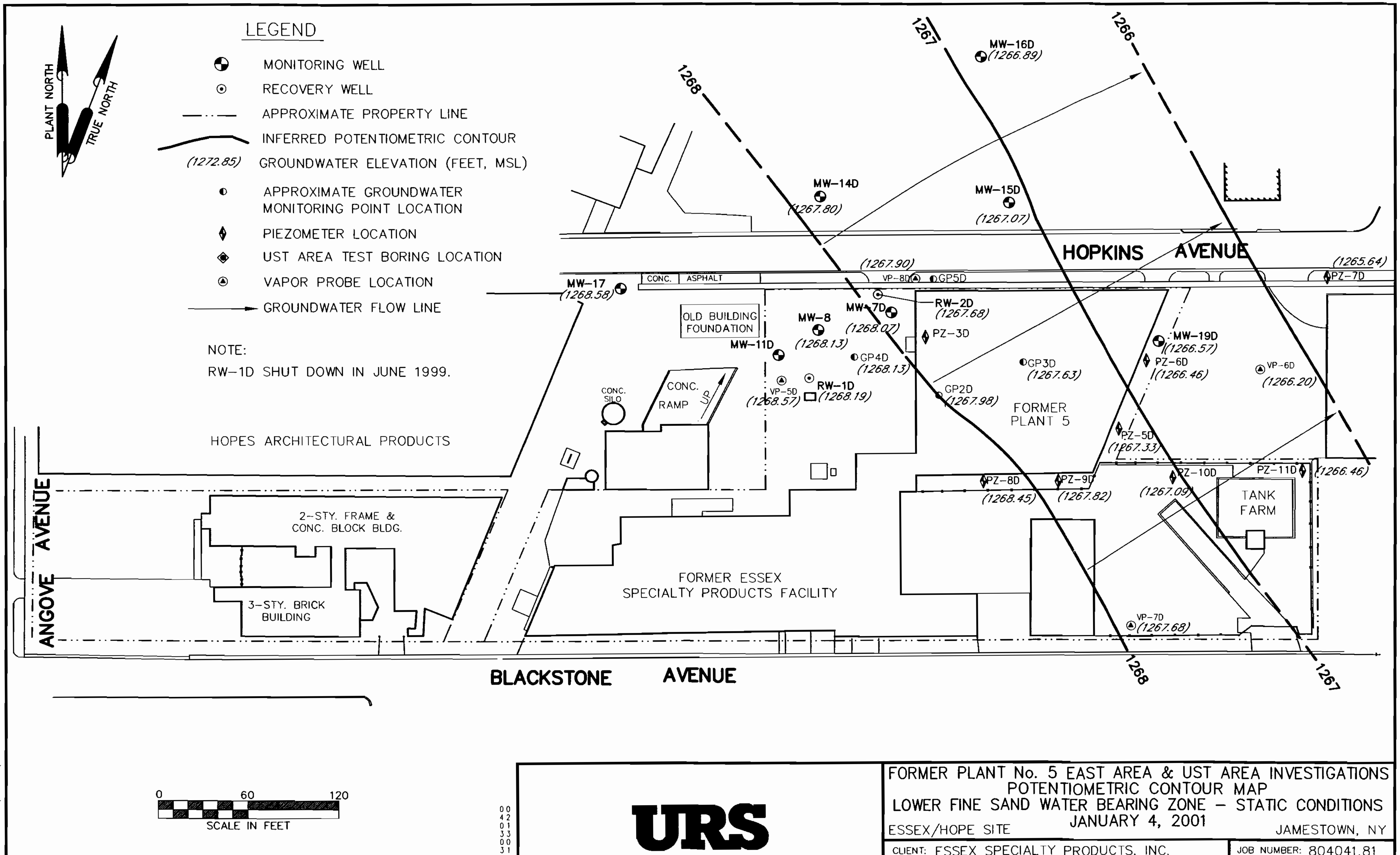
URS

FORMER PLANT No. 5 EAST AREA & UST AREA INVESTIGATIONS
WATER TABLE CONTOUR MAP – STATIC CONDITIONS
JANUARY 4, 2001

ESSEX/HOPE SITE — JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.	JOB NUMBER: 804041.81
SCALE: AS SHOWN	FIGURE NUMBER A-3 — REV 0



VERTICAL BENCH MARK INFORMATION CAME FROM U.S.G.S. PLAQUE U-88-S.E. ABUTT. ERIE R.R. BRIDGE OVER BUFFALO ST., ELEV.=1296.034 (NATIONAL GEODETIC VERTICAL DATUM, 1929).

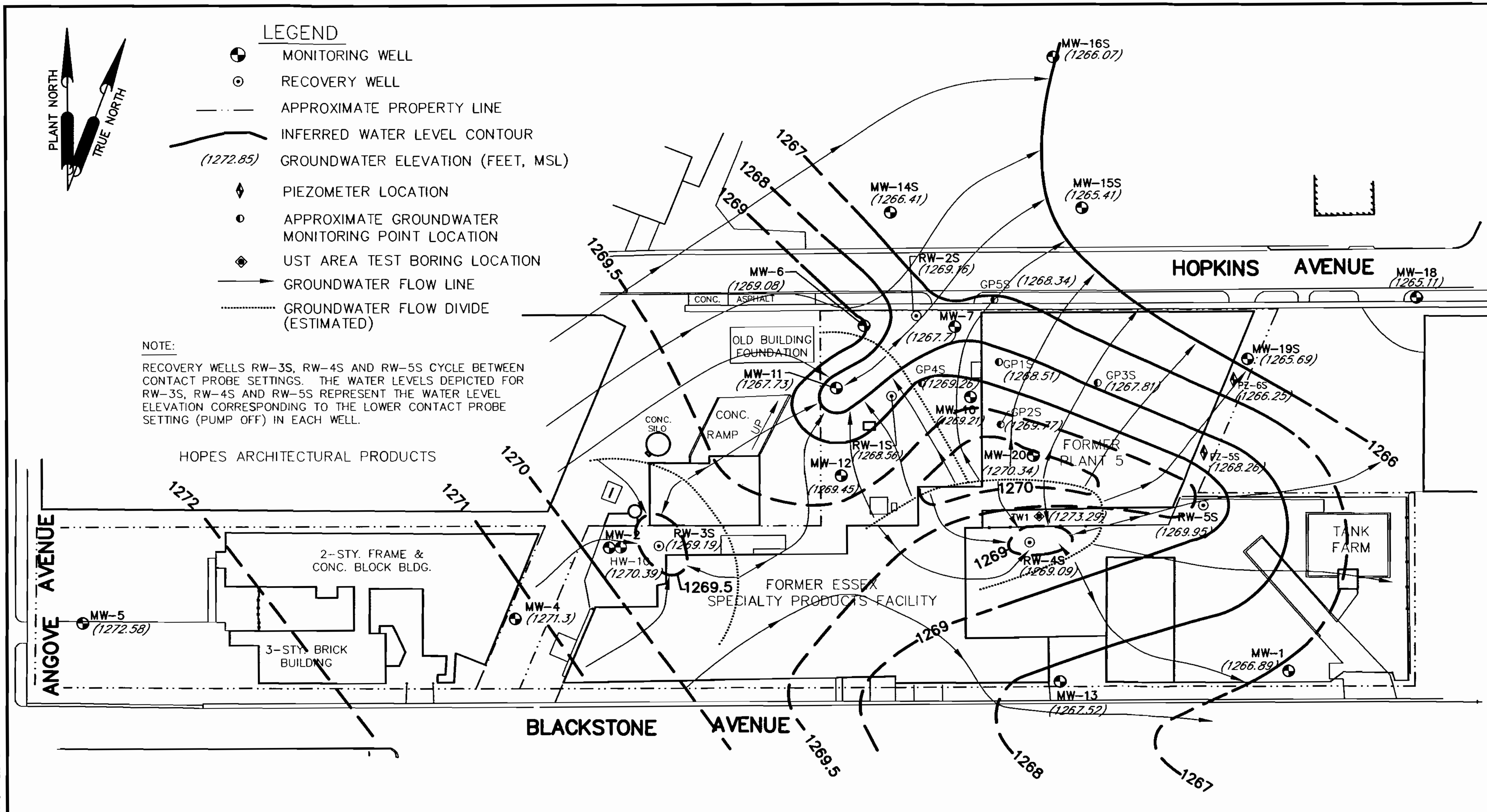
FILE: J:ESSEXHOP\804041\80404141.DWG

URS

FORMER PLANT No. 5 EAST AREA & UST AREA INVESTIGATIONS
POTENTIOMETRIC CONTOUR MAP
LOWER FINE SAND WATER BEARING ZONE – STATIC CONDITIONS
JANUARY 4, 2001

ESSEX/HOPE SITE — JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.	JOB NUMBER: 804041.81
SCALE: AS SHOWN	FIGURE NUMBER A-4 — REV 0



0 60 120
SCALE IN FEET

VERTICAL BENCH MARK INFORMATION CAME FROM U.S.G.S. PLAQUE U-88-S.E. ABUTT. ERIE R.R. BRIDGE OVER BUFFALO ST., ELEV.=1296.034 (NATIONAL GEODETIC VERTICAL DATUM, 1929).

FILE: J:\ESSEXHOP\804041\80404142.DWG

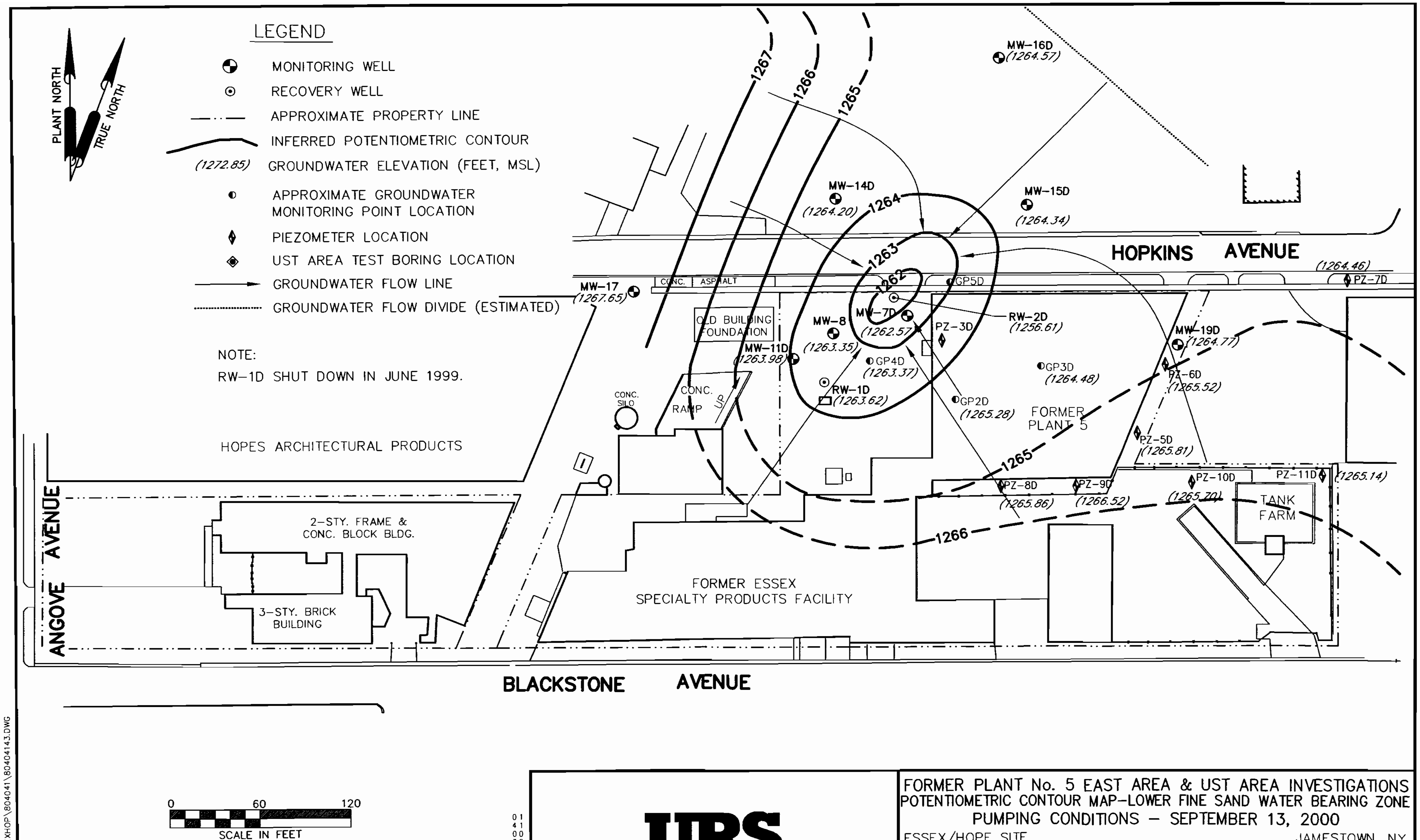
01 41 00 38 00 30 KK GG

URS

FORMER PLANT No. 5 EAST AREA & UST AREA INVESTIGATIONS
WATER TABLE CONTOUR MAP
PUMPING CONDITIONS – SEPTEMBER 13, 2000

ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.	JOB NUMBER: 804041.81
SCALE: AS SHOWN	FIGURE NUMBER A-5 · REV 0



VERTICAL BENCH MARK INFORMATION CAME FROM U.S.G.S. PLAQUE U-88-S.E. ABUTT. ERIE R.R. BRIDGE OVER BUFFALO ST., ELEV.=1296.034 (NATIONAL GEODETIC VERTICAL DATUM, 1929).

FILE: J:ESSEXHOP\804041\80404143.DWG

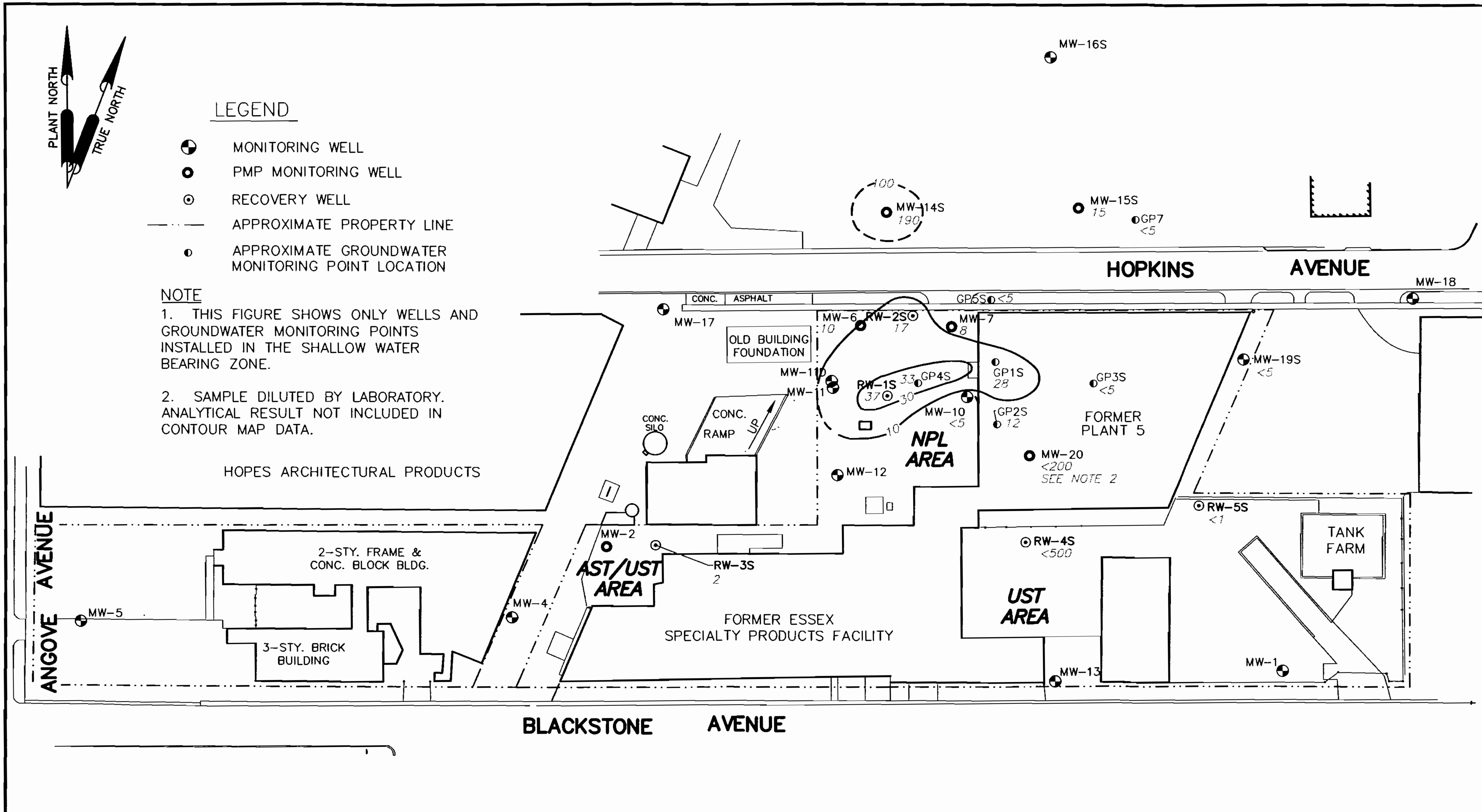
01 41 00 38 00 30 KK GG

URS

FORMER PLANT No. 5 EAST AREA & UST AREA INVESTIGATIONS
POTENTIOMETRIC CONTOUR MAP-LOWER FINE SAND WATER BEARING ZONE
PUMPING CONDITIONS – SEPTEMBER 13, 2000

ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.		JOB NUMBER: 804041.81	
SCALE: AS SHOWN	FIGURE NUMBER A-6		REV 0



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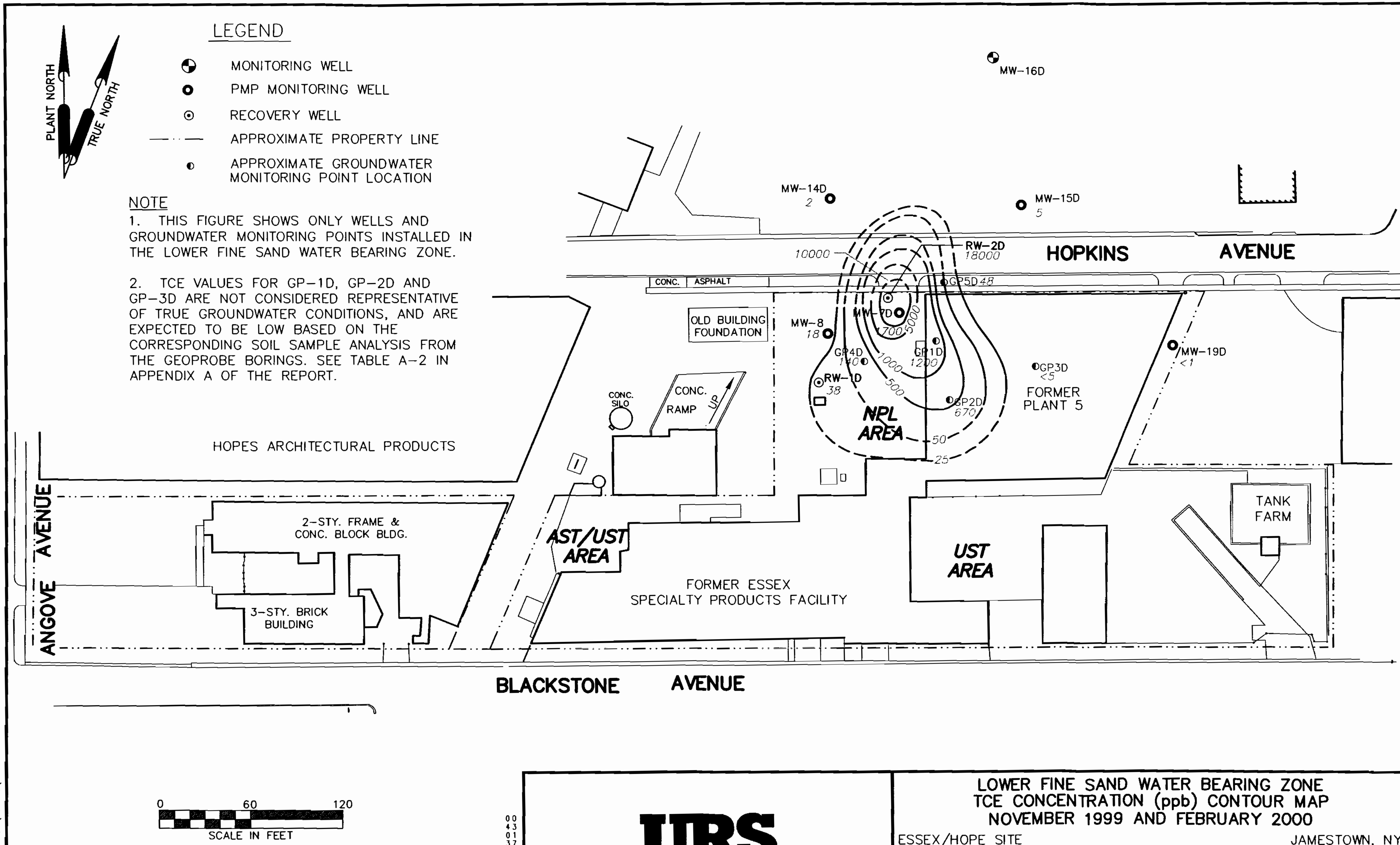
URS

SHALLOW WATER BEARING ZONE
TCE CONCENTRATION (ppb) CONTOUR MAP
NOVEMBER 1999 AND FEBRUARY 2000

ESSEX/HOPE SITE — JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.		JOB NUMBER: 804041.81	
SCALE: AS SHOWN	FIGURE NUMBER A-7		REV 0

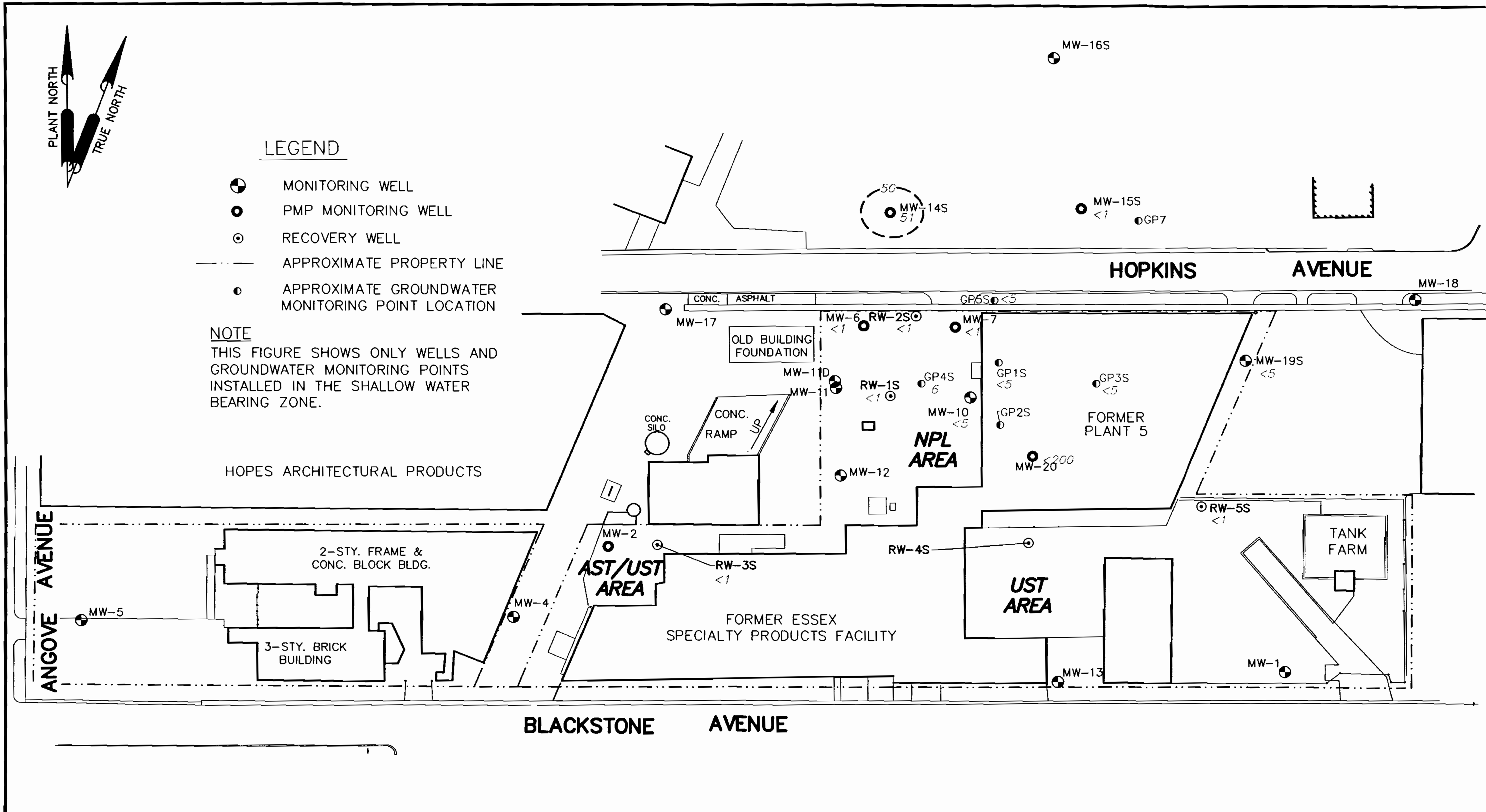


URS

LOWER FINE SAND WATER BEARING ZONE
TCE CONCENTRATION (ppb) CONTOUR MAP
NOVEMBER 1999 AND FEBRUARY 2000

ESSEX/HOPE SITE	JAMESTOWN, NY
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.	JOB NUMBER: 804041.81
SCALE: AS SHOWN	FIGURE NUMBER A-8 — REV 0

FILE: ESSEXHOP\804041\80404145



URS

SHALLOW WATER BEARING ZONE
VINYL CHLORIDE CONCENTRATION (ppb) CONTOUR MAP
NOVEMBER 1999 AND FEBRUARY 2000

ESSEX/HOPE SITE — JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.		JOB NUMBER: 804041.81	
SCALE: AS SHOWN	FIGURE NUMBER A-9		REV 0

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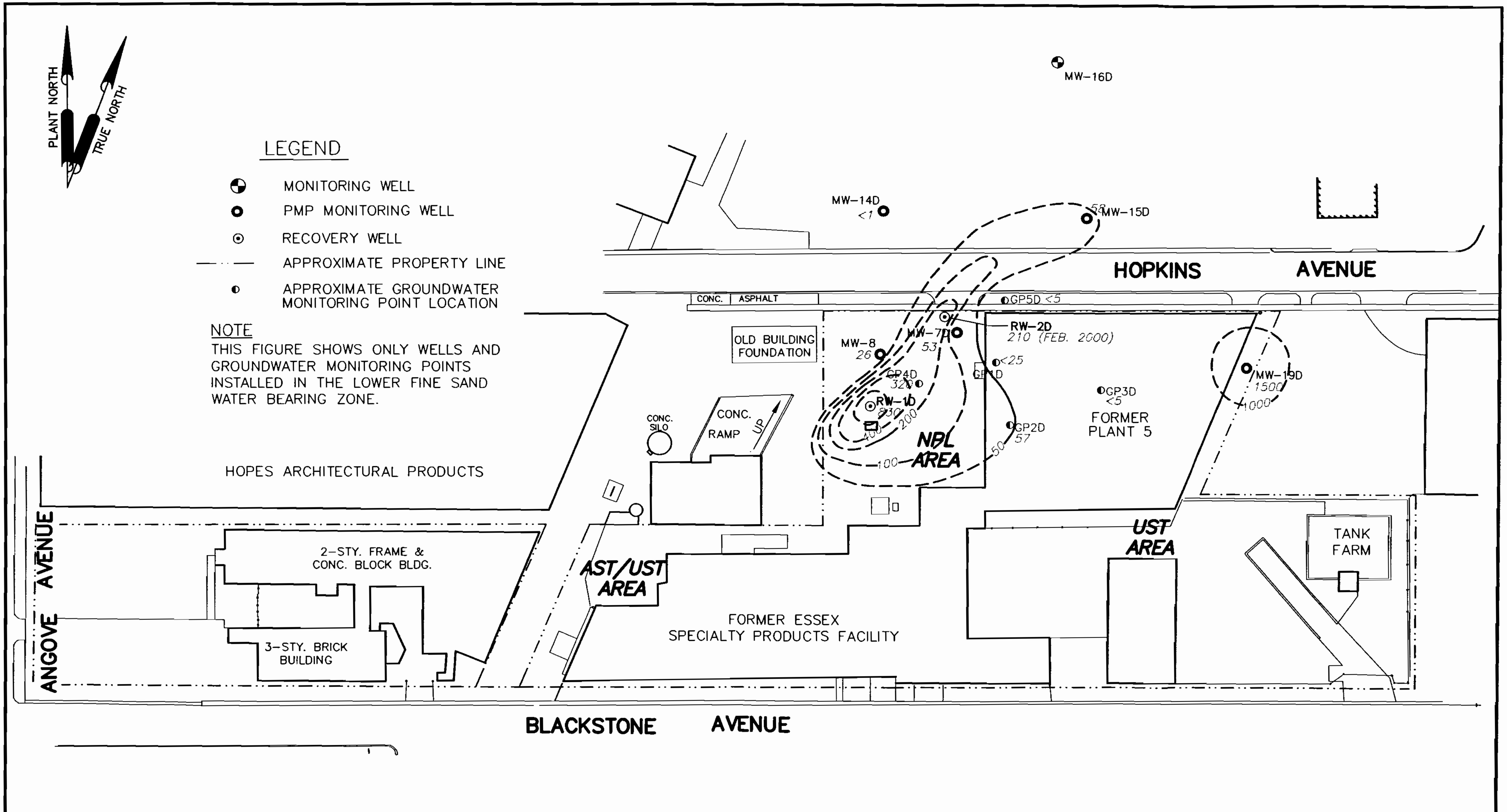

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00 43 01 37 00 30 KK GG

URS

LOWER FINE SAND WATER BEARING ZONE
VINYL CHLORIDE CONCENTRATION (ppb) CONTOUR MAP
NOVEMBER 1999 AND FEBRUARY 2000

ESSEX/HOPE SITE — JAMESTOWN, NY

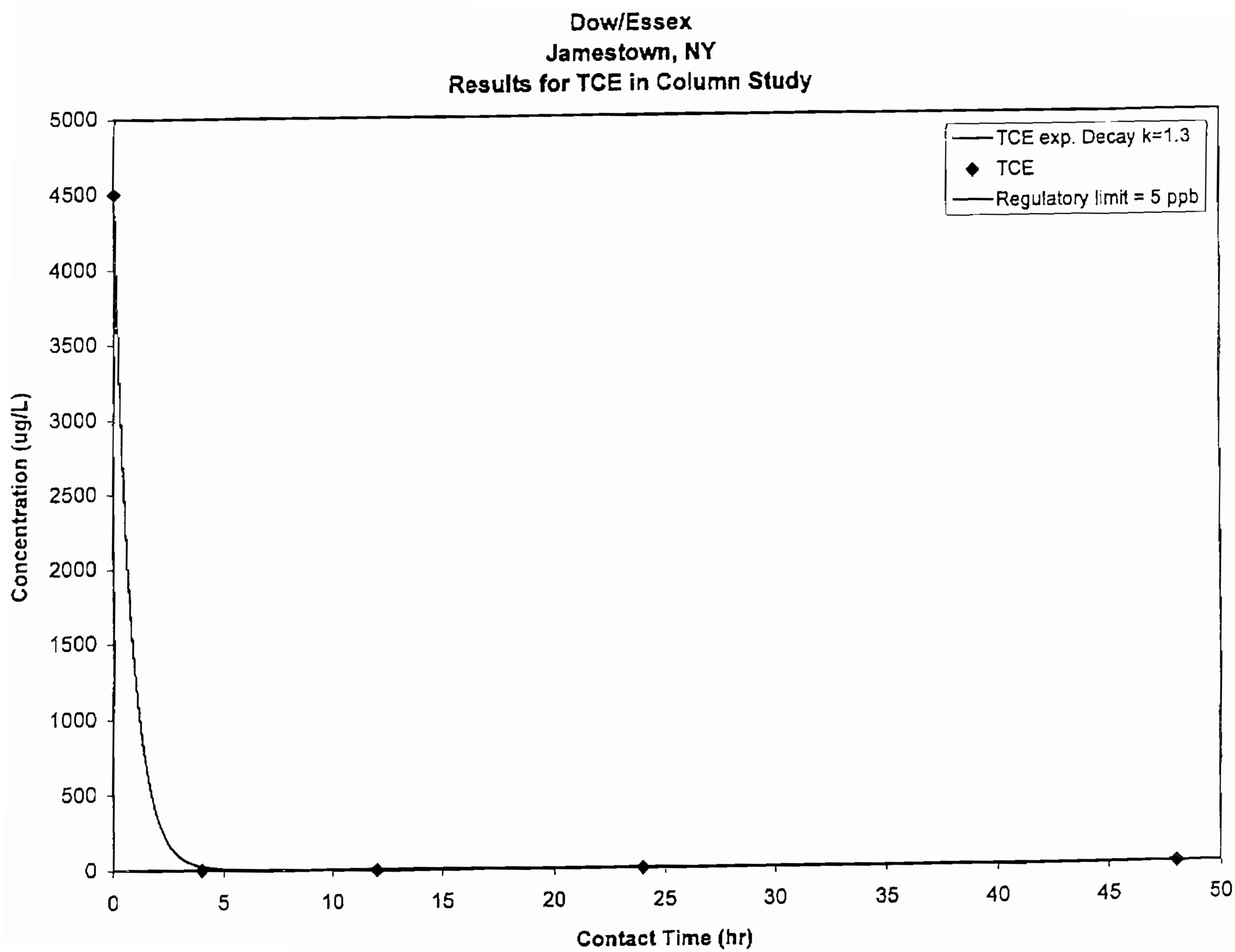
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.		JOB NUMBER: 804041.81	
SCALE: AS SHOWN	FIGURE NUMBER A-10		REV 0

Appendix B
Bench-Scale Testing Summary

Dow/ x
Jamestown, NY
VOC Results from Bench Scale Study

		Column Test 1				Column Test 2					
Sample ID		DC-0	DC-0A	DC-6	DC-12*	DC-0B	DC-0C	DC-1C	DC-3C	DC-6C	DC-12C
Contact Time (hours)		0	0	24	48	0	0	4	12	24	48
Sampled		4/7/2000	4/11/2000	4/11/2000	4/11/2000	4/18/2000	4/20/2000	4/20/2000	4/20/2000	4/20/2000	4/20/2000
Chloroethane	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dicholorethane	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	ug/L	10000	15000	31	ND	7200	3300	180	5.5	28	ND
trans-1,2-Dichloroethene	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ug/L	12000	14250	ND	ND	7100	4500	ND	ND	ND	ND
Vinyl Chloride	ug/L	ND	ND	10	ND	ND	ND	ND	11	8.4	ND

* Sample had detections of Tetrachloroethene = 4.2 ug/L and 1,1,1-Trichloroethane = 2.0 ug/L. Trip blank results were not available for this batch due t
sample loss.
ND = Analyte not detected


Dow/Essex
Jamestown, NY
Results for TCE in Column Study
Concentration (ug/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
25
30
35
40
45
50
Contact Time (hr)
TCE exp. Decay k=1.3
TCE
Regulatory limit = 5 ppb

Dow/Essex
Jamestown, NY
Results for cis-1,2-Dichloroethene in Column Study

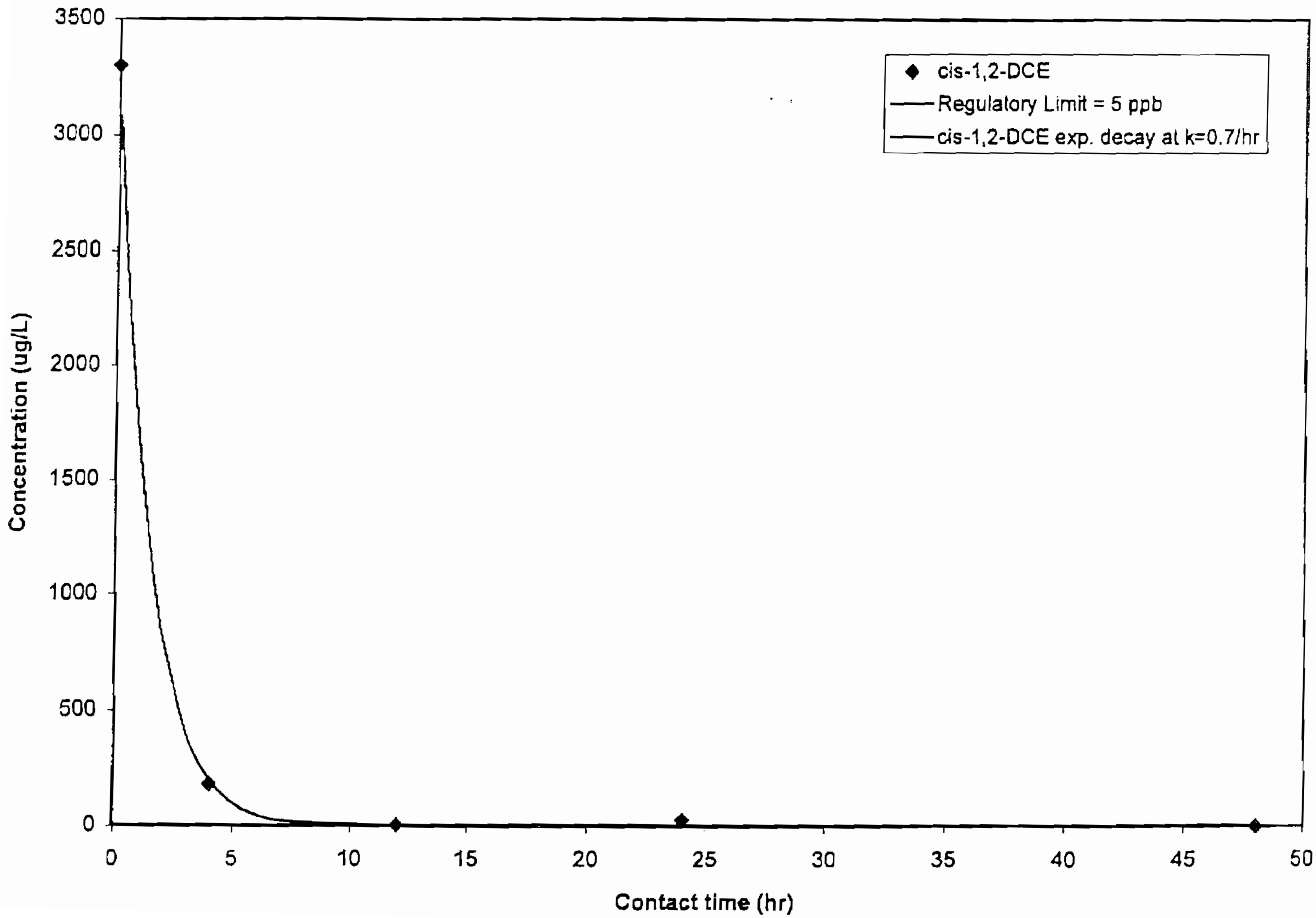


Table B-1
Permeable Reactive Barrier - Pilot Test Design (P = 5ug/l VOC)
Essex Jamestown Site

1. VOC Degradation Rate (k1) Estimate

Ref: Bench Column Test No. 2, 4/20/2000

Time	VOC Conc., ug/l (P)		Po/P		ln Po/P		k1 (slope ln Po/P v. t)		Notes
hrs	TCE	cis 1,2 DCE	TCE	cis 1,2 DCE	TCE	cis 1,2 DCE	TCE	cis 1,2 DCE	
0 (Po)	4500	3300	1	1	0	0	-	-	VOC sample result
1	3500	2500	1.29	1 32	0.25	0.28	-	-	VOC est linear projection
2	2200	1900	2.05	1.74	0.72	0 55	-	-	VOC est linear projection
3	1000	1200	4.50	2.75	1.50	1.01	-	-	VOC est linear projection
4	5	180	900	18.33	6.80	2.91	**2.04**	-	VOC sample result
12	5	5.5	900	600	6 80	6.40	**0.574**	**0.567**	VOC sample result

2. Iron Quantity, Baseline Estimate

W/A= F (un/k1) ln (Po/P)

where: W/A = weight iron/area of PRB, lb/ft2
u = groundwater seepage velocity, ft/d
n = formation porosity, use 0.3
k1 = VOC degradation rate, first order

ln = natural log
Po = initial VOC conc., ug/l
P = VOC target conc., ug/l
F = safety factor

Ref: Permeable Reactive Barrier Technologies for Contaminant Remediation, Appendix C, USEPA ORD, EPA/600/R-98/125, 9/98

P = 5 ug/l

VOC	u, ft/day	k1	Po, ug/l (1)	P, ug/l	Po/P	ln Po/P	F	PRB W/A, lb/ft2	BORING W/A, tons/ft (2)
TCE	note (3)								10 ft radius injection
	10	2.04	4500	5	900	6.80	3	30.01	0.300
	10	2.04	18000	5	3600	8.19	3	36.13	0.361
	10	2.04	286000	5	57200	10.95	3	48.33	0.483
NPL Area- Deep	4.24	2.04	4500	5	900	6.80	3	12.72	0.127
	4.24	2.04	18000	5	3600	8.19	3	15.32	0.153
	4.24	2.04	286000	5	57200	10.95	3	20.49	**0.205**
NPL Area- Shallow	2.54	2.04	4500	5	900	6.80	3	7.62	0.076
	2.54	2.04	18000	5	3600	8.19	3	9.18	0.092
	2.54	2.04	286000	5	57200	10.95	3	12.28	**0.123**
Hot Spot Area- Deep	0.31	2.04	4500	5	900	6.80	3	0.93	0.009
	0.31	2.04	18000	5	3600	8.19	3	1.12	0.011
	0.31	2.04	286000	5	57200	10.95	3	1.50	**0.015**
	0.1	2.04	4500	5	900	6.80	3	0.30	0.003
	0.1	2.04	18000	5	3600	8.19	3	0.36	0.004
	0.1	2.04	286000	5	57200	10.95	3	0.48	0.005
cis 1,2 DCE	10	0.567	3300	5	660	6.49	3	103.05	1.031
	10	0.567	7800	5	1560	7.35	3	116.71	1.167
NPL Area - Deep	4.24	0.567	3300	5	660	6.49	3	43.69	0.437
	4.24	0.567	7800	5	1560	7.35	3	49.48	**0.495**
NPL Area - Shallow	2.54	0.567	3300	5	660	6.49	3	26.18	0.262
	2.54	0.567	7800	5	1560	7 35	3	29.64	**0.296**
Hot Spot Area- Deep	0.31	0.567	3300	5	660	6.49	3	3.19	0.032
	0.31	0.567	7800	5	1560	7.35	3	3.62	**0.036**
	0.1	0.567	3300	5	660	6.49	3	1.03	0.010
	0.1	0.567	7800	5	1560	7.35	3	1.17	0.012

Notes:

1. Initial VOC concentrations, Po, used are: Pilot Test VOC concs., historical max concs. in groundwater, and adjusted max conc. in Plant #5 hot spot area based on soil VOC levels (TCE only)
2. W/A (INJ) = 2r (W/A) (PRW) - maximum W/A values are shaded and bold
3. Deep groundwater zone mean seepage velocities estimated for NPL Area and Building #5 hot spot are 4.24 and 0.31 ft/d, resp. (shown in bold)
Shallow zone mean seepage velocity estimated for NPL Area = 2.54 ft/d.

Table B-2
Permeable Reactive Barrier - Pilot Test Design (P = 100 ug/l VOC)
Essex Jamestown Site

1. VOC Degradation Rate (k1) Estimate

Ref: Bench Column Test No. 2, 4/20/2000

Time	VOC Conc., ug/l (P)		Po/P		ln Po/P		k1 (slope ln Po/P v. t)		Notes
hrs	TCE	cis 1,2 DCE	TCE	cis 1,2 DCE	TCE	cis 1,2 DCE	TCE	cis 1,2 DCE	
0 (Po)	4500	3300	1	1	0	0	-	-	VOC sample result
1	3500	2500	1.29	1.32	0.25	0.28	-	-	VOC est linear projection
2	2200	1900	2.05	1.74	0.72	0.55	-	-	VOC est linear projection
3	1000	1200	4.50	2.75	1.50	1.01	-	-	VOC est linear projection
4	5	180	900	18.33	6.80	2.91	**2.04**	-	VOC sample result
12	5	5.5	900	600	6.80	6.40	**0.574**	**0.567**	VOC sample result

2. Iron Quantity, Baseline Estimate

W/A= F (un/k1) ln (Po/P)

where: W/A = weight iron/area of PRB, lb/ft2
u = groundwater seepage velocity, ft/d
n = formation porosity, use 0.3
k1 = VOC degradation rate, first order

ln = natural log
Po = initial VOC conc., ug/l
P = VOC target conc., ug/l
F = safety factor

Ref: Permeable Reactive Barrier Technologies for Contaminant Remediation, Appendix C, USEPA ORD, EPA/600/R-98/125, 9/98

P = 100 ug/l

VOC	u, ft/day	k1	Po, ug/l (1)	P, ug/l	Po/P	ln Po/P	F	PRB W/A, lb/ft2	BORING W/A, tons/ft (2)
TCE	note (3)								10 ft radius injection
	10	**2.04**	4500	100	45	3.81	3	16.79	0.168
	10	**2.04**	18000	100	180	5.19	3	22.91	0.229
	10	**2.04**	286000	100	2860	7.96	3	35.11	0.351
NPL Area- Deep	**4.24**	**2.04**	4500	100	45	3.81	3	7.12	0.071
	4.24	**2.04**	18000	100	180	5.19	3	9.71	0.097
	4.24	**2.04**	286000	100	2860	7.96	3	14.89	**0.149**
NPL Area- Shallow	**2.54**	**2.04**	4500	100	45	3.81	3	4.27	0.043
	2.54	**2.04**	18000	100	180	5.19	3	5.82	0.058
	2.54	**2.04**	286000	100	2860	7 96	3	8.92	**0.089**
Hot Spot Area- Deep	**0.31**	**2.04**	4500	100	45	3.81	3	0.52	0.005
	0.31	**2.04**	18000	100	180	5.19	3	0.71	0.007
	0.31	**2.04**	286000	100	2860	7.96	3	1.09	**0.011**
	0.1	**2.04**	4500	100	45	3.81	3	0.17	0.002
	0.1	**2.04**	18000	100	180	5.19	3	0.23	0.002
	0.1	**2.04**	286000	100	2860	7.96	3	0.35	0.004
cis 1,2 DCE	10	**0.567**	3300	100	33	3.50	3	55.50	0.555
	10	**0.567**	7800	100	78	4.36	3	69.15	0.692
NPL Area - Deep	**4.24**	**0.567**	3300	100	33	3.50	3	23.53	0.235
	4.24	**0.567**	7800	100	78	4.36	3	29.32	**0.293**
NPL Area - Shallow	**2.54**	**0.567**	3300	100	33	3.50	3	14.10	0.141
	2.54	**0.567**	7800	100	78	4.36	3	17.57	**0.176**
Hot Spot Area- Deep	**0.31**	**0.567**	3300	100	33	3.50	3	1.72	0.017
	0.31	**0.567**	7800	100	78	4.36	3	2.14	**0.021**
	0.1	**0.567**	3300	100	33	3.50	3	0.56	0.006
	0.1	**0.567**	7800	100	78	4.36	3	0.69	0.007

Notes:

1. Initial VOC concentrations, Po, used are: Pilot Test VOC concs., historical max concs. in groundwater, and adjusted max conc. in Plant #5 hot spot area based on soil VOC levels (TCE only)
2. W/A (INJ) = 2r (W/A) (PRW) - maximum W/A values are shaded and bold
3. Deep groundwater zone mean seepage velocities estimated for NPL Area and Building #5 hot spot are 4.24 and 0.31 ft/d, resp. (shown in bold)
Shallow zone mean seepage velocity estimated for NPL Area = 2.54 ft/d.

Appendix C-
Vapor Monitoring and Recovery Operations

Contents:

PRB Pilot Test Vapor Monitoring

Field Vapor Monitoring

Field vapor monitoring has been conducted since August 30 in and around the PRB Pilot Test Area, to provide qualitative data on combustible gas presence and migration from the iron injection pilot test areas. Monitoring frequency was weekly initially, and was reduced to monthly after data trends were established.

Field monitoring ~~is being~~ was performed with the following instrumentation:

-LEL/O2 Meter, for combustible levels of vapors and oxygen levels,

-Flame Ionization Detector (FID), for concentrations of organic gases, except hydrogen

-Photoionization Detector (PID), for concentrations of volatile organic gases responsive to a 10.6 EV lamp

Existing monitoring wells and piezometers and newly installed vapor probes ~~are~~ were included in the monitoring. Vapor measurements ~~are~~ were taken by placing the instrument intake probe directly in the headspace of the monitoring point casings. The open casing pipes were temporarily taped and were allowed to stabilize a minimum 8 hours prior to insertion of the instrument probes through the tape into the headspace.
All data to-date is summarized on the attached tables. Figure 1 shows the monitoring points.

Background and Chronology of Events

The need for vapor monitoring was first raised on August 11, 2000 when Chet Van Arsdale, CPM VP, called the URS Pittsburgh office and said that the Pilot Test deep zone piezometer, PZ-3D, in Plant #5 was emitting vapor and water into the building. He indicated that there was a small quantity of liquid (< 1 gal) and that there were no strong odors. Piezometers 3D and 4D are 1/2 inch dia. casings installed into the lower groundwater zone the week of July 17 to monitor groundwater for the Pilot Test. About 10 tons of iron with guar were injected into 4 borings in the Plant #5 area during the week of July 26, 2000. K Dodrill and M Dowiak of URS told Mr Van Arsdale that this wasn't an emergency situation and they'd get back with him later that day. URS talked again late in the afternoon with Mr Van Arsdale and he indicated that the discharge had subsided and CPM cleaned up the liquid. Since they were not working that weekend, URS and CPM mutually agreed to not do anything over the weekend and check it the following week when Keith Dodrill was going to be at the site.

August 14, 2000- Keith Dodrill looked at the Plant #5 piezometers and did not observe any discharges. There was a noticeable odor around the well head. VOC readings by PID were at acceptable levels, < 50 ppm. URS decided to take an air sample from the PZ-3D casing to characterize the vapor constituents. The sample was taken on August 17 by extracting headspace gas from the well casing (1/2 in) with a syringe, through a temporary well cap. The sample results were received on 8/22 and indicated that low concentrations (<<LELs) of potentially combustible gases were present. (This sample result was later found to be misreported by the lab, Microseeps. See Vapor Analytical Results table)

URS also planned to sample the iron injection piezometers and selected monitoring wells during the week of August 21 to obtain the first round of pilot test performance monitoring data. URS checked the PZ's and wells for offgassing and took a confirmatory air sample from PZ-3D.

August 24- URS field tech, Tony Clemente, was onsite to take the pilot test performance monitoring samples and the air sample from PZ-3D. He had a PID and LEL/O2 meter to check the well casing headspace and surrounding work areas while he was sampling. PZ-3D and 4D both were under pressure and emitted vapor/liquids during sampling. Generally, the LEL readings in the well casings were above action levels (10%) in piezometers PZ-1D through PZ-4D, pumping well RW-2D, and monitoring wells 7S and 7D. PZ-3D and 4D had the highest LEL's, and also had LEL's above 10% as measured 6 inches from the top of the well at the floor level. These points are all in and around the iron injection borings. All other well readings (GP's 1-5, PZ-5D, PZ-8, PZ-9) were at acceptable levels (<10%). These other locations are all further away from the iron injections.

August 25- URS recommended some mitigating safety actions in the Plant #5 area. URS planned to go to the site on Aug 29 and install vents into PZ-3D and 4D to discharge well vapors outside of the building.

K Dodrill and Mark Dowiak called Carlo Montesimo, President of CPM, to update him on the situation and tell him they planned to come to the site the following week to do some further work on the gas emission problem. He was not upset about the situation, but expressed concern for the safety of his workers and the potential for explosions. The facility does welding and hot cutting work in Plant #5. URS told him that the data has not indicated any immediate safety concerns in the injection work area, however, as a precaution, they should not do any work in the injection area until the vents are installed.

August 30- Keith Dodrill was at the site to check the iron injection piezometers in Plant #5 (PZ-3D and PZ-4D) , take more vapor readings in selected monitoring points with a PID, FID and an LEL/O2, and determine the details for venting the Plant #5 PZ's. The flame ionization detector (FID) is calibrated to methane and provides a semi-quantitative reading of combustible gas concentration. URS also discussed venting options with Chet Van Arsdale (CPM VP). Notes from field visit:

1. The Plant #5 PZ's and surrounding monitoring points in the iron injection area appear to be stabilized, ie, they are not visibly offgassing or emitting water.

2. Mr Van Arsdale is concerned, but he isn't anxious to install any gas vents unless URS feels it is necessary. URS told him the results of the previous gas sampling and monitoring. This was that VOCs and combustible gases were being formed in the subsurface beneath Plant #5, mainly the deep zone, however, the potentially explosive levels are confined to the well casings and that LEL action levels have not been detected inside of the plant, except in isolated cases around the PZ's when we have the caps off. URS recommended that these PZs be vented as a safety precaution until they can better quantify what's happening in the subsurface. He said ok, but he did not want any vents projecting above floor level because of his equipment traffic and work operations.

3. Keith Dodrill took additional readings of monitoring points in and around the iron injection area. In summary, the PZ's in the Plant #5 iron injection area had the highest FID , PID and LEL readings. These levels were highest in the well casings, typically as follows:

-LEL =100%
-FID> 1000 ppm (max conc on readout)
-PID ~ 870 ppm

Readings at the ground floor around the PZs were at acceptable levels. Other readings of note were in the PRW pilot test pumping well RW-2D and PZ-1D (near RW-2D), which both had FIDs > 1000 ppm. The SHALLOW zone monitoring points all had readings that were at acceptable levels, well below the deep zone levels. This is significant since it indicates that the combustible gases are being generated in the deep zone, and are apparently isolated in that zone at this time. Based on this, there probably are not significant gas levels in the shallow zone beneath and around the Plant #5 building. A question remaining is the extent of gas migration in the deep zone. Keith Dodrill planned to take readings in deep monitoring points around the iron injection area, and beyond the property line.

4. Keith Dodrill mapped the Plant #5 floor slab and structure around the injection area to allow us to detail the best venting retrofit. Basically, the floor needs to be saw cut and the vent pipe should be run outside to the existing treatment building. The pipe trenches need to be finished flush with the existing floor. A modified well cap will be constructed to allow venting and sampling the well. The vent pipe will be run to the roof line of the treatment building. Water knockouts and future connections to the SVE system are also under consideration.

5. URS ~~is~~ evaluat~~ing~~ed options for additional air sampling to better quantify gas constituents and concentrations. The previous syringe air samples (~~summarized in 8/28~~ e-~~mail~~) have low levels of gases that do not correlate with the FID, nor do they total up to 100%. URS didn't think any major gases were missed in the analyses. URS checked with the lab (Microseeps) on the accuracy of the analytical method.

August 30, 2000- Vapor Monitoring (See attached Air Monitoring Summary Tables)

DEEP Groundwater zone:
There are high FID detections (>1000 ppm) around the iron injection areas and in the 2 piezometers east of Plant #5 (PZ-5D and 6D). LEL readings in these locations were all at 100%. All other points monitored, including wells offsite to the north, and the UST Area to the south, were at very low FID and LEL levels. An exception are the UST Area PZ's 8D, 9D and 10D, and MW-19D (east of Plant #5). These points had non-detect FID and PID readings, but 100% LELs. The readings were double-checked and found to be consistent.
The preliminary conclusion is that the combustible gases were still confined to the site property, mainly in the iron injection areas, and they've possibly migrated beneath and to the east of Plant #5.

SHALLOW groundwater zone:
All readings in the shallow zone were very low or non-detect.

Keith Dodrill also took readings in the treatment plant building equalization tank, This tank is 2000 gal and receives all groundwater from the site recovery wells. About 50% of the flow comes from Recovery Well RW-2D, in the center of the iron injection pilot test. The tank has a closed top and is vented to the outside. FID readings in the tank headspace were >1000 ppm and LEL readings were at 10%. Historically LEL readings have always been zero. Readings above the tank top were all zero. Note that the treatment building is Class 1 Div 1 construction (explosion -proof) and is equipped with an active ventilation system. URS will continue to monitor this area

Keith Dodrill planned to meet today with CPM Pres, Carlo Montesimo, to go over gas venting options.

September 13, 2000- Vapor Monitorng

1. Plant #5 PZ Vents and Vapor Probes (VPs)-
On Sept. 7-8 URS installed passive vent pipes on piezometers PZ-3D and 4-D located in Plant #5, in the iron source injection area. These PZ's were the ones that had been off-gassing as previously reported. A wellhead T assembly was installed on each PZ, and a vent pipe was run beneath the Plant #5 floor slab to outside of the building west wall. The vent was run to the roofline of the treatment plant building. The well T permits us to continue sampling of the PZ. The Plant #5 floor was finished flush with concrete. Chet Van Arsdale (CPM VP) was pleased with the vent installation. The PZ vents have consistently had LEL readings of 100% and FID levels >1000 ppm.
URS also installed two 1/2 in dia. gas probes (12- inch long screens) directly beneath the Plant #5 concrete floor, in the area of the iron injections. These probes, VP-1S and VP-2S, will be monitored weekly for indications of combustible vapor beneath the concrete floor slab. So far, these probes have not had any LEL detections.

2. Equalization Tank Vent-

Keith Dodrill is planning to extend the treatment plant equalization tank vent to above the building roofline. The equalization tank, which receives groundwater primarily from pumping well RW-2D, has been accumulating combustible vapors. The most recent reading was LEL = 14%, FID > 1000 ppm. The tank vent normally discharges through a carbon filter for VOC removal. The carbon is not effective for removal of methane or hydrogen. URS shut off the vent and closed the tank lid until the vent can be extended. URS planned to do this the following week. So far, LEL readings have not been found above action levels (10%) in the treatment plant building room.

3. Corrected Air Sample Data-

The previously reported (8/28 e-mail) results of the PZ-3D well headspace samples taken for offsite analyses were incorrect. URS questioned this data because the reported vapor concentrations were low (<< LELs) and they did not correlate with the field monitoring data URS contacted the lab (Microseeps) and found out that the data was reported as equilibrium concentrations in the LIQUID phase. Microseeps sent corrected results in units of vapor phase (PPMV).

CORRECTED VAPOR SAMPLE RESULTS, PZ-3D HEADSPACE

Compound	Conc., Aug 18/00	Conc, Aug 22/00	Compound LEL
CO2	0.1% V (by volume)	0.19% V	na
O2	2.64% V	39.4 % V	na
N	47.3% V	29.3% V	na
CH4	0.29% V	0.18% V	5% (50,000 ppmv)
H2	44.4% V	35.6% V	4 % (40,000 ppmv)
Ethane	4426 ppmv (vapor)	4637 ppmv	3% (30,000 ppmv)
Ethylene	8012 ppmv	8161 ppmv	2.7%
Propane	191 ppmv	236 ppmv	2.1%
Propylene	208 ppmv	252 ppmv	2.4%
Butanes	219 ppmv	319 ppmv	1.8% (18,000 ppmv)

Of note is that the gas levels are much higher than previously reported, with Hydrogen above it's LEL. Total organic gases are at approx. 1.6% by volume, which is almost at the LEL for butane. Note that our action levels are 10% LEL. For the case of butane, this would be at 0.15 x 18,000 = 2700 ppmv. These results indicate that the mixture of hydrogen and organic gases is above LELs, which correlates with the field monitoring readings. URS evaluated other vapor sampling and analyses methods to determine if a better quantification of gas types and concentrations is necessary. The syringe method is considered semi-quantitative. For now, the data provides useful information on the gas types and approx. concentrations.

4. Vapor Monitoring Data Summary

PLANT #5 SubFloor Probes-
No detectable levels found.

SHALLOW Groundwater Zone-
All readings continued to be very low or non-detect.

DEEP Groundwater Zone-
The high FID and LEL levels continue to be present in the areas within and adjacent to the iron injections. The combustible gases have not migrated north of Hopkins Ave., however, the gases appear to have migrated to the east and southeast of Plant #5. High LEL and FID levels were found in the UST Area (PZ-8D,9D and 10D) and east of Plant #5 (PZ- 5D, 6D and MW-19D) in the most recent monitoring. Levels have also increased in PZ-11D, in the former tank farm area southeast of the site. These gas levels were not found in these areas the previous week.
This may be significant if the gases continue to migrate eastward because of the manufacturing facilty offsite to the east of Plant #5.

URS recommended that some additional deep gas probes be installed. The existing monitoring wells are not screened in ideal locations to detect gas, and the wells do not have sufficient areal covergae around the site. Keith Dodrill may be able to pull up the geoprobe wells (GP- 3D,4D and 5D) to raise the screens to the base of the upper confining clay. These GP wells are ok to modify since they are not monitored for groundwater data. There are no suitable monitoring points to the north and west of the injection areas. Monitoring probes were recommended in the east area, and beneath CPM's welding room floor adjacent to the UST Area. URS estimated that 3 deep zone and 2 floor subbase gas probes will be needed, assuming the 3 GP wells can be used.

September 18, 2000- Vapor Monitoring

1. Monitoring Results.

SHALLOW Zone-
The latest set of data shows increasing gas levels in the UST Area (TW-01, MW-1) and the NPLS Area (MW-7S). LEL and FID readings are above action levels in TW-01 and MW-7S. MW-1, near Blackstone Ave to the south of the site, had an FID of 54 ppm, but the LEL was 4%. All other shallow readings were below action levels or were non-detect. These readings suggest that gases are migrating upward near the PRW Pilot Test area (RW-2D) and in the UST Area, where the confining clay has been removed. URS planned to install 2 subfloor gas probes in the UST Area to check for shallow gas migration. These will be in Plant #5 directly north and west of the UST Area. CPM has approved the installations.

DEEP Zone-
The latest data indicates that the gases have migrated to the east and southeast of Plant #5, which confirms the previous set of data PZ's 8D, 9D, 10D and 11D, extending east from the UST Area to the former Tank Farm, all have high LEL and FID levels. It's notable that the PID levels in these PZs are all very low (0-2.9 ppm) which indicates that the gases are not VOCs. It's also noted that PZ-7D, offsite near MW-18, in the east parking lot , has increasing FID levels over the last 3 monitoring periods (5 ,10, 21 ppm), although LEL and FID levels are still below action levels.
A key question is the presence/extent of offsite gas migration. It's possible that the gas has migrated offsite in the east/southeast area of the site based on the recent PZ data. The current monitoring points do not provide any data offsite in these areas, other than PZ-7D. URS did not think that the monitoring points to the north and east provide representative gas data because the well screens are in the lower portion of the deep zone, beneath the likely location of a migrating gas plume.

2. Deep Zone Gas Probes
On September 19 Keith Dodrill attempted to pull up the GP-3D deep well to raise the screen to below the confining clay. This was unsuccessful since the pipe well broke off. URS decided to not attempt this with the other 2 GPs. GP-3D was grouted and abandoned.

3. Equalization Tank Vent- URS extended the outside vent to above the treatment building roof line. The vent valve was opened and the tank was passively venting. Gas levels have reduced slightly. URS will continue to monitor the tank and treatment room.

September 25, 2000- Vapor Monitoring

1. Vapor Monitoring Summary

SHALLOW Zone-
The low levels of combustible gas found in the last round of monitoring (Sept. 18) continue to be present. The latest data indicates that combustible vapors were found in the shallow zone at RW-2D (NPLS Area) and the UST Area. Vapor levels continue to be non-detect in the subfloor probes in Plant #5. Note that the UST SVE system and the RW-2D vapor recovery test were started on Sept. 26, after these measurements were taken. Vacuum recovery in these areas will hopefully control the migration of the shallow gases.

DEEP Zone-
Deep zone vapor levels continue to be found at the same locations and at approx the same levels as the previous week's results. The latest data confirms the presence of combustible vapors to the east and southeast of Plant #5 (PZ's 8D, 9D, 10D and 11D).

2. Deep Zone Gas Probes
URS plans to install the 4 deep zone probes starting today, Oct 2. The locations will be as described in the previous e-mail (9/21/00). These are basically:
north of Plant #5, NPLS parking lot west, east parking lot, and UST Area near Blackstone Ave. Nothnagle Drilling will install 2 in. dia probes, some of which can double as monitoring wells as planned for the Plant #5 East Area . URS planned to have the probes installed by the end of next week (October 20).

2. Vapor Recovery System at Pumping Well RW-2D

URS retrofitted RW-2D with a vacuum line and connected it to the NPLS SVE blower to perform a vapor recovery test. The line is on the parking lot surface approx 50 feet from the Plant #5 doorway. The system was started on Tuesday, Sept 26, and has been running continuously. The vapor recovery system is intended to recover vapors from the deep groundwater zone by drawing down the aquifer and vacuuming the headspace above the drawdown cone. RW-2D is pumping at 6-7 gpm, over twice it's normal operating rate. The vacuum pump is operating at about 50 inches of water at the well, with an air flow of approx. 100 cfm.
Numerous data is being collected, including:
-LEL, FID and PID levels in monitoring points within an approx 100 ft radius and at the RW-2D discharge line, 2-4 times/day
-water levels in monitoring wells around the test area
-vapor samples from the RW-2D air discharge line, for gas offsite analyses, 2/day
-vacuum levels in monitoring wells around the test area, with a portable magnahelic gage, accuracy to 0.05 inches water

Preliminary results from the field monitoring indicate that over 100,000 cf of vapors have been pumped from the recovery well RW-2D. The FID levels have been consistently been over 1000 ppm. Constituents and total mass of the gases removed will be determined after the syringe vapor samples are analyzed (this week). RW-2D is drawing down the deep zone groundwater levels lower than previously recorded. The drawdown is increasing continuously, but it will be months until the drawdown approaches steady-state conditions. The extent of drawdown below the base of the confining clay is presently limited to the area around RW-2D, but it is expected to expand over time. The vapor recovery operation should continue over at least 2 months to observe the potential benefit from the increased drawdown. URS setup piping to connect PZ 3D and 4D (Plant #5 wells currently vented) to the vacuum line. URS planned to do this work once a baseline of data for RW-2D only was obtained. URS also considered placing the RW-2D vacuum line underground to continue the test since CPM has expressed concerns about the line being in the way of their operations.

October 10, 2000- Vapor Monitoring

URS started the RW-2D vapor recovery operation on September 26, prior to the latest monitoring date. (See the vapor recovery section of this data summary report.). The vapor

recovery effort has had a dramatic effect on the monitoring results around RW-2D in the NPLS Area.
URS completed the installation of 5 new vapor probes in the deep zone as described previously. These probes were constructed from Oct. 9- 17 by Nothnagle Drilling. The probes are identified as VP- 5D, 6S/ 6D, 7D and 8D. URS previously had installed 4 shallow probes beneath the Plant #5 floor. These are VP- 1S, 2S, 3S and 4S.

1. Vapor Monitoring Summary

SHALLOW Zone-

NPLS/Plant #5 Areas- The low levels (<action levels) of vapor readings continue to be present in the shallow zone in the NPLS and Plant #5 Areas. Two "trends" are noted in these areas:

1) The vapor readings are significantly lower in the area around pumping well RW-2D. Note RW-1S, RW-2S, MW-7S and PZ-1S. This is likely a result of the vapor recovery testing started on Sept. 26 in RW-2D.

2) The shallow vapor probes in Plant #5 have for the first time had low level hits with the LEL and FID meters. These levels are still below action levels, but are higher than all previous readings.

UST Area- This area continues to have vapor readings above the referenced "action levels". Note that VP-3S and 4S are adjacent to the UST Area, and are possiblly influenced by the UST Area levels. These probes have recently had higher readings, but below action levels. MW-13, near Blackstone Ave., continues to have high vapor levels, with LEL at 100% and FID > 1000 ppm. URS continued to watch this closely.

DEEP Zone-

Vapor readings above "action levels" continue to be present in the deep zone in the NPLS and Plant #5 Areas, in the UST Area and in the East Parking Lot Area (east of Plant #5). Deep zone levels have decreased significantly in the NPLS Area. The 5 new vapor probes generally confirm the historic data. Three notable findings were observed from the initial probe readings:

1) Vapor levels in the VP-8D probe, directly north of Plant #5, are non-detect for LEL and below action levels for FID/PID. This is consistent with the vapor levels found at points north of Hopkins Avenue. This indicates that vapors are not migrating north of Plant #5.

2) Vapor levels in the VP-5D probe, in the NPLS parking lot, are non-detect for LEL and PID, and are below action levels for FID. This indicates that vapors are not migrating west of the NPLS/Plant #5 Areas.

3) Vapor probe VP-7D, southeast of the UST Area near Blackstone Avenue, has significantly exceeded the action levels for all of the monitoring readings. LEL levels are 100% and FID levels are >1000 ppm. This confirms the previous monitoring data which showed high levels in the UST Area and the East Parking Lot Area, directly east of Plant #5. Vapor probe VP-6 in the center of the east parking lot has significantly lower vapor levels, indicating that vapor migration to the east has not proceeded much beyond Plant #5.

In summary, the latest data indicates that the vapor levels are being reduced in the deep and shallow zones in NPLS Area as a result of the vapor recovery operation. Vapor recovery actions have had no apparent effect in the Plant #5 Area or to the east and southeast . Significant vapor levels persist in the UST Area and southeast of Plant #5. The UST Area SVE system was restarted on September 26, however, there is no notable effect on vapor levels at this time. Vapor migration has apparently extended to the UST Area and further south to Blackstone Ave in both the shallow and deep zones.

October 17, 2000- Vapor Monitoring

The vapor recovery system at RW-2D has been operating continuously since Sept. 26. URS added PZ-3D/4D (in Plant #5) to the vacuum system on October 11, and also fixed the short-circuit problem in RW-2D. The 6-inch dia. casing extension that was previously spliced to the 4 inch well during the remedial construction work was leaking at the splice joint. This caused a considerable volume of air to be sucked into the well head from the shallow zone. URS grouted the casing and this plugged the leak. This has resulted in the RW-2D air flow reducing from about 130 to 13 cfm.

SHALLOW ZONE-

NPLS/Plant #5 Areas:
The low levels (<action levels) of vapor readings continue to be present in the shallow zone. This includes all of the floor probes (VP1S - 4S) beneath Plant #5. The addition of PZ-3D/4D to the vapor recovery system has had no noticeable effect on the shallow vapor levels.

UST Area:
MW-13 and TW-01 continue to have vapor readings significantly above the "action levels". The monitoring to-date suggests that vapors are migrating from the deep zone in the iron injection area to the deep and shallow zones in this area. The confining clay is not continuous in the UST Area. URS planned to take a gas strippping sample this week at MW-13 to characterize the dissolved gas constituents in the well water. This area remains the primary area of concern for potential offsite migration of combustible vapors to the south of the site.

East Parking Lot Area:
All of the shallow monitoring points in this area were significantly below the action levels.

DEEP ZONE-

Vapor readings above action levels continue to be present in the deep zone throughout all areas of the site. Vapor levels have decreased in some of the monitoring points in the area of the vapor recovery testing (around RW-2D and PZ-3D/4D). The vapor readings above action levels are confined to within the site property in all directions, with the possible exception of the UST Area to the southeast of the iron injections.
Of note is that the new vapor probe VP-7D, near Blackstone Ave. on the south end of the site, has consistently had 100% LEL and >1000 ppm FID levels since it was installed . URS took a well vapor sample on Oct. 17 and plans to take a gas stripping sample this week to characterize vapor constituents in the well.

November, 2000- Vapor Monitoring

The PZ-3D/4D vacuum vapor recovery line was shutdown on November 8 because of concerns over potential detrimental effects on the Hot Spot Pilot Test. The 2-in vacuum line valve was closed and the passive vent line was opened. The passive vent discharges at the roofline of the treatment plant building.
The RW-2D vapor recovery line was shutdown on November 28. The vapor recovery operations were shutdown for the following reasons:

1. Vacuum extraction did not remove significant quantities of gases relative to the theoretical quantities predicted by ZVI reactions and TCE degradation. The vacuum extraction technique was not effective in the deep zone based on the very limited propagation of negative pressure throughout the monitoring zone. See the attached operating data.
2. Vacuum extraction appeared to enhance oxidation in and around RW-2D and increase mineral (Fe) precipitation and biofouling of the well, pump and discharge lines.
3. ZVI – generated vapors (hydrogen and organic gases) have not migrated outside of the injection areas or into the shallow groundwater zone beneath Plant No. 5 based on lab vapor analyses completed to-date. High LEL/FID readings in the UST Area, outside of the pilot test areas, appears to be caused by methane and TEX vapors which are not related to the PRB pilot tests. See vapor analyses section.
4. CPM snow clearing operations in the NPL Area would require removal and modification of the vapor recovery line from RW-2D.

SHALLOW ZONE-

NPLS/Plant #5 Areas:
Low levels (<action levels) of vapor readings continue to be present in the shallow zone. This includes all of the floor probes (VP1S - 4S) beneath Plant #5.

UST Area:

MW-13 and TW-01 continue to have vapor readings significantly above the "action levels". This area remains the primary area of concern for potential offsite migration of combustible vapors to the south of the site.

East Parking Lot Area:
All of the shallow monitoring points in this area were significantly below the action levels.

DEEP ZONE-

Vapor readings above action levels continue to be present in the deep zone throughout all areas of the site. Vapor levels have decreased in some of the monitoring points in the area of the vapor recovery testing (around RW-2D and PZ-3D/4D). The vapor readings above action levels are confined to within the site property in all directions, with the possible exception of the UST Area to the southeast of the iron injections.

December, 2000- January, 2001 - Vapor Monitoring

SHALLOW ZONE-

NPLS/Plant #5 Areas:
Low levels (<action levels) of vapor readings continue to be present in the shallow zone. This includes all of the floor probes (VP1S - 4S) beneath Plant #5. The shutdown of the vapor recovery system has had no noticeable effect on the shallow vapor levels.

UST Area:
MW-13 and TW-01 continue to have vapor readings significantly above the "action levels". The UST Area vapors are primarily methane and TEX compounds and do not appear to be related to the Pilot Test-generated gases.

East Parking Lot Area:
All of the shallow monitoring points in this area were significantly below the action levels.

DEEP ZONE-

Vapor readings above action levels continue to be present in the deep zone throughout all areas of the site. The vapor readings above action levels are confined to within the site property in all directions, with the exception of the UST Area to the southeast of the iron injections. These vapors do not appear to be related to the Pilot Test. The shutdown of the vapor recovery system has had no noticeable effect on the deep zone vapor levels.

March, 2001 - Vapor Monitoring

SHALLOW ZONE-

NPLS/Plant #5 Areas:
Low levels (<action levels) of vapor readings continue to be present in the shallow zone. This includes all of the floor probes (VP1S - 4S) beneath Plant #5. The shutdown of the vapor recovery system has had no noticeable effect on the shallow vapor levels.

UST Area:
MW-13 and TW-01 continue to have vapor readings significantly above the "action levels". The UST Area vapors are primarily methane and TEX compounds and do not appear to be related to the Pilot Test-generated gases.

East Parking Lot Area:
All of the shallow monitoring points in this area were significantly below the action levels.

DEEP ZONE-

Vapor readings above action levels continue to be present in the deep zone throughout all areas of the site. The vapor readings above action levels are confined to within the site property in all directions, with the exception of the UST Area to the southeast of the iron injections. These vapors do not appear to be related to the Pilot Test. The shutdown of the vapor recovery system has had no noticeable effect on the deep zone vapor levels.
The PZ's in the injection area (PZs 1D, 2D, 3D and 4D) have shown a decline in vapor levels that appear to have started in January, 2001, after the vapor recovery system was shutdown. This decline is most evident in the NPL Area.

April, 2001 - Vapor Monitoring

SHALLOW ZONE-

NPLS/Plant #5 Areas:
Low levels (<action levels) of vapor readings continue to be present in the shallow zone. This includes all of the floor probes (VP1S - 4S) beneath Plant #5. The shutdown of the vapor recovery system has had no noticeable effect on the shallow vapor levels.

UST Area:
MW-13 and TW-01 continue to have vapor readings significantly above the "action levels". The UST Area vapors are primarily methane and TEX compounds and do not appear to be related to the Pilot Test-generated gases.

East Parking Lot Area:
All of the shallow monitoring points in this area were significantly below the action levels.

DEEP ZONE-

Vapor readings above action levels continue to be present in the deep zone throughout all areas of the site. The vapor readings above action levels are confined to within the site property in all directions, with the exception of the UST Area to the southeast of the iron injections. These vapors do not appear to be related to the Pilot Test. The shutdown of the vapor recovery system has had no noticeable effect on the deep zone vapor levels.
The PZ's in the injection area (PZs 1D, 2D, 3D and 4D) have shown a continuing decline in vapor levels that appears to have started in January, 2001, after the vapor recovery system was shutdown. This decline is most evident in the NPL Area.

Note: After April, 2001, the vapor monitoring was discontinued since the vapor levels were confirmed to be confined within the deep groundwater zone in the pilot test area and were also on an apparent declining trend. Additional vapor sampling and analyses was planned for later in year 2001 to confirm these findings.

Vapor Analytical Results

Samples were taken for offsite laboratory analyses to characterize individual compounds and determine their concentrations in the well headspace vapor and dissolved groundwater phases. Vapor samples were taken from selected monitoring points by extracting headspace gases from the well casings with a syringe. Vapor samples from the groundwater phase were also taken by the field gas stripping method (Microseeps).

Gas stripping sampling procedures are described later in this section.

Analytical results are summarized on the attached tables:

-Vapor Analytical Results

-Groundwater Gas Strip Analytical Results

All vapor analyses was done for the following suite of compounds:

-Carbon dioxide
-Oxygen
-Nitrogen
-Hydrogen
-Methane
-Ethane
-Ethylene
-Propane
-Propylene
-Butanes

Vapor analytical data for RW-2D and PZ-3D are plotted graphically on the attached figures.

Vapor sampling was initiated in August, 2000 at selected monitoring points, and continued until July, 2001. No vapor samples have been taken after July, 2001. Groundwater gas strip sampling was performed less frequently, and was limited to monitoring points with a 2 inch diameter or greater casing. Smaller size casings did not permit insertion of pump tubing and generally did not have sufficient discharge to conduct the test.

Vapor Recovery Operations

Background

Vapor recovery was initiated on September 26, 2000 to collect and control the migration of potentially combustible vapors generated as a result of the iron injection pilot testing. Vapor monitoring and analyses indicated that hydrogen and organic vapors, notably ethylene, ethane and methane, were being generated in the area of the RW-2D and Plant #5 PRW Pilot Testing.

Vapor recovery was implemented using the existing SVE system in the NPLS Area. Recovery well RW-2D and piezometers PZ-3D and 4D, all in the deep groundwater zone in the pilot test area, were connected to the NPLS vacuum blower to attempt to remove vapors in the well headspaces, and in the case of RW-2D, in the aquifer headspace above the cone of depression.

Vapor Recovery Test Setup

On September 25, RW-2D was retrofitted with a 2-inch diameter PVC vacuum line connected to the NPLS Area vacuum blower in the treatment plant building. The pumping rate was increased 100% to approximately 6.5 gpm to maximize drawdown in the deep water-bearing zone.The recovery test was started on September 26 with only RW-2D connected to the blower.
On October 11, PZ-3D and 4D were connected to the RW-2D vacuum line using a 2-inch diameter PVC line connected to the PZ-3D/4D vent line previously constructed by URS. Both of the 2-inch vacuum lines are running across the parking lot pavement and are temporarily protected from traffic with wooden boards.
The vacuum system ran continuously from September 26 through November 28, 2000, except for temporary shutdowns. PZ-3D/4D were disconnected from the active system on November 8, 2000.
Operational data indicated that an air short-circuit was occuring in the RW-2D well or vacuum line. URS evaluated the system and found that ambient air was leaking into the well casing at a 4-inch to 6-inch casing extension installed during the remedial construction. The well annulus was grouted on October 12 and the short-circuiting was eliminated.

Vapor Recovery Operation and Monitoring

Numerous operating and monitoring data is being collected during the operation. Data collection was on a daily basis for the first 2 weeks of the testing and has been gradually cut back to a weekly basis as of the week of October 23.
Data is collected for the following:

Operations- vacuum line velocity, blower pump vacuum and temperature, RW-2D pumping rate

Vacuum pressure- monitoring wells and piezometers in iron injection areas

Groundwater levels- monitoring wells and piezometers in the site area

Vapor levels- LEL/O2, FID and PID measurements in monitoring wells and piezometers in iron injection areas

Summaries of the operations and monitoring data is contained on the subsequent data tables.

Vapor Monitoring Data - LEL

PRW Pilot Testing
Essex/Hope Site, Jamestown, New York

	Water-Bearing Zone	Well No.	LEL (%) - see note (1)														
			8/30/00	9/13/00	9/18/00	9/25/00	10/10/00	10/17/00	10/24/00	11/6/00	11/28/00	12/11/00	1/3/01	1/29/01	3/6/01	3/26/01	4/24/01
							note (2)	note (3)	note (4)		note (5)	note (6)	note (7)		note (8)	note (9)	note (10)
			Pre-Vapor Recovery Operations				Vapor Recovery Operations					Post-Operations					
NPLS AREA	Shallow	RW-1S		2	0	2	4	4	4	0	0	0	0	0	0	0	0
		RW-2S	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
		MW-7S	0	8	18	16	0	0	4	0	0	0	0	0	0	0	0
		MW-10		0	2	0	0	0	0	0	0	0	0	0	0	0	0
		MW-11S		0	0	0	0	0	0	n/a	0	0			0	0	0
		GP-4S		0	0	0	0	0	0	0	0	0	0	0	0	0	0
		GP-5S		0	0	0	0	0	0	0	0	0	4	0	0	0	0
		MW-17		n/a	0	2	4	0	0	0	0	0	0	0	0	0	0
		MW-6		0	2	2	4	0	0	0	0	0	4	8	4	0	0
		PZ-1S	0	1	2	0	0	0	0	0	0	0	8	0	0	0	0
	Deep	RW-1D	0	3	4	0	0	0	0	0	0	0	0	0	0	0	0
		RW-2D	5	1	2	2	0	0	0	4	2	0	0	0	0	0	0
		MW-7D	82	80	100	100	4	0	0	0	0	0	0	0	0	4	0
		MW-8		2	0	0	0	2	2	0	0	0	4	4	0	0	0
		MW-11D	0	0	0	0	0	2	4	n/a	0	0			0	0	0
		GP-4D		2	4	16	0	0	0	0	0	0	0	0	0	0	0
		GP-5D		0	0	0	0	2	4	2	4	8	4	8			0
		PZ-1D	100	100	100	100	100	100	100	100	100	100	0	60	28	0	0
		PZ-2D	60	80	100	100	100	100	42	40	60	100	0	40	0	4	0
		VP-5D					0	0	0	0	0	0	0	0	0	0	0
PLANT 5	Shallow	VP-1S		0	0	0	0	0	0	0	0	0	0	0	0	0	0
		VP-2S		0	0	0	2	2	0	0	0	0	0	0	0	0	0
		VP-3S				n/a	2	2	2	2	2	0	0	0	0	0	0
		VP-4S				n/a	8	4	2	2	2	0	0	0	0	0	0
		GP-1S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		GP-2S	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
		GP-3S	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
		MW-20	0	0	0	0	0	0	4	0	4	4	0	0	0	0	0
	Deep	GP-2D	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0
		GP-3D	5	0	0	0	0	0	4	2	0	0	0	4	0	0	0
		PZ-3D	100	100	100	100	100	40	0	100	18	100	0	60	100	80	58
		PZ-4D	100	100	100	18	100	80	0	0	0	100	40	100	16	20	4
		PZ-3D/4D STACK		100		n/a	4	4	0	0	0	0	0	0	0	0	0
		VP-8D					0	2	4	4	4	4	0	0	4	0	0
North of Hopkins Ave	Shallow	MW-14S	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
		MW-15S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		MW-16S		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Deep	MW-14D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		MW-15D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		MW-16D		0	0	0	0	0	0	0	0	0	0	0	0	0	0
East Parking Lot	Shallow	MW-19S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		PZ-5S	2	0	0	0	4	8	0	2	0	0	0	4	0	0	0
		PZ-6S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		MW-18		0	3	0	0	0	0	0	0	0	0	0	0	0	0
	Deep	MW-19D	100	100	100	94	100	100	100	44	100	100	100	100	0	58	0
		PZ-5D	100	100	100	100	100	100	100	80	100	100	100	100	100	100	100
		PZ-6D	100	100	100	100	80	100	100	18	100	100	100	100	100	100	30
		PZ-7D	2	0	0	0	0	2	0	0	8	10	8	4	0	0	0
		VP-6S					0	0	0	0	0	0	0	0	24	0	0
		VP-6D					0	2	0	0	0	0	4	8	0	38	34
UST AREA	Shallow	RW-4S	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
		RW-5S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TW-01	0	20	36	12	24	20	24	18	0	4	24	20	9	0	0
		MW-1			4	4	4	4	4	6	8	10	0	0	0	100	0
		MW-12		0			0	0	0	4	4	4	0	0	0	0	0
		MW-13					100	100	100	100	100	100	100	100	100	0	100
	Deep	PZ-8D	100	100	100	96	100	42	100	100	60	100	40	42	100	60	
		PZ-9D	100	100	100	100	38	100	100	100	80	100	100	100	100	100	100
		PZ-10D	100	100	100	100	100	100	98	100	56	80	100	100	100	90	30
		PZ-11D	0	18	18	22	20	24	8	4	8	4	18	24	100	100	0
		VP-7D					100	100	100	100	100	100	100	100	100	100	100
Wastewater Treatment Plant		Equalization Tank		14	12	8	0	8	8	8	12	28	8	12	9	10	10
		Plant Room		2	0	0	0	n/a	n/a	0	0	0			0	0	0

Note:
1. All vapor readings taken from headspace inside of monitoring point inner casing. Values in **bold** exceed standard safety action levels for vapor monitoring in work areas: LEL= 10%,
2. Vapor recovery test started on 9/26/00, RW-2D connected to vacuum blower
3. PZ-3D/4D connected to vapor recovery test on 10/11/00
4. PZ 3D/4D cleaned and purged on 10/19/00
5. All vacuum lines for vapor recovery operations, PZ-3D/4D and RW-2D, disconnected on 11/8/00 and 11/28/00, respectively
6. All PZ's cleaned and purged from 12/4/00 through 12/7/00
7. All of the PZ caps in the NPLS Area were damaged/open as a result of ice in the wellhead cover. The caps were repaired on 1/3/01. RW-2D pump off from 12/29/00- 1/3/01
8. Cap broken on GP-5D, Water in well frozen - no readings
9. GP-5D - Water still frozen in well
10. PZ-8D covered from UST Pilot Test

Vapor Monitoring Data - FID

PRW Pilot Testing
Essex/Hope Site, Jamestown, New York

Location	Water - Bearing Zone	Well No.	FID (ppm)- see note (1)														
			8/30/00	9/13/00	9/18/00	9/25/00	10/10/00	10/17/00	10/24/00	11/6/00	11/28/00	12/11/00	1/3/01	1/29/01	3/6/01	3/26/01	4/24/01
							note (2)	note (3)	note (4)		note (5)	note (6)	note (7)		note (8)	note (9)	note (10)
			Pre-Vapor Recovery Operations				Vapor Recovery Operations					Post-Operations					
NPLS AREA	Shallow	RW-1S		200	0	6.2	0	0	0		0	0	0	0	0	0	0
		RW-2S	1	300	58	64	0	0	0		0	0	0	0	0	0	0
		MW-7S	1	600	>1000	200	20	85	610	80	88	110	50	20	200	200	0
		MW-10		0.4	0	2.2	20	0	0		0	0	0	0	0	0	0
		MW-11S		0	0	0	0	0	0		0	4.2			0	0	0
		GP-4S		0	0	12	0	0	0		0	0	0	0	0	0	0
		GP-5S		0	0	0.2	20	4	6		0	0	8	6	0	0	0
		MW-17		0	0	1	0	0	0		0	0	0	0	0		0
		MW-6		12	0	0.6	120	19	14		0	4	24	20	0	0	0
		PZ-1S	20	0	0	7.8	0	2	1.6	6.2	8.4	6.8	0	0	0	0	0
	Deep	RW-1D	2.2	10	20	6	10	4	4.1		0	0	10	6	0	0	0
		RW-2D	> 1000	30	24	84	100	2.2	2.8	0	0	4	4	8	55	560	>1000
		MW-7D	40	>1000	>1000	>1000	120	35	5	4	4	8.8	24	24	>1000	600	0
		MW-8		3.8	0	4.4	0	8	4		4	6.7	10	6	0	0	0
		MW-11D	0.2	0	0	0	0	4	0		0	0			0	0	0
		GP-4D		0	0	2.4	0	0	0		6	4.6	0	0	0	0	0
		GP-5D		0	0	0	0	0	0		4	2.8	0	0			0
		PZ-1D	140	400	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000	0	380	18	200	0
		PZ-2D	4.4	10	>1000	880	>1000	>1000	>1000	>1000	>1000	>1000	0	240	20	45	0
		VP-5D					20	32	41		0	0	26	24	0	0	0
PLANT 5	Shallow	VP-1S		1.5	0.4	1.4	40	18	4.4	2	0	0	0	0	0		0
		VP-2S		2	0.2	0.8	30	12	8.1	4	0	0	0	0	0		0
		VP-3S				6.8	10	8	2.8	0	0.8	0	0	0	0		0
		VP-4S				104	10	10	8	2	0.4	0	0	0	0		0
		GP-1S	0	3.5	2	0	0	4	6.1		0	0	11	8	0		0
		GP-2S	0	0	0	0	0	20	3.4	88	2.2	2	0	0	0		0
		GP-3S	1.2	0	0	0	0	0	4	100	2.4	2.2	0	0	0		0
		MW-20	11	50	24	0.2	20	66	86	92	4.8	4.6	0	0	30		0
	Deep	GP-2D	0	0.2	7	1	0	28	80	76	4.6	0	0	0	0		0
		GP-3D	1.5	0	0	0	0	26	11	120	90	110	20	24	0		0
		PZ-3D	> 1000	60	>1000	>1000	>1000	50	3	>1000	>1000	>1000	46	360	>1000		0
		PZ-4D	> 1000	300	>1000	4	>1000	200	6.2	0.4	5.4	>1000	120	>1000	>1000		10
		PZ-3D/4D STACK		>1000		900	>1000	8	1.2	0	0	0	0	0	0		100
		VP-8D					20	100	98		12	9.6	21	24	80	350	0
North of Hopkins Ave	Shallow	MW-14S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		MW-15S	0	0.4	0	0.1	0	0	0	0	0	0	0	0	0	0	0
		MW-16S		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Deep	MW-14D	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0
		MW-15D	0	0.6	0	0	0	4	1.1	0	0	0	0	0	0	0	0
		MW-16D		0	0	0	0	0	0	0	0	0	0	0	0	0	0
East Parking Lot	Shallow	MW-19S	0	0	0	0.2	0	0	16		4	10.2	0	0	0		0
		PZ-5S	1	0	0	0.4	0	0	32		9.8	36	0	0	0		0
		PZ-6S	1	0	0	0.8	20	0	48		16	220	0	0	0		0
		MW-18		0	1.9	0	0	0	4		0	4.4	0	0	0		0
	Deep	MW-19D	0	>1000	>1000	>1000	>1000	>1000	>1000		>1000	>1000	>1000	>1000	0		0
		PZ-5D	>1000	>1000	>1000	>1000	>1000	>1000	>1000		>1000	>1000	>1000	>1000	>1000		>1000
		PZ-6D	>1000	>1000	>1000	>1000	>1000	>1000	>1000		>1000	>1000	>1000	320	>1000		>1000
		PZ-7D	5	10	21	3	5	2.8	42		10	9.8	3.6	20	10		0
		VP-6S					280	41	12		0	0	32	16	>1000		0
		VP-6D					160	26	90		0	0	26	24	0		>1000
UST AREA	Shallow	RW-4S	0	50	46	38	40	0	0		0	0	0	0	0	0	0
		RW-5S	0	0	0	3	0	0	0		0	0	0	0	0	9	0
		TW-01	0	800	>1000	42	>1000	>1000	>1000		78	48	>1000	>1000	450	95	0
		MW-1			54	160	80	88	530		4	2.2	50	64	0	>1000	>1000
		MW-12		0			0	0	0		0	0	0	0	0	0	0
		MW-13					>1000	>1000	>1000		>1000	>1000	>1000	>1000	>1000	0	>1000
	Deep	PZ-8D	0	>1000	>1000	>1000	>1000	>1000	>1000		>1000	>1000	>1000	>1000	>1000	>1000	
		PZ-9D	0	160	210	>1000	>1000	>1000	>1000		>1000	>1000	>1000	>1000	>1000	>1000	>1000
		PZ-10D	0.2	>1000	>1000	>1000	>1000	>1000	>1000		>1000	>1000	>1000	>1000	>1000	>1000	>1000
		PZ-11D	0	>1000	420	220	>1000	>1000	>1000		>1000	>1000	>1000	>1000	>1000	>1000	0
		VP-7D					>1000	>1000	>1000		>1000	>1000	>1000	>1000	>1000	>1000	>1000
Wastewater Treatment Plant		Equalization Tank		>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000
		Plant Room		20	14	0	40	n/a	n/a		0	44			2.8	0	10

Note:
1. All vapor readings taken from headspace inside of monitoring point inner casing. Values in bold exceed standard safety action levels for vapor monitoring in work areas: FID = 50 ppm
2. Vapor recovery test started on 9/26/00, RW-2D connected to vacuum blower
3. PZ-3D/4D connected to vapor recovery test on 10/11/00
4. PZ 3D/4D cleaned and purged on 10/19/00
5. All vacuum lines for vapor recovery operations, PZ-3D/4D and RW-2D, disconnected on 11/8/00 and 11/28/00, respectively
6. All PZ's cleaned and purged from 12/4/00 through 12/7/00
7. All of the PZ caps in the NPLS Area were damaged/open as a result of ice in the wellhead cover. The caps were repaired on 1/3/01. RW-2D pump off from 12/29/00- 1/3/01
8. Cap broken on GP-5D, Water in well frozen - no readings
9. FID not working half way through monitoring and GP-5D - Water still frozen in well
10. PZ-8D - Covered from UST Pilot Test;

Vapor Monitoring Data - PID

PRW Pilot Testing
Essex/Hope Site, Jamestown, New York

Location	Water-Bearing Zone	Well No.	PID (ppm) - see note (1)														
			8/30/00	9/13/00	9/18/00	9/25/00	10/10/00	10/17/00	10/24/00	11/6/00	11/28/00	12/11/00	1/3/01	1/29/01	3/6/01	3/26/01	4/24/01
							note (2)	note (3)	note (4)		note (5)	note (6)	note (7)		note (8)	note (9)	note (10)
			Pre-Vapor Recovery Operations				Vapor Recovery Operations					Post-Operations					
NPLS AREA	Shallow	RW-1S		0	9.9	4.5	0	0		0	0	0	0	0	0	0	0
		RW-2S	2.6	0	0	1.3	0	0		0	0	0	0	0	0	0	0
		MW-7S	0	0	**50.9**	5.6	0	3.7		2.5	1.3	0	6.7	4.8	0.9	0	0
		MW-10		0	0	0	0	0		0	0	0	0	0	0	0	0
		MW-11S		0	0	0	0	0		n/a	0	1.3				0	0
		GP-4S		0	0	0	0	0		0	0	0	0	0		0	0
		GP-5S		0	0	0	0	1.7		0	0	0	3.6	2.8		0	0
		MW-17		0	0	1.2	0.8	0		0	0	0	0	0		3.2	11.5
		MW-6		0	1.5	0.9	0	0		0	0	0	1.8	2.6		4.4	0
		PZ-1S	14	6	8.4	21.3	0	0		0	0	0	0	0	0.8	0	0
	Deep	RW-1D	0	0	0	4	0	1.2		0	0	0	2.6	1.8		0	2.5
		RW-2D	**100.3**	6.3	5.2	8.7	0	0		0	0	0	3.8	4.2	10.6	**189**	**1620**
		MW-7D	8	4.2	22.8	36.4	0	1.2		0	0	0	6.2	3.8	**942**	**340**	**390**
		MW-8		0	14.7	1.2	0	0		0	0	0	2.2	0		0	2.8
		MW-11D	0	0	0.4	0.9	0	0		n/a	3.2	2.7				0	0
		GP-4D		0	0	8.4	0.6	0		0	0	0	0	0		0	0
		GP-5D		0	0	0.3	0.6	3.7		2.5	4.6	3.4	2.8	2.8			0
		PZ-1D	34	**333**	**464**	**599**	**331**	**551**		**183.3**	**224.9**	**176.2**	0	**413**	**529**	47.8	45.2
		PZ-2D	16	**52**	**64.4**	10.9	31.9	**88.6**		12.5	**87.6**	**134.7**	0	**90.6**	**52.6**	0	0
		VP-5D					0	3.7		2.5	0	0	3.2	3.6		0	1.4
PLANT 5	Shallow	VP-1S		0	0.8	0.6	n/a	0		4.3	2.7	7.3	0	0	0	0	0
		VP-2S		0	0.4	0.8	n/a	0		2.5	4.3	3.4	0	0	0	0	0
		VP-3S				0.9	0	0		2.5	9.7	6.2	0	0	0	0	0
		VP-4S				10.2	2.4	1.2		2.5	6.2	5.1	0	0	0.5	0	0
		GP-1S	0	0	0	0	0	0		0	2.1	3.1	0	0	0	0	0
		GP-2S	0	0	0.9	0.7	0.2	3.7		0	13.4	16.6	0	0	0	0	0
		GP-3S	0	0	0	0.4	0.4	0		**57**	6.6	12.3	0	0	0.4	0	0
		MW-20	0	0	2.2	1.3	2.4	0		0	12.2	9.3	0	0	0.5	0	0
	Deep	GP-2D	0	12.6	9.9	14.6	12.8	26		37.6	17.4	22.7	0	0	8.4	0	0
		GP-3D	1.3	0	0	0	0	**1492**		0	9.4	3.4	**464**	**492**	**179**	0	0
		PZ-3D	**876.5**	0	**279**	**133**	**475**	3.7		**349**	**199**	**827**	**1470**	**497**	**896**	**403**	**125**
		PZ-4D	**814**	0	1.4	**86.4**	**498**	3.7		0	5	**1711**	**3504**	**847**	**788**	**309**	29.2
		PZ-3D/4D STACK		**300**		**144**	**158**	3.7		0	0	3.7	0	0		0	3.2
		VP-8D					41	**209.7**		**399**	**277**	**343**	12.8	8.6		**684**	**1854**
North of Hopkins Ave	Shallow	MW-14S	0	0	0	0.9	0	0		0	0	2.4	0	0		0	0
		MW-15S	0	0	0	0	0	0		2.5	0	0	0	0		0	0
		MW-16S		0	0	0.4	0.2	0		0	0	0	0	0		0	0
	Deep	MW-14D	0	0	0	0	0	0		0	0	1.7	0	0		0	0
		MW-15D	0	0	0	5.1	0	0		0	0	1.3	0	0		5.0	0
		MW-16D		0	0	0.2	0.6	0		0	0	0	0	0		0	0
East Parking Lot	Shallow	MW-19S	0	0	0.5	0.8	0.2	0		0	0	0	0	0		0	0
		PZ-5S	0	0	0.2	0.4	0	0		0	0	0	0	0		0	0
		PZ-6S	0	0	0.4	0.2	0	0		0	0	2.6	0	0		0	0
		MW-18		0	0	0	0	1.2		0	0	0	2.6	1.6		0	0
	Deep	MW-19D	0	0	0	0	0	0		0	0	22.6	0	0		0	5.9
		PZ-5D	0	0	0	0	0	0		0	0	0	0	0		0	6.8
		PZ-6D	0	0	0	1	0	0		0	0	4.3	0	0		0	10.6
		PZ-7D	0	0	1.1	0.8	n/a	28.5		47.8	33.7	21.9	22.8	18.9		0	34.4
		VP-6S					n/a	3.7		2.5	1.3	3.4	3.2	2.6		0	0
		VP-6D					n/a	**78.6**		**62.7**	48.9	**62.7**	**58.8**	**64.7**		48	10.5
UST AREA	Shallow	RW-4S	0	**54.9**	21.4	19.7	n/a	0		0	0	0	0	0		9.3	0
		RW-5S	0	0	0	0	n/a	0		0		0	0	0		0	1.0
		TW-01	49	**1842**	**2916**	**296**	n/a	**2999**		n/a	**1708**	**1311**	**>9999**	**>9999**		**90.9**	**835**
		MW-1			0	0	n/a	3.7		2.5	3.7	1.3	3.6	4.8		0	0
		MW-12		0			0	0		0	0	0	0	0		0	0
		MW-13					n/a	1.8		2.5	0	0	2.8	1.8		0	35.0
	Deep	PZ-8D	0	0	0	0	n/a	0		2.5	0	0	0	0		0	
		PZ-9D	0	0	0	0	n/a	0		0	0	0	0	0		0	23.7
		PZ-10D	0	0	2.9	3.4	n/a	0		0	0	0	0	0		0	13.4
		PZ-11D	0	0	0	0	n/a	0		0	0	0	0	0		0	4.6
		VP-7D					n/a	0		0	0	0	0	0		0	7.9
TREATMENT PLANT		Equalization Tank		**63**	**58.4**	**204**	n/a	**68.4**		37.6	**53.6**	**108.1**	**531**	41.7	**98**	**157**	**142**
		PLANT ROOM		0	2	0	n/a			0	1.7	4.6			0	0	0

Note:
1. All vapor readings taken from headspace inside of monitoring point inner casing. Values in **bold** exceed standard safety action levels for vapor monitoring in work areas: PID = 50ppm
2. Vapor recovery test started on 9/26/00, RW-2D connected to vacuum blower
3. PZ-3D/4D connected to vapor recovery test on 10/11/00
4. PID broken. No readings this week.
5. All vacuum lines for vapor recovery operations, PZ-3D/4D and RW-2D, disconnected on 11/8/00 and 11/28/00, respectively
6. All PZ's cleaned and purged from 12/4/00 through 12/7/00
7. All of the PZ caps in the NPLS Area were damaged/open as a result of ice in the wellhead cover. The caps were repaired on 1/3/01. RW-2D pump off from 12/29/00- 1/3/01
8. PID damaged during testing and Cap broken on GP-5D - Water frozen in well.
9. GP-5D - Water still frozen in well.
10. PZ-8D - Covered from UST Pilot Test

Well Headspace Vapor - Analytical Results

PRB Pilot Testing

Vapor Monitoring and Recovery Operations, Sept., 2000- July, 2001

Essex Jamestown Site

Sample note (1)	Date/Time	Compound (note 2) CO2 %V	O2 %V	N %V	CH4 ppmv	H2 ppmv	Ethane ppmv	Ethylene ppmv	Propane ppmv	Propylene ppmv	Butanes ppmv	H2/Ethane	H2/Ethene	Notes
PZ-1S	Shallow groundwater zone monitoring point, NPL Area PRB Test													
	7/13/2001	0.088	23	75	6.8	1.4	0.16	0.18	<0.03	<0.03	<0.03	8.75	7.78	
PZ-1D	Deep groundwater zone monitoring point, NPL Area PRB Test													
	7/13/2001	0.13	21	73	8600	21000	3200	4100	140	56	138	6.56	5.12	
PZ-2D	Deep groundwater zone monitoring point, within ZVI injection boring INJ 3, NPL Area													
	7/13/2001	0.09	17	76	25000	4800	13000	6400	410	82	486	0.37	0.75	
PZ-3D	Deep groundwater zone monitoring point in Plant #5, samples taken with vent and vacuum line valves closed													
	8/17/2000	0.1	2.64	47.29	2900	444000	4426	8012	190.7	208.4	218.82	100.32	55.42	
	8/24/2000	0.19	39.36	26.26	1800	356000	4637	8161	235.9	252.2	321.2	76.77	43.62	
	9/21/2000	0.05	17.41	59.59	1700	160000	5403	8842	254	254	364.4	29.61	18.10	9/8/00, vent installed at PZ-3D/4D
	10/17/2000	0.05	20.16	73.19	54	927	79.4	119	4.26	3.71	4.72	11.68	7.79	10/11/00, PZ-3D/4D connected to vac line
	11/8/2000	0.03	12.7	73.07	12.2	1.22	0.25	0.11	2.76	<0.03	<0.03	4.88	11.09	10/19/00, PZ-3D/4D wells cleaned and purged
	11/28/2000	0.06	21.25	75.56	38.2	1909	93.06	158	3.76	4.34	4.39	20.51	12.08	11/8/00, PZ-3D/4D vac line shutdown
	1/31/2001	0.061	21	76	24.0	380	62	64	2.7	1.5	3.78	6.13	5.94	
	3/7/2001	0.045	10	73	1300	140000	4900	7600	160	190	181	28.57	18.42	
	7/13/2001	0.051	5.4	15	20000	590000	81000	93000	2100	2300	2470	7.28	6.34	
PZ-4D	Deep groundwater zone monitoring point in Plant #5 for PRW pilot test, samples taken with vent and vacuum line valves closed													
	9/21/2000	0.06	21.11	74.61	8.42	2900	28.3	44.8	1.2	1.05	1.42	102.47	64.73	9/8/00, vent installed at PZ-3D/4D
	10/4/2000	0.08	6.97	37.41	3600	614003	15477	24023	709	732	1047	39.67	25.56	10/11/00, PZ-3D/4D connected to vac line
	PZ-3D/4D vacuum line disconnected on 11/8/00													10/19/00, PZ-3D/4D wells cleaned and purged
	1/31/2001	0.068	21	75	58	2800	240	350	8.6	8.9	10.8	11.67	8.00	
	3/7/2001	0.045	12	80	750	31000	3800	5500	140	160	179	8.16	5.64	
	7/13/2001	0.093	15	48	4800	310000	19000	22000	450	500	561	16.32	14.09	
PZ-3D/4D	NPLS vacuum blower connected to PZ-3D/4D on 10/11/00, sample taken with syringe from vacuum line													
	10/12/00- 1430	0.05	20.37	73.53	8.31	514	22.3	30.7	1.09	0.86	1.28	23.05	16.74	
	10/17/00- 1415	0.05	18.19	66.74	600	84946	2663	4148	146	147	169.9	31.90	20.48	
	10/24/2000	0.04	20.16	72.73	8.50	2.35	0.18	0.14	0.42	<0.03	0.10	13.06	16.79	10/19/00, PZ-3D/4D wells cleaned and purged
	11/7/2000	0.04	12.8	80.55	3.48	3.6	0.81	0.29	1.76	<0.03	<0.03	4.44	12.41	
	PZ-3D/4D vacuum line disconnected on 11/8/00													
PZ-6D	Deep groundwater zone monitoring point, east of Plant #5 building													
	11/8/2000	0.62	10.3	64.94	95900	1.41	<0.01	112	0.07	<0.03	0.27			
PZ-9D	Deep groundwater zone monitoring point in UST Area, south of Plant #5 building													
	11/8/2000	0.12	11.4	79.02	25800	6.05	<0.01	1.35	0.09	<0.03	0.30			

Notes:

1. Vapor samples taken with syringe from well headspace, except as noted for RW-2D and PZ-3D/4D
2. Vapor analyses by Microseeps, Inc.,

Well Headspace Vapor Analytical Results

Sample note (1)	Date/Time	Compound (note 2) CO2 %V	O2 %V	N %V	CH4 ppmv	H2 ppmv	Ethane ppmv	Ethylene ppmv	Propane ppmv	Propylene ppmv	Butanes ppmv			Notes
RW-2D	Deep groundwater zone recovery well, NPLS vacuum blower connected to RW-2D only on 9/26/00, sample taken with syringe from vacuum line													
	9/26/2000-1515	0.53	11.02	84.56	33.1	7.42	1.68	0.88	0.36	<0 03	0.54	4.42	8.43	RW-2D short-circuiting
	9/26/2000-1830	0.43	10.14	85 66	26.4	16 6	1.23	0 66	0.17	<0.03	<0.03	13.50	25.15	
	9/27/00- 1100	0.34	10.01	86.21	14.7	8.71	0.53	0.37	0 12	<0.03	0 15	16 43	23.54	
	9/27/00- 1500	0.37	11.66	83.91	26.5	10.3	0.87	0.76	0.17	<0 03	0.26	11 84	13.55	
	9/28/00- 1200	0.28	13.01	76.69	16.8	8 8	0.58	0.44	0.16	<0 03	0.23	15 17	20.00	
	10/4/00- 915		6.97	37.41	7 45	1 78	0.21	0.04	0.1	<0 03	0.32	8 48	44 50	
	10/9/00- 635	0.2	21.11	72.17	32.9	0.97	0 88	0.32	0 27	<0.03	0.61	1.10	3 03	
	10/10/00- 640	0.31	14.71	78.67	12.2	3.83	0.37	0.22	0.28	<0 03	0.39	10.35	17.41	
	10/11/00- 630	0.25	17.71	75.16	21.5	1.58	0.66	0 22	0.27	<0 03	0.47	2.39	7.18	
	10/17/00- 1400	0.05	20.2	72.8	11 2	1 81	0 62	1.09	0 07	<0.03	0.19	2 92	1.66	10/12/00, RW-2D grouted, short-circuiting reduced
	10/24/2000	0.04	20.25	72.97	5.69	0.95	0.13	0.2	0 04	<0.03	0.17	7.31	4 75	
	11/7/2000	0.03	7.09	76.21	1 36	9.48	0.38	0 62	0 04	<0 03	0.08	24 95	15.29	
	11/28/2000	0.04	21.17	75.47	14.2	0.84	0.12	0.3	<0 03	<0 03	0.09	7.00	2.80	
	RW-2D vacuum system shutdown on 11/28/00													
	3/7/2001	0.044	19	78	56	1 4	8 8	7 6	0.56	0.17	0 75	0 16	0 18	
	7/13/2001	0.32	20	75	5600	39	660	1800	22	38	21 5	0.06	0 02	
MW-7S	Shallow groundwater zone monitoring well, approx. 12 ft. from RW-2D													
	10/4/00- 940	0.34	16.68	64.70	1206	56896	3215	3626	132	95.1	149 7	17 70	15.69	
	1/31/2001	0 08	21	75.00	180	25	0.18	0.097	0 055	<0.03	0 18	138.89	257.73	
	7/13/2001	0.16	24	67.00	190	5.5	4 2	9 1	0 2	<0 03	<0.03	1 31	0 60	
MW-7D	Deep groundwater zone monitoring well, approx. 14 ft. from RW-2D													
	10/4/00- 950	0.12	15.98	81.87	143	18.3	0 7	0 61	0.17	<0.03	0 41	26 14	30 00	
	7/13/2001	0.097	23	75	160	16	4 2	12	0.17	0 23	<0 03	3 81	1.33	
MW-13	Shallow groundwater monitoring well in UST Area on south end of site													
	10/24/2000	0.24	12.40	72.45	0.26	1.28	<0 01	0.05	<0.03	<0 03	<0 03			
TW-01	Shallow groundwater zone test well in UST Area													
	10/4/00- 900	2.27	10	78.25	924	4 63	0 06	0.18	0.08	<0.03	0.32	77 17	25 72	
VP-7D	Deep groundwater zone vapor probe in UST Area on south end of site													
	10/17/2000	1.4	10.25	37.2	433000	35.9	<0.01	14 65	0.18	0.2	0.53			
	11/29/2000	0.4	18.62	65 9	117500	8 42	<0 01	2 92	<0 03	<0.03	0 13			
VP-8D	Deep groundwater zone vapor probe adjacent to Hopkins Ave, NE corner of Plant #5													
	7/13/2001	0.088	24	75	16	4.6	0.26	0 71	<0 03	<0 03	<0.03	17.69	6.48	
GP-2D	Geoprobe well in SE corner of Plant #5, ~ 40 ft south of Hot Spot Area													
	7/13/2001	0 46	24	72	9900	2	2 1	60	0 12	<0 03	<0 03	0.95	0 03	
GP-3D	Geoprobe well in center of Plant #5, ~ 65 ft east of Hot Spot Area													
	7/13/2001	0.15	22	75	940	8.5	0 23	3.5	<0 03	<0 03	<0.03	36 96	2.43	
GP-4D	Geoprobe well in center of NPL Area, ~ 48 ft west of Hot Spot Area													
	7/13/2001	0.08	25	74	210	2.2	0 07	0 37	<0.03	<0 03	<0 03	31.43	5 95	

Notes:

1. Vapor samples taken with syringe from well headspace, except as noted for RW-2D and PZ-3D/4D
2. Vapor analyses by Microseeps, Inc.,

Groundwater Gas Strip Analytical Results

PRB Pilot Testing

Vapor Recovery Testing, Sept. - July, 2001

Essex Jamestown Site

Sample note (1)	Date/Time	Compound (note 2)											Notes
		CO2 mg/L	O2 mg/L	N mg/L	CH4 ug/L	H2 nM	H2 (est) ug/l (note 3)	Ethane ng/L	Ethylene ng/L	Propane ng/L	Propylene ng/L	Butanes ng/L	
RW-2D	10/3/2000	11.71	2.51	14.14	3058	1857	1.12	33038	121862	1584	3478	1716	vacuum line short-circuit
	10/25/2000	16.02	0.81	15.4	4080	-		59694	189282	2927	6758	2876	10/12/00- RW-2D grouted,
	11/9/2000					31.7	0.013						short-circuiting reduced
	7/13/2001				4600	66		78000	310000	3500	6200	3230	RW-2D vac shutdown on 11/28/00
MW-7S	10/3/2000	28.91	2.04	14.06	439.9	80693	40.3	1037889	2150527	54238	65839	57712	
	11/9/2000	4.39	3.51	10.86	911.1	161820	71.9	916912	2373283	45713	67554	50317	
	7/13/2001				8.9	320		4200	4800	190	100	176	
MW-7D	10/3/2000	17.57	1.37	14.69	2629	57.7	0.04	6174	47162	322	659	153	
	7/13/2001				3600	3.1		59000	460000	2400	3900	1840	
TW-01	10/3/2000	26.72	1.55	15.83	1068	3.38	<0.01	25	197	<25	30	<25	
VP-7D	10/25/2000	67.38	1.53	4.96	21600	-		404	7362	62	318	37	
	11/9/2000					1.04	<0.01						

Notes:

1. Vapor samples taken from well groundwater by field gas stripping method, reference Microseeps, Inc. Gas Stripping Cell Method
2. Vapor analyses by Microseeps, Inc.
3. Hydrogen concentration estimated based on nM H2/volume of water stripped. (ug/l H= nM H * (0.002/liter water)

Operating Data

Vapor Recovery Testing, Sept. - Oct./2000
Essex Jamestown Site

Date/Time	Vapor Discharge Lines- 2in. Dia. Velocity (fpm), note (1) RW-2D	PZ-3D/4D	Flow (cfm) RW-2D	PZ-3D/4D	Vacuum Blower Pump, note (2) Press. Inches H2O	Temp In (F)	Temp Out (F)	Well Discharge note (3) RW-2D gpm	RW-1S/2S gpm	Notes
9/26/2000										NPLS vacuum pump started on 9/26/00
1050	4000		88		100	52	106			All other NPLS SVE valves off
1115	4500		99		39	58	92	6.5		
1215	3900		85.8							
1400	4600		101.2		36	65	100			
1600	4500		99		36	63	100			vapor sample-1515 hrs- RW-2DV
1800	3600		79.2		36	64	100			vapor sample -1830 hrs- RW-2DV
9/27/2000										
900	4600		101.2		36	59	96	6.7		
1100	4500		99		36	60	98			vapor sample-1100 hrs- RW-2DV
1430	4200		92.4		36	70	104			
1610	4400		96.8		35	68	106	6.74		vapor sample-1500 hrs- RW-2DV
9/28/2000										
800	4500		99		32	58	92	6.68		
1200	4800		105.6		33	61	95			vapor sample- 1200 hrs- RW-2DV
1715	5000		110		36	59	97			
1720	5800		127.6		50	59	100	6.71		vac. pump press increased @1720 hrs
9/29/2000										
820	6000		132		50	56	100	6.66		
1230	6000		132		50	52	103			
9/30/2000										
730	6000		132		50	56	100			
10/1/2000										
730	6000		132		50	56	102			
10/3/2000										gas strip sample- RW-2D
1625	5900		129.8		50	70	114	6.3		
10/4/2000										new flowmeter installed for RW-2D
755	5000		110		40	56	96			
1050	5500		121		40	58	96			vapor sample-915 hrs-RW-2DV
1600	6000		132		35	60	100			
10/5/2000										
735	6000		132		40	56	94			
1430	5500		121		40	54	96			
10/6/2000										
650	6000		132		40	56	92			
1423	5900		129.8		35	62	104			

Notes

1. Dwyer Thermal Anemometer Series 470, measurements taken in well/piezometer 2 in. discharge line
2. Vac. pressure in condensate tank upflow of blower, temp in at condensate tank, temp out at blower outlet
3. Well discharge measured in treatment plant @ pipe rack flowmeter, see operating log

Operating Data

Date/Time	Vapor Discharge Lines- 2in. Dia.				Vacuum Blower Pump, note (2)			Well Discharge note (3)		Notes
	Velocity (fpm), note (1) RW-2D	PZ-3D/4D	Flow (cfm) RW-2D	PZ-3D/4D	Press. Inches H2O	Temp In (F)	Temp Out (F)	RW-2D gpm	RW-1S/2S gpm	
10/7/2000										
630	6000		132		40	54	92			
1400	6000		132		40	54	90			
10/8/2000								4.0		
635	6000		132		40	46	84			
1500	6000		132		40	56	92			
10/9/2000								4.9		
655	6000		132		40	50	86			vapor sample- 635 hrs- RW-2DV
10/10/2000								4.8		vapor sample- 640 hrs- RW-2DV
10/11/2000										vapor sample- 630 hrs- RW-2DV
1350	5250	150	115.5	3.3	35					PZ-3D/4D connected to vac pump
1535	5500	35	121	0.77						
1655	0	200	0	4.4	90					RW-2D vac line closed, PZ-3D/4D open
1930	0	400	0	8.8	90					
10/12/2000								4.76	0.42	RW-2D annulus grouted
800	0	150		3.3	90					vapor sample- 1430 hrs- PZ 3D/4DV
10/14/2000										RW-2D vac line open, PZ-3D/4D open
710		310		6.82	140	58	128			
10/15/2000										
900		750		16.5	143	64	134			
10/16/2000										
?	100		2.2							
10/17/2000								4.6		
900	150	75	3.3	1.65	90	64	142			vapor sample- 1400 hrs- RW-2DV
1400		75		1.65						vapor sample- 1415 hrs- PZ-3D/4DV
10/19/2000								4.52		PZ-3D/4D screens cleaned/flushed
935	75	200	1.65	4.4	98	58	136			
1300		800		17.6	98					PZ-3D/4D purged to bottom of screen
10/20/2000										
700		600		13.2	92					
10/24/2000								4.45	0.62	
1100	600	200	13.2	4.4	92	64	142			
11/6/2000										
1220	75	60	1.65	1.32	100	52	132			
11/8/2000										PZ-3D/4D vac line disconnected @ 1800 hrs
1900	75	0	1.65		100	65	154			PZ-3D/4D vent opened
11/28/2000										
1100	50	0	1.1		100	48	132			RW-2D vac line disconnected @1700 hrs

vapor samples?

Notes
1. Dwyer Thermal Anemometer Series 470, measurements taken in well/piezometer 2 in. discharge line
2. Vac. pressure in condensate tank upflow of blower, temp in at condensate tank, temp out at blower outlet
3. Well discharge measured in treatment plant @ pipe rack flowmeter, see operating log

RW-2D pump cleaned.

Vacuum Pressure Monitoring

Vapor Recovery Testing, Sept. - Oct./2000

Essex Jamestown Site

Date/Time	Monitoring Well/Piezometer Vacuum Pressure Reading, Inches of Water (see note 1):													Notes
	Vac Pump	RW-2D (note 2)	MW-7S	GP-4S	PZ-1S	PZ-1D	PZ-2D	PZ-3D/4D (note 2)		PZ-5S	PZ-5D	PZ-6S	PZ-6D	
	NPLS	vac line						well	vac. line					
9/26/2000	NPLS vac pump started, connected to RW-2D only													see vac pump
9/28/2000														mechanical data
1100	33		ND	ND	ND	(+P)	0.00	0.00		ND	ND	ND	ND	
1330	35		ND	0.0	1.25	(+P)	0.05	0.00		0.00	0.00	0.00	0.00	
1810	35		0.00	0.0	1.25	(+P)	0.00	ND		0.00	0.00	0.00	0.00	
9/29/2000														See note (3)
830	50		ND	0.0	1.43	(+P)	0.00	0.00		0.00	0.00	0.00		
1110	50		0.00	0.0	1.50	(+P)	0.00	0.00		0.00	0.00	0.00	0.00	
10/1/2000	Treatment Plant (NPLS vac pump and RW-2D) down for approx. 8 hrs from approx. 0730 to 1526													
10/2/2000														
600	50		ND	ND	1.35	1.75 (+P)	0.00	0.00		0.00	0.00	0.00	0.00	See note (4)
1800	50		ND	ND	1.40	0.5 (+P)	0.00	0.00		0.00	0.00	0.00	0.00	
10/3/2000														
1810	50		0.00	0.00	1.40	0.35 (+P)	0.00	0.00		0.00	0.00	0.00	0.00	
10/4/2000														
1050	40		0.00	0.00	2.40	0.05 (+P)	0.00	0.00		0.00	0.00	0.00	0.00	
1240	40	20			2.44	1.25 (+P)								
10/5/2000														
733	40	20	0.00	0.00	1.75	1.50 (+P)	0.00	0.00		0.00	0.00	0.00	0.00	
1430	40	20	0.00	0.00	1.75	0.00	0.00	0.00		0.00	0.00	0.00	0.00	
10/6/2000														
800	40	20	0.00	0.00	2.00	1.75 (+P)	0.00	0.00		0.00	0.00	0.00	0.00	
1530	35	20	0.00	0.00	2.00	1.50 (+P)	0.00	0.00		0.00	0.00	0.00	0.00	
10/7/2000														
718	40	20	0.00	0.00	2.00	2.00 (+P)	0.00	0.00		0.00	0.00	0.00	0.00	
1545	40	20	0.00	0.00	2.20	1.50 (+P)	0.00	0.00		0.00	0.00	0.00	0.00	
10/8/2000														
645	40	20	0.00	0.00	2.40	1.75 (+P)	0.00	0.00		0.00	0.00	0.00	0.00	
1500			0.00	0.00	2.2	2.00 (+P)	0.00	0.00		0.00	0.00	0.00	0.00	

Notes:

1. Vacuum/pressure readings at wellhead taken with Dwyer Magnahelic Gage, 0-2.0 inches water range, graduated @ 0.05 inches water
2. RW-2D and PZ-3D/4D vacuum readings taken at 2 inch vacuum discharge lines near wells
3. Vacuum pump pressure increased to 50 in.on 9/28, 1720 hrs.
4. PZ-1D exhibits positive pressure responses (+P), pressure level measured as indicated

Vacuum Pressure Monitoring

Vapor Recovery Testing, Sept. - Oct./2000

Essex Jamestown Site

Date/Time	Monitoring Well/Piezometer Vacuum Pressure Reading, Inches of Water (see note 1):													Notes
	Vac Pump	RW-2D (note 2)	MW-7S	GP-4S	PZ-1S	PZ-1D	PZ-2D	PZ-3D/4D (note 2)		PZ-5S	PZ-5D	PZ-6S	PZ-6D	
	NPLS	vac line						well	vac line					
10/10/2000														
830	38	18	0	0	2.00	2.00(+P)	0.00	0.00		0	0	0	0	
10/11/2000														
1300										PZ-3D/4D vacuum line connected				
1535		17							24					
1655	90	0	RW-2D vac line shut off					90	80-100 (est)					
10/12/2000														RW-2D grouted-
1500									90					no short-circuiting
10/14/2000	RW-2D vac line open (@710), PZ-3D/4D vac line open													
710	140	90												
10/15/2000														
900	144	90												
10/16/2000														
1805	95	90			0	2.00(+P)	0.25							
10/17/2000														
545	95	90	0	0	0	2.00(+P)	0.00			0	0	0	0	
10/19/2000														PZ 3D/4D cleaned
830	98	96							94					and purged
1300									98					
10/20/2000														
700									92					
10/24/2000														
1100	95	92	0	0	0	0	0			0	0	0	0	

Notes:

1. Vacuum/pressure readings at wellhead taken with Dwyer Magnahelic Gage, 0-2.0 inches water range, graduated @ 0.05 inches water
2. RW-2D and PZ-3D/4D vacuum readings taken at 2 inch vacuum discharge lines near wells
3. Vacuum pump pressure increased to 50 in.on 9/28, 1720 hrs.
4. PZ-1D exhibits positive pressure responses (+P), pressure level measured as indicated

Groundwater Level Monitoring

Vapor Recovery Testing, Sept. - Oct./2000

Essex Jamestown Site

Date/Time	RW-1D	RW-2D	MW-7S	MW-7D	MW-8	MW-14S	MW-14D	PZ-1S	PZ-1D	PZ-2D	PZ-3D	PZ-4D	PZ-5S	PZ-5D	PZ-6S	PZ-6D	Notes
	Monitoring Well/Piezometer Groundwater Level, Feet Below Measuring Point (see note 1):																
9/25/2000	RW-2D started pumping at 6.5 gpm (60 Hz) at approx. 2100 hrs. RW-1S and 2S operating at normal flows																see RW-2D pumping
9/26/2000																	log in plant
820		34.52	9.33	23.55	19.51												
1050		34.40		20.51													start vac pump
1410				20.74													
1600				20.74													
1800			9.52	20.85													
9/27/2000																	
900			9.70	21.35	19.60												
1430		35.60	9.70	21.40	19.70												
9/28/2000																	
630			9.84	21.61													
800	18.00	36.01	9.84	21.65	19.92												
1030								8.29	14.31	19.20	15.58	17.52					
1330	18.03	36.31	9.91	21.71	20.01			8.31	14.84	20.33	15.59	17.52	6.54	11.12	8.63	11.95	See note (2)
1810	18.05	36.29	9.92	21.71	20.02			8.38	14.84	19.22			6.59	11.15	8.65	11.62	See note (3)
9/29/2000																	
830	18.19	36.05	10.09	21.81	20.08			8.44	14.91	19.19	15.64	18.19	6.68	11.29	8.74	11.84	
1110	18.17	36.96	10.11	21.87	20.12			8.41	14.92	19.23	15.71	18.14	6.69	11.29	8.75	11.76	
10/1/2000	Treatment Plant and mechanical systems down for approx. 8 hrs from approx. 0730 to 1526																
10/2/2000																	
600	15.12	34.68	10.89	22.64				8.69	15.12		16.02	17.81	6.52	11.11	8.61	11.74	
1800	14.98	33.02	11.49	21.82				8.72	14.98	18.53			6.98	11.31	9.02	11.81	
10/3/2000																	
1700	18.51	35.87	11.82	21.38		15.23	20.09	8.82	15.01	19.21		20.09	7.19	11.61	9.15	13.86	See note (4)
10/4/2000																	
1050	16.51	29.41	11.17	19.31	18.78	15.12	18.81	8.51	14.32	17.27	15.53	16.73	5.63	11.49	8.37	12.18	10/4, heavy rain in am
10/5/2000																	new flow meter on RW2D
1545	14.59	26.27	14.15	17.20	16.53	10.02	17.19	7.56	12.89	15.43	14.11	15.05	5.66	11.06	8.03	11.62	10/5, heavy rain all day
10/6/2000																	
800	14.87	27.49	14.61	17.83	16.32	13.59	17.13	7.66	13.08	15.67	14.12	15.07	4.51	10.61	7.03	11.51	10/6, heavy rain all day

Notes:

1. Measuring points at the top of well pipe, inside of the protective casing/cover, unless otherwise noted
2. Measuring points modified for vacuum fittings, PZ-1D MP +1.50 in., PZ- 2D MP +1.00 in.
3. Measuring point modified for vacuum fitting, PZ-1S MP +0.5 in.
4. PZ-6D not recovered from 10/3 sampling purging

Groundwater Level Monitoring

Vapor Recovery Testing, Sept. - Oct./2000

Essex Jamestown Site

Date/Time	Monitoring Well/Piezometer Groundwater Level, Feet Below Measuring Point (see note 1):																Notes
	RW-1D	RW-2D	MW-7S	MW-7D	MW-8	MW-14S	MW-14D	PZ-1S	PZ-1D	PZ-2D	PZ-3D	PZ-4D	PZ-5S	PZ-5D	PZ-6S	PZ-6D	
10/6/2000																	
1530	14.59	27.19	9.62	17.34	16.32	13.59	17	7.65	12.84	15.33	13.92	14.89	4.81	10.54	7.16	11.19	
10/7/2000																	
720	14.45	27.55	9.61	17.12	16.31	13.51	16.82	7.67	12.69	15.08	13.72	14.86	5.16	10.36	7.52	10.94	
1545	14.31	26.83	9.58	17.03	16.08	13.43	16.71	7.59	12.58	14.93	13.58	14.63	5.07	10.28	7.57	10.89	
10/8/2000																	
800	15.39	32.26	9.62	17.81	16.71	13.23	17.19	7.62	13.41	16.03	13.79	15.28	4.89	10.11	7.41	10.76	
1600	15.59	32.58	9.45	18.91	17.16	13.29	17.36	7.52	12.78	16.02	13.86	15.32	4.82	10.01	7.36	10.73	
10/9/2000																	
830	15.87	33.09	9.53	19.17	17.63	13.44	17.69	7.56	13.01	16.33	13.92	15.68	4.96	10.6	7.37	10.69	
1630	15.85	33.21	9.47	19.21	17.58	13.45	17.72	7.58	13.04	16.39	13.92	15.53	5.01	9.91	7.41	10.62	
10/10/2000																	
700	15.85	33.34	9.48	19.18	17.79	13.51	17.69	7.78	13.03	16.41	13.88	15.65	5.16	9.79	7.55	10.43	
10/11/2000																	
1300	PZ-3D/4D vacuum line connected																
1645											13.53	20.22					
1655	RW-2D vac line shut off																
1930											13.69	14.73					
10/12/2000																	
800											13.85	15.71					
10/14/2000																	
710	RW-2D vac line open, PZ-3D/4D vac line open																
10/17/2000																	
1325	16.05	28.95	10.95	19.32	17.93	14.21	17.94	8.49	13.37	16.35	13.84	15.34	6.41	10.46	8.55	10.72	
10/19/2000	PZ 3D/4D cleaned and purged																
10/24/2000																	
1130	16.28	29.13	11.47	19.51	18.16	14.75	18.19	9.15	13.58	16.34	13.26	10.17	7.55	10.85	9.23	10.87	

Notes:

1. Measuring points at the top of well pipe, inside of the protective casing/cover, unless otherwise noted
2. Measuring points modified for vacuum fittings, PZ-1D MP +1.50 in., PZ- 2D MP +1.00 in.
3. Measuring point modified for vacuum fitting, PZ-1S MP +0.5 in.

LEL Monitoring

Vapor Recovery Testing, Sept. - Oct./2000

Essex Jamestown Site

Date/Time	LEL Reading, % (see note 1):											Notes
	RW-2D	Blower Discharge	MW-7S	MW-7D	PZ-1S	PZ-1D	PZ-2D	PZ-3D/4D		PZ-6D	TW-01	
	well (Note 2)							vent closed	well (Note 2)			
9/26/2000												
1235				0								
1410			2	2		>100	>100					
9/27/2000												
1000			0	2		>100	>100					
1630			0	0		>100	>100					
9/28/2000												
1100		10	0	2	0	>100	>100					
1900		5	0	0	0	>100	>100					
9/29/2000												
915		0	0	2	0	>100	>100					
1250		0	0	2	0	>100	>100					
10/1/2000	NPLS vac pump and RW-2D down for approx. 8 hrs from approx. 0730 to 1526											
10/4/2000												
1440	0		0	0	0	80	70	40		16	6	
10/5/2000												
733	3	0	0	0	4	90	>100	>100		12	4	
1430	4	0	0	0	0	>100	>100	>100		>100	4	
10/6/2000												
705	4	0	0	0	0	>100	>100	>100		>100	4	
1400	0	0	0	0	0	>100	>100	>100		>100	8	
10/7/2000												
655	0	0	0	0	4	>100	>100	>100		>100	6	
1430	0	0	0	0	4	>100	>100	>100		>100	4	
10/8/2000												
645	4	4	0	0	0	>100	>100	>100		>100	16	
1500	4	4	0	0	0	>100	>100	>100		>100	20	
10/9/2000												
730	0	4	0	0	0	>100	>100	>100		>100	20	
10/10/2000												
800	0		0	4	0	100	100	4		80	24	

Notes:

1. MSA Combustible Gas And Oxygen Meter, Model 261
2. RW-2D and PZ-3D/4D readings taken at well vapor discharge line sample ports using a Tedlar sampling bag filled by a hand vacuum pump

LEL Monitoring

Date/Time	LEL Reading, % (see note 1):											Notes
	RW-2D	Blower Discharge	MW-7S	MW-7D	PZ-1S	PZ-1D	PZ-2D	PZ-3D/4D		PZ-6D	TW-01	
	well (Note 2)							vent closed	well (Note 2)			
10/11/2000								???				
1300	PZ-3D/4D vac-line open											
1655	RW-2D vac-line shut off											
10/12/2000												
800								4	0			RW-2D short-circui fixed
10/14/2000												
710	RW-2D vac-line open, PZ-3D/4D vac-line open											
10/17/2000												
1100	0		0	0	0	100	100	4		100	20	
10/19/2000	PZ-3D/4D cleaned and purged											
935	0								0			
1300									0			
1315								0				
10/20/2000												
700								0	0			

Notes:

1. MSA Combustible Gas And Oxygen Meter, Model 261
2. RW-2D and PZ-3D/4D readings taken at well vapor discharge line sample ports using a Tedlar sampling bag filled by a hand vacuum pump

FID Monitoring

Vapor Recovery Testing, Sept. - Oct./2000

Essex Jamestown Site

Date/Time	FID Reading, PPM (see note 1): RW-2D well (note 2)	Blower Discharge	MW-7S	MW-7D	PZ-1S	PZ-1D	PZ-2D	PZ-3D/4D vent closed	well (note 2)	PZ-6S	PZ-6D	TW-01	Notes
9/26/2000													
1235				0									
1410		78	360	2.2		>1000	>1000	>1000					
1600			600	350		>1000	>1000	>1000					
9/27/2000													
1000			0	0		>1000	>1000	>1000					FID pump problems at MW-7S & MW-7D
1630			500	>1000		>1000	>1000	>1000					
9/28/2000													
1100		620	80	400	0	>1000	>1000	>1000					
1900		475	400	500	0	>1000	>1000	>1000					
9/29/2000													
915		190	>1000	>1000	8	>1000	>1000	>1000					
1250		300	>1000	>1000	6	>1000	>1000	>1000					
10/1/2000	NPLS vac pump and RW-2D down for approx. 8 hrs from approx. 0730 to 1526												
10/4/2000													
1030		140	>1000	350	250	>1000	>1000	>1000		60	>1000	>1000	
1440	210		260	300	510	>1000	>1000	>1000		60	>1000		FID out at TW-01
10/5/2000													
733	300	80	>1000	>1000	0	>1000	>1000	>1000		80	>1000	>1000	
1430	280	60	350	400	0	>1000	>1000	>1000		60	>1000	>1000	
10/6/2000													
705	260	60	100	300	0	>1000	>1000	>1000		20	>1000	>1000	
1400	240	60	100	300	0	>1000	>1000	>1000		60	>1000	>1000	
10/7/2000													
655	160	20	160	240	0	>1000	>1000	>1000		50	>1000	>1000	
1430	280	100	100	180	0	>1000	>1000	>1000		40	>1000	>1000	
10/8/2000													
645	80	20	80	60	0	>1000	>1000	>1000		40	>1000	>1000	
1500	60	20	60	60	0	>1000	>1000	>1000		80	>1000	>1000	
10/9/2000													
730	120	40	120	200	0	>1000	>1000	>1000		20	>1000	>1000	
10/10/2000													
800	100		20	120	0	>1000	>1000	>1000		20	>1000	>1000	

Notes:

1. Century OVA Model 128 with charcoal pre-filter
2. RW-2D and PZ-3D/4D readings taken at well vapor discharge line sample ports using a Tedlar sampling bag filled by a hand vacuum pump

FID Monitoring

Date/Time	FID Reading, PPM (see note 1): RW-2D well (note 2)	Blower Discharge	MW-7S	MW-7D	PZ-1S	PZ-1D	PZ-2D	PZ-3D/4D vent closed	well (note 2)	PZ-6S	PZ-6D	TW-01	Notes
10/11/2000								???					
1300	PZ-3D/4D vac-line open												
1540	200								160				
1655	RW-2D vac-line shut off							>1000					
1930									260				
10/12/2000													
800									40				
10/14/2000													
710	RW-2D vac-line open, PZ-3D/4D vac-line open												
10/17/2000													
1100	2.2		85	35	2	>1000	>1000	8?		0	>1000	>1000	
10/19/2000	PZ-3D/4D cleaned and purged												
935	2								7				
1300								2.4?	5				
10/20/2000													
700								1.3?	1.4				

PID Monitoring

Vapor Recovery Testing, Sept. - Oct./2000

Essex Jamestown Site

Date/Time	PID Reading, PPM (see note 1):												Notes
	RW-2D	Blower Discharge	MW-7S	MW-7D	PZ-1S	PZ-1D	PZ-2D	PZ-3D/4D		PZ-6S	PZ-6D	TW-01	
	well (note 2)							vent closed	well (note 2)				
9/26/2000													
1235				0									
1410			0	0		**508**	37.9						
1600			2	0.2		**280**	**340**						
9/27/2000													
1000		0	5.2	3.1		**596**	**561**						
9/29/2000													
915		0.2	27.7	28.6	0	**632**	**532**						
1250		0.2	18.3	22.8		**640**	**470**						
10/1/2000	NPLS vac pump and RW-2D down for approx 8 hrs from 0730 to 1526												
10/4/2000													
1440	0.4	0.1	0.7	2.1	0	**619**	**555**	**527**		0.4	2	**201**	
10/5/2000													
733	0.6	0	23.2	27.6	0	**646**	**497**	**357/401**		0.1	1.8	**189**	
1430	1	0.2	3.1	16.3	0	**793**	**533**	**673**		0.8	2.2	**193**	
10/6/2000													
705	1	0	0.9	19.9	0	**701**	10.9	**712**		0	1.2	**1185**	
1400	0.8		20.1	25.8	0	**747**	**497**	**737**		0.8	2.8	**885**	
10/7/2000													
655	0.9	0	21	23.4	0	**683**	**442**	**698**		0.4	2.2	**1497**	
1430	0.4	0	20.6	11.7	0	**698**	**449**	**699**		0.2	2.6	**2799**	
10/8/2000													
645	0.6	0.2	22.1	9.6	0	**758**	**456**	**744**		0.3	2.4	**4465**	
1500	0.3	0.4	16.9	6.1	0	**735**	**435**	**717**		4.5	2	**>7999**	
10/10/2000													
800	0		0	0	0	**331**	31.9	**158**		0	0		

Notes:

1. Mini RAE 2000 PID with 10.6 EV lamp
2. RW-2D and PZ-3D/4D readings taken at well vapor discharge line sample ports using a Tedlar sampling bag filled by a hand vacuum pump

PID Monitoring

Date/Time	PID Reading, PPM (see note 1):												Notes
	RW-2D	Blower Discharge	MW-7S	MW-7D	PZ-1S	PZ-1D	PZ-2D	PZ-3D/4D		PZ-6S	PZ-6D	TW-01	
	well (note 2)							vent closed	well (note 2)				
10/11/2000								???					
1300	PZ-3D/4D vac-line open												
1540	0								7.3				
1655	RW-2D vac-line shut off								31.8				
1930													
10/12/2000													
800									0				
10/14/2000													
710	RW-2D vac-line open, PZ-3D/4D vac-line open												
10/17/2000													
1100	2.2		3.7	1.2	0	**551**	**88.6**	3.7?		0	0	**>2999**	
10/19/2000	PZ-3D/4D cleaned and purged												
935	0								3.7				
1300								0?	0				
10/20/2000													
700								0?	0				

Oxygen Monitoring

Vapor Recovery Testing, Sept. - Oct./2000

Essex Jamestown Site

Date/Time	Oxygen Reading, % (see note 1):												Notes
	RW-2D	Blower Discharge	MW-7S	MW-7D	PZ-1S	PZ-1D	PZ-2D	PZ-3D/4D		PZ-6S	PZ-6D	TW-01	
	well (note 2)							vent closed	well (note 2)				
9/26/2000													
1235				20									
1410		18				16	18						
9/27/2000													
1000			20	20		20	20						
9/29/2000													
915		20	21	21	22	19	22						
1250		21	21	21	21	19	21						
10/1/2000	NPLS vac pump and RW-2D down for approx. 8 hrs from approx. 0730 to 1526												
10/5/2000													
733	20	21	21	21	21	17	19	11		18	18	19	
1430	21	21	21	21	21	19	19	15		20	18	19	
10/6/2000													
705	21	21	21	21	21	18	19	14		21	18	20	
1400	20	21	21	21	21	19	19	15		21	19	19	
10/7/2000													
655	21	21	21	21	21	18	19	15		21	16	14	
1430	21	21	21	21	21	18	19	15		21	17	14	
10/8/2000													
645	21	21	21	21	21	18	18	14		20	17	11	
1500	21	19	21	21	21	18	19	17		21	18	15	
10/9/2000													
730	21	20	21	21	21	18	19	15		21	19	14	
10/10/2000													
800	21		21	19	21	18	19	20		21	19	18	

Notes:

1. MSA Combustible Gas And Oxygen Meter, Model 261
2. RW-2D and PZ-3D/4D readings taken at well vapor discharge line sample ports using a Tedlar sampling bag filled by a hand vacuum pump

Oxygen Monitoring

Date/Time	Oxygen Reading, % (see note 1):												Notes
	RW-2D	Blower Discharge	MW-7S	MW-7D	PZ-1S	PZ-1D	PZ-2D	PZ-3D/4D		PZ-6S	PZ-6D	TW-01	
	well (note 2)							vent closed	well (note 2)				
10/11/2000								???					
1300	PZ-3D/4D vac-line open												
1655	RW-2D vac-line shut off												
10/14/2000													
710	RW-2D vac-line open, PZ-3D/4D vac-line open												
10/17/2000													
1100	21		21	21	21	18	19	19		20	18	18	
10/19/2000	PZ-3D/4D cleaned and purged												
935	21								21				
1300									21				
1315								21					
10/20/2000								21					
700								21	21				

Notes:

1. MSA Combustible Gas And Oxygen Meter, Model 261
2. RW-2D and PZ-3D/4D readings taken at well vapor discharge line sample ports using a Tedlar sampling bag filled by a hand vacuum pump

RADIAN INTERNATIONAL
A DAMES & MOORE GROUP COMPANY

CALCULATION SHEET

CALC. NO. ____

SIGNATURE ____ DATE 11/10/00 CHECKED ____ DATE ____

PROJECT Essex Jamestown JOB NO. ____

SUBJECT H_2 conc est. SHEET ____ OF ____ SHEETS

H_2 CONC. IN WATER BASED ON GAS - Strip H_2 CONC. IN nM.

nM H_2 = nano Moles Hydrogen

1 Mole = 2 g

∴ 1 nM = 10^{-9} M.

= 2×10^{-9} g

= 2 ng H_2

1. RW-2D, 10/3/00

H_2 (gas strip) = 1857 nM

Volume water pumped for gas strip sample

$222 \frac{ml}{min} (15 \text{ min}) = 3.33\ l$

assume stripping 100% efficient

∴ H_2 conc in water =

$$= \frac{1857 \text{nM} \left(\frac{2 \text{ ng } H_2}{\text{nM}}\right)\left(\frac{\mu g}{10^3 \text{ ng}}\right)}{3.33\ l}$$

$$\cong 1.12\ \mu g/l$$

CONVERSION = $[X \text{ nM}] \times \frac{0.002}{l\text{-water vol pumped}}$

JPH-3 D:\fn\38776.fn7

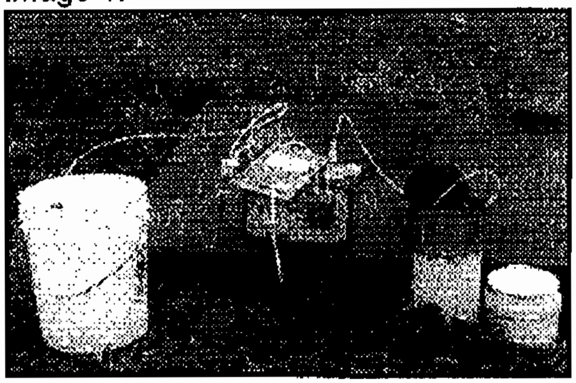
Microseeps Gas Stripping Cell Instructions

Back to Microseeps Homepage

INSTALLATION AND OPERATION

To place the gas stripping cell into service:

Image 1.



1. Remove one of the cell assemblies from the packing carton. See Figure 1.

2. **Image 1.** Connect the inlet tube of the cell to the outlet of your pump. The inlet tube is designed to connect to 1/4 O.D. hard tubing. Secure the connection using binder clips or cable ties.

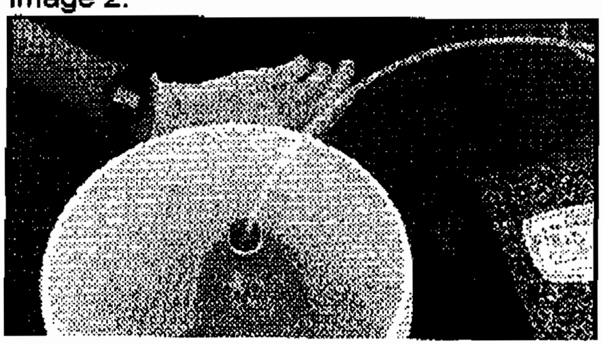
3. Insert the drain tube of the cell into a waste container, keeping the end of the tube at the bottom of the container. Any waste container of suitable size may be used. A 2-Liter soda pop bottle may be placed in the waste container to determine pumping flow rate.

4. Secure the cell assembly so that the housing cover (stopper) is above the glass housing (i.e. upright). A ring stand and clamp are recommended for this purpose.

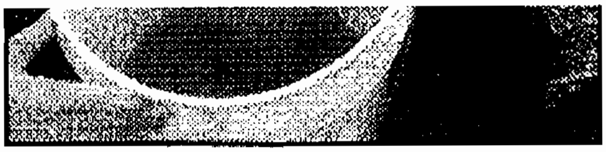
1/2 GAL ~ 2000 ml

5. Turn the pump on and check for leaks. If any leaks are found, seal them before proceeding.

Image 2.



6. **Image 2.** Measure, in mL per minute, the flow rate of the pump. If a 2-Liter soda pop bottle is used, the flow rate can be determined by measuring how many minutes it takes to fill the bottle and substituting the measured time into the following equation:



Flow = 2000 mL/Time to fill (in minutes)

Consult Table 1 to determine the equilibrium time needed to bubble strip at this flow rate.

(Need ~3- liters for test)

Note: Use a flow rate between 100 mL/min. and 500 mL/min. **Do not turn off the pump.**

Image 3.

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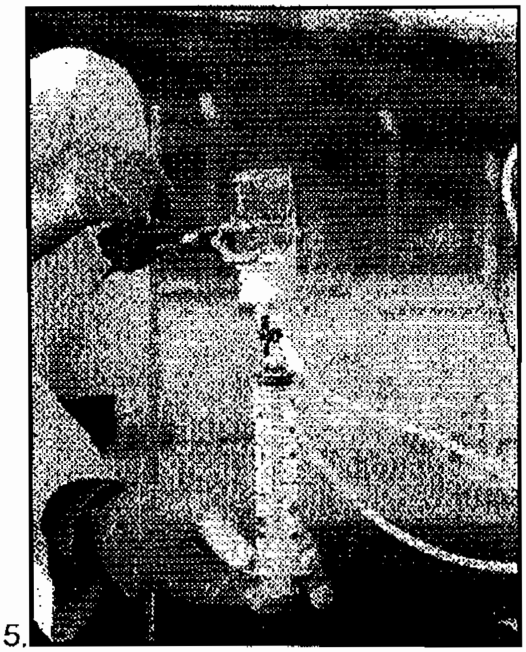
7. **Image 3.** Unclamp the cell assembly, invert it, and re-secure the assembly in the inverted position. Make sure the drain tube is still in the waste container and the end of the drain tube is near the bottom of the bottle.

8. **Image 4.** Connect the stopcock to the syringe and the needle to the stopcock (zoom in on image). Place the stopcock in the open position (so that the stopcock handle is in-line with the syringe). Draw the plunger back on the syringe to the 20.0 mL mark pulling ambient air into the syringe.

Image 4.

9. **Image 5.** Keeping the cell in the inverted position, insert the needle into the needle guide. Pierce the septum and inject the air into the cell creating the bubble. Withdraw the needle from the assembly and carefully place the needle into the cover. Do not discard the syringe apparatus.

Image

5. 

10. Start timing and let the groundwater pump through the cell for time specified in Table 1 for your particular pumping speed. Meanwhile, be sure that the sample vial is properly labeled and that the flow rate and any other relevant field data are recorded in the field log.

Note: Be sure to keep the end of the drain tube at the bottom of the waste container. This will insure that outside air is not drawn into the cell. **Failure to do this will invalidate the sample.**

11. When equilibration time is up, **turn off the pump,** unclamp the cell, and re-clamp it in its upright position. See Image 1. Verify that the plunger of the syringe is pushed all the way in and that the stopcock is in the open position.

Image 6.

12. **Image 6.** Insert the

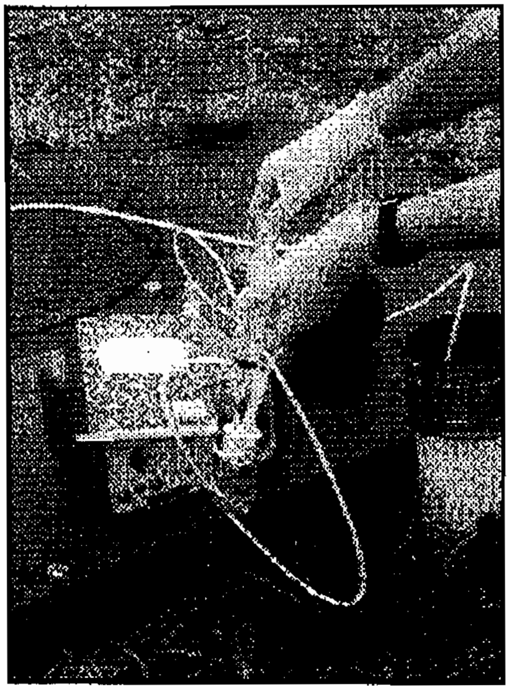


Image 7.

Image 8.

needle into the needle guide and pierce the septum. Withdraw 1 mL of gas by pulling back on the syringe plunger while holding the syringe body in place. Remove the syringe from the cell and expel the sample.

13. Immediately re-insert the needle into the needle guide and pierce the septum. Withdraw a 15 mL sample of gas (being careful not to pull any water into the syringe). With the needle still through the septum, close the stopcock and withdraw the needle from the septum.

14. **Image 7.** Immediately insert the needle through the septum on the sample vial. Keeping the syringe and vial "in line", open the stopcock and completely depress the syringe plunger injecting the entire sample into the vial.

Make sure vial is H_2 septum container

15. **Image 8.** Keeping the plunger depressed, quickly remove the vial from the needle. Your sample is now ready to be packaged and shipped back to Microseeps for analysis. Do not cool the samples.

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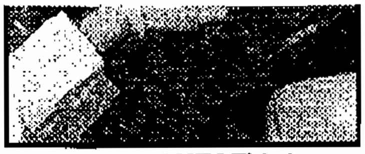
Decontamination/Cleaning

Pump at least 1 liter of potable water through the cell. The cell assembly is now ready for re-use.

The only expendable part of the cell is the sampling septum (part 7). Normally, each septum may be used for the collection of up to 5 samples. If bubbles are seen rising up from the septum when the cell is inverted the septum MUST be replaced. Instructions for replacing the septum are provided below.



SAMPLING QUESTIONS?

CALL MICROSEEPS AT **1-412-826-5245**

MON.- FRI. 7:30 AM TO 6 PM EST

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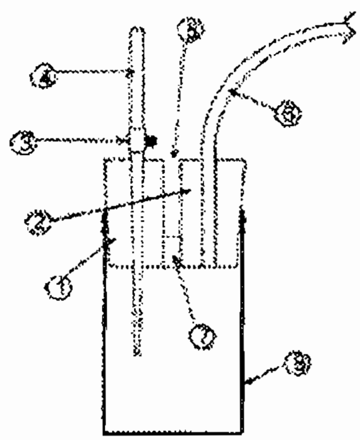
Figure 1. Cross section of Microseeps Gas Stripping Cell



1. Housing Cover
2. Jet Spray Nozzle
3. Nylon Tie
4. Inlet Tube
5. Needle Guide Port
6. Drain Tube
7. Replaceable Septum
8. Glass Housing

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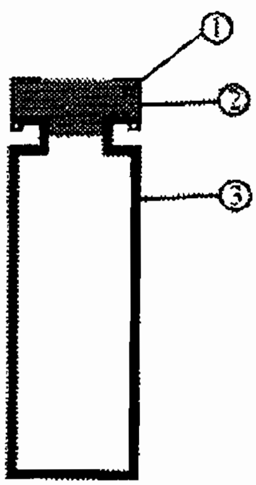

Figure 2. Cross section of septum bottle

1. Septum
2. Metal Closure
3. Glass vial

Replacing the Sampling Port Septum

All part numbers refer to Figure 1.

1. Remove the housing cover (part 1) from the glass housing (part 8).

2. Use a handy, blunt tipped object to push the replaceable septum (part 7) out of the housing cover. The cover to a needle works well for this purpose, but be sure that the needle is **NOT** in the cover. Discard the old septum.

4. Take a new septum and wet both the new septum and the housing cover with potable water.

5. Carefully using the same blunt instrument used in step three above, slide the new septum into the hole from which the old septum was removed. The bottom of the new septum must be flush with the narrow end of the housing cover.

6. If the housing cover is not still wet, wet it again with potable water. Place the bottom end of the housing cover into the glass housing and push it in until less than 3/8" are above the rim of the glass housing. This may require some force.

7. Follow the cleaning procedures described above to prepare the cell for a return to service.

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Table 1.

Flow rate (ml/min)	Sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

Return to Step 6

Back to Microseeps Homepage

Figure 1. Cross section of Microseeps Gas Stripping Cell

1. Housing Cover
2. Jet Spray Nozzle
3. Nylon Tie
4. Inlet Tube
5. Needle Guide Port
6. Drain Tube
7. Replaceable Septum
8. Glass Housing

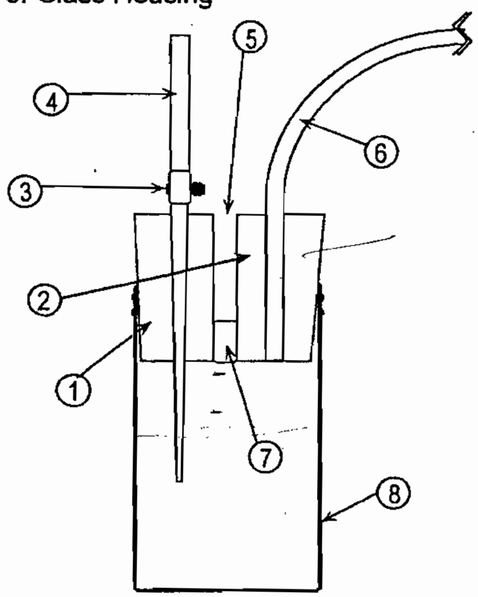

Figure 2. Cross section of septum bottle

1. Septum
2. Metal Closure
3. Glass vial

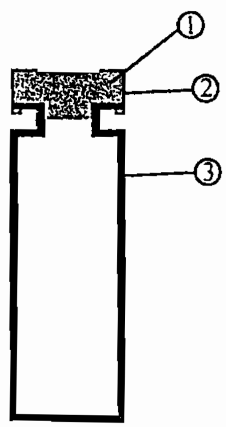

Table 1.

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100-120	30
130-150	25
160-200	20
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>300	10 ←

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5. Carefully using the same blunt instrument used in step three above, slide the new septum into the hole from which the old septum was removed. The bottom of the new septum must be flush with the narrow end of the housing cover.
6. If the housing cover is not still wet, wet it again with potable water. Place the bottom end of the housing cover into the glass housing and push it in until less than 3/8" are above the rim of the glass housing. This may require some force.
7. Follow the cleaning procedures described above to prepare the cell for a return to service.

URS CSD

GAS STRIP SAMPLE DATA SHEET

Project: Essex Jamestown
Project No: 804041.82
Location: Jamestown, NY
Date/Time: 10/3/00

Sample Location: PZ-6D
Sampler(s): M. Dowiak, T. Clemente

WELL DATA

Measuring Point: TOC (1"φ)
Initial Water Level: 11.80' (1015)
Final Water Level: See @ right

Post Flow Testing:
1105 - 16.11'
1115 - 15.50'
1210 - 14.12'
1600 - 12.77'

Note: Flow testing purged well dry

FLOW TEST DATA

Pumping Equipment: ISCO peristaltic 150 portable pump

Flow Test No.1	
Pump Setting: fast?	
Time	Volume
1030 am	0
1033	2 liters
Flow Rate: 2000/3 = 667 ml/min.	

Flow Test No.2	
Pump Setting: slowest	
Time	Volume
0	
5 min	1 liter
Flow Rate: 1000/5 = 200 ml/min	

See notes below

SAMPLING DATA (Method ______________________)

Air Injection- Time: Volume:
Start Pumping- Time: Volume:
Stop Pumping- Time:
Sample- Time: Vapor Volume:
Containers-
Purge Cell With Potable Water: _______ Yes
Analyses:

No Sample Taken - well has insufficient discharge for sampling

NOTES:
Flow Test 1 - Flow too high, stripping cell stopper won't secure
Flow Test 2 - PZ pumped dry, gray solids in discharge & cell

flow rate (ml/min)	sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

URS CSD

GAS STRIP SAMPLE DATA SHEET

Project: Essex Jamestown
Location: Jamestown, NY
Project No: 804041.02
Date/Time: 10/3/00

Sample Location: PZ-6P
Sampler(s): M. Powiak, T. Clemente

WELL DATA

Measuring Point: TOC
Initial Water Level: 12.77 (1600)
Final Water Level:

FLOW TEST DATA

Pumping Equipment: ISCO 150

Flow Test No. 1	
Pump Setting:	
Time	Volume
Flow Rate: 300 ml/min	

Flow Test No. 2	
Pump Setting:	
Time	Volume
Flow Rate:	

SAMPLING DATA (Method ______________________________)

Air Injection- Time: Volume:
Start Pumping- Time: Volume:
Stop Pumping- Time:
Sample- Time: Vapor Volume:
Containers-
Purge Cell With Potable Water: ______ Yes
Analyses:

No sample - well discharge insuffient, very turbid

NOTES:

flow rate (ml/min)	sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

URS CSD

GAS STRIP SAMPLE DATA SHEET

Project: Essex Jamestown
Location: JAMESTOWN, NY

Project No: 804041.82
Date/Time: 10/3/00

Sample Location: TW-01 V
Sampler(s): M. Dowiak, T. Clemente

WELL DATA
Measuring Point: TOC (2"ϕ)
Initial Water Level: 6.73' (12:15)
Final Water Level: 7.17' (12:38)

FLOW TEST DATA
Pumping Equipment: ISCO 150 Peristaltic Pump.

Flow Test No. 1	
Pump Setting:	
Time	Volume
12:25	
12:29	2 l
Flow Rate: 2000/4 = 500 ml/min	

Flow Test No. 2	
Pump Setting:	
Time	Volume
Flow Rate:	

SAMPLING DATA (Method Microseeps)
Air Injection- Time: 12:41 Volume: 20 CC
Start Pumping- Time: 12:41 Volume: ~ 5 liters.
Stop Pumping- Time: 12:51
Sample- Time: 1300 Vapor Volume: 15 CC.
Containers- VAPOR - (1) 40 ml glass vial, water - (2) 40 ml VOA viles
Purge Cell With Potable Water: ✓ Yes (1 min)
Analyses: CO_2, O_2, N, CH_4, H_2, ethane, ethylene, propane, propylene, butanes

NOTES:

flow rate (ml/min)	sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

URS CSD

GAS STRIP SAMPLE DATA SHEET

Project: Essex Jamestown
Project No: 804041.82
Location: Jamestown, NY
Date/Time: 10/3/00

Sample Location: MW-7D V
Sampler(s): M. Dowiak, T. Clemente

WELL DATA
Measuring Point: TOC
Initial Water Level: 22.73 (13:20)
Final Water Level: 22.71 (13:37)

FLOW TEST DATA
Pumping Equipment: ISCO 150

Flow Test No. 1	
Pump Setting:	
Time	Volume
1330	
1338	2 l
Flow Rate: 2000/8 = 250 ml/min	

Flow Test No. 2	
Pump Setting:	
Time	Volume
1338	
1344.5	2 l
Flow Rate: 2000/6.5 = 307 ml/min	

SAMPLING DATA (Method Microseeps)
Air Injection- Time: 13:48 Volume: 20 cc.
Start Pumping- Time: 13:48 Volume: ~3 l
Stop Pumping- Time: 13:58
Sample- Time: 14:02 Vapor Volume: 15 cc
Containers- Vapor- (1) 40 ml glass vial, water-(2)-40 ml VOA viles
Purge Cell With Potable Water: ✓ Yes Stopper septum use - 2
Analyses: CO_2, O_2, N, CH_4, H_2, ethane, ethylene, propane, propylene, butanes

NOTES:

flow rate (ml/min)	sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

URS CSD

GAS STRIP SAMPLE DATA SHEET

Project: Essex Jamestown
Project No: 804041.82
Location: Jamestown, NY
Date/Time: 10/3/00

Sample Location: MW-7S V
Sampler(s): M. Dowiak, T. Clemente

WELL DATA
Measuring Point: TOC
Initial Water Level: 11.64 (1410)
Final Water Level: 13.22 (1445)

FLOW TEST DATA
Pumping Equipment: ISCO 150

Flow Test No. 1	
Pump Setting:	
Time	Volume
1415	
1418	N/A
Flow Rate: Tubing leak, repair made	

Flow Test No. 2	
Pump Setting:	
Time	Volume
1437	
1442	2 l
Flow Rate: 2000/5 = 400 ml/min	

SAMPLING DATA (Method Microseeps)
Air Injection- Time: 1448 Volume: 20 CC
Start Pumping- Time: 1448 Volume: 4 l
Stop Pumping- Time: 1458
Sample- Time: 1502 Vapor Volume: 15 CC
Containers- Vapor - (1) 40ml glass vial, water - (2) 40 ml VOA viles
Purge Cell With Potable Water: ✓ Yes stopper septum use - 3
Analyses: CO_2, O_2, N, CH_4, H_2, ethane, ethylene, propane, propylene, butanes

NOTES:

flow rate (ml/min)	sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

URS CSD

GAS STRIP SAMPLE DATA SHEET

Project: Essex Jamestown　　Project No: 804041.82
Location: Jamestown, NY　　Date/Time: 10/3/00

Sample Location: RW-2DV (@ sample port in plant)
Sampler(s): M. Dowiak, T. Clemente

WELL DATA
Measuring Point: N/A
Initial Water Level:
Final Water Level:

FLOW TEST DATA
Pumping Equipment:

Flow Test No. 1	
Pump Setting:	
Time	Volume
1515	
1524	2 l
Flow Rate: 2000/9 = 222 ml/min	

Flow Test No. 2	
Pump Setting:	
Time	Volume
Flow Rate:	

SAMPLING DATA (Method Microseeps)
Air Injection- Time: 1525　Volume: 20cc
Start Pumping- Time: 1525　Volume: 3.3l
Stop Pumping- Time: 1540
Sample- Time: 1545　Vapor Volume: 15cc
Containers- Vapor-(1) 40ml glass vial, water-(2) 40ml VOA viles
Purge Cell With Potable Water: ✓ Yes　stopper septum use - 4
Analyses: CO_2, O_2, N, CH_4, H_2, ethane, ethylene, propane, propylene, butanes

NOTES:

flow rate (ml/min)	sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

URS CSD

GAS STRIP SAMPLE DATA SHEET

Project: Essex / Hope **Project No:** 804041.82

Location: Jamestown NY **Date/Time:** 10/25/00

Sample Location: VP-7D

Sampler(s): T. Clemente, R. Rupiper

WELL DATA

Measuring Point: TOC

Initial Water Level: 13.65 ft

Final Water Level: 15.82 ft

FLOW TEST DATA

Pumping Equipment: ISCO

Flow Test No.1	
Pump Setting:	
Time	**Volume**
1010:05	0
1011:50	591 mL
1:	
Flow Rate: 337 mL/min	

Flow Test No.2	
Pump Setting:	
Time	**Volume**
1012:00	0
1013:49	591
Flow Rate: 326 mL/min	

SAMPLING DATA (Method Microseeps **)**

Air Injection- Time: 1024 **Volume:** 20mL

Start Pumping- Time: 1025 (900) **Volume:** ~4 l (for test)

Stop Pumping- Time: 1038

Sample- Time: 1040 **Volume:** Air - 30mL (2 vials 15mL ea.) Water - 2 Amber Vials

Containers- 2 VOAs, 2 Amber (VOID H2 ANALYSES, WRONG SAMPLE CONTAINER FOR VAPOR) ANALYSES;

Purge Cell With Potable Water: X **Yes**

NOTES:

Tip on inlet tube (into bottle) kept plugging w/ sediment and pvc shavings. Called Linda @ Microseeps. Cut off ~1/16 in. off of tip

flow rate (ml/min)	sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

URS CSD

GAS STRIP SAMPLE DATA SHEET

Project: Essex / Hope **Project No:** 80441.82

Location: Jamestown NY **Date/Time:** 10/25/00

Sample Location: RW-2D (in treatment building)

Sampler(s): T. Clemente, R. Rupiper

WELL DATA

Measuring Point: N/A

Initial Water Level:

Final Water Level:

FLOW TEST DATA

Pumping Equipment: N/A

Flow Test No.1	
Pump Setting:	
Time	Volume
Flow Rate:	

Flow Test No.2	
Pump Setting:	
Time	Volume
Flow Rate:	

SAMPLING DATA (Method Microseeps **)**

Air Injection- Time: 0535 **Volume:** 20mL

Start Pumping- Time: 0535 **Volume:**

Stop Pumping- Time: 0605

Sample- Time: 0605 **Volume:** Air - 15mL, Water - 2 Amber Vials

Containers- 1 VOA, 2 Amber (VOID H_2 ANALYSES, WRONG SAMPLE CONTAINER FOR VAPOR ANALYSES)

Purge Cell With Potable Water: Yes **Yes**

NOTES:

Sample taken from RW-2D valve in treatment building

flow rate (ml/min)	sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

URS CSD

GAS STRIP SAMPLE DATA SHEET

Project: ESSEX/HOPE
Project No: ~~804044~~ 801419.1001
Location: JAMESTOWN NY
Date/Time: 11-09-00

Sample Location: RW-2D (valve inside Treatment Building)
Sampler(s): T. Clemente, R. Rupiper

WELL DATA N/A
Measuring Point:
Initial Water Level:
Final Water Level:

FLOW TEST DATA
Pumping Equipment:

Flow Test No. 1	
Pump Setting:	
Time	Volume
0630:15	0
0631:58	1000mL
Flow Rate: (581mL/min) ≥500 mL/min	

Flow Test No. 2	
Pump Setting:	
Time	Volume
0633:00	0
0635:02	1000mL
Flow Rate: ~ 495 mL/min	

SAMPLING DATA (Method Microseeps)
Air Injection- Time: 0644 **Volume:** 20mL
Start Pumping- Time: 0645 **Volume:** ~ 5 l
Stop Pumping- Time: 0655
Sample- Time: 0656 **Volume:** 15mL
Containers- 1 VOA vial - vapor
Purge Cell With Potable Water: ✓ Yes
Analyses: H_2 only

NOTES:

flow rate (ml/min)	sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

URS CSD

GAS STRIP SAMPLE DATA SHEET

Project: ECCI/HOPE [illegible]
Location: JAMESTOWN, NY
Project No: 3[illegible]
Date/Time: 11[illegible]

Sample Location: MW-7S
Sampler(s): T. Clemente [illegible]

WELL DATA
Measuring Point: TOC
Initial Water Level: [illegible]
Final Water Level: 11.9[illegible]

FLOW TEST DATA
Pumping Equipment: Peristaltic Pump

Flow Test No. 1	
Pump Setting:	
Time	Volume
0[illegible]:30	0
0850:32	[illegible]
Flow Rate: 199 mL/min	

Flow Test No. 2	
Pump Setting: same	
Time	Volume
0[illegible]:55	0
[illegible]5:47	[illegible]
Flow Rate: 205 mL/min	

SAMPLING DATA (Method M[illegible])
Air Injection- Time: 0856 **Volume:** 20mL
Start Pumping- Time: 0856 **Volume:**
Stop Pumping- Time: 0917 [illegible](0923)
Sample- Time: 0948 **Volume:** [illegible]
Containers- 1 VOA, 2 Amber
Purge Cell With Potable Water: ✓ Yes
Analyses: [illegible] butane

[illegible] START OVER [illegible] inject air (20 mL) @ 0925 start 0925 stop 09[illegible]

NOTES:

flow rate (ml/min)	sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

URS CSD

GAS STRIP SAMPLE DATA SHEET

Project: ESSEX / HOPE **Project No:** 8014 9. 00

Location: JAMESTOWN, NY **Date/Time:** -0-00

Sample Location: VP-7D

Sampler(s): T. Clerrare, R. Ruhfer

WELL DATA

Measuring Point: TOC

Initial Water Level: 13.00 ft

Final Water Level: 13.96 ft

FLOW TEST DATA

Pumping Equipment: peristaltic pump

Flow Test No.1	
Pump Setting:	
Time	**Volume**
0732:30	0
0733:58	1000mL
Flow Rate: (>500)	

Flow Test No.2	
Pump Setting:	
Time	**Volume**
0735:15	0
0737:37	1000mL
Flow Rate: 422 mL/min	

Flow Test No. 3 (same settings as No. 2)

Time	Volume
0738:00	0
07[illegible]:20	[illegible] mL

429 mL/min

SAMPLING DATA (Method Microseeps)

Air Injection- Time: 0742 **Volume:** 20mL

Start Pumping- Time: 0742 **Volume:** [illegible]

Stop Pumping- Time: 0752

Sample- Time: 0754 **Volume:** 15 mL

Containers- 1 - VOA

Purge Cell With Potable Water: ✓ Yes

Analyses: H_2 (Vapor)

NOTES:

flow rate (ml/min)	sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

Appendix D
Pilot Test Photos and Verification Borings

RADIAN INTERNATIONAL
A DAMES & MOORE GROUP COMPANY

CALCULATION SHEET

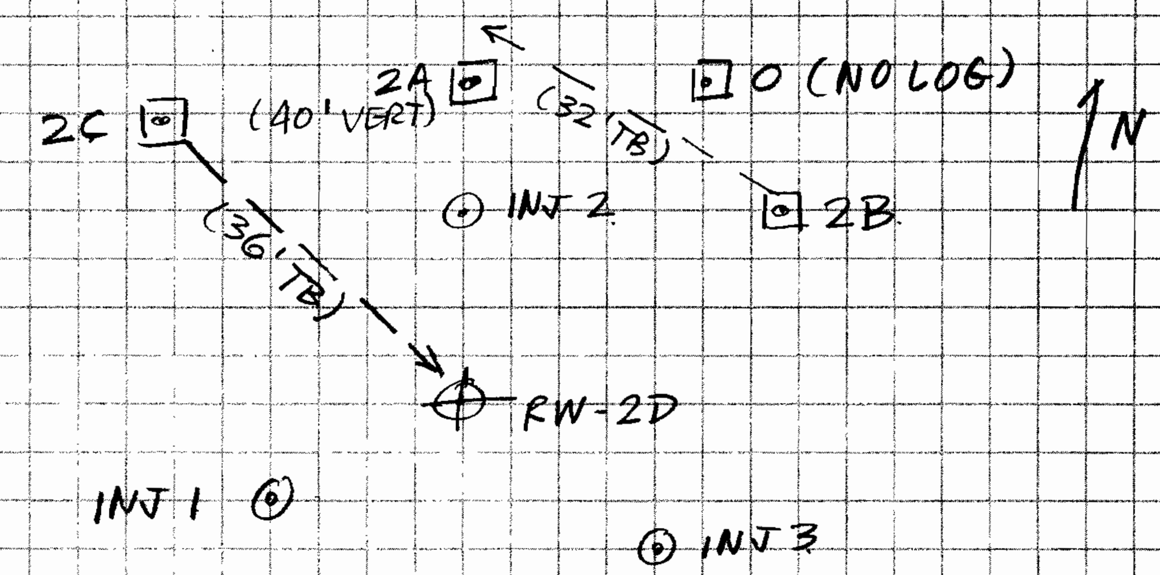
CALC. NO. ______

SIGNATURE ______ DATE 8/7/00 CHECKED ______ DATE ______

PROJECT Essex JAMESTOWN JOB NO. ______

SUBJECT PRB TEST BORINGS SHEET 1 OF ______ SHEETS

PRB TEST BORING LOGS



2A TB 2A - (VERTICAL BORING)
LOGGED BY K. DODRILL
UNDISTURBED SAMPLES SENT TO URS MIL, 8/8/00

2B TB 2B - (ANGLED BORING)
LOGGED BY K. DODRILL
UNDISTURBED SAMPLES SENT TO URS MIL, 8/8/00

2C TB 2C - (ANGLED BORING)
LOGGED BY K. DODRILL
UNDISTURBED SAMPLES SENT TO URS MIL, 8/8/00

JPH-3 D:\fh\38776.fh7

QC TB 2A

RADIAN INTERNATIONAL

TEST BORING INJ Z-A (VERTICAL) PAGE 1 OF 2

BY KD	PROJECT NAME ESSEX/HOPE	PROJECT NO. 804041
DATE 8-3-00	LOCATION JAMESTOWN NY	GEOLOGIST KEITH DODRILL
CHK BY	DRILLING CONTRACTOR URS SCS	DRILLER RODGER MILLER
DATE	DRILLING METHOD GEOPROBE	RIG TYPE VIPER 3
	DRILLING START DATE 8-3-00	DRILLING COMPLETION DATE 8-3-00
	SURFACE ELEVATION	STICK-UP ELEVATION N/A

DEPTH FEET	SOIL SAMPLE NO.	REC. (IN.)	BL./6"	VISUAL CLASSIFICATION AND REMARKS	PROFILE	STATIC WATER LEVEL (FT)	OVA READING	DEPTH (FEET)	REMARKS
0				FINE-COARSE SAND & GRAVEL AND SILT	Fe ↓			0	ZERO VALENT Fe DETECTED w/ RARE EARTH MAGNET
5								5	
10								10	0-12' CORE OPENED FOR VISUAL INSPECTION. NO IRON OBSERVED IN 0-12' ZONE
				12 — SILT CONFINING LAYER					
15								15	
20				20 — SILTY FINE SAND (LFSWBZ)				20	IRON LAYERS:
									21.6' TO 21.9'
									22.5' TO 23.1'
25				IRON LAYERS ~ 50% Fe / 50% FORMATION (VARIES)				25	24.6' TO 24.8'
									25.2' TO 26.25'
									26.8' TO 27.2'
									28.2' TO 29.2'
30								30	29.4' TO 29.7'
35								35	34.2' TO 34.9'

ADDITIONAL REMARKS

1. SEE RW-2D LOG FOR GEOLOGIC DETAIL
2. BORING ORIENTATION VERTICAL AND LOCATED 2.5-FT NORTH OF INJZ INJECTION POINT WITHIN NORTH PANEL.
3. UNDISTURBED SAMPLES SHIPPED TO MILWAUKEE FOR INSPECTION.

FILE: \FORMATS\TB

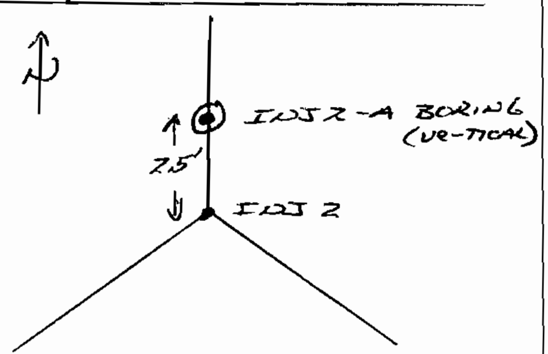
RADIAN INTERNATIONAL

TEST BORING INJ 2-A (VERTICAL)

BY KD	PROJECT NAME ESSEX/HOPE		PROJECT NO. 804041
DATE 8-3-00	LOCATION JAMESTOWN NY	GEOLOGIST KEITH DODRILL	
CHK BY	DRILLING CONTRACTOR URS SCS	DRILLER RODGER MILLER	
DATE	DRILLING METHOD GEOPROBE	RIG TYPE VIPER 3	
	DRILLING START DATE 8-3-00	DRILLING COMPLETION DATE 8-3-00	
	SURFACE ELEVATION	STICK-UP ELEVATION	

DEPTH FEET	SOIL SAMPLE NO.	REC. (IN.)	BL./6"	VISUAL CLASSIFICATION AND REMARKS	PROFILE	STATIC WATER LEVEL (FT)	OVA READING	DEPTH (FEET)	REMARKS
35				SILTY FINE SAND (LFSWB?)				35	ZERO VALENT FE DETECTED WITH RARE EARTH MAGNET
40				TOTAL DEPTH OF BORING 40-FT LOWER CONFINING CLAY				40	39.4' TO 39.9'

MAP VIEW (NOT TO SCALE)



ADDITIONAL REMARKS

QC TB 2B

RADIAN INTERNATIONAL

TEST BORING INJ 2 - B (ANGLE BORING) **PAGE** 1 **OF** 1

PROJECT NAME ESSEX/HOPE — PROJECT NO. 804041

LOCATION JAMESTOWN NY — GEOLOGIST KEITH DODRILL

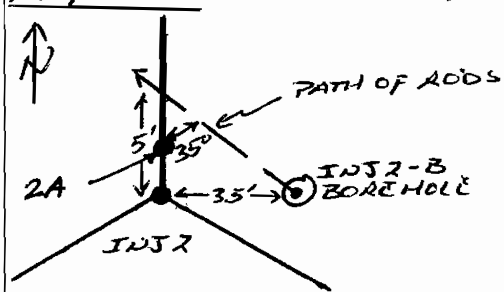
BY K.D — DRILLING CONTRACTOR URS SCS — DRILLER RODGER MILLER

DATE 8-4-00 — DRILLING METHOD GEOP-OBE — RIG TYPE VIPER 3

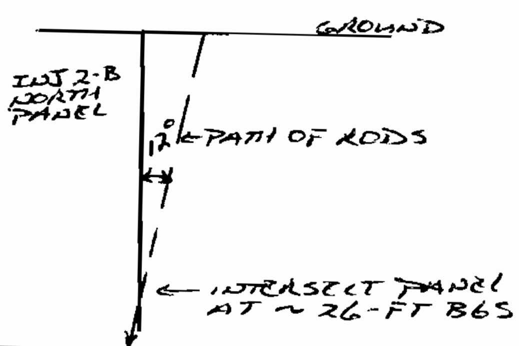
CHK BY ____ — DRILLING START DATE 8-4-00 — DRILLING COMPLETION DATE 8-4-00

DATE ____ — SURFACE ELEVATION ____ — STICK-UP ELEVATION N/A

DEPTH FEET	SOIL SAMPLE NO.	REC. (IN.)	BL./6"	VISUAL CLASSIFICATION AND REMARKS	PROFILE	STATIC WATER LEVEL (FT)	OVA READING	DEPTH (FEET)	REMARKS
20				SILTY FINE SAND (LFSWBZ)				20	21.1' TO 21.25' 21.45' TO 21.5'
25								25	24.85' TO 24.9'
									27.05' TO 27.3' 27.6' TO 27.8'
30								30	
				BORING TERMINATED AT 32-FT					
35				MAP VIEW (NOT TO SCALE)				35	ZERO VALENT Fe DETECTED WITH RARE EARTH MAGNET



PROFILE (NOT TO SCALE)
VIEW TO NORTH



ADDITIONAL REMARKS

1. SEE RW-2D LOG FOR GEOLOGIC DETAIL
2. BORING ORIENTED 12° OFF VERTICAL, INTERSECTS INJ 2 NORTH PANEL 5-FT NORTH OF INJECTION POINT AT APPROX 26-FT BGS AT 35° ANGLE
3. UNDISTURBED SAMPLES SHIPPED TO MILWAUKEE FOR INSPECTION

QC ID 2C

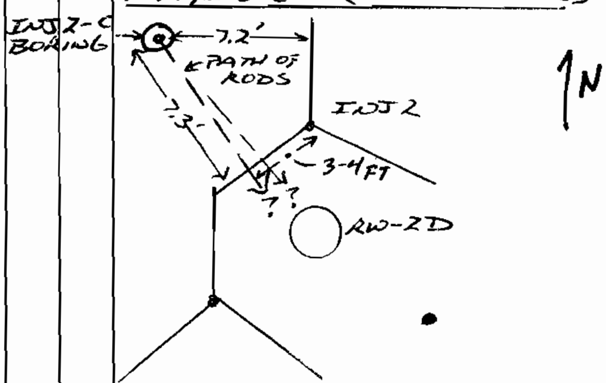
TEST BORING INJ 2-C (ANGLE BORING) **PAGE** 1 **OF** 1

RADIAN INTERNATIONAL

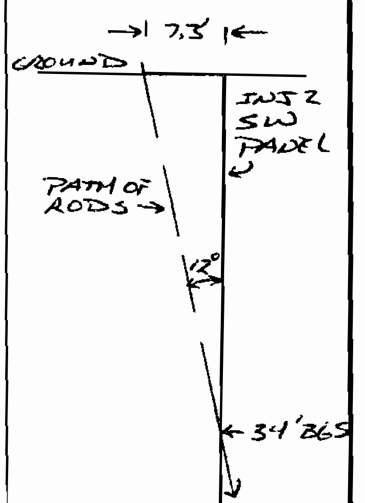
BY KD	PROJECT NAME ESSEX/HOPE	PROJECT NO. 804041
DATE 8-4-00	LOCATION JAMESTOWN NY	GEOLOGIST KEITH DODRILL
CHK BY	DRILLING CONTRACTOR URS SCS	DRILLER RODGER MILLER
DATE	DRILLING METHOD GEOPROBE	RIG TYPE VIPER 3
	DRILLING START DATE 8-4-00	DRILLING COMPLETION DATE 8-4-00
	SURFACE ELEVATION	STICK-UP ELEVATION

DEPTH FEET	SOIL SAMPLE NO.	REC. (IN.)	BL./6"	VISUAL CLASSIFICATION AND REMARKS	PROFILE	STATIC WATER LEVEL (FT)	OVA READING	DEPTH (FEET)	REMARKS
20				SILTY FINE SAND (LFSWB7)				20	20.4' TO 20.8' 21.3' TO 21.7' 22.0' TO 22.15' 22.9' TO 23.3' 24.0' TO 24.3'
25								25	26.15' TO 26.5' 28.0' TO 28.65' 29.0' TO 29.85'
30				NO SAMPLE 31.4 TO 32-FT				30	30.85' TO 31.0'
35								35	34.8' TO 35.8' ↑ ZERO VALENT FE DETECTED WITH RARE EARTH MAGNET
				BORE HOLE TERMINATED AT 36-FT (RODS DEVIATED TOWARD RW-2D AT DEPTH).					

MAP VIEW (NOT TO SCALE)



PROFILE (NOT TO SCALE)



ADDITIONAL REMARKS

1. SEE RW-2D LOG FOR GEOLOGIC DETAIL
2. BORING ORIENTATION 12° OFF VERTICAL, INTERSECTS INJ 2 SOUTH WEST PANEL AT APPROX 34-FT BGS & APPROX 3 TO 4-FT SOUTH WEST OF INJECTION POINT. (NOTE: RODS DEVIATED IN EAST DIRECTION AT DEPTH).
3. UNDISTURBED SAMPLES SHIPPED TO MILWAUKEE FOR INSPECTION.

URS

Facsimile

Date: 8/8/00 | Page 1 of: 6

To: Tom Reed | From: M. Powiak

Firm: | cc: K. Dodrill

Facsimile: (303) 420 1801

Subject: Essex Jamestown

FAXED

Message:

1. Attached are QC test boring logs (3) for PRW Pilot Test

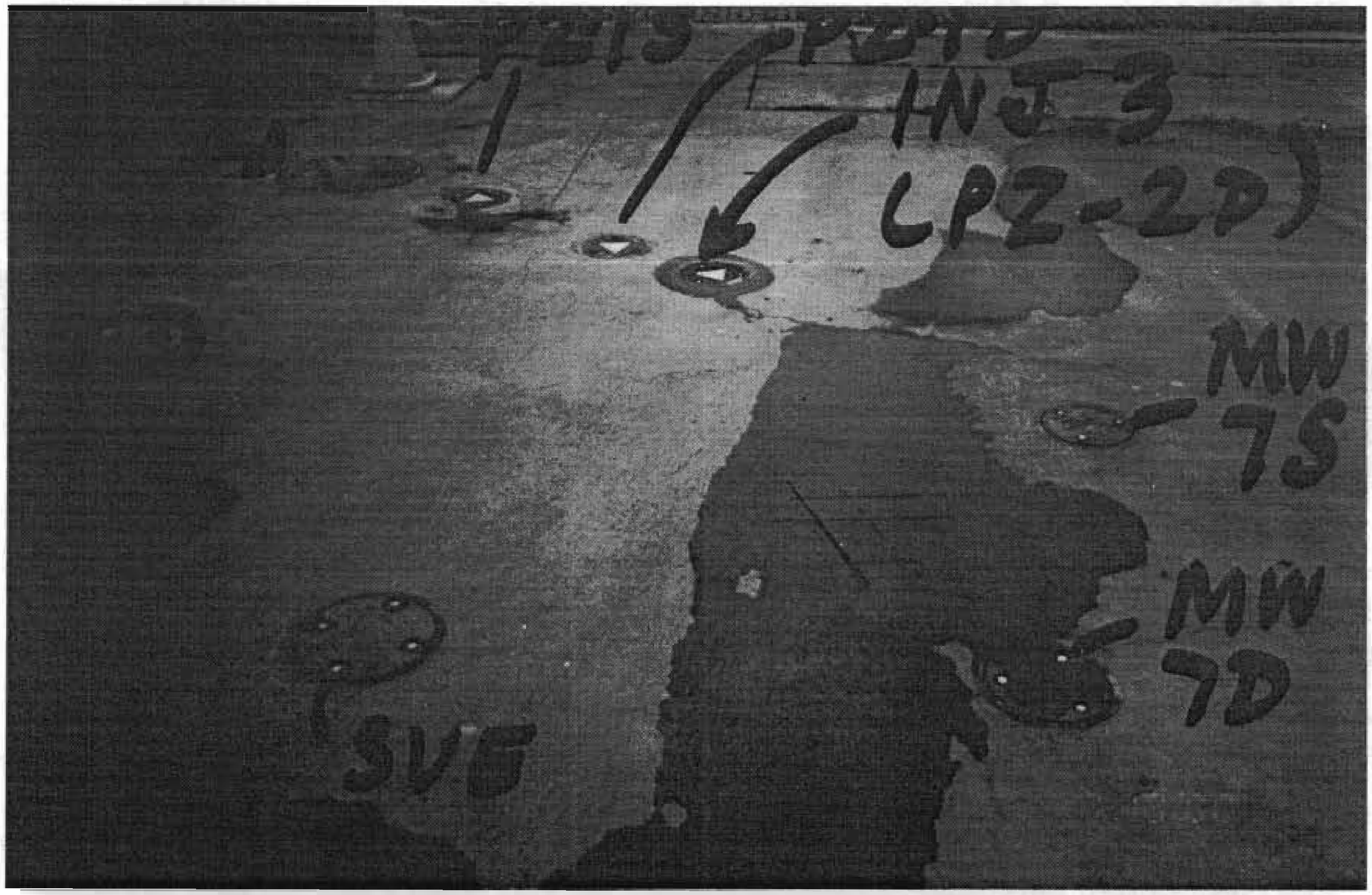
2. K. Dodrill indicated that you requested we sample PRW monitoring wells ASAP (today). We need bottles, lab info, and any specific sampling protocols (if needed). Also, we have nobody available till possibly next Tues/Wed. Give us at least 24 hrs notice.

Thanks Mark

URS Corporation
Twin Towers, Suite 250
4955 Steubenville Pike
Pittsburgh, PA 15205
Tel: 412-788-2717
Fax: 412-788-1316
www.urscorp.com

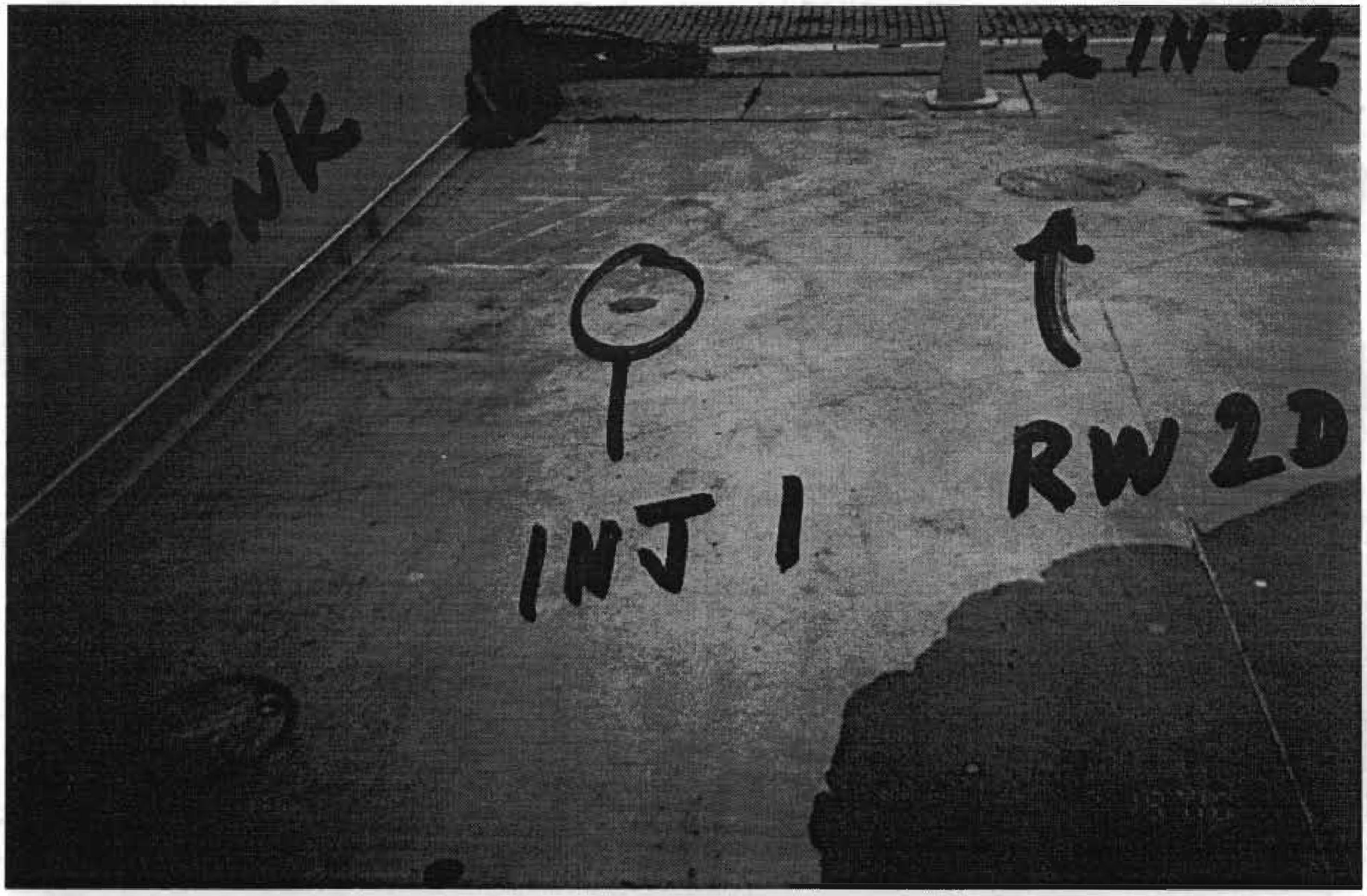
ZVI Injection – Pilot Test

Completed injection points with recovery and monitoring wells



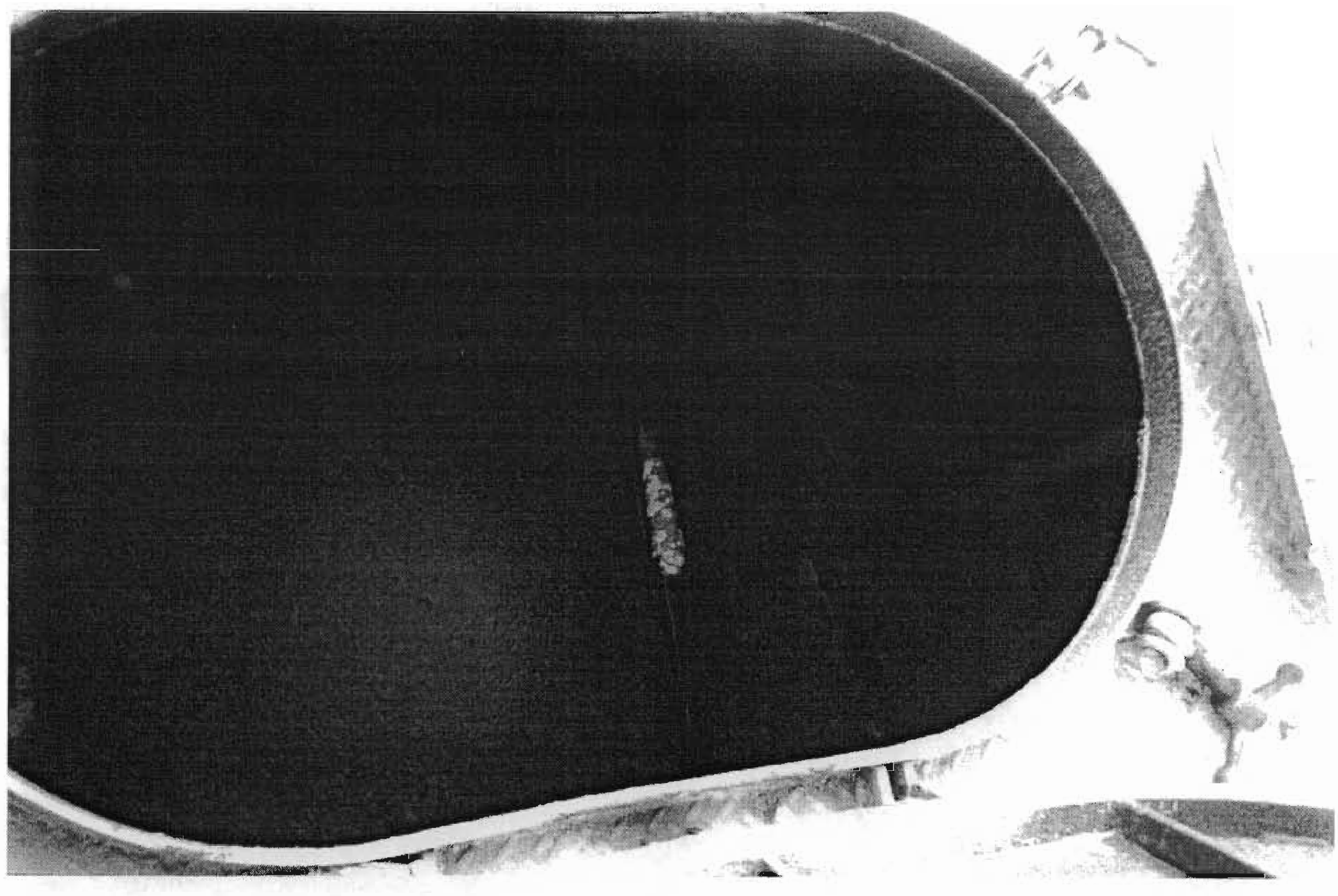
ZVI Pilot Test

Completed injection points and recovery wells

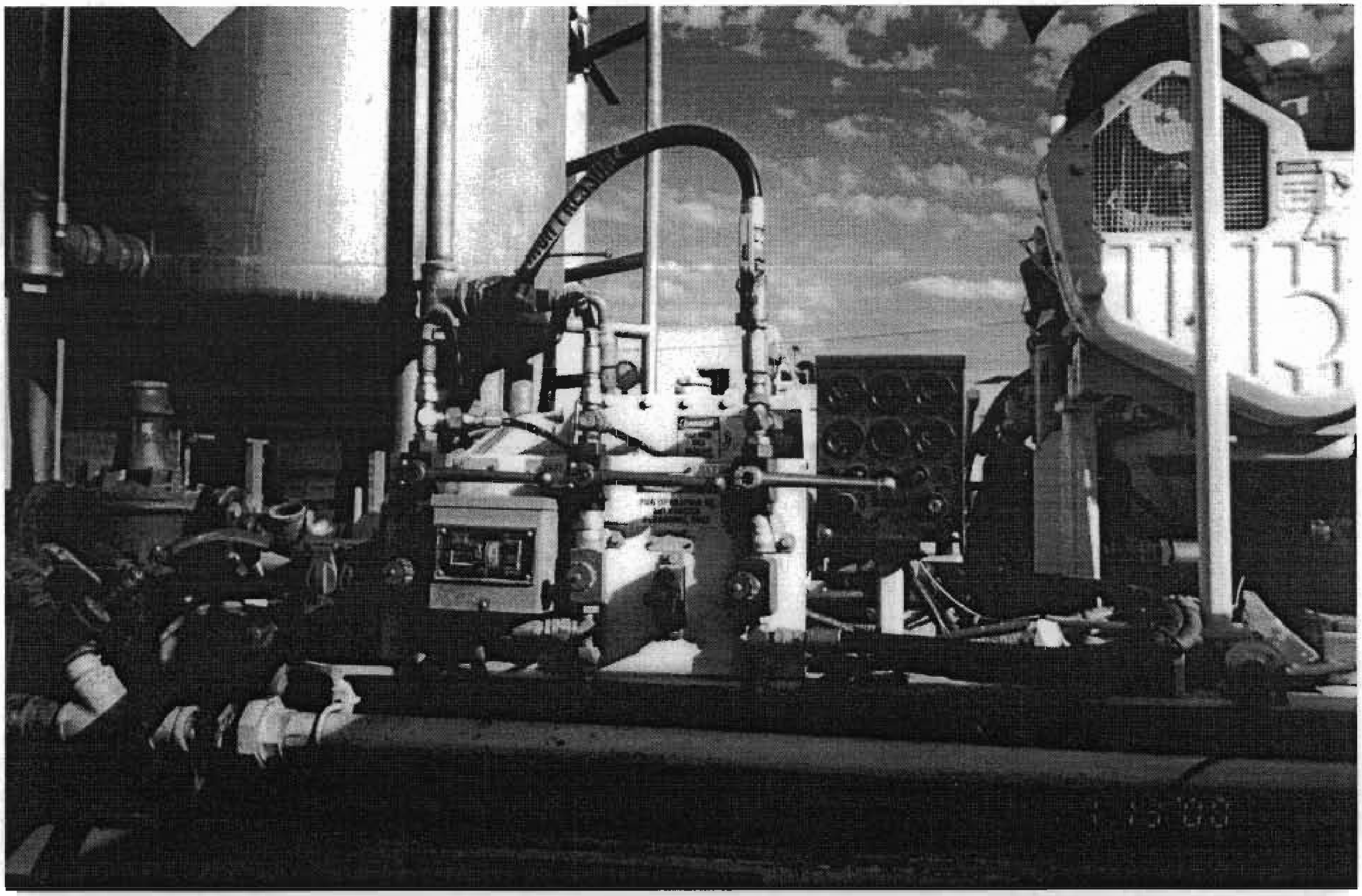


<u>Guar Mix Tank</u>

(Bio fouled black guar)



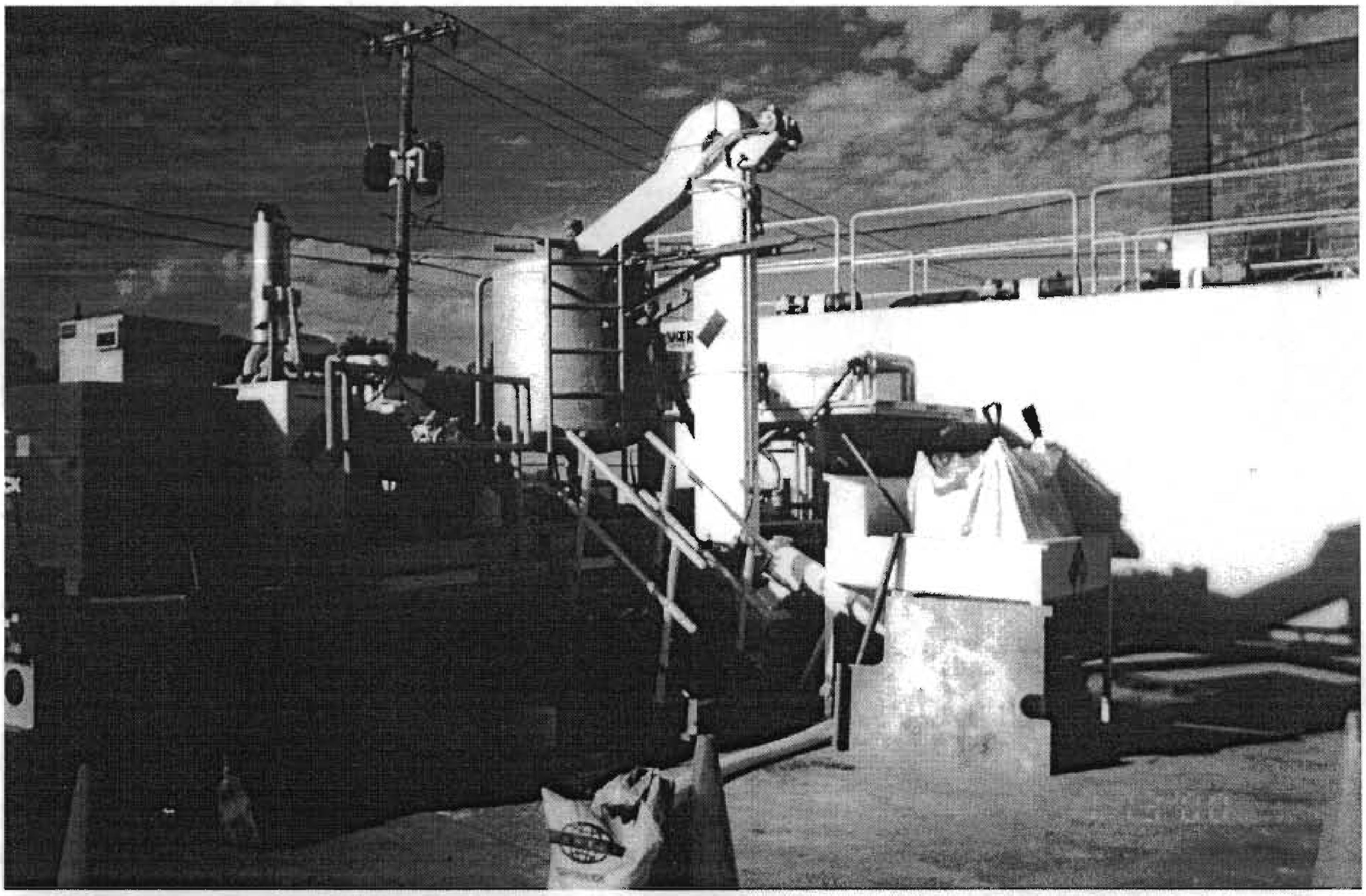
BAP Unit Control Panel



ZVI Injection – Geoprobe Viper III

ZVI Injection System

ZVI feed conveyor, batch mix tank for ZVI/guar, frac tank in background



ZVI Injection System

BAP Unit - Mix tank for iron with pump to lower right, diesel generator to far right