PILOT TEST FINAL REPORT - BIMETALLIC NANOSCALE PARTICLE TREATMENT OF GROUNDWATER AT AREA I

Volume I of III

Naval Air Engineering Station Site
Lakehurst, New Jersey

PREPARED FOR

U.S. Navy

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NAVAL AIR ENGINEERING STATION SITE
LAKEHURST, NEW JERSEY
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BACKGROUND

The Naval Air Engineering Station (NAES) is located in Lakehurst, Ocean County, New Jersey; hereinafter the "Site." The Site consists of an area of approximately 7,300-acres. There are more than 300 buildings in use, two 5,000-foot long runways, a 12,000-foot long test runway, a one-mile long jet car test track, four one and one-quarter mile long jet car test tracks, a parachute jump circle, a 79-acre golf course, and a 3,500-acre conservation area (Envirogen, 2000).

The Site boundary forms the southern border of Area I, which is the location of the Bimetallic Nanoscale Particle (BNP) pilot test. Area I is largely developed and includes various Navy testing facilities. These facilities include a steam plant and catapult launching area.

The pilot test area is underlain by approximately 75 feet of unconsolidated sediments characterized as a fairly uniform, brown-yellow, fine to coarse sand (Envirogen, 2000). Grain size analyses characterized the sediments as 0.5 to 5.9% gravel, 85.8 to 93.6% sand, and 5.4 to 8.6% clay. Total organic carbon levels ranged from 40 to 800 milligrams per kilogram (mg/kg).

The principal contaminants found in the groundwater at Area I include tetrachloroethene (PCE), trichloroethene (TCE), 1,1,1-trichloroethane (1,1,1-TCA) and degradation products such as cis-dichloroethene (cis-DCE) and vinyl chloride. The contamination extends vertically 70 feet below the groundwater table. The largest amount of contamination is in the zone from 30 to 50 feet below the groundwater table (U.S. Navy, 2001).

1.0 INTRODUCTION

In accordance with the PARS Environmental, Inc. (PARS) proposal (August 29, 2001) and the U.S. Navy request document (Request No. N62472-01-M-3130), the pilot test for the BNP technology was performed at Area I of the Site from October 2001 to March 2002. The U.S. Navy also contracted VAL Associates Laboratory, Inc. to perform additional groundwater monitoring on May 6, 2002.

Area I is under investigation for groundwater impacts from various past facility activities and releases. The volatile organic compound (VOC) impacts emanate from several diffuse sources and extend approximately 5,000 feet downgradient (Envirogen, 2000). The pilot test area was selected due to the relatively high contaminant concentrations at monitoring well LK in Area I (see Figure 1). In February 2000, total VOC concentrations at LK were approximately 900 micrograms per liter (μg/L) (U.S. Navy).

Based on an assumed treatment area of 300 square feet (ft^2) (see Figure 1), an impacted groundwater thickness of 20 feet and a porosity of 0.3, the estimated volume of groundwater within the test area is 1,800 cubic feet (ft^3) or 13,500 gallons. Although the assumed thickness of the treatment area was 20 feet, the water bearing zone at Area I extends to greater than 100-feet below ground surface. No monitoring wells are screened below 65-feet within the treatment area; therefore, the vertical migration of the BNP slurry could not be assessed as part of this pilot test.

The average hydraulic conductivity of the aquifer at Area I is 88.31 feet per day (ft/day) (U.S. Navy). Based on the groundwater elevations measured by PARS on October 25, 2001, the hydraulic gradient was estimated to be 0.002 ft/ft in the vicinity of the pilot test area. Given the hydraulic gradient and hydraulic conductivity, PARS estimated the groundwater velocity to be 0.59 ft/day.

The primary objective of this pilot test was to assess the feasibility of using BNP as an *in-situ* remedial treatment for the chlorinated hydrocarbon impacted groundwater at Area I. It was assumed that the pilot test area is not located in a source area where significant contaminant mass may be sorbed to soils. Given that the pilot test area is located within a groundwater contaminated plume and based on the limited scope of the test, the remedial goal of the test was to reduce, not completely degrade, chlorinated hydrocarbon concentrations within the assumed treatment area. In addition, during the pilot test, the groundwater chemistry changes elicited by the BNP reactions was also evaluated.

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2.0 BNP TECHNOLOGY

2.1 TECHNOLOGY OVERVIEW

BNP consists of submicron particles of zero valent iron (Fe^0) with a trace coating of palladium (approximately 0.1% by weight) that acts as a catalyst. BNP's rapid destruction of a wide range of recalcitrant contaminants can be accomplished either *in-situ* or *ex-situ*, and is based on a redox process where the zero-valent iron serves as the electron donor.

Two factors contribute to BNP's capabilities as an extremely versatile remediation tool. The first is their extremely small particle size (on the order of 10-100 nanometers). Due to this attribute, the BNP-water mixture can be injected under pressure to the contaminated zone where treatment is needed. The particles can be transported by groundwater to establish *in-situ* treatment zones. The technology can effectively treat not only the dissolved plume but also highly concentrated source areas. Given its mobility, BNP can be used to treat contaminant areas that are inaccessible to conventional technologies such as reactive barriers (beneath buildings, deep aquifers, etc.).

The second factor is BNP's reactivity. The substantial body of research on Fe^0 transformation processes strongly suggests that the reactions are surface-mediated. The high reactivity of the particles is directly attributable to their high specific surface area (approximately 33.5 m^2/g).

Unlike the Permeable Reactive Barrier (PRB) technology, there are no depth limitations for treatment using the BNP technology. In general, the injection concentration of BNP is approximately 0.1 percent of the volume of the injected mixture. The low concentration of the injected suspension minimizes the potential for clogging of the water-bearing zone.

There are two possible application methods for the BNP technology: gravity feed and pressure injection. BNP suspension injected by gravity is suitable for areas that have reasonably permeable formations (i.e. high hydraulic conductivity aquifers). With high permeability, BNP may be transported easily without causing clogging.

Pressure injection, including direct-push methodologies, is suitable for most type of formations. BNP suspension injected by pressure will spread the particles away from the injection point to increase the influence area of the BNP "plume". Direct-push methods also allow for injection without the cost of additional wells. Regardless of which application method is used to inject the BNP suspension, recirculation may be a helpful tool in achieving better BNP treatment. Recirculation not only increases the hydraulic gradient for better BNP transportation, but also aids in mixing of BNP with the contaminants.

Finally, this technology induces the creation of strongly negative redox conditions within the injection zone. Microbial reductive dechlorination processes are typically anaerobic and reducing conditions are a prerequisite for the natural attenuation of chlorinated hydrocarbons. Additionally, studies show that hydrogen, which is produced from iron corrosion, supports the growth of anaerobic cultures capable of dechlorinating TCE to ethane. Hence, the BNP process supports and is compatible with natural attenuation of chlorinated hydrocarbons.

2.2 APPLICABILITY TO THE NAES SITE

BNP rapidly transforms chlorinated hydrocarbon contaminants to innocuous end products, namely ethane, ethene, and chloride. The transformations are a complex series of redox reactions in which zero valent iron (Fe^0) is oxidized while the contaminant is reduced.

Fe^0 can react with an amenable compound such as a chlorinated hydrocarbon as follows:

$$Fe^0 + R\text{-}Cl + H^+ \rightarrow Fe^{2+} + R\text{-}H + Cl^- \qquad (1)$$

In this generalized reaction, iron serves as the electron donor. A reaction more pertinent to the Site is the reaction of Fe^0 with trichloroethene (TCE):

$$4Fe^0 + C_2HCl_3 + 5H^+ \rightarrow 4Fe^{2+} + C_2H_6 + 3Cl^- \qquad (2)$$

The driving force for these reactions is the fact that chlorinated hydrocarbons are relatively oxidized compounds and therefore exhibit a greater propensity towards reductive processes as opposed to oxidative processes such as aerobic biodegradation.

2.3 BENCH-SCALE TEST RESULTS

Bench-scale tests have been conducted in the Environmental Engineering Laboratory at Lehigh University with groundwater samples from the Site. Based on the results of these tests, contaminants in groundwater at Area I can be reduced effectively with uncoated nanoscale zero valent iron (nZVI), palladium or silver coated BNP. Among the three kinds of nanoscale iron, the palladium coated BNP was the most effective at treating contaminants. The reaction of palladium coated BNP with TCE was first order. The reaction constant was 3.8 hr^{-1} and the half-life of TCE was approximately 0.2 hours at a BNP dose of 0.6 g/L. The half-life of TCE reacting with BNP is noted to be significantly less than the hydrolysis TCE half-life of 10.7 months to 4.5 years and the anaerobic degradation half-life of TCE of 98 days to 4.5 years. The BNP bench scale test was performed at a temperature of 20 °C. Based on available data, there is not information indicating that the reaction of BNP is independent of temperature. Therefore, the conclusion of the bench-scale tests was that *in-situ* reduction of chlorinated hydrocarbons with the BNP technology is likely feasible at the Site. The bench-scale tests also recommended the use of palladium coated BNP for the pilot test.

3.0 PILOT TEST OVERVIEW

3.1 WELL SURVEY

More than 30 piezometers and monitoring wells were already installed and developed at the pilot test area. For this pilot test, only select piezometers and monitoring wells were used to monitor groundwater elevations, the dispersion of BNP, and the degradation of chlorinated volatile organic compounds. These piezometers and monitoring wells are depicted in the figures included in this report. The BNP pilot test layout is provided as Figure 1.

According to the Biodegradation Pilot Test Report (Envirogen, 2000) and the well information provided by the U.S. Navy, the piezometers and monitoring wells are screened from 45 to 65 ft below ground surface (bgs). However, OW-6 is screened from 50 to 60 ft bgs, LJ is screened from 30 to 45 ft bgs, and LK is screened from 55 to 70 ft bgs.

During the pilot test, it was necessary for PARS to alter the elevations of several piezometers and monitoring wells. Therefore, PARS conducted well surveying on January 24, 2002 to obtain new elevations and a detailed layout of the pilot test area. Based on the survey information, the geological cross-section of the pilot area was prepared and is shown in Figure 2. Additionally, surveyed casing elevations are presented in Table 1.

3.2 BASELINE SAMPLING

The purpose of the baseline sampling is to provide data regarding VOC concentrations and groundwater geochemistry at the test area prior to the injection of BNP. One baseline sampling event was performed during the pilot test. On October 25, 2001, groundwater samples were collected from MW-4, MW-6, MW-8, LIW-3, LIW-4, LIW-7 and LIW-8. Groundwater sampling forms are provided as reference in Appendix A. Samples were collected utilizing the Environmental Protection Agency (EPA) low-flow sampling methodologies (see Appendix B). The samples were analyzed for VOCs, chloride, dissolved iron, and total iron. The baseline groundwater quality results are provided in Table 4.

Additionally, a suite of intrinsic geochemical parameters, which included dissolved oxygen (DO), pH, oxidation-reduction potential (ORP), temperature, and specific conductance were collected using a water quality meter. Baseline geochemical parameters were also measured on February 4, 2002, the day before injection of BNP, at GIW-4, GIW-3, MW-5, LIW-3, LIW-4, LIW-7, and LIW-8. Geochemical readings are presented in Table 3.

Groundwater levels were measured on October 25, 2001 and January 24, 2002 (see Table 1). Based on the groundwater levels measured on October 25, 2001, the groundwater elevation is depicted in Figure 5. The observed gradient across the pilot plot area was approximately 0.002 ft/ft. The groundwater velocity in the test area was approximately 0.59 ft/day. The groundwater flow direction was mainly toward MW-6. However, a component of the groundwater flow direction was observed toward MW-2 and GIW-3.

3.3 GROUNDWATER RECIRCULATION

To enhance in-situ mixing and gain hydraulic control over the pilot test area, groundwater was pumped continuously from MW-4 at a rate of approximately 10 gallons per minute (gpm) and reinjected into MW-3 at approximately the same rate. Groundwater recirculation was initiated on February 4, 2002, the day before injection of BNP. On February 14, 2002, PARS personnel noted that an automatic shutdown of the pump had occurred between February 11 and February 14, 2002. At that time the recirculation of groundwater was ceased. The total volume of groundwater recirculated has been assumed to be between 100,800 to 144,000 gallons over a 7 to 10-day period. The total volume of water was determined based on the pumping rate and estimated hours of operation.

Groundwater levels were measured on February 5, 2002 during the recirculation (see Table 1). Based on the groundwater level measurements, the groundwater elevation is depicted in Figure 6. The observed gradient across the pilot plot was approximately 0.02 ft/ft. This hydraulic gradient was approximately 10 times greater than the gradient prior to groundwater recirculation. The groundwater velocity also increased during recirculation from 0.59 ft/day to 6.77 ft/day. Groundwater generally flowed from MW-3 toward MW-4 under the conditions induced by groundwater recirculation.

3.4 INJECTION OF BNP

BNP injection was performed from February 5 to February 7, 2002. The injection equipment setup and injection location are shown in Figure 3.

A 150-gallon tank was used for BNP injection. The tank contained a mixed BNP-water suspension that was made with on-Site groundwater from MW-4. A mechanical agitator was fitted to the tank to minimize settling of the BNP during injection. The BNP suspension was injected using a piston pump (GS1000 Grout Machine) directly through open probe rods (i.e. no screen was utilized). A Bottom-Up Injection Procedure was utilized to inject BNP. Figure 4 depicts the scenario of this injection procedure. The water/BNP budgets used during the injections are provided as Table 2.

The additional injection methodologies and processes will be discussed in this section of this report.

BNP Injection IP-1

BNP was injected at IP-1, which is approximately 5.0 ft southeast of MW-3 on February 5. The string of probe rods were retracted from 65 to 43 feet bgs at an injection rate of approximately 2.5 gpm.

At the start of the injection BNP concentrations were approximately 0.8 g/L. PARS increased the BNP concentrations to 1.3 g/L after injecting approximately 400 liters of BNP suspension. A total of approximately 2,260 liters of 1.4 g/L BNP suspension (average concentration) was injected (i.e. 7.14 pounds of BNP) into IP-1.

During the injection, an *in-situ* multiple-parameter water quality meter was used to monitor groundwater ORP and pH at GIW-4 and LIW-3. Groundwater ORP and pH did not significantly change in these wells.

BNP Injection IP-2

BNP was injected at IP-2, which is approximately 5.9 ft southeast of MW-3 and 3.6 ft northwest of LIW-3 on February 6. The string of probe rods were retracted from 65 feet below grade to the ground surface. Due to problems with the grout pump (likely from pressure build-up), the rods had to be pulled up to ground surface. The injection rate was approximately 2.5 gpm.

At the start of the injection BNP concentrations were approximately 1.6 g/L. PARS adjusted the BNP concentrations to 1.9 g/L after injecting approximately 400 liters of BNP suspension. A total of approximately 2,070 liters of 1.5 g/L BNP suspension (average concentration) was injected (i.e. 7.0 pounds of BNP) into IP-2.

Groundwater ORP and pH did not significantly change at LIW-3 during the injection. However, ORP and pH changes were observed at GIW-4. The ORP at GIW-4 dropped from 232 millivolts (mV) on February 5 to 34 mV during the injection. Additionally, pH increased from 4.89 on February 5 to 6.25 during the injection (see Table 3).

BNP Injection IP-3

BNP was injected at IP-3, which is approximately 7.5 ft south of MW-3 on February 7. The string of probe rods were retracted from 65 to 34 feet below grade. The injection rate was approximately 2.5 gpm. A total of approximately 2,315 liters of 1.4 g/L BNP suspension (average concentration) was injected (i.e. 7.05 pounds of BNP) into IP-3. Groundwater ORP and pH did not significantly change at MW-4 and LIW-3 during the injection.

3.5 AQUIFER MONITORING

After injection, PARS conducted four groundwater sampling events to assess the overall performance of the pilot test. An *in-situ* multiple-parameter water quality meter was used to track changes in groundwater geochemistry after injection. A total of eight rounds of *in-situ* geochemical data was collected during the pilot test. The geochemical results are provided in Table 3. Results of geochemical monitoring and groundwater analysis are discussed in Section 4.0 of the report. The schedule for the sampling events was determined based on geochemical and hydrogeological field observations. The schedule for the sampling events was 1, 7, 14, and 28 days subsequent to injection.

Groundwater samples were collected from MW-2, MW-4, MW-5, MW-8, LIW-3, LIW-4, LIW-7, LIW-8 and GIW-3 during these events. The sampling locations for each event were selected based on field observations (i.e. groundwater geochemistry). Groundwater sampling forms are provided as reference in Appendix A. All groundwater samples were collected utilizing low-flow sampling methodologies (see Appendix B). The samples were analyzed for VOCs, chloride, dissolved and total iron, and a suite of geochemical parameters, which included DO, pH, ORP, temperature, and specific conductance. The groundwater sampling results are provided in Table 4.

Groundwater levels were measured prior to each sampling round. All groundwater elevations are shown in Table 1. Figure 7 depicts the groundwater elevation on February 21, 2002, two weeks after the injection of BNP. As shown in the figure, the groundwater elevation on this date was similar to the elevation observed prior to groundwater recirculation and injection of BNP (see Figure 5). The observed gradient across the pilot plot was approximately 0.002 ft/ft. The groundwater flow velocity in the test area was approximately 0.59 ft/day. Groundwater flow was toward MW-6 with a component toward MW-2 and GIW-3.

The U.S. Navy contracted VAL Associates Laboratory, Inc. to perform an additional groundwater sampling event on May 6, 2002, approximately two months after the completion of the pilot test. Groundwater samples were collected from MW-2, MW-3, MW-4, MW-5, MW-6, MW-8, GIW-3, OW-6, LIW-2, LIW-3, LIW-4, and LIW-7. The samples were analyzed for VOCs and a suite of geochemical parameters, which included DO, pH, ORP, temperature, and specific conductance. The groundwater sampling results are summarized in Table 4. The groundwater elevations are shown in Figure 8. As shown in the figure, groundwater flow was toward GIW-7 and LIW-7. This groundwater flow direction differs from the flow directions observed during the pilot test (see Figures 5 and Figures 7).

4.0 PILOT TEST RESULTS AND DISCUSSION

4.1 GROUNDWATER CHEMISTRY CHANGES ELICITED BY THE BNP REACTIONS

BNP technology relies on zero valent iron (ZVI) chemistry and reactivity as the means by which amenable contaminants (such as chlorinated hydrocarbons) are transformed to innocuous end products. The ZVI corrosion process is the fundamental reaction in BNP technology. The corrosion process is that ZVI, denoted as Fe^0, reacts with oxygen (O_2) in the atmosphere or in water to form oxidized iron (Fe^{+2}, Fe^{+3}):

$$2\ Fe^0 + O_2 \rightarrow 2\ Fe^{+2} + 2\ H_2O \quad (3)$$

$$2\ Fe^0 + O_2 + 2\ H_2O \rightarrow 2Fe^{+2} + 4\ OH^- \quad (4)$$

Under aerobic conditions, the above equation actually proceeds further such that ferric (+III) iron is formed, which subsequently precipitates as one of a number of iron oxides/hydroxides, depending upon the solution chemistry. Corrosion is therefore an oxidation-reduction ("redox") process. Simultaneously, the BNP can react with water, albeit more slowly, to evolve hydrogen, thus reinforcing the reduction conditions. The following equation depicts the reaction of BNP with water:

$$Fe^0 + 2\ H_2O \rightarrow Fe^{+2} + H_2 + 2\ OH^- \quad (5)$$

Thus, ZVI corrosion typically proceeds with iron serving as the electron donor and oxygen (and/or water) serving as the electron acceptor. It is also noteworthy to point out that these three equations result in the consumption of oxygen during the process with a consequent lowering of the formation ORP.

In addition to lowering the ORP, ZVI reacts with chlorinated hydrocarbons to consume protons (H^+), meaning that the pH is expected to increase.

BNP changes the groundwater chemistry at least temporarily as it migrates through the subsurface. The parameters most affected are ORP, DO, and pH. Table 3 summarizes the geochemical data for each monitoring location. In this sub-section, the geochemistry is discussed in the context of these aforementioned reactions, with a focus on the ORP and pH changes associated with BNP-mediated contaminant reduction. In addition, concentrations of chloride and total and dissolved iron in the groundwater are discussed in this sub-section.

4.1.1 BNP Effects on Groundwater ORP

ORP is used to describe the relative oxidizing or reducing capacity of a medium (e.g. air, water) and refers to the concentration of electrons in solution. Oxidizing conditions are such that the medium contains comparatively few electrons and is described as exhibiting a positive ORP. The opposite is true for reducing conditions.

The pre-injection ORP levels are depicted in Figure 9. As shown in the figure, the ORP levels ranged from +170 to +311 mV. This indicates that the pilot test area is under moderate oxidizing conditions.

ORP levels were observed to decline after the injection of BNP. Figures 10 through 12 depict the observed ORP levels approximately one week, two weeks, and four weeks after the BNP injection. As shown in the figures, some monitoring locations, including MW-2, MW-3, MW-4, and GIW-3, exhibited dramatic decreases in ORP with strong reducing conditions being established. ORP levels ranged from –100 to –400 mV in these monitoring wells. This is attributable to the consumption of dissolved oxygen by BNP and the reaction with chlorinated hydrocarbons.

The injected BNP not only had effects on the ORP at the above referenced wells, but also on the entire pilot test area. The ORP levels that are depicted in Figure 9 and Figure 12 provide a comparison of the BNP influence before injection and four weeks after the injection of BNP. The ORP levels in most wells before BNP injection were above +200 mV. Four weeks after the injection, reductions were observed at monitoring wells throughout the pilot test area.

Approximately two months after the completion of the pilot test, ORP levels indicate that reducing conditions continue to exist in most monitoring wells within the pilot test area (see Figure 13). During this monitoring period, it was observed that reducing conditions were established at GIW-7 and LIW-7. Establishment of reducing conditions at these monitoring wells was attributed to the change in groundwater flow direction within the pilot test area (see Figure 8). Based on these findings, it appears that the transport direction of the BNP plume has changed with the groundwater flow direction, resulting in reduced ORP levels at GIW-7 and LIW-7.

BNP processes are surface-mediated and require the sorption of the species before any reaction occurs. The reaction between chlorinated hydrocarbons and BNP presumably proceeds at a slower rate than the reaction between DO and BNP as the chlorinated hydrocarbons sorb more slowly. Therefore, it is reasonable to hypothesize that immediately upon arrival of the BNP plume, the reaction with DO ensues rapidly. The drop of ORP can be observed in the field as an indicator to predict the potential reduction of chlorinated hydrocarbons. In addition, the established reducing conditions are a prerequisite for the natural attenuation of chlorinated hydrocarbons. Figures 14-1 through 14-12 summarize the ORP changes in several monitoring wells within the pilot plot area.

4.1.2 BNP Effects on Groundwater pH

As indicated by equations 1 and 2, BNP reacts with chlorinated hydrocarbons, causing pH to rise temporarily. The pH rise is caused by the consumption of protons (H^+) that, along with an electron pair from iron, are added to the contaminant while displacing chloride (Cl^-). The natural buffering capacity (i.e. alkalinity) in most groundwater, as well as, the dilution due to the flow of groundwater ensures that the pH rise (1-2 standard units) is temporary. However, for poorly buffered groundwater, the pH rise can be significant (>2 standard pH units) and persistent.

Figures 14-1 through 14-12 summarize the pH changes in several monitoring wells within the pilot plot area. The pH increased approximately 0.3 to 1.0 standard units at most of the downgradient monitoring wells after injection. The average groundwater pH throughout the test area after injection was approximately 5.2 standard units. Given the well-buffered groundwater at the test area, the pH rise was temporary.

4.1.3 Total and Dissolved Iron

Table 4 summarizes the concentrations of total iron and dissolved iron at each monitoring well during the pilot test.

Based on historic data, the groundwater at the pilot test area contains high concentrations of total iron and dissolved iron (Envirogen, 2000). Additionally, due to the seasonal elevation changes of the water table, fluctuations are observed in the total iron and dissolved iron concentrations. Therefore, it is difficult to evaluate BNP transportation based on the total iron and dissolved iron results obtained during this pilot test.

4.1.4 Chloride

Chloride concentrations can be used for evaluating the extent of VOC breakdown. The more chloride that appears in the groundwater samples, the more chlorinated hydrocarbons have been reduced by BNP. However, not only is chloride liberated from the contaminant, but it is also detected as residual chloride from the production process of BNP.

At MW-4, LIW-3, and LIW-4, the chloride concentrations dramatically increased from the February 21 to March 7, 2002 sampling event. The chloride concentrations increased from 7.5 mg/L to 565 mg/L in LIW-3 and from 7.5 mg/L to 465 mg/L in MW-4. The chloride concentration also increased in LIW-4 from 8.0 mg/L to 115 mg/L. Given that a reduction of chlorinated hydrocarbons was observed at these wells, the elevated chloride concentrations can be attributed to liberated chloride from the chlorinated hydrocarbons. However, it is expected that residual chloride from the production of BNP contributed to most of the elevated chloride concentrations given the low levels of contamination of the pilot test area. Chloride concentrations at each monitoring well are summarized in Table 4.

4.2 CAPABILITY OF THE BNP TO DEGRADE CHLORINATED HYDROCARBONS

Table 4 summarizes the results of detected chlorinated hydrocarbons at each monitoring well sampled during this pilot test. Figures 16-1 to 16-4 depict VOC concentration trends at MW-4, LIW-3, LIW-4, and LIW-8. Additionally, analytical results are presented as Volume II and III of this report.

PARS performed the baseline sampling on October 25, 2001. However, due to electrical supply problems at the pilot test area, the BNP injection was delayed for approximately three months subsequent to the baseline sampling. In addition, it is worth noting that seasonal elevation changes of the water table result in fluctuations in chlorinated hydrocarbon concentrations. These fluctuations are clearly observed in historical sample results for LK (see Table 5 and Figure 15). Therefore, the VOC results from October 25, 2001 are not suitable for use as a baseline for the BNP pilot test. Only the VOC results from four post-injection sampling events during the pilot test and the groundwater sampling event conducting by the U.S. Navy on May 6, 2002 will be discussed in this section. The historic data collected at Area I will not be used to support the conclusions of this pilot test. VOC data and historic water levels at LK were only referenced to provide background information regarding the pilot test area.

At LIW-3, the first downgradient well from the injection points, PCE and TCE reductions were achieved of approximately 90% and 72%, respectively. These results are based on the groundwater analytical data from February 8 and May 6, 2002. In addition, cis-DCE was reduced approximately 75%. The total VOC reduction at LIW-3 was approximately 83%. The VOC concentration trends for this monitoring well are depicted in Figure 16-2.

Based on the groundwater analytical results from February 14, 2002 and the results from May 6, 2002, PCE and TCE were reduced in MW-4 by approximately 100% and 74%, respectively. Cis-DCE was also reduced approximately 89% during this time period. The reduction of total VOCs was approximately 88%. As mentioned previously, immediately upon arrival of the BNP plume, the drop of ORP can be observed in the field as an indicator to potential reduction of chlorinated hydrocarbons. As shown in Figure 14-3, the ORP at MW-4 dropped from 169 mV on February 11 to –246 mV on February 28. Although ORP levels began to increase after the February 28 monitoring event, reducing conditions continue to prevail in this monitoring well. Given the ORP changes at MW-4, the reduction of VOCs can be directly attributed to the reaction with BNP. The VOC concentration trends for MW-4 are depicted in Figure 16-1.

PCE and TCE concentrations at LIW-4 were reduced approximately 79% and 69%, respectively, based on the groundwater analytical results from February 8 and March 7, 2002. The reduction of cis-DCE during this time period was approximately 68%. Reduction of total VOCs from February 8 to March 7, 2002 was approximately 71%. After injection, the ORP levels in this well dropped from 237 mV on February 11 to 45 mV on March 4, 2002. Additionally, the pH increased from 5.08 to 5.55. Two months after the completion of the pilot test, VOC concentrations began to increase in this monitoring well. Total VOC reduction from February 8 to May 6, 2002 was approximately 50%. VOC concentration trends for LIW-4 are shown in Figure 16-3.

Several monitoring wells outside the proposed treatment area (see Figure 1) exhibited reductions in VOC concentrations. These wells include LIW-8, MW-2, and GIW-3. At LIW-8, total VOC reductions were approximately 40% from February 7 to March 7, 2002. PCE, TCE and cis-DCE reductions were achieved of approximately 12%, 10%, and 14%, respectively. LIW-8 was not sampled on May 6, 2002; however, ORP levels continue to remain low at this monitoring well (see Table 3). VOC concentration trends for LIW-8 are shown in Figure 16-4.

MW-2 and GIW-3 were sampled on March 7, 2002 given the reducing conditions observed at these wells. ORP levels at MW-2 and GIW-3 on February 28, 2002 were -167 mV and -446 mV, respectively. The low ORP levels indicated that the BNP Plume had reached the monitoring wells given the observed groundwater flow pathway (see Figure 5 and Figure 7). Although ORP levels began to increase after February 28, 2002, VOC reductions were observed at these wells based on the results from March 7 to May 6, 2002. PCE and TCE reductions were achieved of approximately 82% and 81%, respectively. Cis-DCE was reduced approximately 76%. Additionally, total reduction of VOCs was approximately 77%. At GIW-3, PCE reduction was approximately 100% during this time period. TCE and cis-DCE reductions at GIW-3 were achieved of approximately 11% and 5%, respectively. Total VOC reduction at GIW-3 during this period was 28%.

In general, the average reductions of PCE, TCE and cis-DCE at the assumed treatment area were approximately 67% to 87% from February 8 to May 6, 2002. The total reduction of VOCs within the treatment area during this period was approximately 74%.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results described herein and the limited scope of this test (see Section 1.0), PARS concludes that the BNP technology pilot test at Area I of the Site achieved the remedial goal of the study to reduce chlorinated hydrocarbon concentrations within the assumed treatment area.

Specific conclusions of the pilot test results include the following:

1. The BNP reactions had an effect on groundwater chemistry at the pilot test area. In general, the ORP levels declined in all monitoring wells after the injection of BNP. Approximately two months after the completion of the pilot test, the reducing conditions were still observed at most of the monitoring wells throughout the pilot test area. Additionally, slight increases in pH were observed in a number of wells. This indicates that the target contaminants consumed H^+ while reacting with BNP.

2. ORP levels had dramatically decreased at MW-2, MW-3, MW-4, and GIW-3 during the pilot test. The BNP plume created reducing conditions in the vicinity of these wells and other wells in the pilot test area. This decrease in ORP is not only an indicator of the potential reduction of chlorinated hydrocarbons, but also provides a reducing condition, a prerequisite for the natural attenuation of chlorinated hydrocarbons.

3. The BNP reduced approximately 90% of PCE, 72% of TCE, and 75% of cis-DCE in LIW-3 from February 8 to May 6, 2002. The reduction of total VOCs was approximately 83%.

4. At MW-4, PCE and TCE were reduced approximately 100% and 74%, respectively from February 14 to May 6, 2002. Cis-DCE was also reduced approximately 89%. The reduction of total VOCs was approximately 88%.

5. At LIW-4, PCE and TCE were reduced approximately 79% and 69%, respectively, from February 8 to March 7, 2002. Cis-DCE was also reduced approximately 68%. The reduction of total VOCs was approximately 71%. VOC concentrations at this well increased from March 7 to May 6, 2002. The reason for this increase is not immediately obvious based on the data analyzed. However, total reduction of total VOCs was 50% from February 8 to May 6, 2002.

6. The average reductions of PCE, TCE and cis-DCE at the treatment area were approximately 67 to 87% from February 8 to May 6, 2002. Total VOC reduction was approximately 74%.

7. Reduced ORP levels and chlorinated hydrocarbon concentrations were also detected in monitoring wells outside the proposed treatment area. These monitoring wells include LIW-8, MW-2, and GIW-3. MW-2 had the largest reduction in total VOC concentrations of these wells. Reduction of total VOCs was approximately 77% at MW-2 from March 7 to May 6, 2002.

8. Two months after the completion of the pilot test, reducing conditions were still observed within the pilot plot area. If ORP levels remain low, continued VOC reductions can be expected within the pilot plot area.

Reduction in VOC concentrations observed at LIW-3, LIW-4, MW-4, and other wells indicate that BNP effectively degraded chlorinated hydrocarbons at the Site. Changes in geochemical data (i.e. ORP and pH) also indicate that the BNP plume had effected groundwater within the entire pilot test area.

Given the above conclusions, PARS recommends conducting a larger scale pilot test at Area I. The test will be designed to treat a larger area of the pilot plot. In order to reduce a greater percentage of chlorinated hydrocarbons, the amount of BNP injected into the formation will be increased. This will be achieved by increasing the concentration of BNP in the injected suspension and increasing the number of injection points. BNP will be injected in a grid pattern to create a reaction zone. Spacing of the grid will be depended on the concentrations of BNP used at each injection point and the injection method.

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2. U.S. Navy, October 2001. " Workplan for Bimetallic Nanoscale Particle Treatment of Groundwater at Area I."
3. Zhang, W.X., Elliott, D.W., September 2000. "Summary Report of Pilot Test of Nanoscale Bimetallic Particles"
4. Lampron, K.J., Chiu, P.C., Cha, D.K., 1998. "Biological Reduction of Trichloroethene Supported by Fe (0)." Bioremediation Journal, 2(3&4):175-181
5. Daniels, L., N. Belay, B.S. Rajagopal, and P.J. Weimer, 1987. "Bacterial Methanogenesis and Growth from CO_2 with Elemental Iron as the Sole Source of Electrons." Science 237:509-511
6. Till, B.A., L.J. Weathers, and P.J.J. Alvarez, 1998. "Fe(0)-supported Autographic Denitrification." Environ. Sci. Technol. 32:634-639

FIGURES

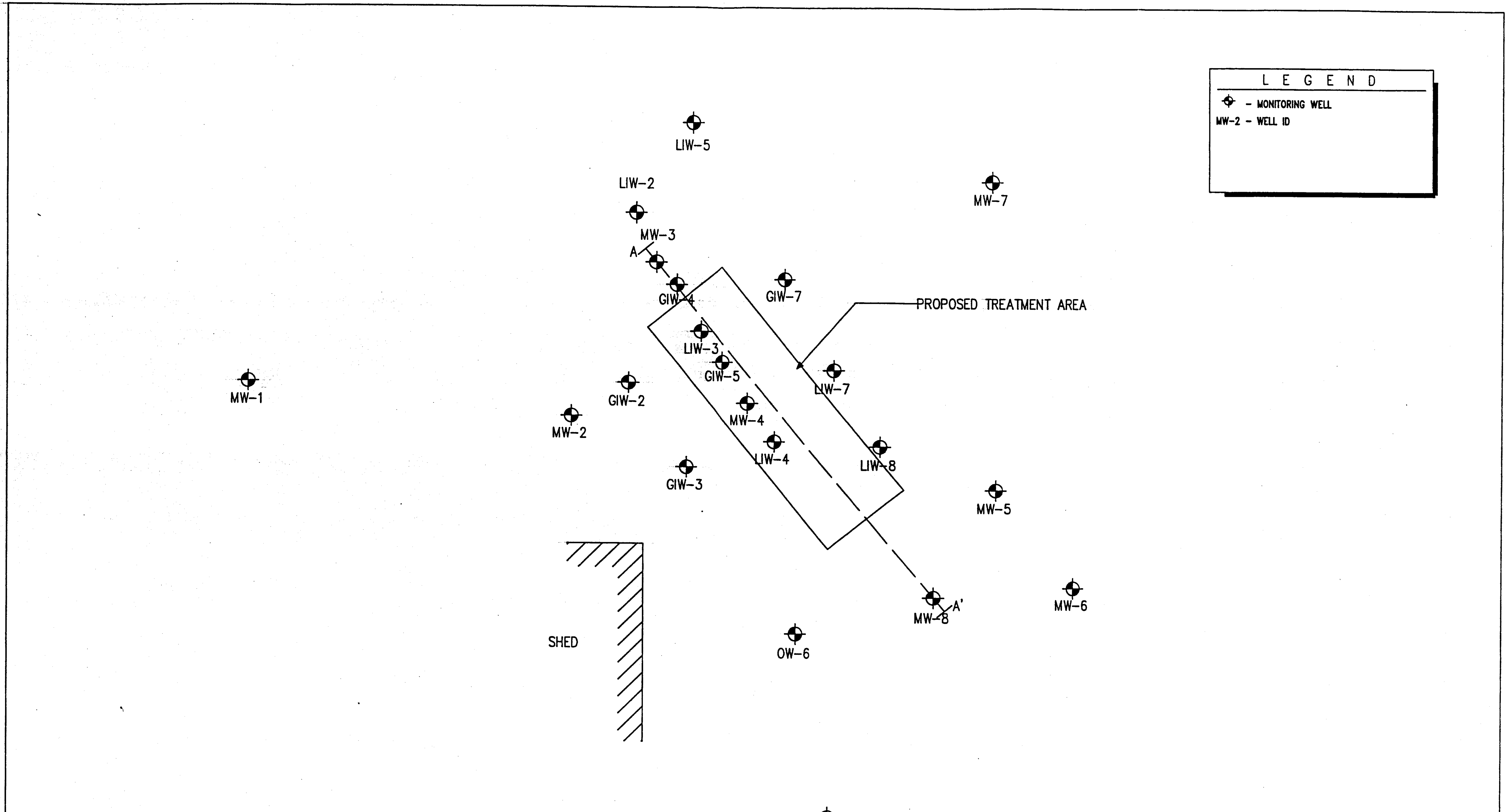


FIGURE 1
BNP PILOT TEST AREA
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: 1" = 10'	JOB No.: 586-02
CK'D. BY: JK	DATE: 01/28/02	FILE NO.: 586-02
REV. NO.	REV. DATE: / /	FIGURE NO.:1

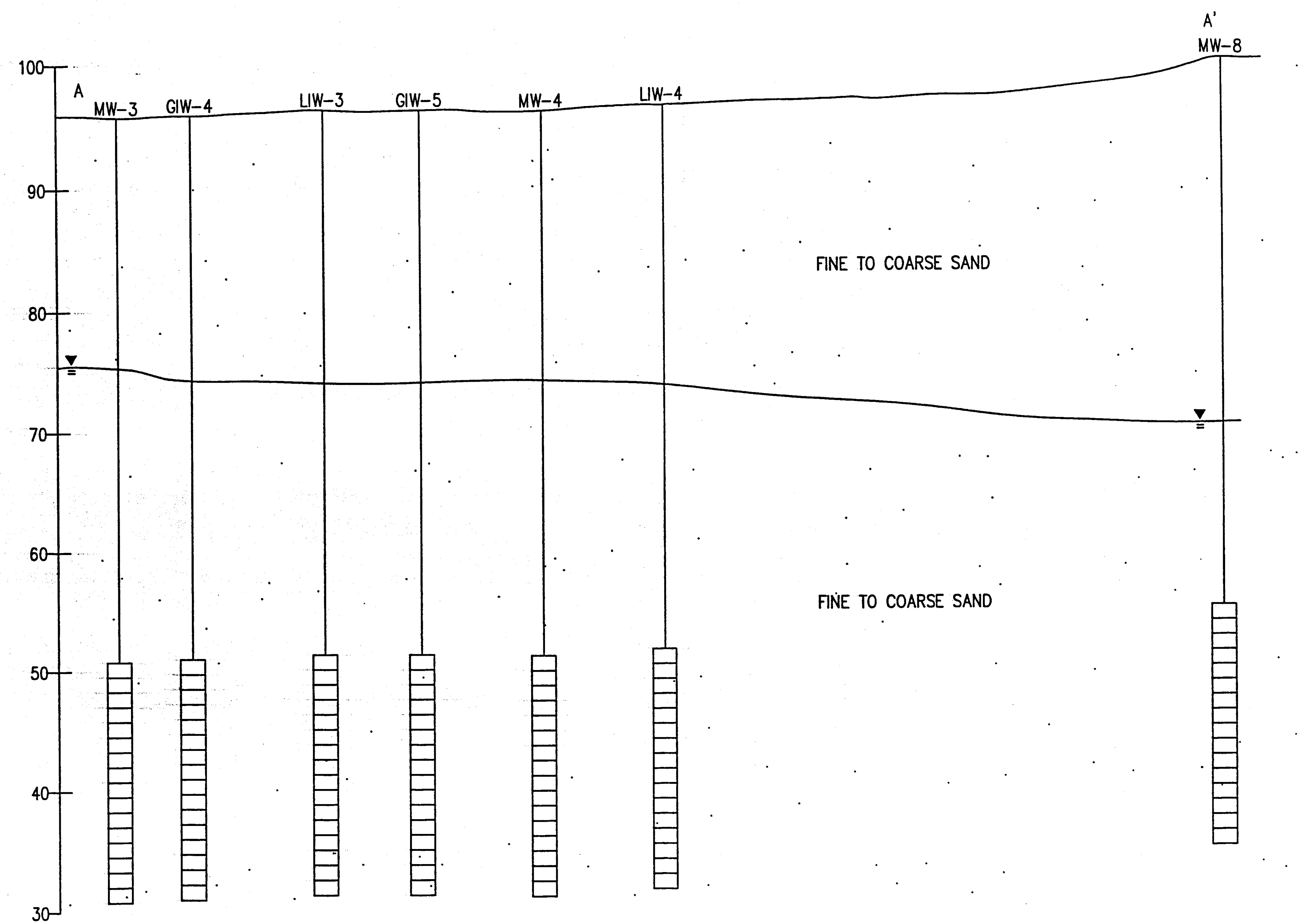


FIGURE 2
PILOT TEST AREA CROSS-SECTION A-A'
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: 1" = 10'	JOB No.: 586-02
CK'D. BY: KL	DATE: 01/28/02	FILE NO.: 586-02
REV. NO.	REV. DATE: / /	FIGURE NO.:2

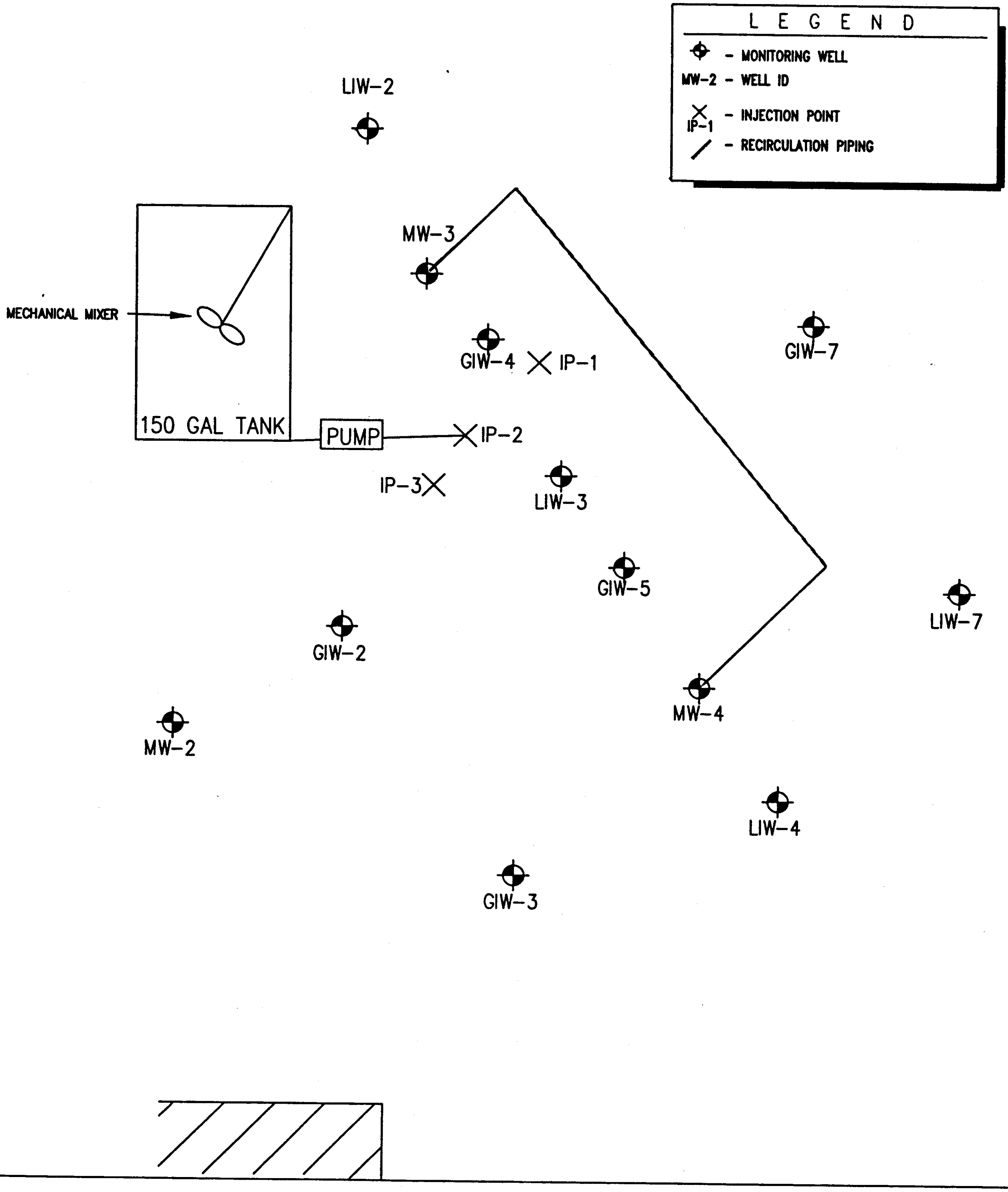


FIGURE 3
INJECTION EQUIPMENT SETUP
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: 1"= 5'	JOB No.: 586-02
CK'D. BY: JK	DATE: 1/4/02	FILE NO.: 586-02
REV. NO.	REV. DATE:	FIGURE NO.:3

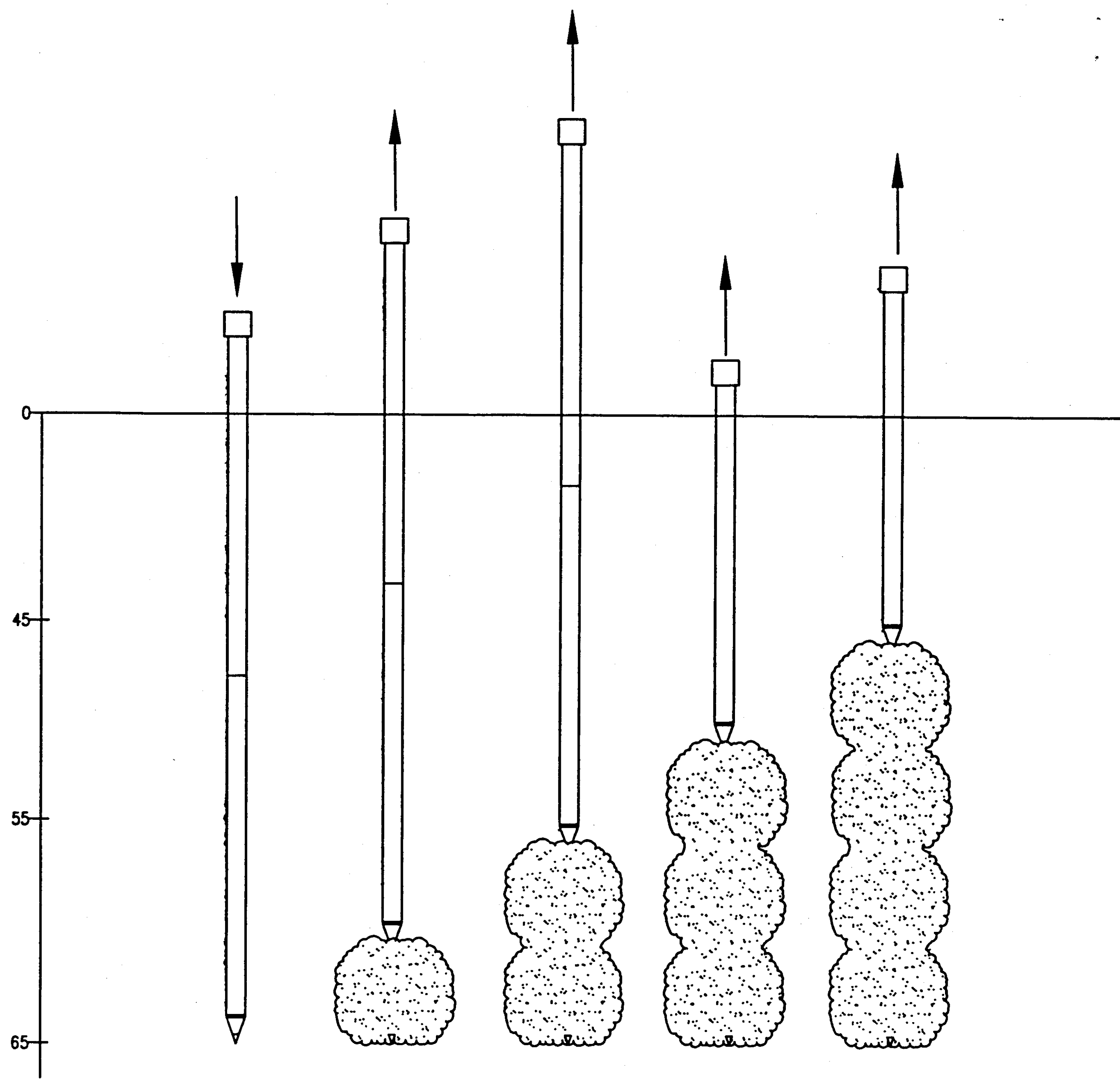


FIGURE 4
BOTTOM-UP INJECTION PROCEDURE
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: NOT TO SCALE	JOB No.: 586-02
CK'D. BY: KL	DATE: 3/28/02	FILE NO.: 586-02
REV. NO.	REV. DATE:	FIGURE NO.: 4

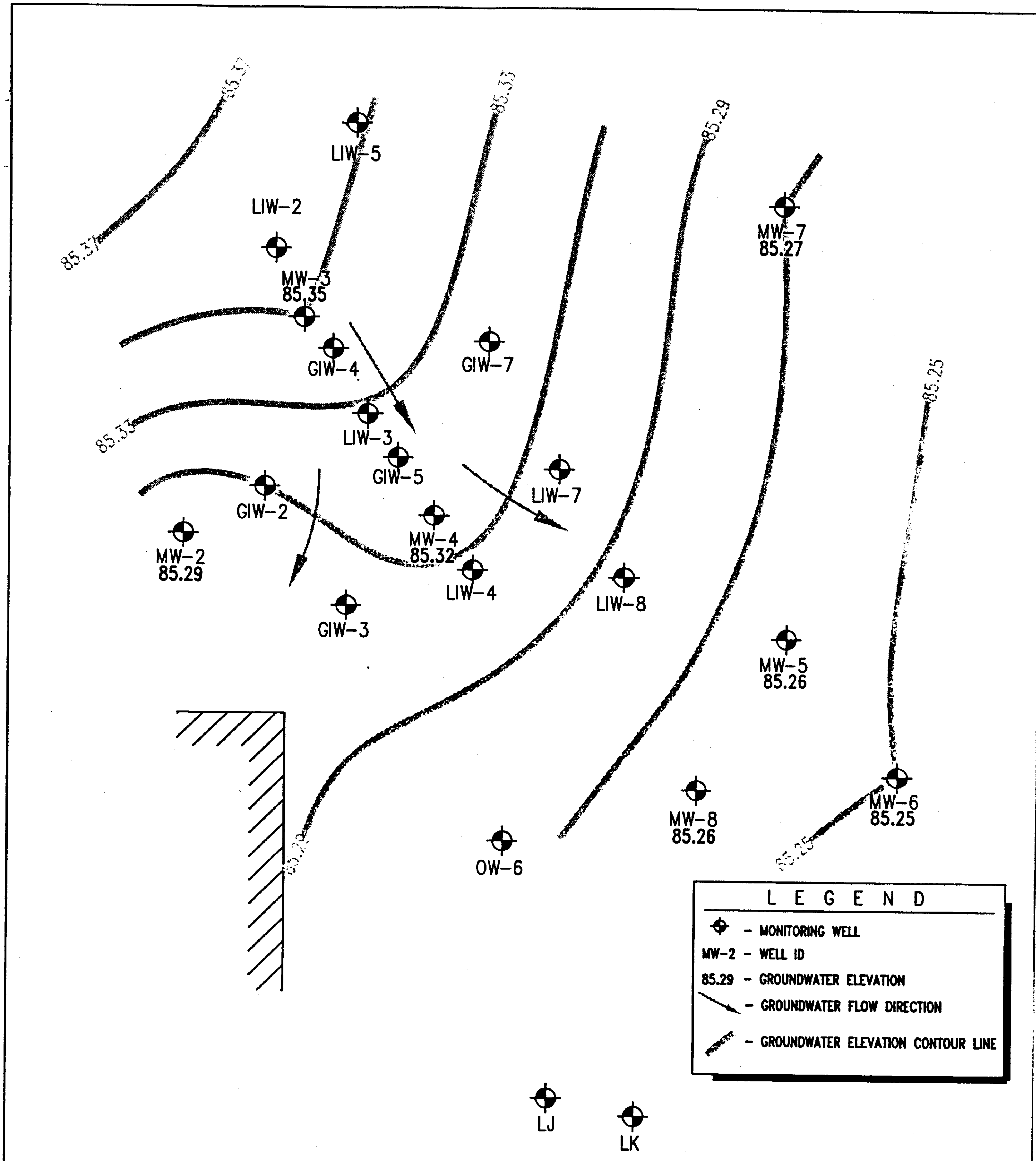
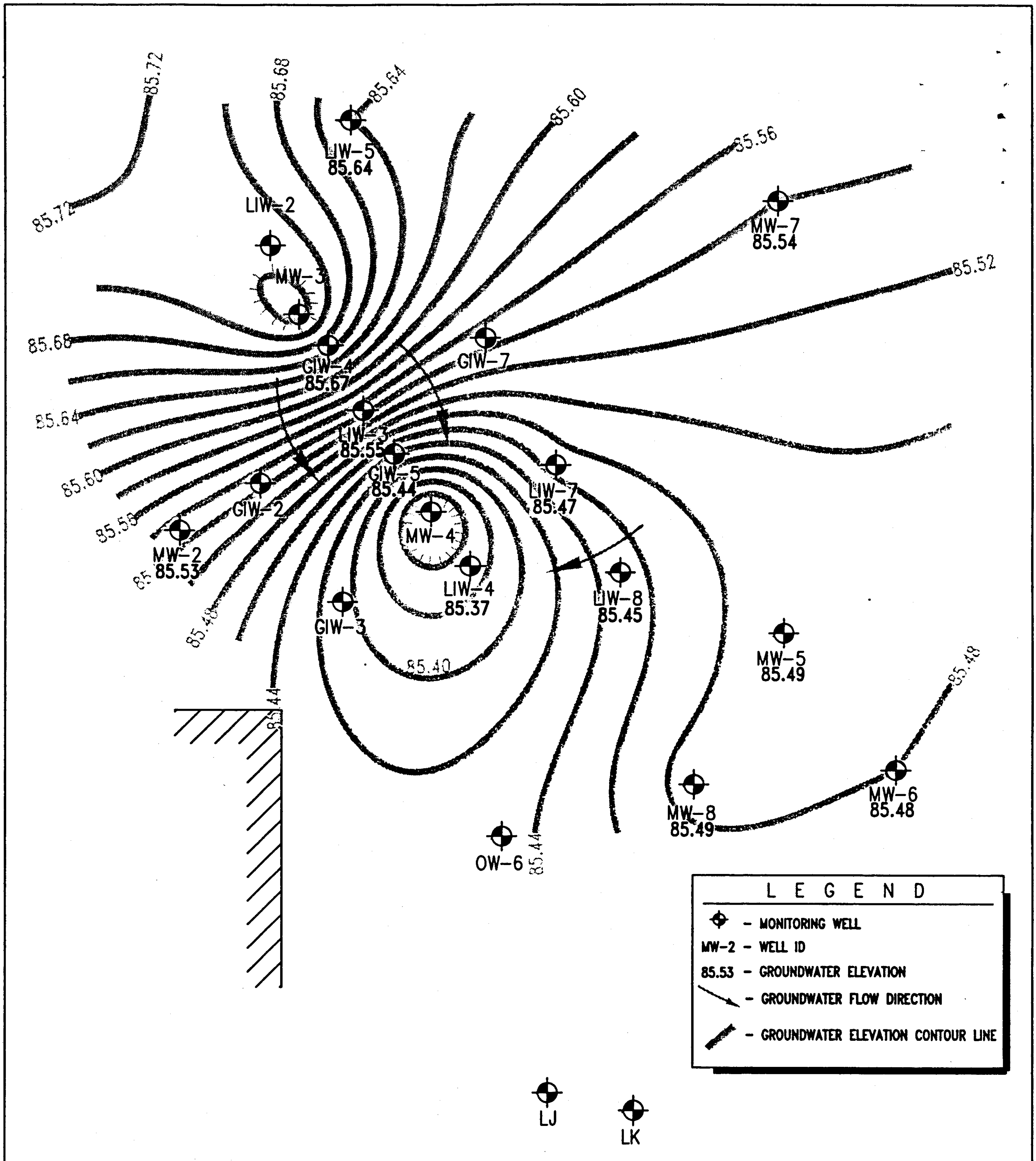


FIGURE 5
GROUNDWATER ELEVATION – 10/25/2001
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: 1" = 10'	JOB No.: 586-02
CK'D. BY: KL	DATE: 3/19/02	FILE NO.: 586-02
REV. NO.	REV. DATE: 6/13/02	FIGURE NO.:5



NOTES:

1. GROUNDWATER WAS EXTRACTED FROM MW-4 AND REINJECTED AT MW-3.

FIGURE 6
GROUNDWATER ELEVATION (DURING RECIRCULATION) - 2/5/2002
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: 1" = 10'	JOB No.: 586-02
CK'D. BY: KL	DATE: 3/19/02	FILE NO.: 586-02
REV. NO.	REV. DATE: 6/13/02	FIGURE NO.:6

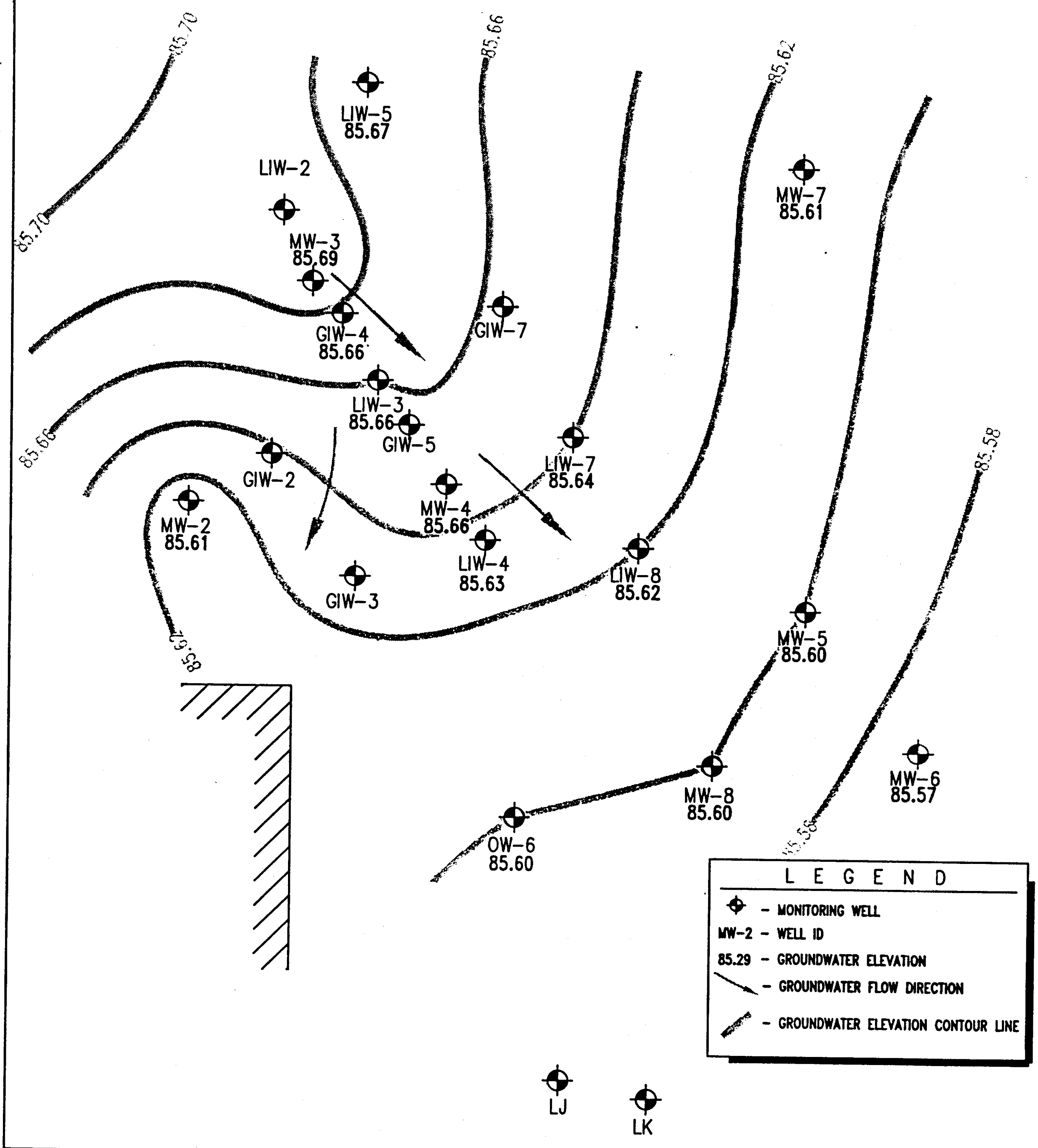


FIGURE 7
GROUNDWATER ELEVATION – 2/21/2002
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: 1" = 10'	JOB No.: 586-02
CK'D. BY: KL	DATE: 3/19/02	FILE NO.: 586-02
REV. NO.	REV. DATE: 6/13/02	FIGURE NO.: 7

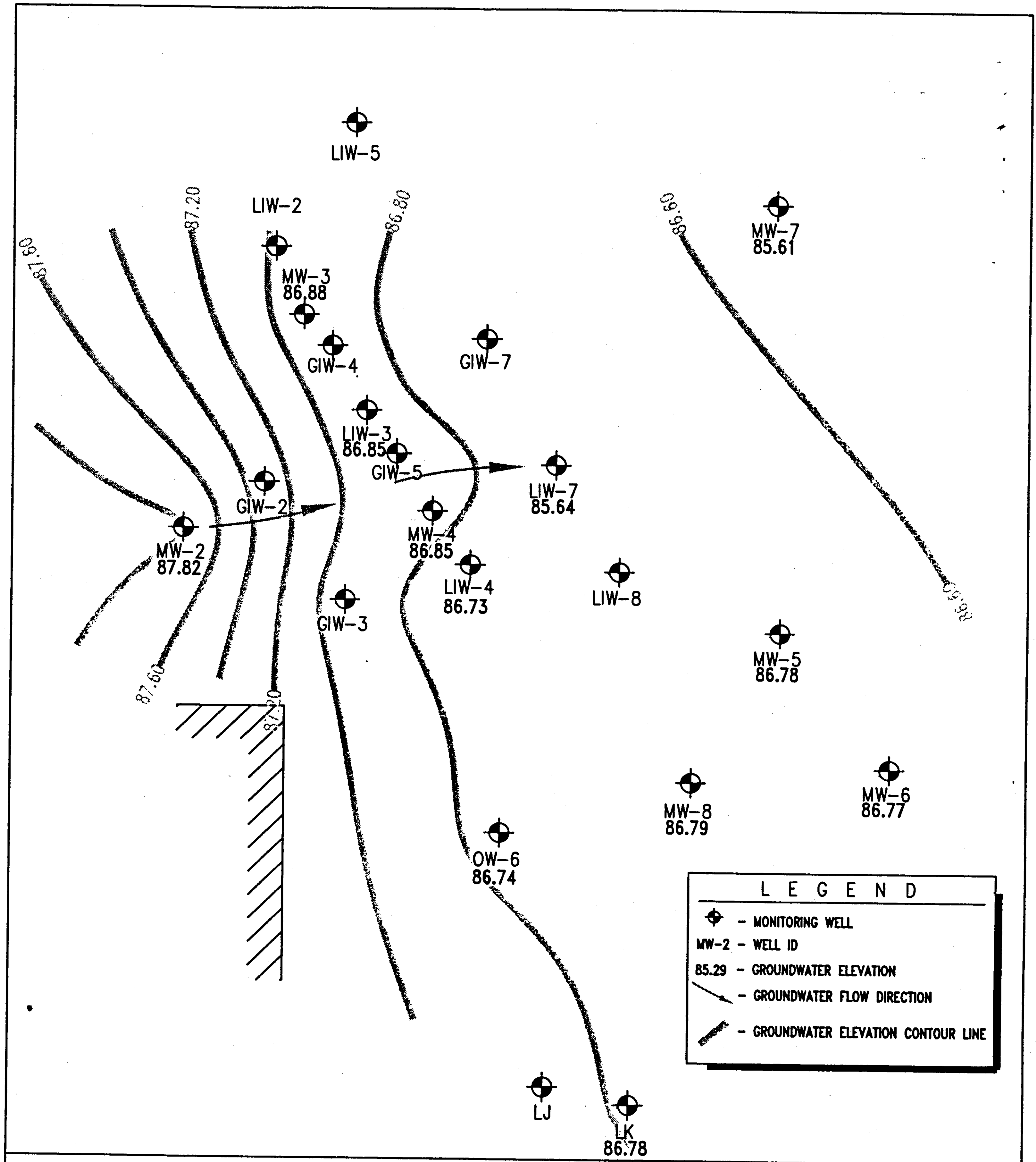


FIGURE 8
GROUNDWATER ELEVATION – 5/6/2002
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: 1" = 10'	JOB No.: 586-02
CK'D. BY: KL	DATE: 3/19/02	FILE NO.: 586-02
REV. NO.	REV. DATE: 6/13/02	FIGURE NO.:8

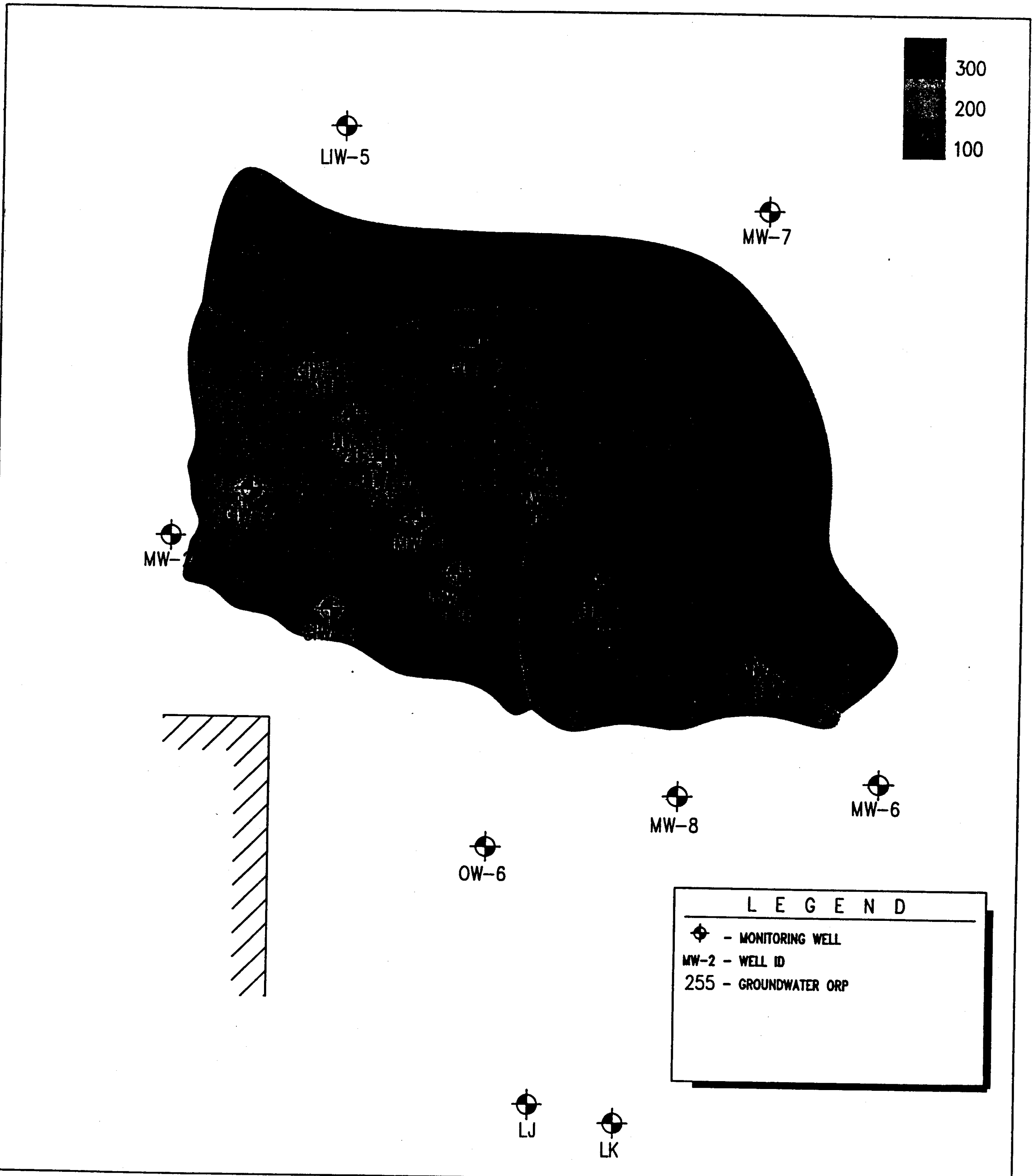


FIGURE 9
GROUNDWATER ORP – 2/4/2002 (BEFORE INJECTION)
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: NOT TO SCALE	JOB No.:	586-02
CK'D. BY: KL	DATE: 3/19/02	FILE NO.:	586-02
REV. NO.	REV. DATE: 6/13/02	FIGURE NO.:	9

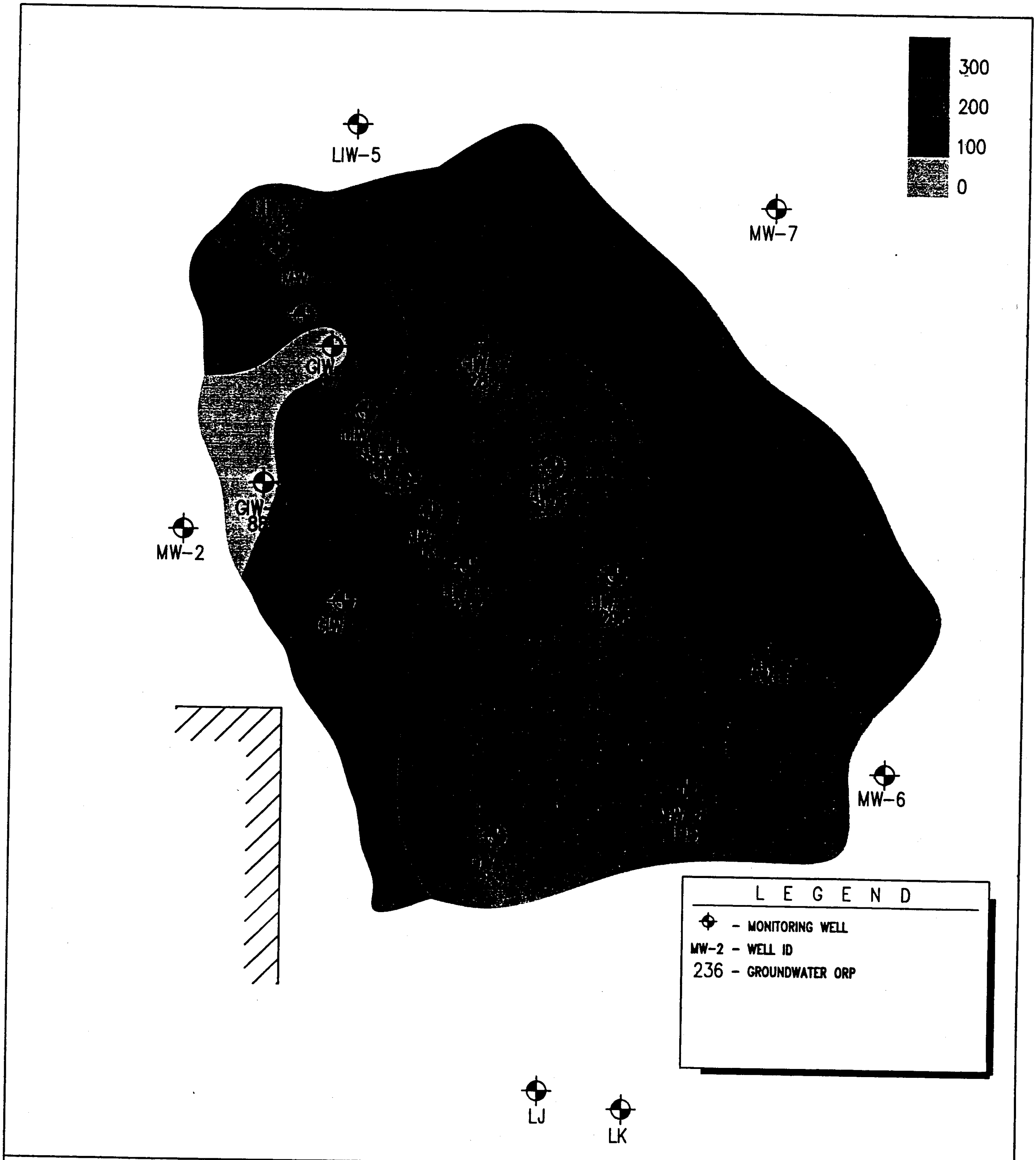


FIGURE 10
GROUNDWATER ORP – 2/11/2002 (AFTER INJECTION)
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: NOT TO SCALE	JOB No.: 586-02	
CK'D. BY: KL	DATE: 3/19/02	FILE NO.: 586-02	
REV. NO.	REV. DATE: 6/13/02	FIGURE NO.:10	

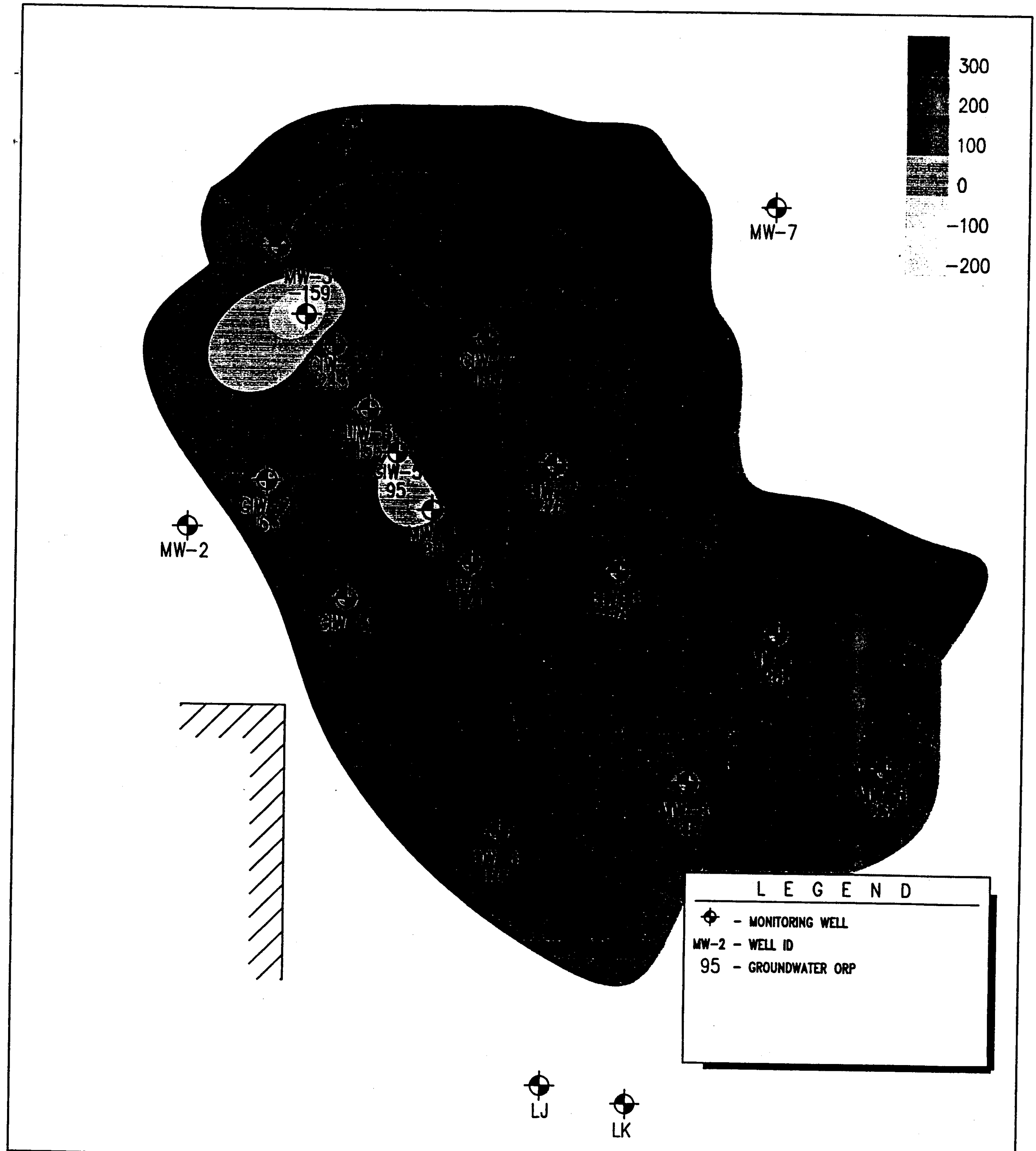


FIGURE 11
GROUNDWATER ORP – 2/19/2002
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: NOT TO SCALE	JOB No.: 586-02
CK'D. BY: KL	DATE: 3/19/02	FILE NO.: 586-02
REV. NO.	REV. DATE: 6/13/02	FIGURE NO.: 11

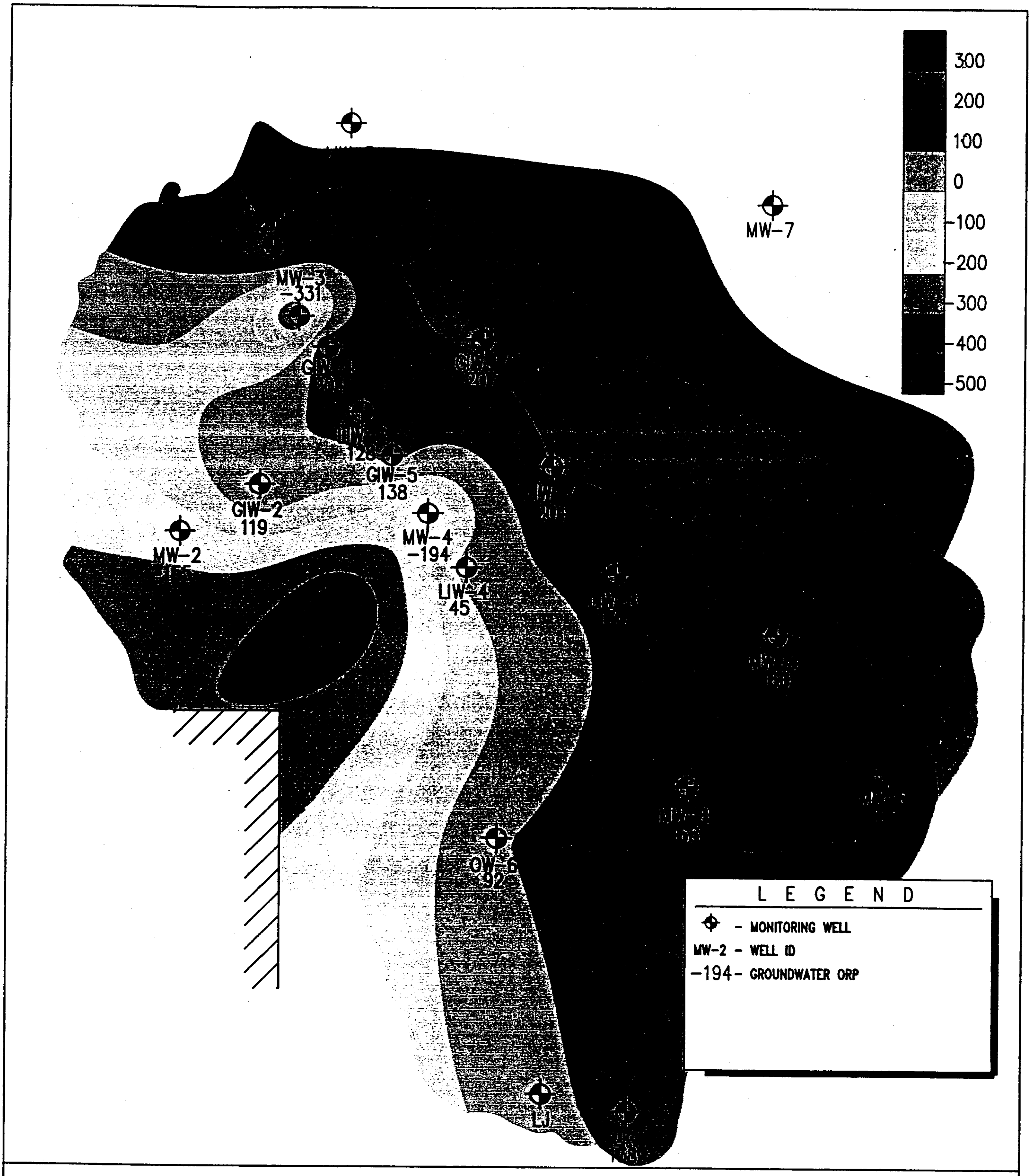


FIGURE 12
GROUNDWATER ORP – 3/4/2002
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: NOT TO SCALE	JOB No.: 586-02	
CK'D. BY: KL	DATE: 3/19/02	FILE NO.: 586-02	
REV. NO.	REV. DATE: 6/13/02	FIGURE NO.: 12	

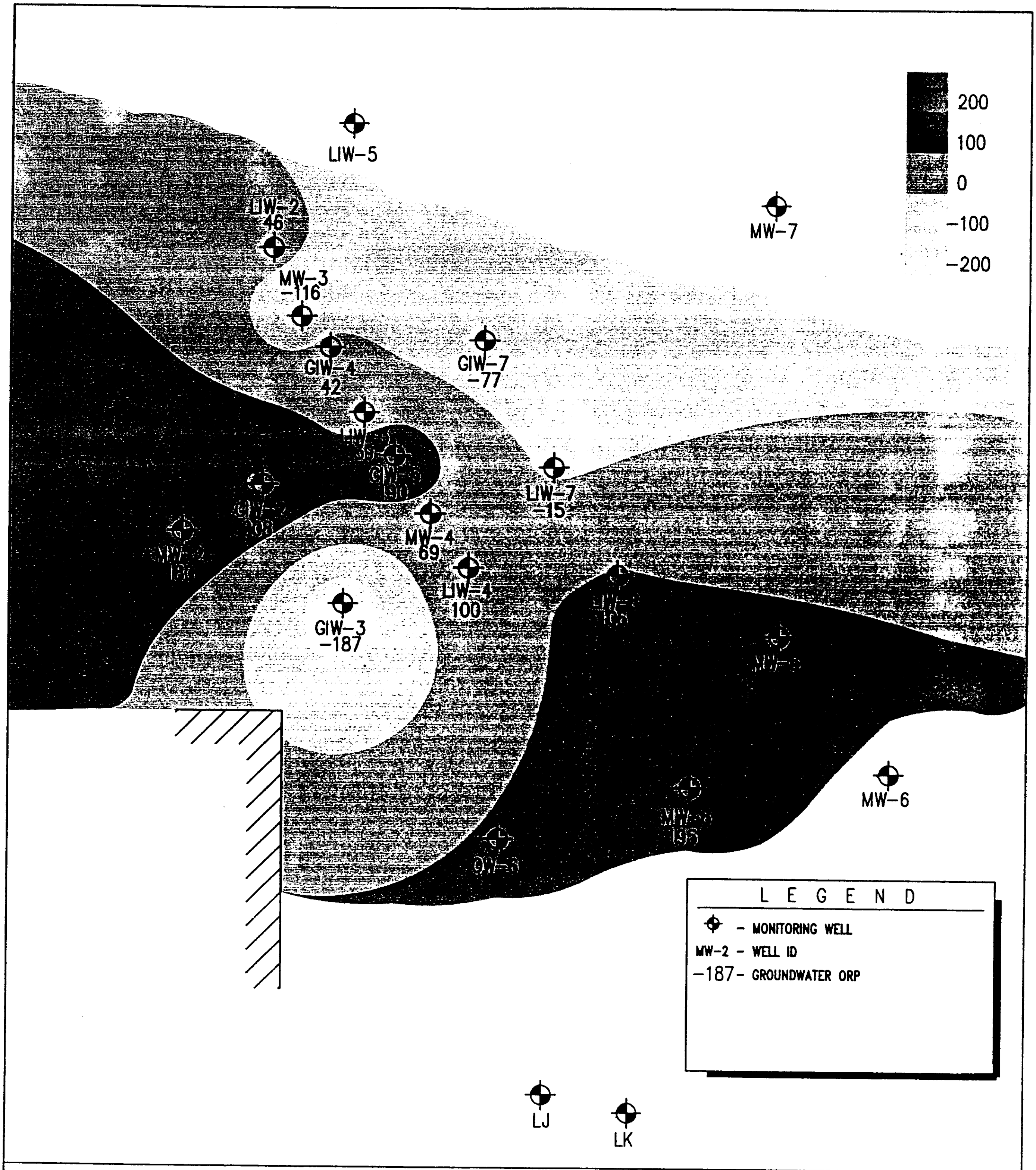


FIGURE 13
GROUNDWATER ORP – 5/15/2002
LAKEHURST, NEW JERSEY

PARS ENVIRONMENTAL, INC.
ROBBINSVILLE, NEW JERSEY

DR. BY: PM	SCALE: NOT TO SCALE	JOB No.: 586-02
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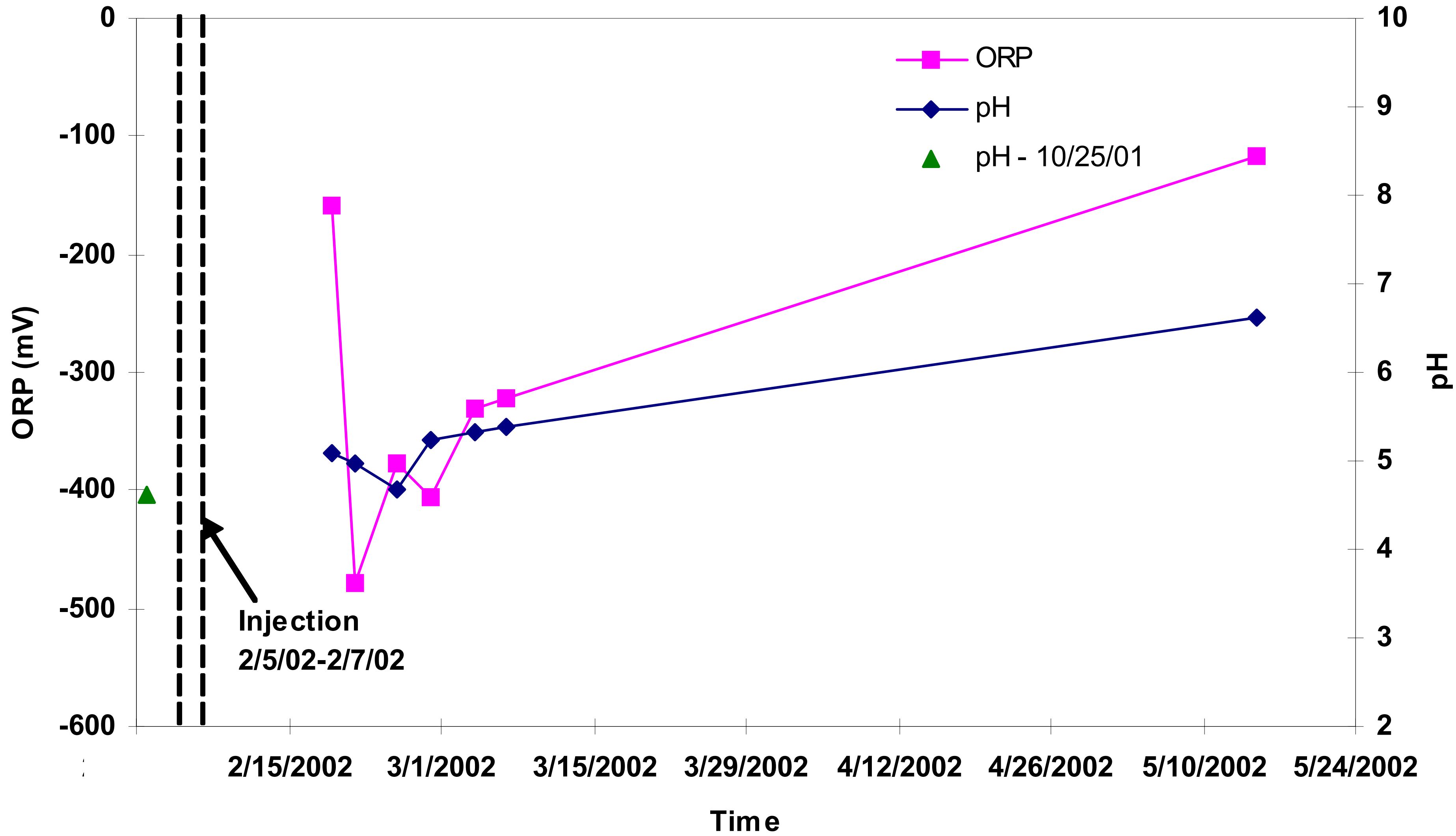

Figure 14-1 MW-3 ORP and pH Trends

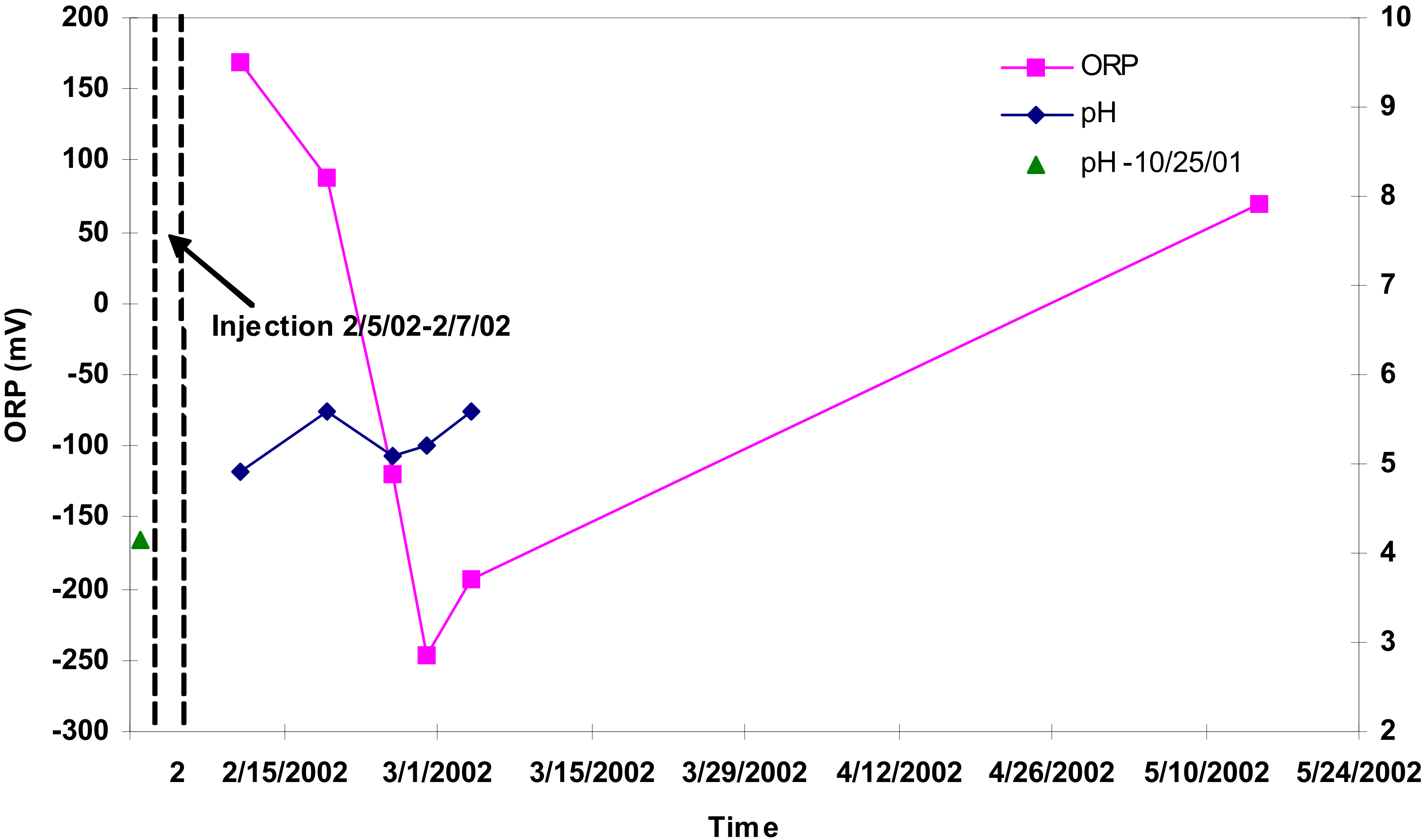

Figure 14-2 MW-4 ORP and pH Trends

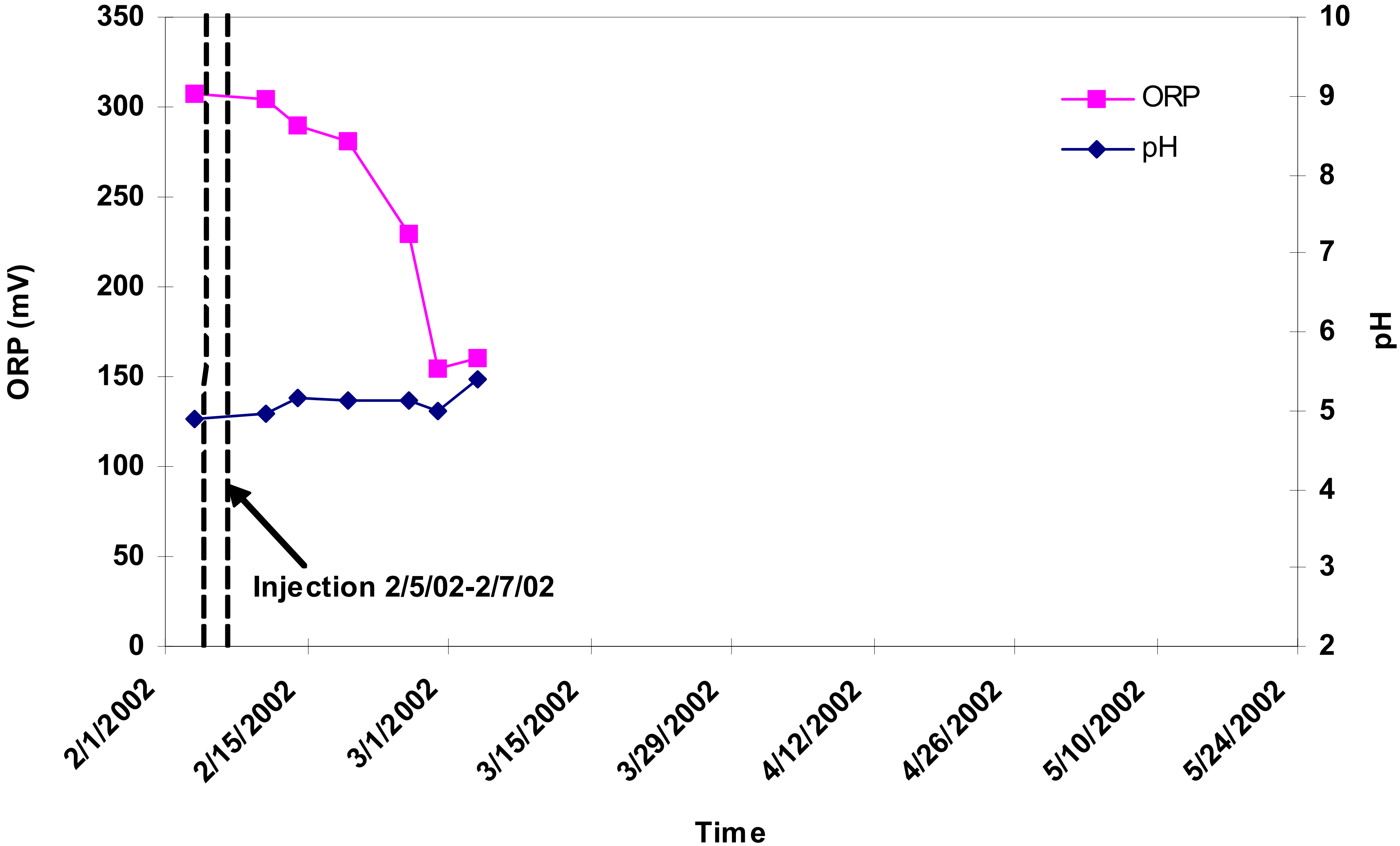

Figure 14-3 MW-5 ORP and pH Trends

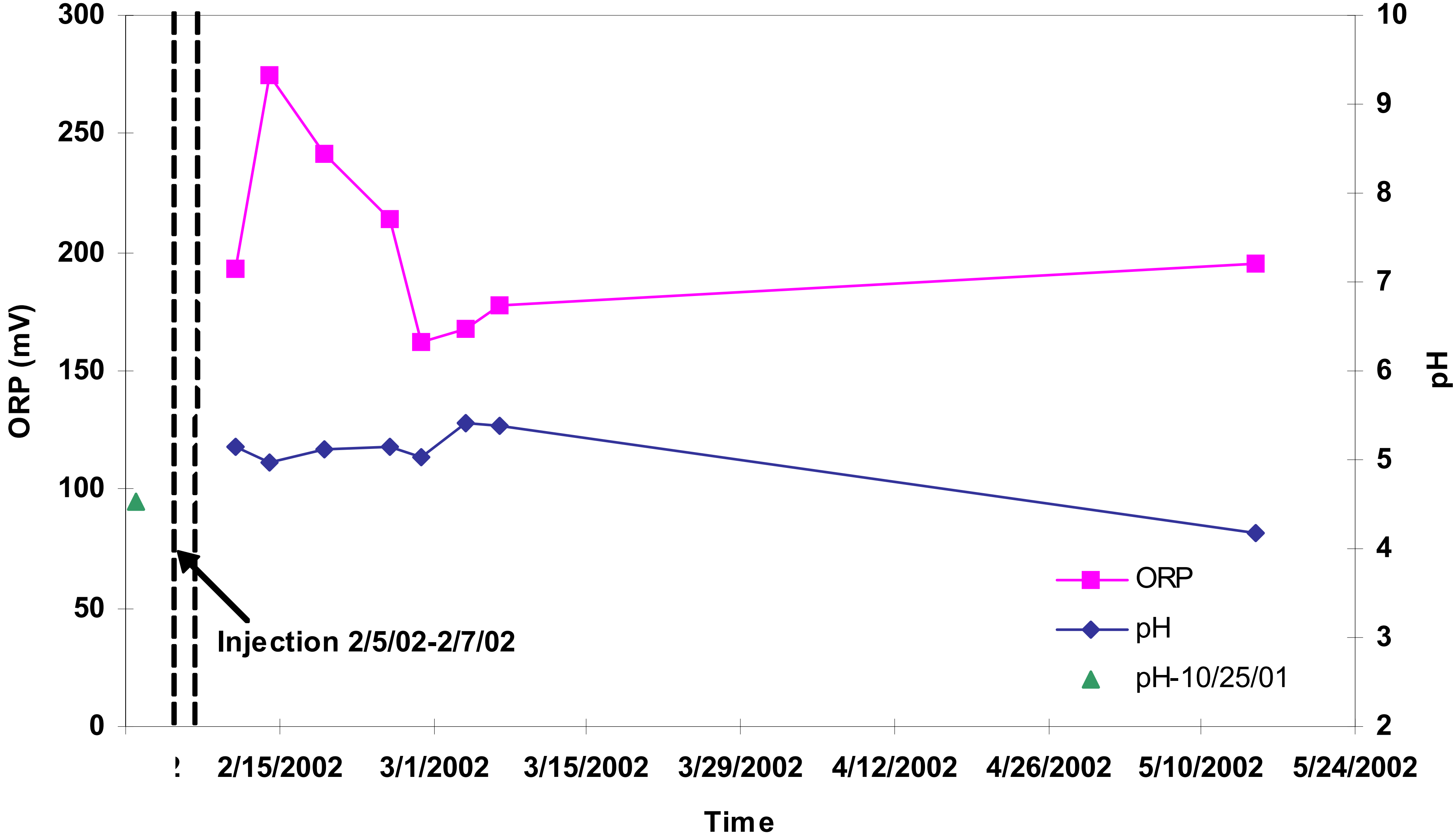

Figure 14-4 MW-8 ORP and pH Trends

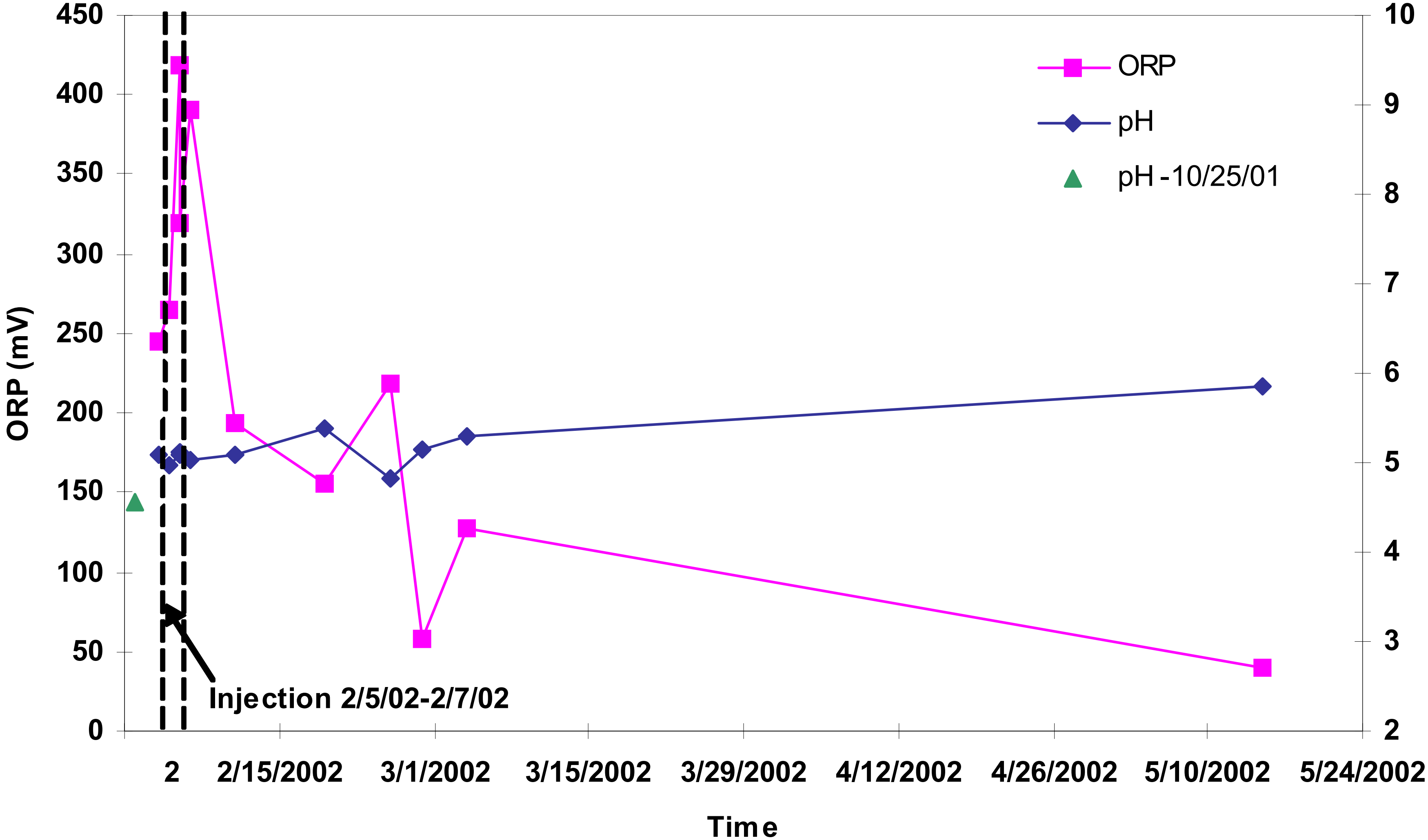

Figure 14-5 LIW-3 ORP and pH Trends

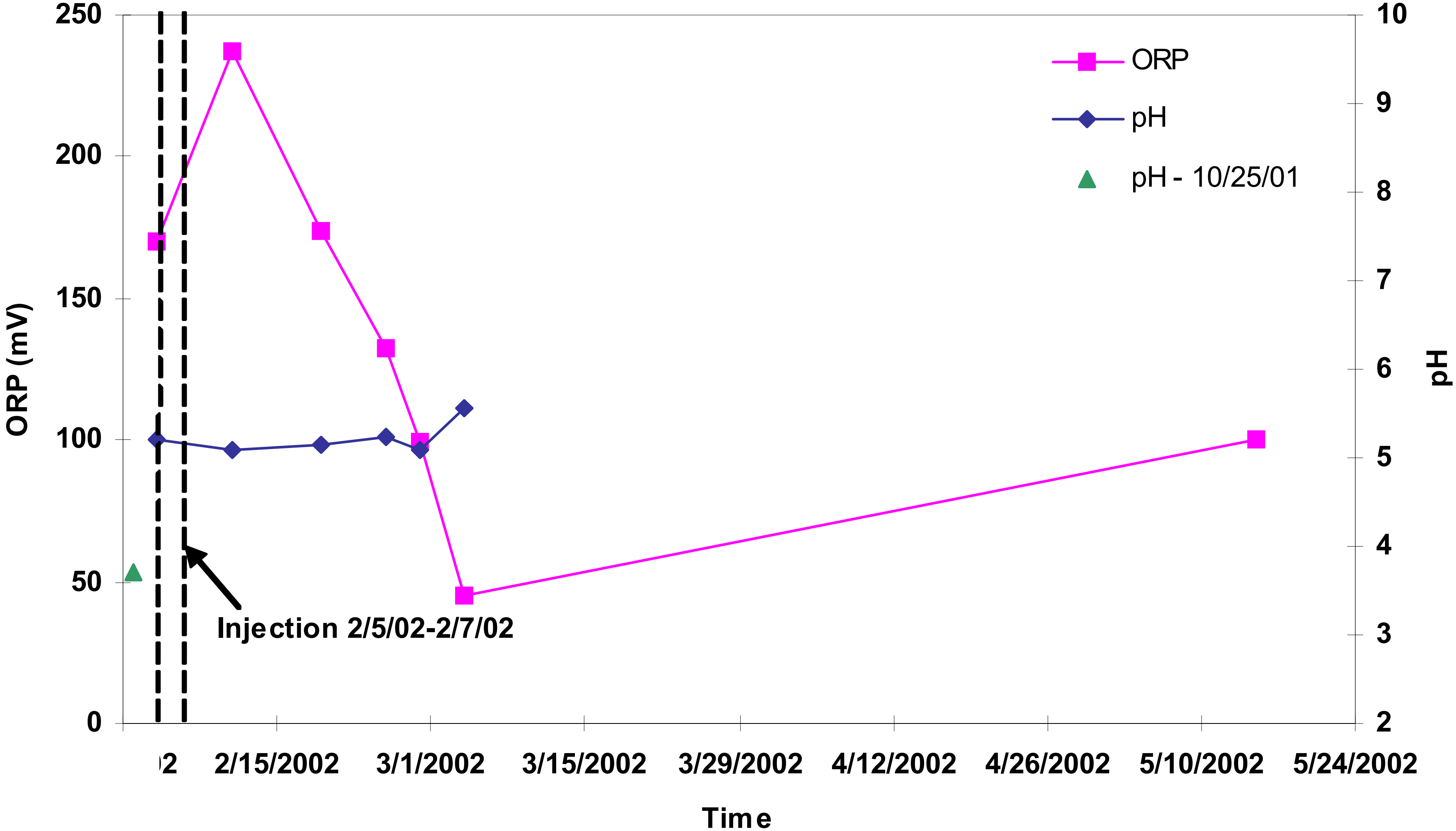

Figure 14-6 LIW-4 ORP and pH Trends

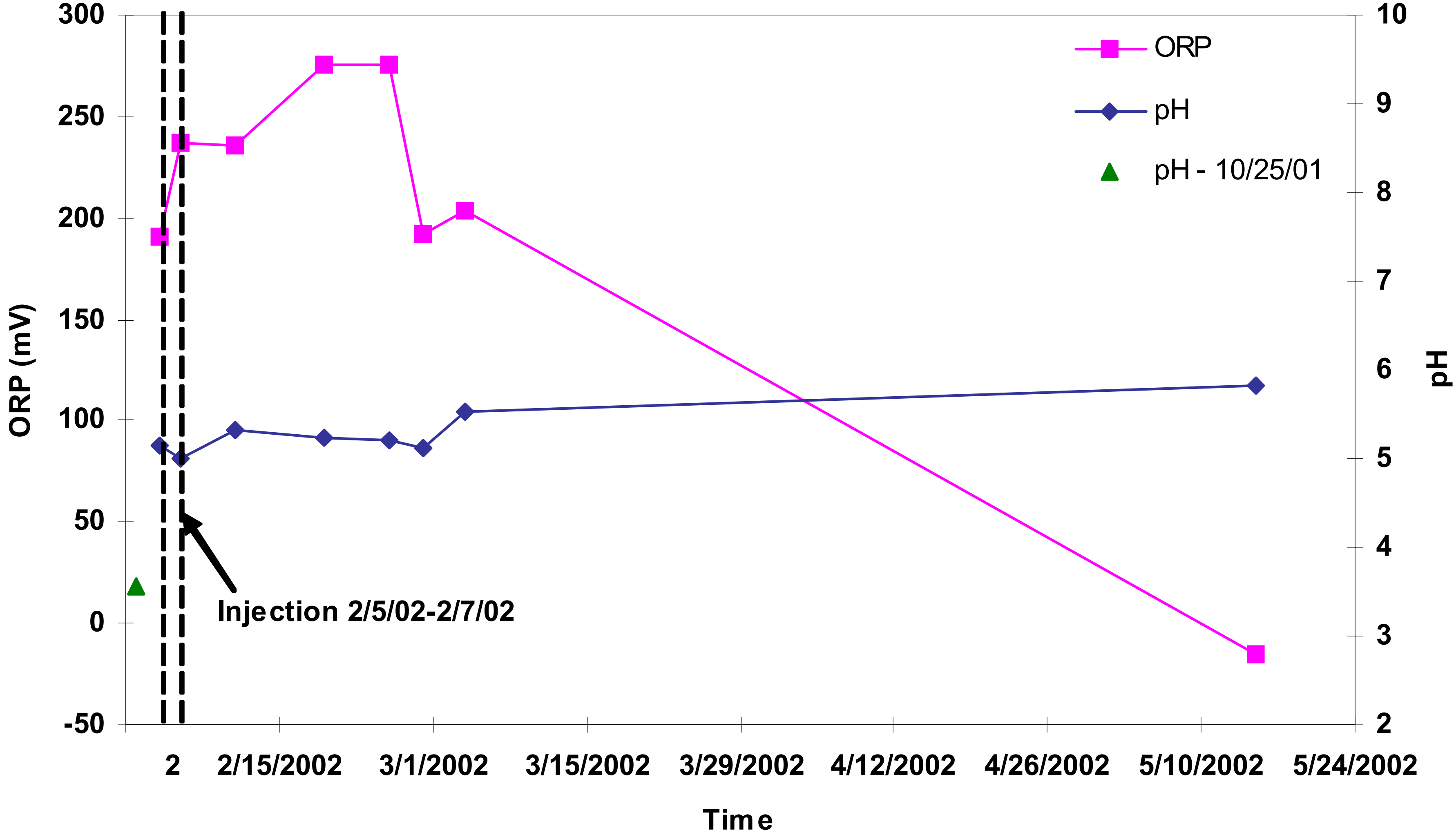

Figure 14-7 LIW-7 ORP and pH Trends

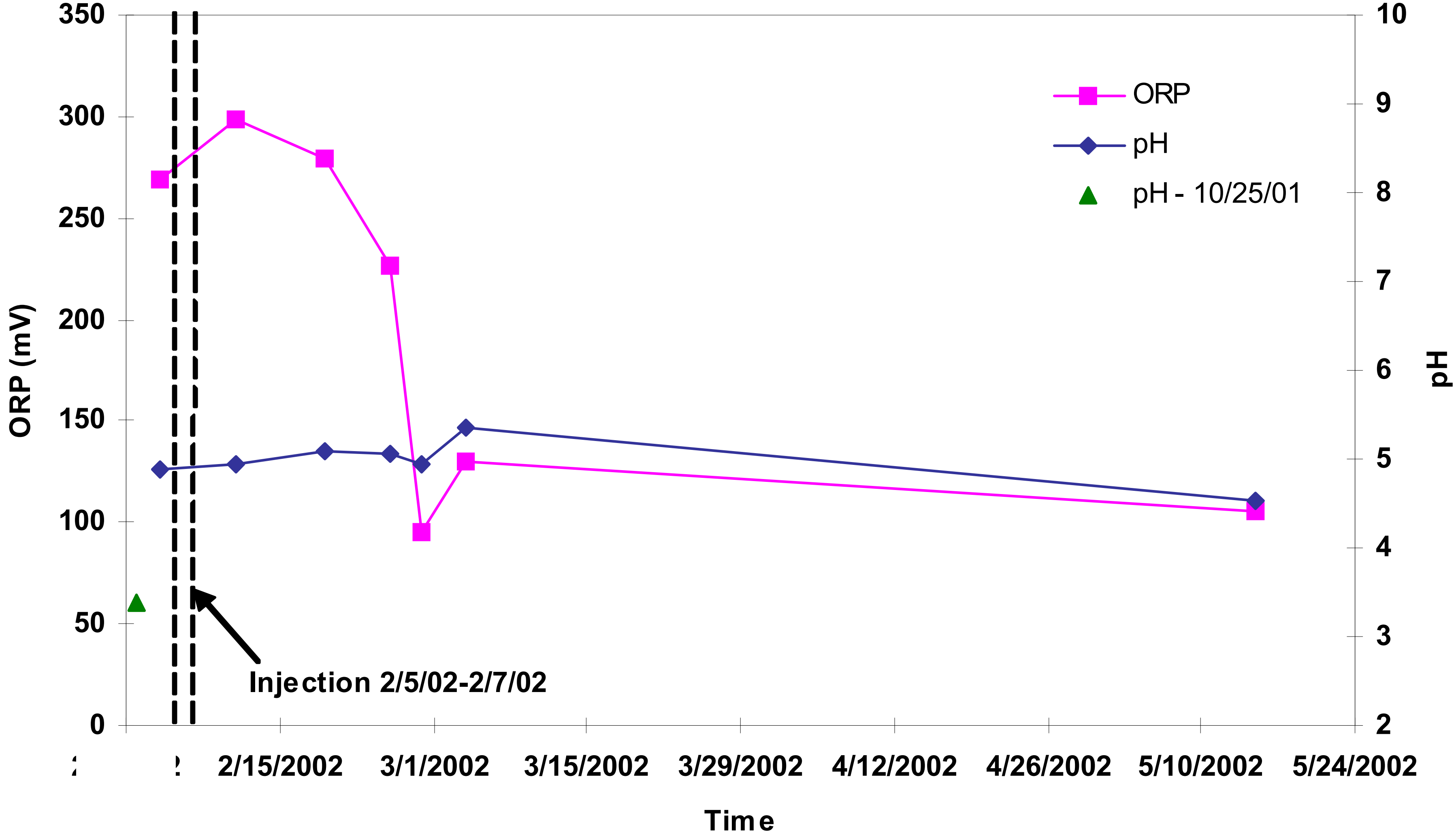

Figure 14-8 LIW-8 ORP and pH Trends

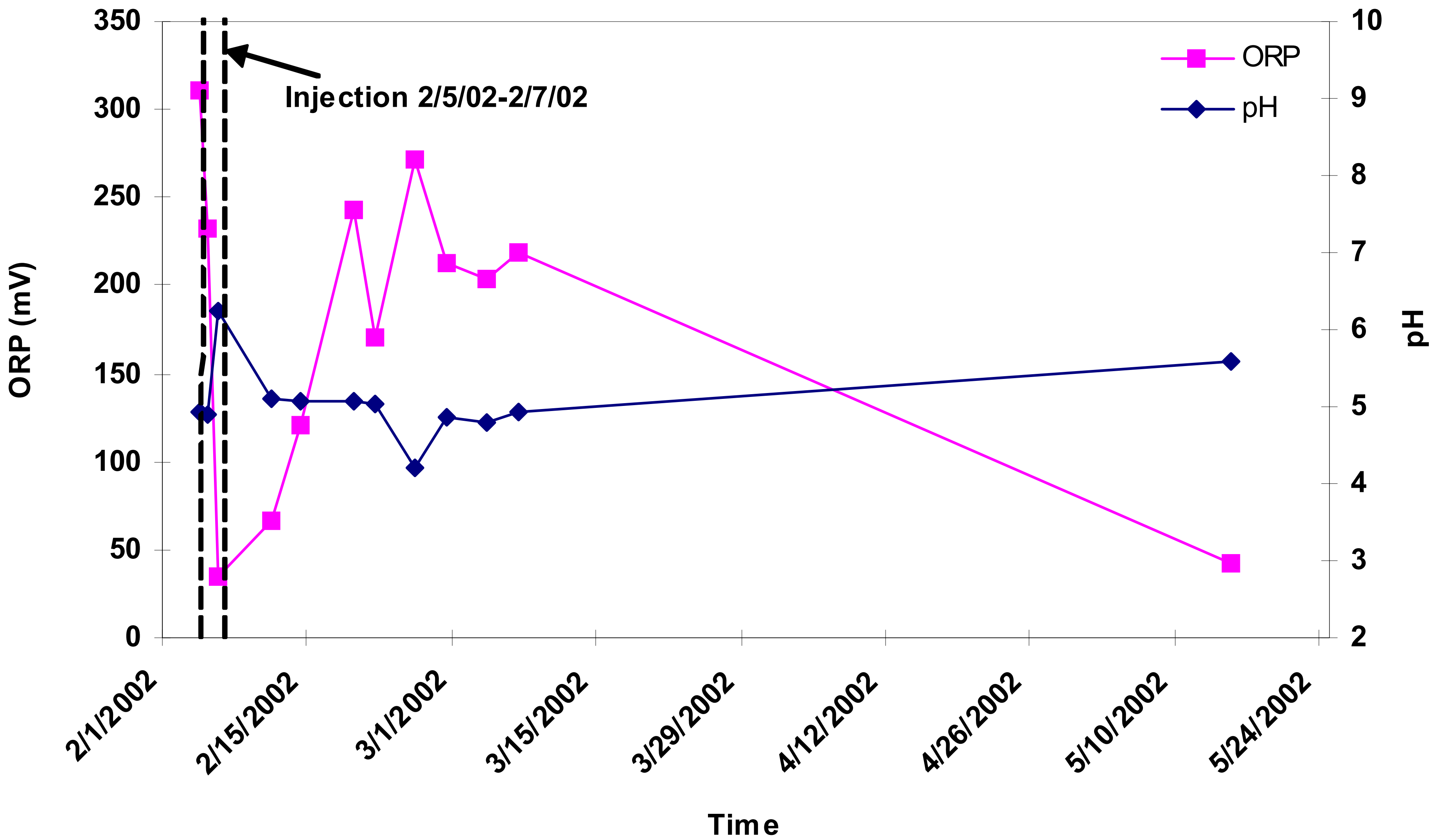

Figure 14-9 GIW-4 ORP and pH Trends

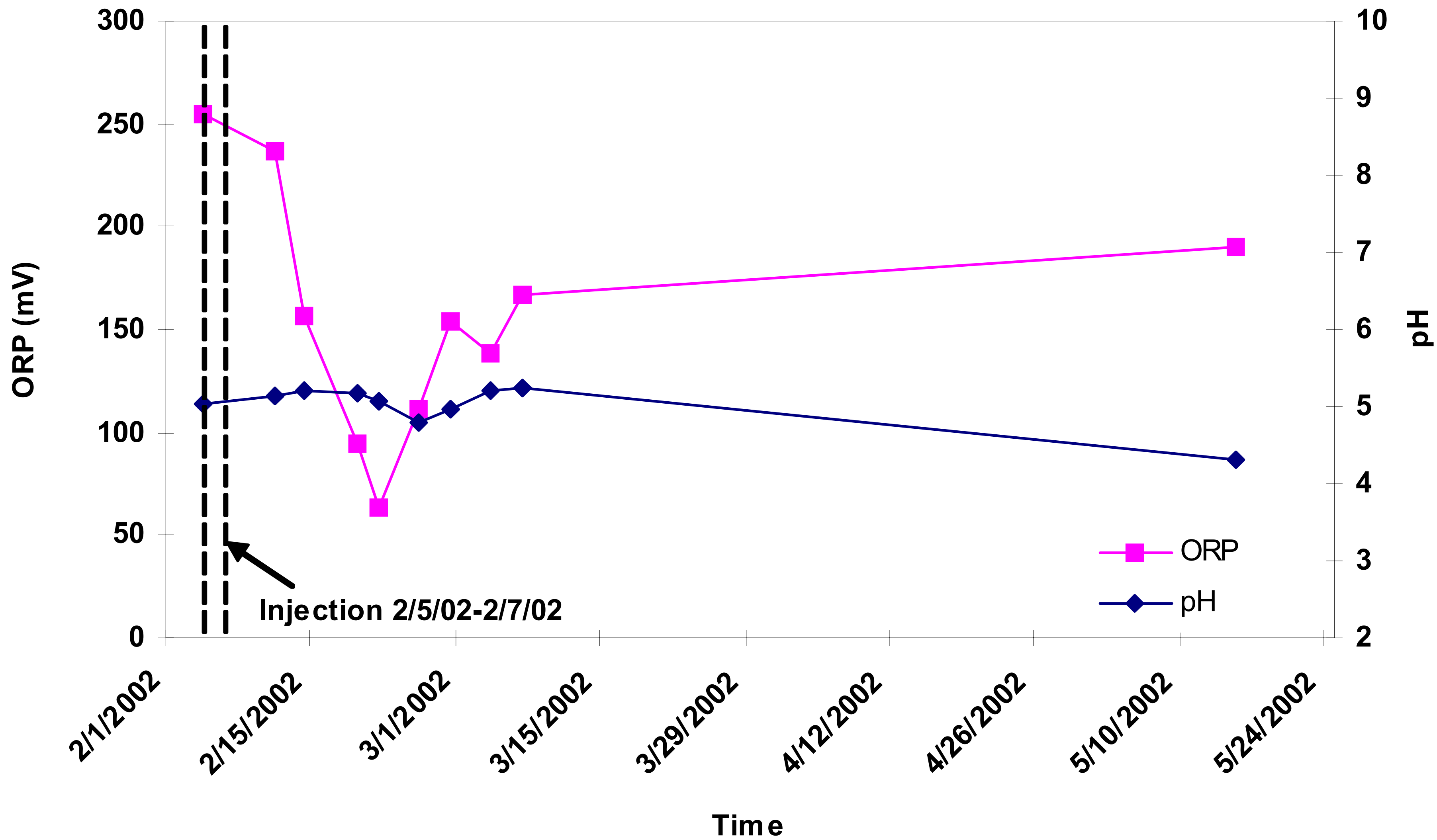

Figure 14-10 GIW-5 ORP and pH Trends

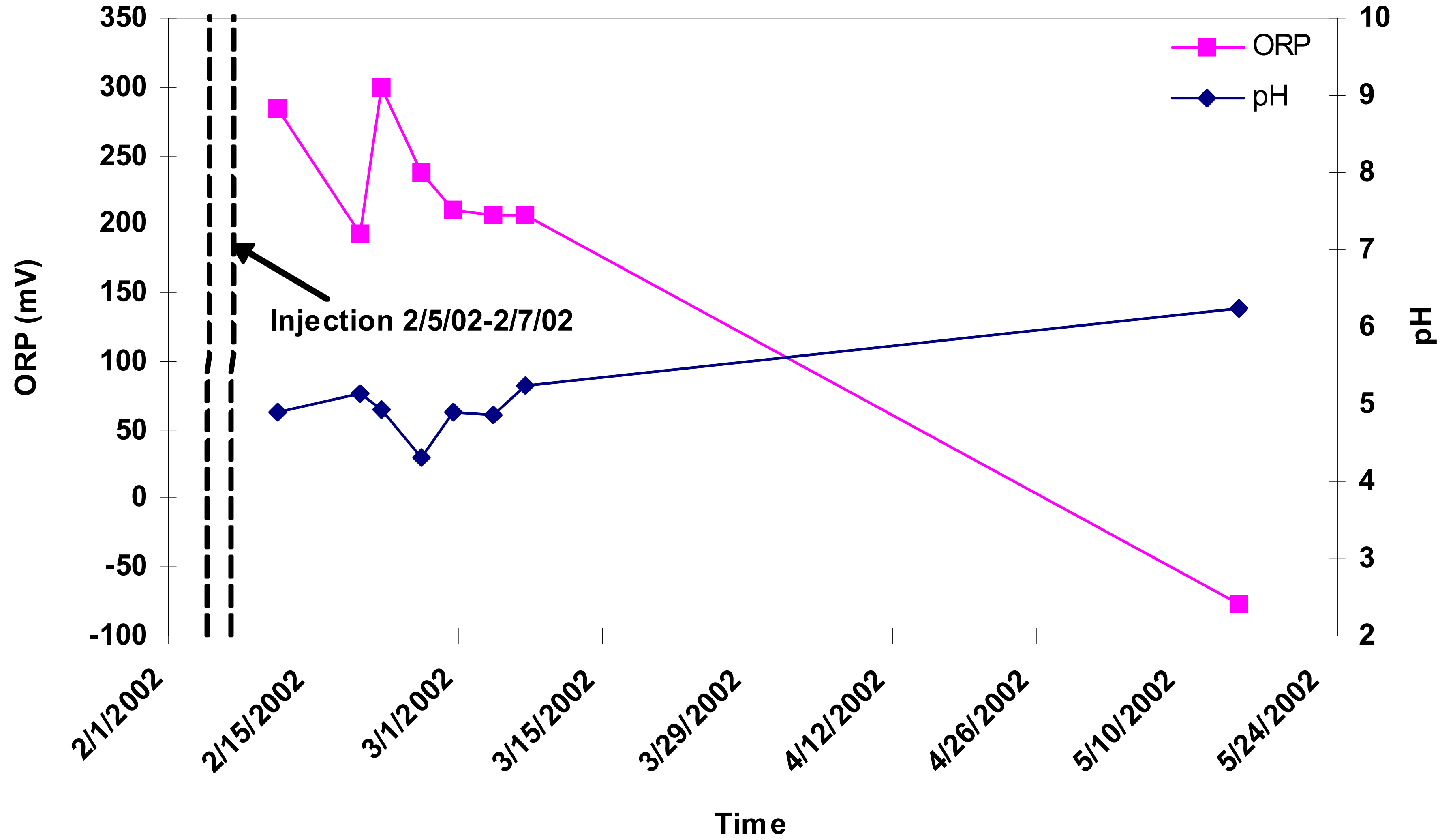

Figure 14-11 GIW-7 ORP and pH Trends

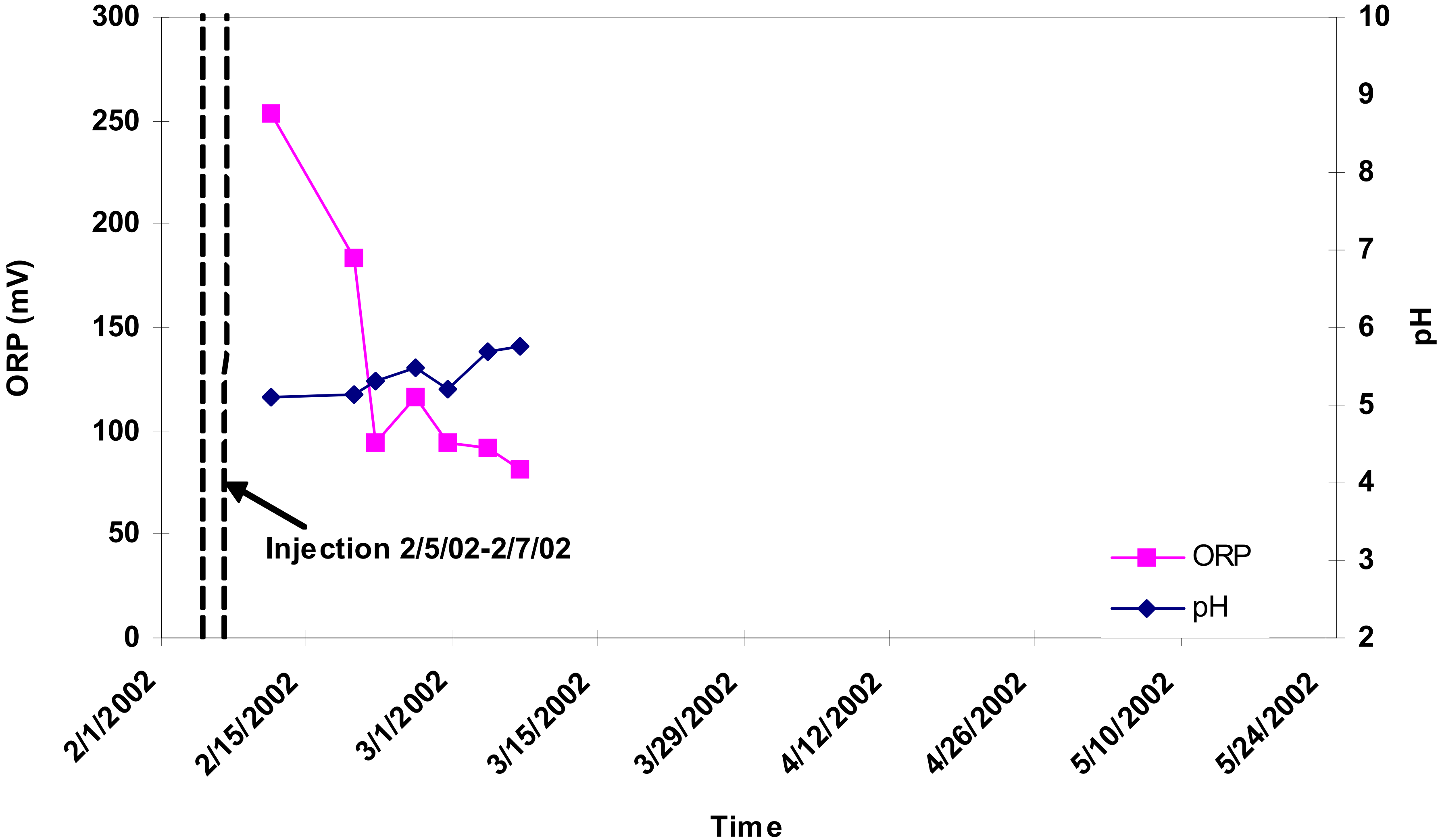

Figure 14-12 OW-6 ORP and pH Trends

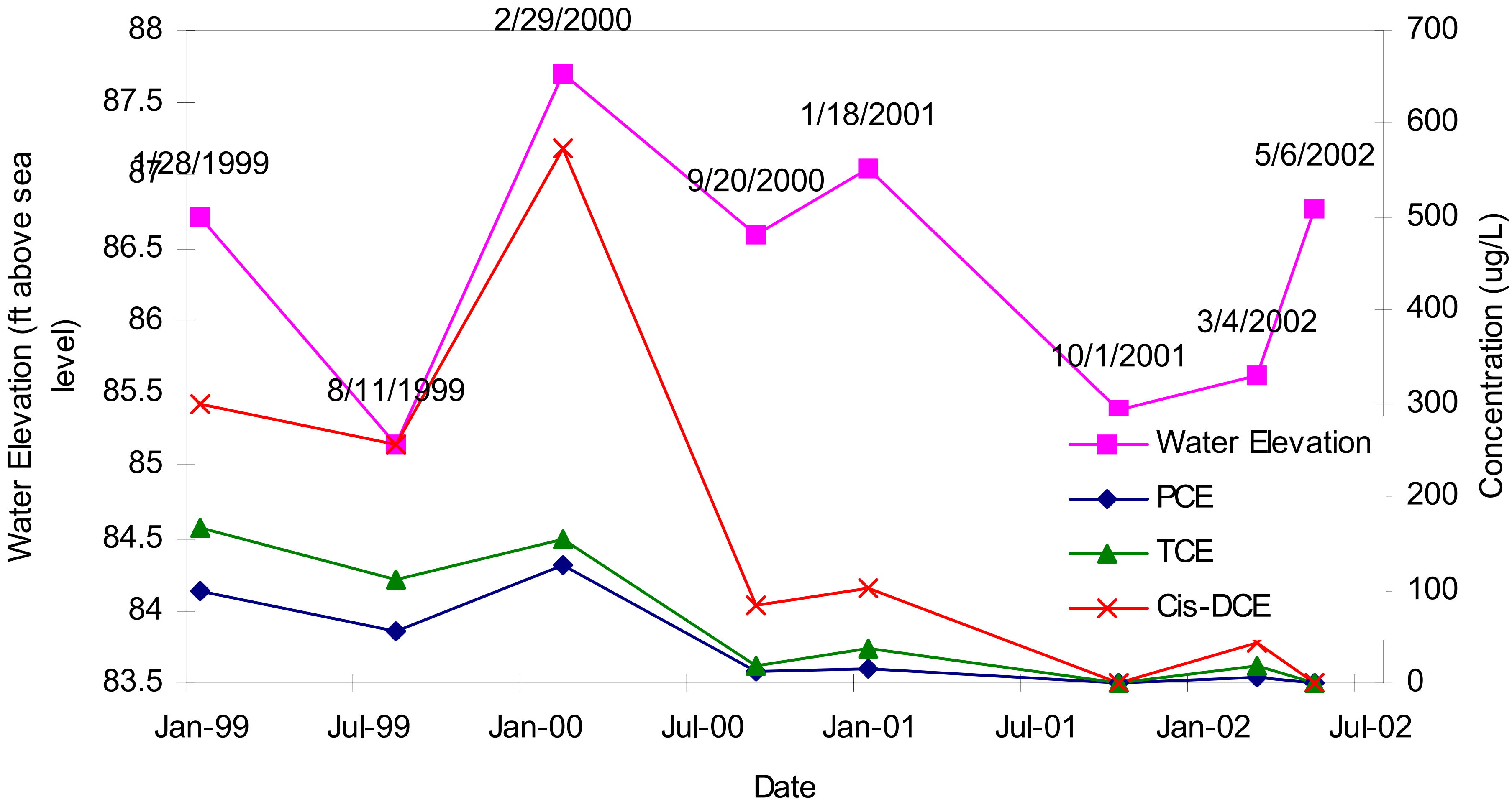

Figure 15 Historical VOC Concentration and Groundwater Elevation Trends at LK

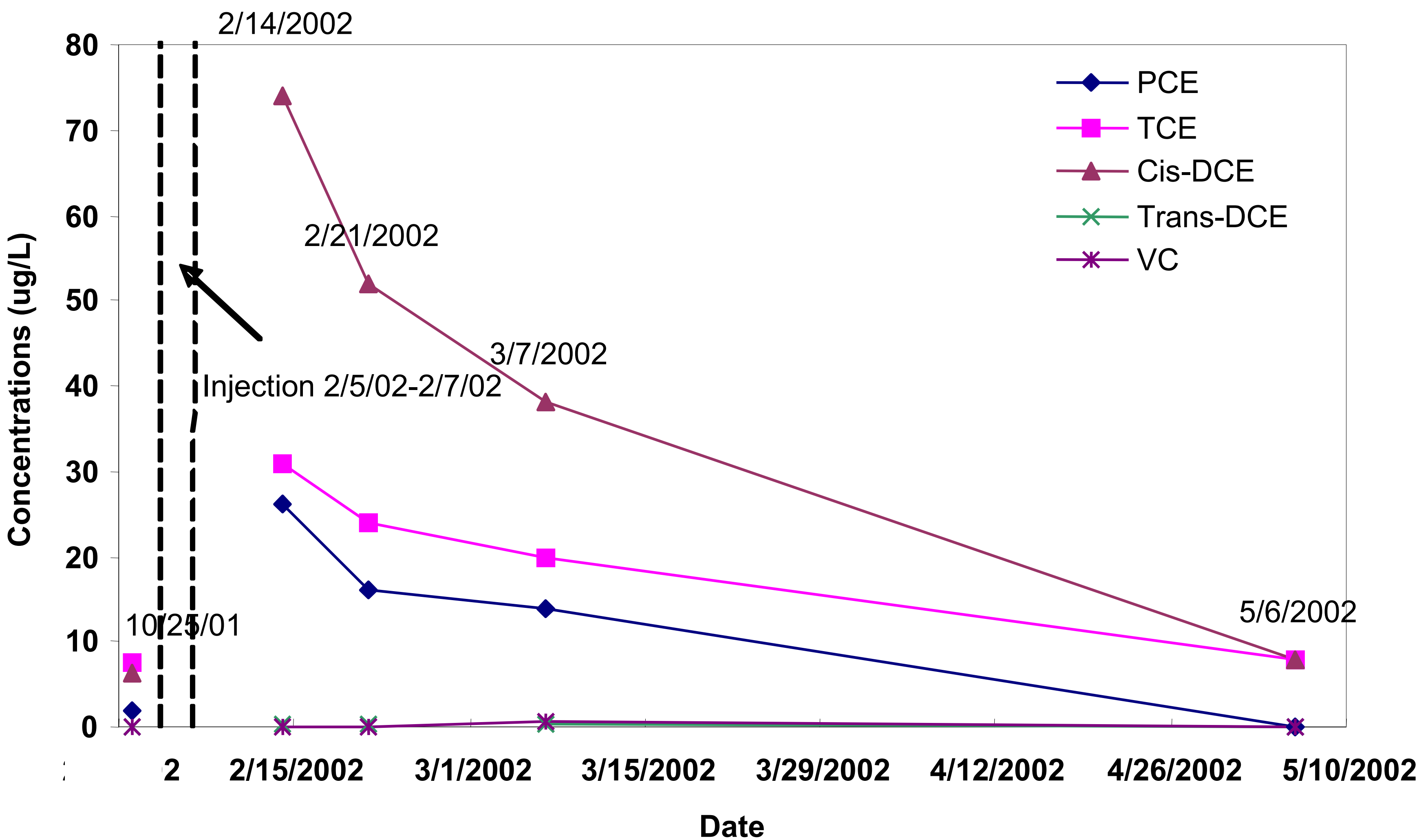

Figure 16-1 MW-4 VOC Concentration Trends

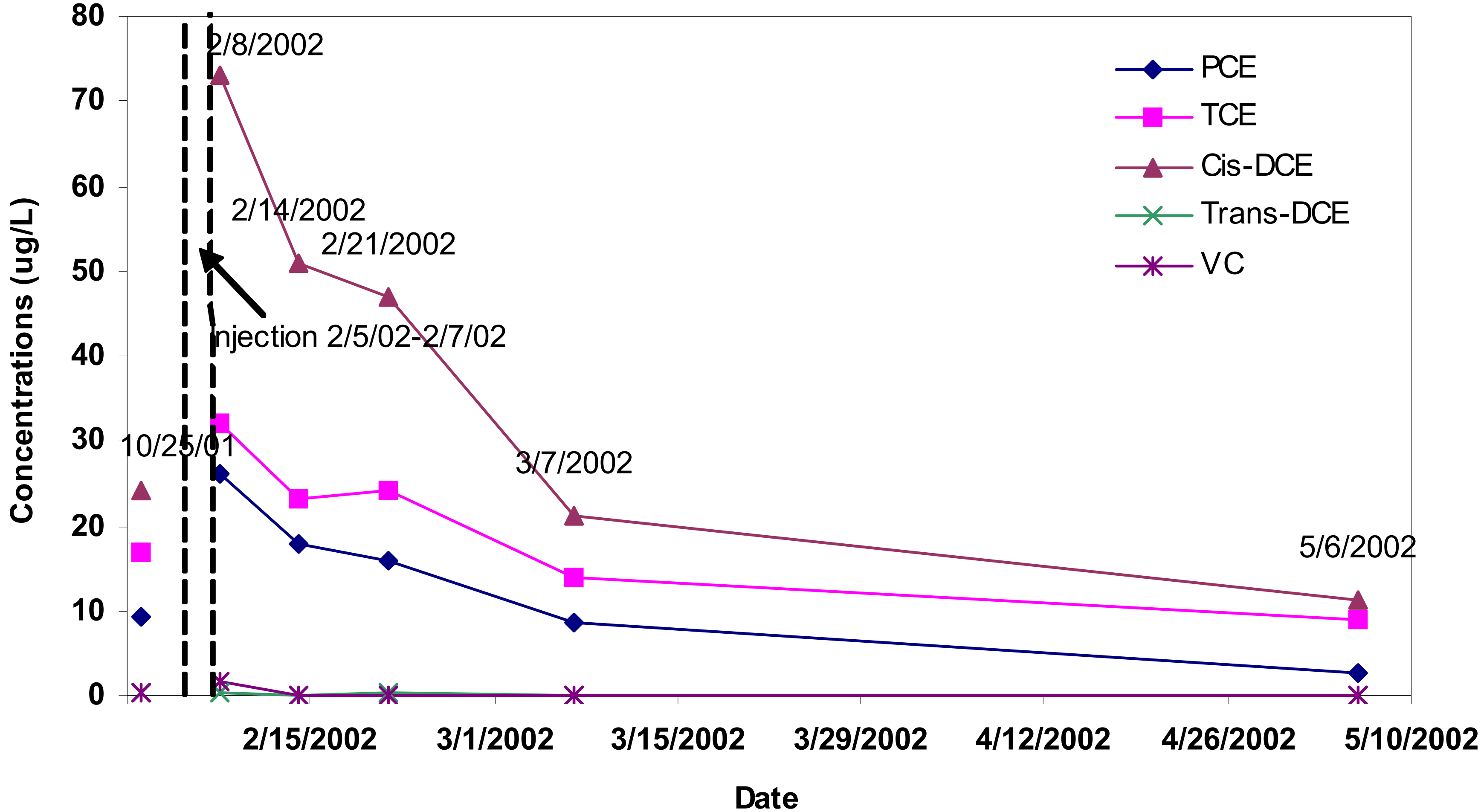

Figure 16-2 LIW-3 VOC Concentration Trends

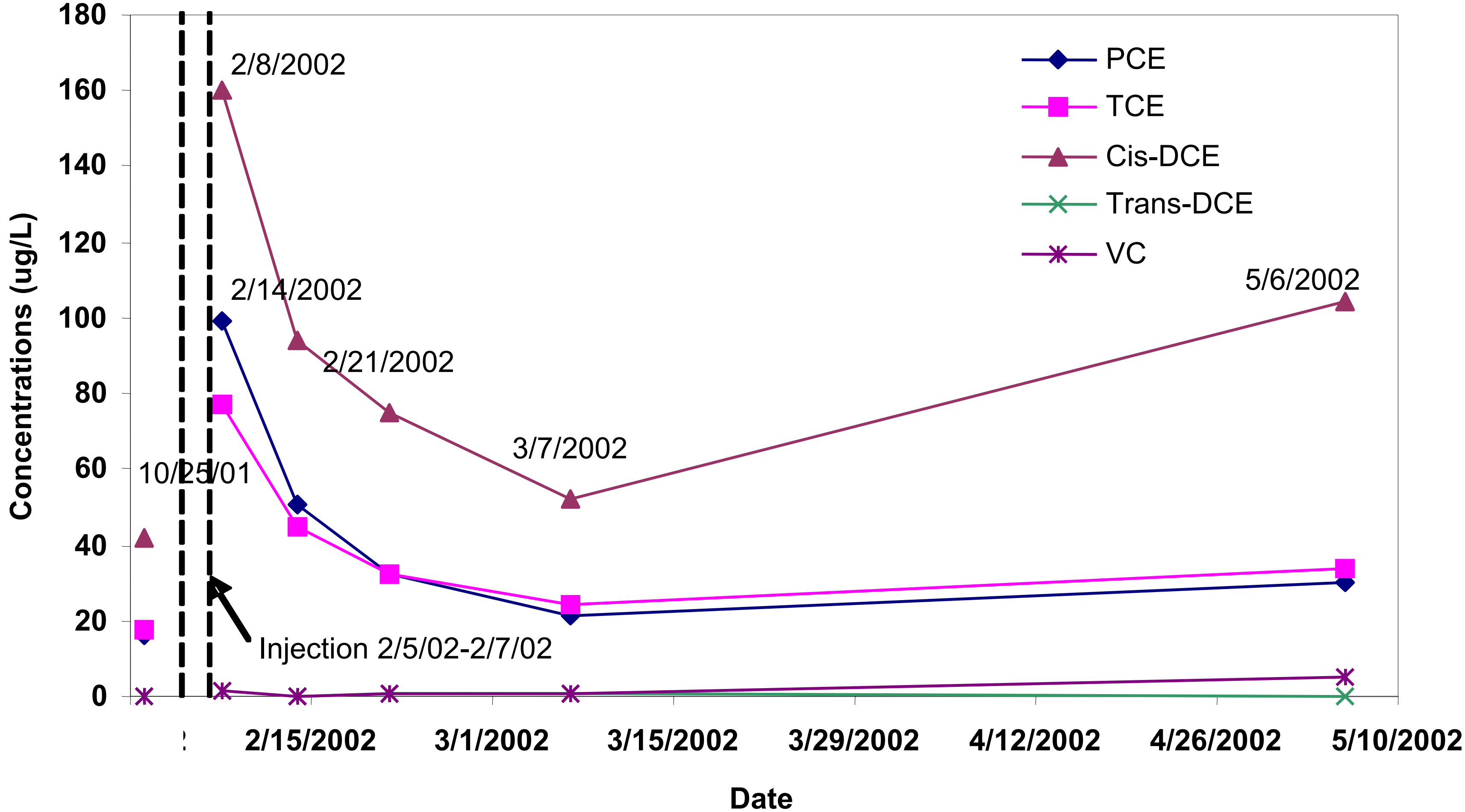

Figure 16-3 LIW-4 VOC Concentration Trends

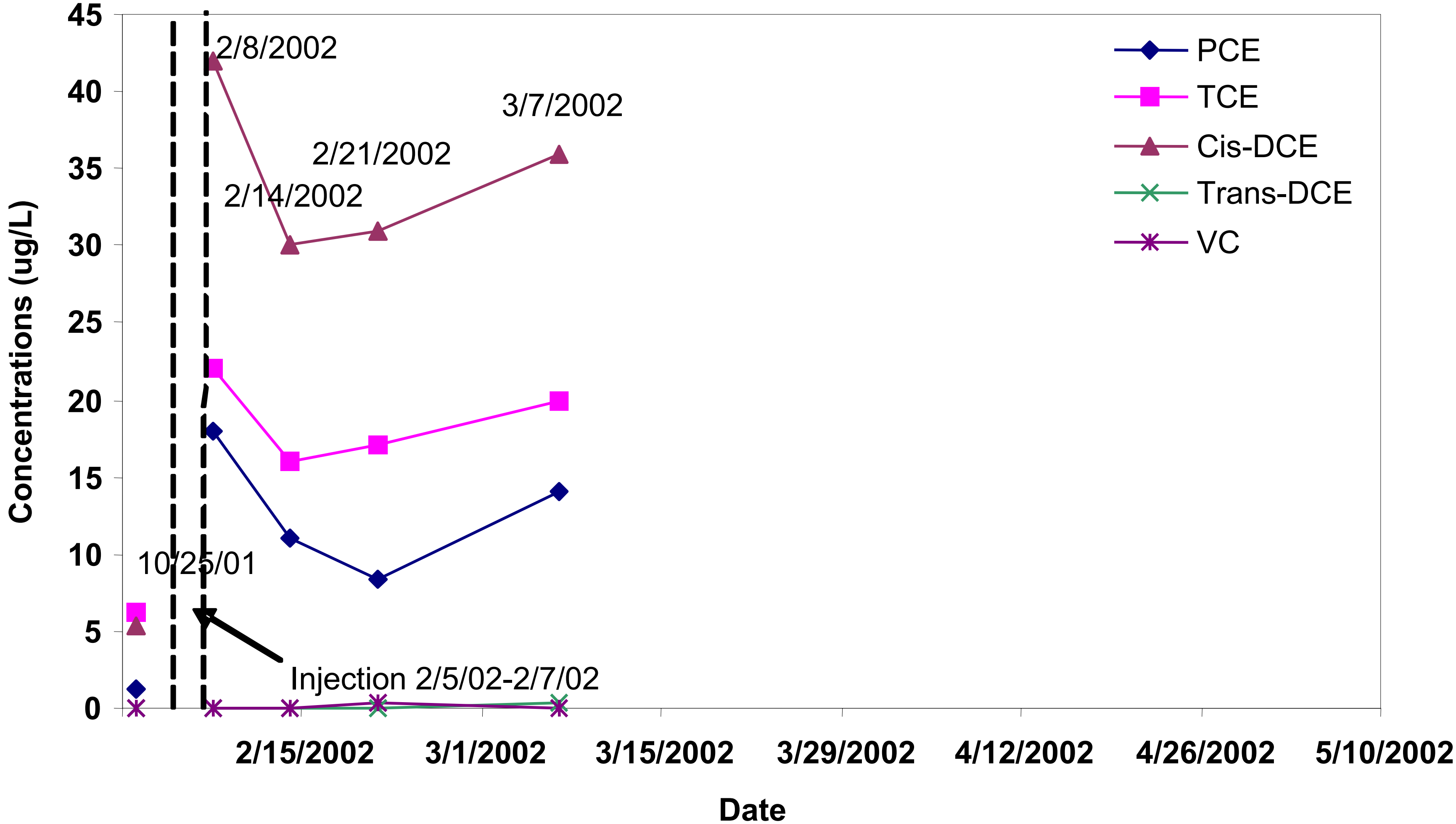

Figure 16-4 LIW-8 VOC Concentration Trends

TABLES

Table 1
Groundwater Elevation Summary
Naval Air Engineering Station, Lakehurst, New Jersey

WELL ID:	MW-1		MW-2		MW-3		MW-4		MW-5		MW-6	
CASING ELEV.:	96.85		96.40		95.65		96.24		98.72		100.17	
DATE	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level
10/25/2001	11.43	85.42	11.11	85.29	10.30	85.35	10.92	85.32	13.46	85.26	14.92	85.25
1/24/2002	11.29	85.56	10.95	85.45	10.15	85.50	10.81	85.43	13.33	85.39	14.76	85.41
2/5/2002	NA	NA	NA	NA	NA	NA	NA	NA	13.26	85.46	14.74	85.43
2/7/2002	11.16	85.69	10.87	85.53	NA	NA	NA	NA	13.23	85.49	14.69	85.48
2/14/2002	11.09	85.76	10.75	85.65	NA	NA	NA	NA	13.10	85.62	14.57	85.60
2/21/2002	11.11	85.74	10.79	85.61	9.96	85.69	10.58	85.66	13.12	85.60	14.60	85.57
3/7/2002	11.04	85.81	10.69	85.71	9.90	85.75	10.53	85.71	13.05	85.67	14.53	85.64
5/6/2002	NA	NA	8.58	87.82	8.77	86.88	9.39	86.85	11.94	86.78	13.40	86.77

Table 1
Groundwater Elevation Summary
Naval Air Engineering Station, Lakehurst, New Jersey

WELL ID:	MW-7		MW-8		LIW-3		LIW-4		LIW-5		LIW-7	
CASING ELEV.:	97.98		100.01		96.55		96.93		95.17		96.64	
DATE	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level
10/25/2001	12.71	85.27	14.75	85.26	NA	NA	NA	NA	NA	NA	NA	NA
1/24/2002	12.54	85.44	14.62	85.39	11.06	85.49	11.45	85.48	9.67	85.50	11.18	85.46
2/5/2002	NA	NA	14.56	85.45	11.01	85.54	11.58	85.35	NA	NA	11.17	85.47
2/7/2002	12.44	85.54	14.52	85.49	11.00	85.55	11.56	85.37	9.53	85.64	11.17	85.47
2/14/2002	12.33	85.65	14.39	85.62	10.86	85.69	11.28	85.65	9.46	85.71	10.98	85.66
2/21/2002	12.37	85.61	14.41	85.60	10.89	85.66	11.30	85.63	9.50	85.67	11.00	85.64
3/7/2002	12.29	85.69	14.35	85.66	10.81	85.74	NA	NA	9.41	85.76	10.93	85.71
5/6/2002	NA	NA	13.22	86.79	9.70	86.85	10.20	86.73	NA	NA	9.85	86.79

Table 1
Groundwater Elevation Summary
Naval Air Engineering Station, Lakehurst, New Jersey

WELL ID:	LIW-8		GIW-3		GIW-4		GIW-5		OW-6		LK	
CASING ELEV.:	96.96		97.07		96.29		96.44		97.82		99.64	
DATE	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level	WATER DEPTH, From TOC	WATER ELEVATION, Above Sea Level
10/25/2001	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1/24/2002	11.54	85.42	11.60	85.47	10.78	85.51	11.05	85.39	NA	NA	NA	NA
2/5/2002	11.54	85.42	NA	NA	10.59	85.70	11.02	85.42	NA	NA	NA	NA
2/7/2002	11.51	85.45	NA	NA	10.62	85.67	11.00	85.44	NA	NA	NA	NA
2/14/2002	11.34	85.62	NA	NA	10.61	85.68	NA	NA	NA	NA	NA	NA
2/21/2002	11.34	85.62	NA	NA	NA	NA	NA	NA	12.22	85.60	NA	NA
3/7/2002	11.27	85.69	11.35	85.72	10.57	85.72	10.72	85.72	12.14	85.68	13.96	85.68
5/6/2002	NA	NA	10.20	86.87	NA	NA	NA	NA	11.08	86.74	12.86	86.78

Table 2
Water/BNP Budget
Naval Air Engineering Station, Lakehurst, New Jersey

Injection Point		Volume (L)	Approx. BNP Conc. (g/L)	Approx. Iron Mass (g)	Injection Intervals (ft bgs)
IP-1	Batch 1	400	0.8	320	65-61
	Batch 2	600	1.3	780	61-55
	Batch 3	400	1.5	600	55-51
	Batch 4	400	1.9	760	51-47
	Batch 5	460	1.7	782	47-43
	Total	**2260**	**1.4**	**3242**	
IP-2	Batch 1	400	1.6	640	65-60
	Batch 2	400	1.9	760	60-55
	Batch 3	445	1.8	801	55-50
	Batch 4	500	1.9	950	50-42
	Batch 5	325	0.1	33	42-ground surface
	Total	**2070**	**1.5**	**3184**	
IP-3	Batch 1	470	1.5	682	65-61
	Batch 2	470	1.3	616	61-55
	Batch 3	500	1.6	785	55-50.5
	Batch 4	500	1.6	800	50.5-44
	Batch 5	375	0.9	319	44-34
	Total	**2315**	**1.4**	**3201**	

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	MW-2					
Date	2/25/2002	2/28/2002	3/4/2002	3/7/2002	5/6/02 [3]	5/15/2002
Time	12:20	12:15	11:45	12:55	11:26	9:35
Method	In-Situ	In-Situ	In-Situ	Low-flow	Low-flow	In-Situ
ORP (mV)	-167	-153	-155	39	100	180
pH (su)	5.45	5.43	5.72	6.03	5.08	NA
Dissolved Oxygen (mg/L)	0.00	0.00	0.00	0.22	1.39	1.87
Conductivity (mS/cm)	0.026	0.026	0.026	0.064	0.147	0.086
Temperture (°C)	14.74	14.72	14.72	15.30	15.97	14.70
Turbidity (NTU)	0.80	OR [2]	10.0	3.70	NA	1.60
Total Dissolved Solids (g/l)	0.02	0.02	0.02	NA	NA	0.06

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	MW-3								
Date	########	2/19/2002	2/21/2002	2/25/2002	2/28/2002	3/4/2002	3/7/2002	5/6/02 [3]	5/15/2002
Time	15:40	10:05	10:40	9:45	9:50	9:40	10:30	10:48	13:45
Method	Low-flow	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	Low-flow	In-Situ
ORP (mV)	NA [1]	-159	-479	-378	-405	-331	-323	-431	-116
pH (su)	4.62	5.08	4.96	4.68	5.25	5.31	5.39	5.67	6.62
Dissolved Oxygen (mg/L)	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.22
Conductivity (mS/cm)	0.061	0.024	0.026	0.026	0.027	0.028	0.029	0.119	0.116
Temperture (°C)	NA	14.76	14.76	14.76	14.73	14.74	14.76	16.06	15.20
Turbidity (NTU)	38.6	86.2	151	311	276	254	433	NA	OR [2]
Total Dissolved Solids (g/l)	NA	0.02	0.02	0.02	0.02	0.02	0.02	NA	0.08

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	MW-4										
Date	########	2/11/2002	2/14/2002	2/19/2002	2/21/2002	2/25/2002	2/28/2002	3/4/2002	3/7/2002	5/6/02 [3]	5/15/2002
Time	10:40	15:25	12:50	11:50	11:00	11:40	13:35	12:35	11:30	11:49	11:00
Method	Low-flow	In-Situ	Low-flow	In-Situ	Low-flow	In-Situ	In-Situ	In-Situ	Low-flow	Low-flow	In-Situ
ORP (mV)	NA [1]	169	257	88	49	-120	-246	-194	19	109	69
pH (su)	4.16	4.92	5.24	5.58	5.19	5.10	5.21	5.59	5.72	4.68	NA
Dissolved Oxygen (mg/L)	0.36	2.68	0.74	0.29	2.10	0.00	0.00	0.00	0.00	0.55	0.26
Conductivity (mS/cm)	0.059	0.024	0.022	0.027	0.070	0.022	0.022	0.022	0.052	0.126	0.064
Temperture (°C)	NA	14.59	14.02	14.66	15.20	14.65	14.63	14.66	14.87	11.63	15.10
Turbidity (NTU)	0.10	23.1	131	73.1	142	81.7	12.9	136	48.3	NA	2.30
Total Dissolved Solids (g/l)	NA	0.02	NA	0.02	NA	0.01	0.01	0.01	NA	NA	0.04

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	MW-5										
Date	2/4/2002	2/7/2002	2/11/2002	2/14/2002	2/19/2002	2/21/2002	2/25/2002	2/28/2002	3/4/2002	3/7/2002	5/6/02 [3]
Time	15:42	12:10	13:15	16:35	13:30	13:40	14:10	14:35	14:25	13:50	9:42
Method	In-Situ	Low-flow	In-Situ	In-Situ	In-Situ	Low-flow	In-Situ	In-Situ	In-Situ	Low-flow	Low-flow
ORP (mV)	307	308	304	290	281	248	229	155	160	203	225
pH (su)	4.89	5.00	4.95	5.17	5.12	5.05	5.13	5.00	5.41	5.40	4.94
Dissolved Oxygen (mg/L)	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.71
Conductivity (mS/cm)	0.026	0.025	0.025	0.025	0.025	0.077	0.027	0.028	0.028	0.028	0.119
Temperture (°C)	14.63	13.42	14.62	14.71	14.67	15.50	14.68	14.70	14.70	15.09	15.52
Turbidity (NTU)	215	44.6	589	269	342	135	201	361	454	561	NA
Total Dissolved Solids (g/l)	0.02	NA	0.02	0.02	0.02	NA	0.02	0.02	0.02	NA	NA

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	MW-6					
Date	########	2/5/2002	2/19/2002	3/4/2002	3/7/2002	5/6/02 [3]
Time	14:05	9:20	13:50	14:45	12:00	9:15
Method	Low-flow	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ
ORP (mV)	380	198	252	165	187	209
pH (su)	3.50	5.10	5.18	5.45	5.39	5.00
Dissolved Oxygen (mg/L)	0.50	0.00	0.00	0.00	0.00	0.72
Conductivity (mS/cm)	0.061	0.025	0.025	0.027	0.030	0.111
Temperture (°C)	15.42	14.52	14.61	14.61	14.58	15.21
Turbidity (NTU)	13.0	29.9	204	362	62.0	NA
Total Dissolved Solids (g/l)	NA	0.02	0.02	0.02	0.02	NA

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	MW-8										
Date	########	2/11/2002	2/14/2002	2/19/2002	2/21/2002	2/25/2002	2/28/2002	3/4/2002	3/7/2002	5/6/02 [3]	5/15/2002
Time	14:10	13:50	16:15	14:10	14:05	14:30	14:50	15:05	12:15	10:08	16:40
Method	Low-flow	In-Situ	In-Situ	In-Situ	Low-flow	In-Situ	In-Situ	In-Situ	In-Situ	Low-flow	In-Situ
ORP (mV)	NA [1]	193	275	242	230	214	162	168	178	270	195
pH (su)	4.53	5.15	4.97	5.13	5.00	5.16	5.02	5.40	5.37	4.78	4.17
Dissolved Oxygen (mg/L)	0.42	0.00	1.68	0.00	1.14	0.00	0.00	0.00	0.00	2.01	2.46
Conductivity (mS/cm)	0.064	0.024	0.028	0.030	0.082	0.029	0.031	0.031	0.031	0.125	0.082
Temperture (°C)	NA	14.52	14.64	14.60	15.10	14.61	14.61	14.62	14.61	15.14	14.90
Turbidity (NTU)	4.30	ND	85.6	91.1	21.7	180	59.6	154	103	NA	2.80
Total Dissolved Solids (g/l)	NA	0.02	0.02	0.02	NA	0.02	0.02	0.02	0.02	NA	0.05

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	LIW-2								
Date	2/11/2002	2/19/2002	2/21/2002	2/25/2002	2/28/2002	3/4/2002	3/7/2002	5/6/02 [3]	5/15/2002
Time	14:35	9:40	10:10	9:25	9:20	9:15	9:55	14:50	14:20
Method	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	Low-flow	In-Situ
ORP (mV)	236	307	309	336	269	292	335	-39	46
pH (su)	4.95	4.95	4.85	4.48	4.70	4.86	4.55	4.66	4.15
Dissolved Oxygen (mg/L)	6.48	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.26
Conductivity (mS/cm)	0.026	0.021	0.028	0.027	0.027	0.027	0.026	0.154	0.055
Temperture (°C)	14.78	14.72	14.77	14.75	14.73	14.75	14.81	12.92	15.20
Turbidity (NTU)	34.1	119	347	OR [2]	108	291	427	NA	OR [2]
Total Dissolved Solids (g/l)	0.02	0.01	0.02	0.02	0.02	0.02	0.02	NA	0.04

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	LIW-3										
Date	########	2/4/2002	2/5/2002	2/6/2002	2/6/2002	2/7/2002	2/8/2002	2/11/2002	2/14/2002	2/19/2002	2/21/2002
Time	11:43	13:40	12:12	13:05	15:05	10:20	13:18	10:45	11:04	10:45	10:00
Method	Low-flow	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	Low-flow	In-Situ	Low-flow	In-Situ	Low-flow
ORP (mV)	NA [1]	245	264	418	320	390	178	193	184	155	203
pH (su)	4.56	5.09	4.97	5.09	5.11	5.04	5.05	5.08	5.20	5.39	5.20
Dissolved Oxygen (mg/L)	0.07	0.00	0.00	0.00	1.14	0.00	1.69	2.52	2.34	0.00	1.87
Conductivity (mS/cm)	0.060	0.024	0.022	0.022	0.023	0.023	0.023	0.022	0.024	0.025	0.074
Temperture (°C)	NA	14.76	14.64	14.70	14.71	14.67	13.47	14.64	13.08	14.72	14.70
Turbidity (NTU)	5.70	ND	ND	24.1	163	84.7	459	322	151	127	106
Total Dissolved Solids (g/l)	NA	0.02	0.01	0.01	0.01	0.01	NA	0.01	NA	0.02	NA

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	LIW-3					
Date	2/25/2002	2/28/2002	3/4/2002	3/7/2002	5/6/02 [3]	5/15/2002
Time	10:45	11:15	10:45	9:55	15:12	12:20
Method	In-Situ	In-Situ	In-Situ	Low-flow	Low-flow	In-Situ
ORP (mV)	219	58	128	116	105	39
pH (su)	4.83	5.15	5.28	4.54	5.01	5.85
Dissolved Oxygen (mg/L)	0.00	0.00	0.00	0.62	0.52	0.55
Conductivity (mS/cm)	0.024	0.023	0.023	0.054	0.147	0.112
Temperture (°C)	14.70	14.70	14.71	14.22	11.10	15.20
Turbidity (NTU)	31.7	42.0	112	94	NA	OR [2]
Total Dissolved Solids (g/l)	0.02	0.01	0.01	NA	NA	0.07

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	LIW-4								
Date	########	2/4/2002	2/8/2002	2/11/2002	2/14/2002	2/19/2002	2/21/2002	2/25/2002	2/28/2002
Time	11:05	12:55	10:31	12:30	13:45	12:10	12:45	13:10	13:10
Method	Low-flow	In-Situ	Low-flow	In-Situ	Low-flow	In-Situ	Low-flow	In-Situ	In-Situ
ORP (mV)	302	170	264	237	256	174	116	132	99
pH (su)	3.71	5.20	5.19	5.08	5.26	5.15	5.17	5.24	5.10
Dissolved Oxygen (mg/L)	0.95	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00
Conductivity (mS/cm)	0.064	0.023	0.020	0.021	0.024	0.023	0.068	0.021	0.021
Temperture (°C)	15.64	14.62	13.65	14.56	13.68	14.65	15.20	14.67	14.66
Turbidity (NTU)	105	15.6	38.0	56.8	135	159	176	236	382
Total Dissolved Solids (g/l)	NA	0.01	NA	0.01	NA	0.01	NA	0.01	0.01

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	LIW-4			
Date	3/4/2002	3/7/2002	5/6/02 [3]	5/15/2002
Time	13:00	10:50	15:31	11:25
Method	In-Situ	Low-flow	Low-flow	In-Situ
ORP (mV)	45	125	133	100
pH (su)	5.55	5.25	5.01	NA
Dissolved Oxygen (mg/L)	0.00	0.00	0.40	0.31
Conductivity (mS/cm)	0.022	0.054	0.138	0.079
Temperture (°C)	14.67	14.65	13.73	15.10
Turbidity (NTU)	496	198	NA	50.1
Total Dissolved Solids (g/l)	0.01	NA	NA	0.05

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	LIW-7								
Date	########	2/4/2002	2/6/2002	2/8/2002	2/11/2002	2/14/2002	2/19/2002	2/21/2002	2/25/2002
Time	12:15	14:55	9:29	11:35	11:55	11:50	12:50	11:50	13:30
Method	Low-flow	In-Situ	In-Situ	Low-flow	In-Situ	Low-flow	In-Situ	Low-flow	In-Situ
ORP (mV)	368	191	237	264	236	369	276	188	275
pH (su)	3.56	5.14	5.01	5.26	5.32	5.41	5.23	5.17	5.20
Dissolved Oxygen (mg/L)	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00
Conductivity (mS/cm)	0.063	0.024	0.023	0.023	0.025	0.026	0.024	0.072	0.024
Temperture (°C)	15.49	14.70	14.67	13.71	14.65	13.71	14.74	15.00	14.73
Turbidity (NTU)	31.6	10.9	274	47.1	232	23.2	64.1	18.0	88.0
Total Dissolved Solids (g/l)	NA	0.02	0.02	NA	0.02	NA	0.02	NA	0.02

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	LIW-7				
Date	2/28/2002	3/4/2002	3/7/2002	5/6/02 [3]	5/15/2002
Time	13:55	13:35	14:15	15:52	15:30
Method	In-Situ	In-Situ	Low-flow	Low-flow	In-Situ
ORP (mV)	192	204	136	185	-15
pH (su)	5.11	5.52	5.27	4.94	5.82
Dissolved Oxygen (mg/L)	0.00	0.00	5.31	0.45	0.29
Conductivity (mS/cm)	0.024	0.024	0.057	0.162	0.122
Temperture (°C)	14.70	14.72	15.05	13.40	15.10
Turbidity (NTU)	OR [2]	68.8	18.2	NA	OR [2]
Total Dissolved Solids (g/l)	0.02	0.02	NA	NA	0.08

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	LIW-8								
Date	########	2/4/2002	2/7/2002	2/11/2002	2/14/2002	2/19/2002	2/21/2002	2/25/2002	2/28/2002
Time	15:30	15:17	14:42	12:50	14:29	13:10	13:15	13:50	14:20
Method	Low-flow	In-Situ	Low-flow	In-Situ	Low-flow	In-Situ	Low-flow	In-Situ	In-Situ
ORP (mV)	402	269	317	298	334	279	201	226	95
pH (su)	3.38	4.89	4.95	4.94	5.12	5.08	5.02	5.05	4.94
Dissolved Oxygen (mg/L)	1.11	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00
Conductivity (mS/cm)	0.063	0.023	0.029	0.024	0.026	0.024	0.071	0.024	0.024
Temperture (°C)	15.54	14.64	13.91	14.59	14.03	14.67	15.00	14.67	14.69
Turbidity (NTU)	3.70	66.5	10.6	520	135	528	138	507	609
Total Dissolved Solids (g/l)	NA	0.01	NA	0.02	NA	0.02	NA	0.02	0.02

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	LIW-8		
Date	3/4/2002	3/7/2002	5/15/2002
Time	14:05	13:30	16:20
Method	In-Situ	Low-flow	In-Situ
ORP (mV)	130	28	106
pH (su)	5.35	5.79	4.54
Dissolved Oxygen (mg/L)	0.00	0.00	0.19
Conductivity (mS/cm)	0.023	0.059	0.039
Temperture (°C)	14.68	14.92	15.10
Turbidity (NTU)	595	33.1	OR [2]
Total Dissolved Solids (g/l)	0.02	NA	0.03

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	GIW-2								
Date	2/11/2002	2/14/2002	2/19/2002	2/21/2002	2/25/2002	2/28/2002	3/4/2002	3/7/2002	5/15/2002
Time	15:00	15:55	12:30	12:40	12:00	11:55	11:25	11:10	11:45
Method	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ
ORP (mV)	88	178	163	139	124	131	119	130	208
pH (su)	5.45	5.31	5.30	5.19	5.10	5.15	5.37	5.28	NA
Dissolved Oxygen (mg/L)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95
Conductivity (mS/cm)	0.024	0.022	0.021	0.022	0.021	0.021	0.022	0.023	0.059
Temperture (°C)	14.69	14.79	14.74	14.73	14.72	14.75	14.74	14.75	15.30
Turbidity (NTU)	173	OR [2]	4.30	50.0	39.0	OR [2]	38.0	18.9	1.00
Total Dissolved Solids (g/l)	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	GIW-3					
Date	2/25/2002	2/28/2002	3/4/2002	3/7/2002	5/6/02 [3]	5/15/2002
Time	12:50	12:50	12:20	12:15	14:17	10:35
Method	In-Situ	In-Situ	In-Situ	Low-flow	Low-flow	In-Situ
ORP (mV)	-425	-446	-413	-209	-558	-187
pH (su)	6.35	6.90	7.58	8.67	6.55	NA
Dissolved Oxygen (mg/L)	0.00	0.00	0.00	0.00	0.32	0.41
Conductivity (mS/cm)	0.041	0.052	0.060	0.127	0.261	0.132
Temperture (°C)	14.69	14.68	14.70	15.16	13.99	15.30
Turbidity (NTU)	OR [2]	OR [2]	OR [2]	137	NA	87.6
Total Dissolved Solids (g/l)	0.03	0.03	0.04	NA	NA	0.09

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	GIW-4								
Date	2/4/2002	2/5/2002	2/6/2002	2/11/2002	2/14/2002	2/19/2002	2/21/2002	2/25/2002	2/28/2002
Time	13:15	14:35	14:15	10:25	15:10	10:25	11:15	10:05	10:10
Method	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ
ORP (mV)	311	232	34	67	120	243	171	272	212
pH (su)	4.93	4.89	6.25	5.11	5.06	5.08	5.03	4.19	4.85
Dissolved Oxygen (mg/L)	6.60	10.05	1.59	2.26	4.16	0.00	0.00	0.49	0.47
Conductivity (mS/cm)	0.022	0.024	0.046	0.025	0.025	0.025	0.026	0.025	0.024
Temperture (°C)	14.89	14.72	14.47	14.77	14.76	14.74	14.75	14.76	14.74
Turbidity (NTU)	96.6	74.0	13.8	OR [2]	OR [2]	181	178	94.5	158
Total Dissolved Solids (g/l)	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	GIW-4		
Date	3/4/2002	3/7/2002	5/15/2002
Time	10:05	10:55	13:10
Method	In-Situ	In-Situ	In-Situ
ORP (mV)	204	219	42
pH (su)	4.80	4.92	5.57
Dissolved Oxygen (mg/L)	0.00	0.00	0.30
Conductivity (mS/cm)	0.024	0.024	0.082
Temperture (°C)	14.73	14.74	15.20
Turbidity (NTU)	128	103	OR [2]
Total Dissolved Solids (g/l)	0.02	0.02	0.05

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	GIW-5									
Date	2/4/2002	2/11/2002	2/14/2002	2/19/2002	2/21/2002	2/25/2002	2/28/2002	3/4/2002	3/7/2002	5/15/2002
Time	14:00	11:10	15:35	11:30	12:05	11:10	11:35	11:05	11:25	12:45
Method	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ
ORP (mV)	255	236	157	95	63	111	154	138	167	190
pH (su)	5.05	5.13	5.22	5.16	5.06	4.81	4.98	5.19	5.24	4.30
Dissolved Oxygen (mg/L)	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Conductivity (mS/cm)	0.021	0.021	0.022	0.022	0.023	0.021	0.021	0.021	0.021	0.077
Temperture (°C)	14.68	14.56	14.72	14.65	14.69	14.68	14.70	14.68	14.68	15.20
Turbidity (NTU)	22.5	35.0	OR [2]	65.1	136	178	259	92.0	144	664
Total Dissolved Solids (g/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	GIW-7							
Date	2/11/2002	2/19/2002	2/21/2002	2/25/2002	2/28/2002	3/4/2002	3/7/2002	5/15/2002
Time	11:30	11:10	11:40	10:25	10:30	10:20	11:45	14:45
Method	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ
ORP (mV)	285	193	299	237	210	207	206	-77
pH (su)	4.90	5.15	4.94	4.32	4.89	4.87	5.25	6.25
Dissolved Oxygen (mg/L)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Conductivity (mS/cm)	0.024	0.022	0.025	0.024	0.024	0.024	0.024	0.085
Temperture (°C)	14.71	14.70	14.78	14.81	14.75	14.76	14.76	15.20
Turbidity (NTU)	ND	64.0	9.70	9.80	OR [2]	5.80	0.00	OR [2]
Total Dissolved Solids (g/l)	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.06

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Well I.D.	OW-6								LK		
Date	2/11/2002	2/19/2002	2/21/2002	2/25/2002	2/28/2002	3/4/2002	3/7/2002	5/6/02 [3]	3/4/2002	3/7/2002	5/6/02 [3]
Time	14:15	14:30	13:10	14:50	15:30	16:05	12:50	13:54	15:25	12:30	8:44
Method	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	Low-flow	In-Situ	In-Situ	Low-flow
ORP (mV)	253	183	95	116	94	92	81	126	138	168	234
pH (su)	5.09	5.15	5.30	5.47	5.22	5.70	5.76	5.10	5.51	5.43	5.11
Dissolved Oxygen (mg/L)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	1.18
Conductivity (mS/cm)	0.027	0.026	0.032	0.031	0.031	0.032	0.032	0.166	0.022	0.022	0.115
Temperture (°C)	14.49	14.55	14.51	14.52	14.56	14.54	14.56	13.20	14.42	14.46	15.17
Turbidity (NTU)	993	4.90	167	17.7	OR [2]	33.0	15.0	NA	10.6	5.80	NA
Total Dissolved Solids (g/l)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	NA	0.01	0.01	NA

Table 3
Geochemical Parameters Results
Naval Air Engineering Station, Lakehurst, New Jersey

Notes:

NA - Not Available

1 - Expected Instrument Failure
2 - Reading Exceeds Range of Instrument
3 - Geochemical Data Provided by the U.S. Navy.

Table 4
Groundwater Sampling Results
Naval Air Engineering Station Site, Lakehurst, New Jersey

Well I.D.	MW-2		MW-3	MW-4				
Sample Date	3/7/2002	5/6/02 *	5/6/02 *	10/25/2001	2/14/2002	2/21/2002	3/7/2002	5/6/02 *
PARS Sample I.D.	034-LNA020307	MW-2	MW-3	001-LNA011025	018-LNA020214	023-LNA020221	032-LNA020307	MW-4
Laboratory Sample I.D.	336638	0205041-007A	0205041-006A	310399	333095	334309	336636	0205041-008A
Volatile Organics (ug/L)								
EPA Method 624								
Tetrachloroethene	81	14.3	ND	1.9	26	16	14	ND
Trichloroethene	110	21.2	4.74	7.6	31	24	20	8.01
Cis-1,2-dichloroethene	390	93.2	3.88	6.2	74	52	38	7.91
Trans-1,2-dichloroethene	3.5	ND	ND	ND	0.2	0.3	0.3	ND
Vinyl chloride	17	9.14	ND	ND	ND	ND	0.5	ND
1,1,1-trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	0.5	ND	ND	ND	ND	0.3	0.4	ND
1,1-dichloroethene	1.1	ND	ND	ND	ND	ND	ND	ND
1,2-dichloroethane	0.9	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	0.2	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	0.6	ND	ND	ND
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND
Total TICs	ND	NA	NA	ND	ND	ND	ND	NA
Total VOCs	604	137.84	8.62	15.9	131.8	92.6	73.2	15.92
Iron (ug/L)								
EPA Method 200.7								
Total iron	3530	NA	NA	998	501	478	805	NA
Dissolved iron	3580	NA	NA	889	213	40.4	395	NA
Chloride (mg/L)								
Chloride	6.0	NA	NA	7.5	8.5	7.5	465	NA

Table 4
Groundwater Sampling Results
Naval Air Engineering Station Site, Lakehurst, New Jersey

Well I.D.	MW-5				MW-6		MW-8		
Sample Date	2/7/2002	2/21/2002	3/7/2002	5/6/02 *	10/25/2001	5/6/02 *	10/25/2001	2/21/2002	5/6/02 *
PARS Sample I.D.	010-LNA020207	027-LNA020221	036-LNA020307	MW-5	005-LNA011025	MW-6	006-LNA011025	028-LNA020221	MW-8
Laboratory Sample I.D.	331619	334313	336640	0205041-004A	310403	0205041-003A	310404	334314	0205041-005A
Volatile Organics (ug/L)									
EPA Method 624									
Tetrachloroethene	6.3	5.1	12	4.13	1.4	2.28	1.2	1.8	1.61
Trichloroethene	18	18	22	13.7	9.7	9.94	6.7	9.3	8.57
Cis-1,2-dichloroethene	37	31	42	25.9	9.2	15.7	7.5	14	15.2
Trans-1,2-dichloroethene	ND	ND	0.2	ND	ND	ND	ND	0.2	ND
Vinyl chloride	ND	1.1	0.9	ND	0.3	ND	ND	0.7	ND
1,1,1-trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	ND	0.6	0.5	ND	0.5	ND	ND	0.5	ND
1,1-dichloroethene	ND	0.4	0.3	ND	ND	ND	ND	0.3	ND
1,2-dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	0.2	ND	0.2	ND	ND
Bromoform	0.6	ND	ND	ND	0.2	ND	ND	ND	ND
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total TICs	23	21	14	NA	7.2	NA	ND	ND	NA
Total VOCs	84.9	77.2	91.9	43.73	28.7	27.92	15.6	26.8	25.38
Iron (ug/L)									
EPA Method 200.7									
Total iron	413	2050	797	NA	466	NA	295	356	NA
Dissolved iron	ND	50.5	39.7	NA	274	NA	ND	104	NA
Chloride (mg/L)									
Chloride	8.0	5.5	6.5	NA	ND	NA	6.5	ND	NA

Table 4
Groundwater Sampling Results
Naval Air Engineering Station Site, Lakehurst, New Jersey

Well I.D.	LIW-2	LIW-3					
Sample Date	5/6/02 *	10/25/2001	2/8/2002	2/14/2002	2/21/2002	3/7/2002	5/6/02 *
PARS Sample I.D.	LIW-2	003-LNA011025	014-LNA020208	016-LNA020214	022-LNA020221	030-LNA020307	LIW-3
Laboratory Sample I.D.	0205041-012A	310401	331623	333093	334308	336634	0205041-013A
Volatile Organics (ug/L)							
EPA Method 624							
Tetrachloroethene	11.2	9.2	26	18	16	8.7	2.61
Trichloroethene	20.5	17	32	23	24	14	8.87
Cis-1,2-dichloroethene	101	24	73	51	47	21	11.2
Trans-1,2-dichloroethene	ND	0.3	0.3	ND	0.2	ND	ND
Vinyl chloride	7.42	0.4	1.5	ND	ND	ND	ND
1,1,1-trichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	ND	0.4	ND	ND	0.4	0.4	ND
1,1-dichloroethene	ND	ND	ND	ND	ND	ND	ND
1,2-dichloroethane	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	0.3	ND	ND	ND	ND	ND
Bromoform	ND	ND	0.5	ND	ND	ND	ND
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND
Total TICs	NA	7.4	ND	3.0	ND	ND	NA
Total VOCs	140.12	59.0	133.3	95.0	87.6	44.1	22.7
Iron (ug/L)							
EPA Method 200.7							
Total iron	NA	3010	58.5	62.0	171	915	NA
Dissolved iron	NA	2620	ND	ND	ND	101	NA
Chloride (mg/L)							
Chloride	NA	5.5	7.5	8.0	7.5	565	NA

Table 4
Groundwater Sampling Results
Naval Air Engineering Station Site, Lakehurst, New Jersey

Well I.D.	LIW-4					
Sample Date	10/25/2001	2/8/2002	2/14/2002	2/21/2002	3/7/2002	5/6/02 *
PARS Sample I.D.	002-LNA011025	012-LNA020208	019-LNA020214	025-LNA020221	031-LNA020307	LIW-4
Laboratory Sample I.D.	310400	331621	333096	334311	336635	0205041-014A
Volatile Organics (ug/L)						
EPA Method 624						
Tetrachloroethene	16	99	51	32	21	29.9
Trichloroethene	18	77	45	32	24	34
Cis-1,2-dichloroethene	42	160	94	75	52	104
Trans-1,2-dichloroethene	0.3	1.2	0.6	0.6	0.7	ND
Vinyl chloride	ND	1.5	ND	0.4	0.4	5.46
1,1,1-trichloroethane	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	0.3	ND	ND	0.3	0.3	0.3
1,1-dichloroethene	ND	0.4	ND	0.3	ND	ND
1,2-dichloroethane	ND	0.9	ND	0.4	ND	ND
Toluene	0.3	ND	ND	ND	ND	ND
Bromoform	ND	0.6	ND	ND	ND	ND
Methylene Chloride	ND	ND	ND	ND	ND	2.78
Total TICs	8.2	15	12	3.2	4.6	NA
Total VOCs	85.1	355.6	202.6	144.2	103.0	176.4
Iron (ug/L)						
EPA Method 200.7						
Total iron	853	223	430	2830	4530	NA
Dissolved iron	492	95.8	235	932	1370	NA
Chloride (mg/L)						
Chloride	10.0	7.5	8.5	8.0	115	NA

Table 4
Groundwater Sampling Results
Naval Air Engineering Station Site, Lakehurst, New Jersey

Well I.D.	LIW-7					
Sample Date	10/25/2001	2/8/2002	2/14/2002	2/21/2002	3/7/2002	5/6/02 *
PARS Sample I.D.	004-LNA011025	013-LNA020208	017-LNA020214	024-LNA020221	037-LNA020307	LIW-7
Laboratory Sample I.D.	310402	331622	333094	334310	336641	0205041-015A
Volatile Organics (ug/L)						
EPA Method 624						
Tetrachloroethene	6.3	42	23	25	27	44.5
Trichloroethene	14	57	40	40	39	70
Cis-1,2-dichloroethene	36	130	100	100	93	212
Trans-1,2-dichloroethene	ND	0.7	0.6	0.6	0.6	ND
Vinyl chloride	0.9	2.6	2.0	1.8	1.5	8.74
1,1,1-trichloroethane	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	0.5	ND	ND	0.4	0.4	ND
1,1-dichloroethene	0.3	0.5	ND	0.6	0.3	ND
1,2-dichloroethane	ND	ND	ND	ND	ND	0.872
Toluene	0.4	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND
Methylene Chloride	ND	ND	ND	ND	ND	2.71
Total TICs	69	120	130	56	38	NA
Total VOCs	127.4	352.8	295.6	224.4	199.8	338.82
Iron (ug/L)						
EPA Method 200.7						
Total iron	58.1	503	ND	88.0	113	NA
Dissolved iron	52.5	ND	ND	ND	ND	NA
Chloride (mg/L)						
Chloride	9.5	8.5	10.0	9.5	9.0	NA

Table 4
Groundwater Sampling Results
Naval Air Engineering Station Site, Lakehurst, New Jersey

Well I.D.	LIW-8					GIW-3		
Sample Date	10/25/2001	2/7/2002	2/14/2002	2/21/2002	3/7/2002	3/7/2002	5/6/2002 *	5/6/2002 *
PARS Sample I.D.	007-LNA011025	011-LNA020207	020-LNA020214	026-LNA020221	035-LNA020307	033-LNA020307	GIW-3	GIW-3 (DUP)
Laboratory Sample I.D.	310405	331620	333097	334312	336639	336637	0205041-010A	0205041-011A
Volatile Organics (ug/L)								
EPA Method 624								
Tetrachloroethene	1.2	18	11	8.4	14	3.6	ND	ND
Trichloroethene	6.2	22	16	17	20	8.0	7.16	6.93
Cis-1,2-dichloroethene	5.3	42	30	31	36	7.8	7.43	7.42
Trans-1,2-dichloroethene	ND	ND	ND	ND	0.3	ND	ND	ND
Vinyl chloride	ND	ND	ND	0.4	ND	ND	ND	ND
1,1,1-trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	0.3	ND	ND	0.4	0.4	0.4	ND	ND
1,1-dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND
1,2-dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	0.4	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	0.9	ND	ND	ND	ND	ND	ND
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND
Total TICs	6.2	47	61	12	6.8	ND	NA	NA
Total VOCs	19.6	129.9	118.0	69.2	77.5	19.8	14.59	14.35
Iron (ug/L)								
EPA Method 200.7								
Total iron	239	ND	69.1	719	335	36500	NA	NA
Dissolved iron	76.0	ND	ND	40.9	114	34900	NA	NA
Chloride (mg/L)								
Chloride	7.5	11.5	11.0	8.0	9.0	115	NA	NA

Table 4
Groundwater Sampling Results
Naval Air Engineering Station Site, Lakehurst, New Jersey

Well I.D.	Trip Blank					
Sample Date	10/25/2001	2/7/2002	2/14/2002	2/21/2002	3/7/2002	5/6/02 *
PARS Sample I.D.	009-LNA011025	015-LNA020207	021-LNA020214	029-LNA020221	038-LNA020307	Trip Blank
Laboratory Sample I.D.	310407	331624	333098	334315	336642	0205041-001A
Volatile Organics (ug/L)						
EPA Method 624						
Tetrachloroethene	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND
Cis-1,2-dichloroethene	ND	ND	ND	ND	ND	ND
Trans-1,2-dichloroethene	ND	ND	ND	ND	ND	ND
Vinyl chloride	ND	ND	ND	ND	ND	ND
1,1,1-trichloroethane	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	ND	ND	ND	ND	ND	ND
1,1-dichloroethene	ND	ND	ND	ND	ND	ND
1,2-dichloroethane	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND
Bromoform	0.6	ND	0.8	ND	ND	ND
Methylene Chloride	ND	ND	ND	ND	ND	ND
Total TICs	ND	ND	ND	ND	ND	NA
Total VOCs	0.6	ND	0.8	ND	ND	ND
Iron (ug/L)						
EPA Method 200.7						
Total iron	NA	NA	NA	NA	NA	NA
Dissolved iron	NA	NA	NA	NA	NA	NA
Chloride (mg/L)						
Chloride	NA	NA	NA	NA	NA	NA

Table 4
Groundwater Sampling Results
Naval Air Engineering Station Site, Lakehurst, New Jersey

Notes:

ND	Not Detected
NA	Not Analyzed
*	Groundwater samples were collected and analyzed utilizing EPA method 524.2 by VAL Associates Laboratory, Inc.

APPENDIX A

GROUNDWATER SAMPLING FORMS

APPENDIX B

LOW-FLOW SAMPLING GUIDANCE