WSRC-TR-96-348
October 29, 1996
Rev. 0

Field Test

of

Single Well DNAPL Characterization

Using Alcohol Injection/Extraction

U.S Department of Energy Office of Technology Development
U.S. Department of Energy Savannah River Operations

Prepared by:

technical personnel at the Savannah River Site

U.S. Department of Energy
Westinghouse Savannah River Company
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Savannah River Site
Aiken, SC 29808

operated by :

Westinghouse Savannah River Company
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SUMMARY

Soils and groundwater beneath an abandoned process sewer line in the A/M Area of the Savannah River Site (SRS) contain elevated levels of volatile organic compounds, specifically trichloroethylene (TCE) and tetrachloroethylene (PCE), two common chlorinated solvents. These compounds have low aqueous solubilities, thus when released to the subsurface in sufficient quantity, tend to exist as immiscible fluids or nonaqueous phase liquids (NAPLs). Because chlorinated solvents are also denser than water, they are referred to by the acronym DNAPLs, or dense non-aqueous phase liquids. Technologies targeted at efficient characterization or removal of DNAPL are not currently proven. For example, most DNAPL studies rely on traditional soil and water sampling and the fortuitous observation of immiscible solvent. Once DNAPL is identified below the water table, slow dissolution and pumping of the contaminated water *is the* baseline cleanup strategy. New cleanup approaches based on enhanced removal by surfactants and/or alcohols have been proposed and tested at the pilot scale. This technology was originally developed in the petroleum industry for recovery of residual oil. As described below, carefully designed experiments similar to the enhanced removal methods may provide important characterization information on DNAPLs.

We performed injection/extraction characterization tests in six existing wells in A/M Area. Water concentrations for TCE and/or PCE in these wells ranged from 0% to 100% of solubility. For each test, small amounts of solubilizing solution were used to try to confirm or deny the presence or absence of DNAPL in the immediate vicinity of the well screen.

Review of the data indicated no distinct pattern of concentration response was observable, even in known DNAPL wells. The wells responses do, however, have important implications with respect to design and operation of remediation systems based on enhanced mobilization using alcohols/cosolvents. The fact that known DNAPL wells did not exhibit concentration behaviors expected from simple theory indicates the injected alcohol solution is not efficiently contacting the DNAPL zone/layer -- even on the small scale of this test (1 to 2 meters of screen). An important factor contributing to the lack of the juxtaposition of the alcohol flood zone and DNAPL are their relative densities. DNAPL has a density greater than water and will be present in the lowest portion of the aquifer and screen; while the alcohol solution has a density less than water and will tend to exit the screen as high as possible and move slightly upward during the test. This behavior suggests the scale of alcohol based techniques for characterizing subsurface DNAPL is critical – microscale testing using a cone penetrometer may provide better data because the juxtaposition of alcohol solution and DNAPL can be more explicitly controlled. Second, such a behavior indicates that alcohol and cosolvent based remediation system design needs to carefully account for the geometry of the field situation and the tendency of the solutions to separate. A modest, but consistent, difference was noted during the ethanol extraction stage in four of the six wells. In these wells, PCE in the ethanol stage decreased in relation to PCE in the bromide/control stage, and/or TCE in the ethanol test increased versus TCE in the bromide/control stage. If this observation proves significant, it may indicate conversion of PCE to TCE during the ethanol stage. One mechanism that would result in such conversion is biological activity stimulated by introduction of ethanol. Further study and replication would be required to confirm this finding and determine a mechanism.

INTRODUCTION

The proposed small scale use of alcohols initially as a characterization tool, rather than as a remediation tool, has several advantages: 1) existing monitoring wells were used -- minimizing additional drilling and intrusion into the contaminated site, and 2) if successful, the test would provide data on the presence or absence of DNAPL in the vicinity of suspect wells. Thus, the primary objective of the alcohol injection field scale test was to determine if this test is a viable characterization tool for determining the presence of DNAPL in the subsurface. A series of six wells with concentrations of trichloroethylene ranging from approximately 0 % of solubility to 100% of solubility were tested. For each well, testing was performed in two stages. Stage 1 was a bromide tracer test conducted to document hydraulic control of the test system. Upon successful completion of stage 1, alcohol injection which is stage 2 was conducted. The following report documents results and conclusions of these tests.

Upon receipt, on May 24, of the approved Underground Injection Control Permit for this test, final preparations to begin field testing were initiated. On June 3, testing was started at Well MSB11F. Testing progressed throughout the summer with the final test being conducted on August 13, 1996. Good tracer recovery (> 62 %) was seen in all wells except MSB 22 (30%). This may be due to preferential flow paths passing through the screened zone of well MSB22. Due to difficulties in mixing the alcohol, the accuracy of the first four alcohol mass balances is in question. A more effective mixing system was employed for tests at wells MSB 22 and MSB 3D and recovery of alcohol is consistent with recovery of bromide. The main emphasis of these tests was to determine if this sequential injection extraction test method would be effective in clearly identifying the presence of DNAPL near existing monitoring wells. Results of the tests are discussed in detail within this report.

BACKGROUND

The M-Area of Savannah River Site was a fuel and target fabrication facility. The mission of this area was processing uranium, lithium and other materials into fuel elements and targets for use in the nuclear production reactors. The processes were primarily metallurgical and mechanical, such as casting, extrusion, plating, hot-die-sizing, welding and magneforming. Solvent cleaning and acid/caustic etching were used to prepare the materials.

The M-Area Settling Basin and associated areas (overflow ditch, Lost Lake, seepage area, and inlet process sewer line) were designated as the M-Area Hazardous Waste Management Facility. This facility received process effluent from 1958 until 1985. VOC contamination of soils and groundwater occurred in M-Area as a result of breaks in the old process-sewer line and disposal to the basin. Other sources in A/M Area include the A-014 Outfall, the solvent storage tank, and surface discharges from the Savannah River Technical Center.

The M-Area Settling Basin Hazardous Waste Management Facility has been capped and closed under RCRA and is a certified closure as a landfill. DNAPL characterization and remediation support the A/M Area groundwater corrective action.

A wide range of research and development activities have been performed in support of the A/M -Area groundwater corrective action. These various activities have been designated the Integrated Demonstration and include use of horizontal wells for remediation, an in situ air stripping test, an in situ bioremediation test, off gas treatment technology tests, a radio frequency heating test, and an ohmic heating test.

Data from operating the A/M Area pump and treat system and from the related research and development activities indicate that characterization of DNAPL above and below the water table is an important component of developing a comprehensive remediation system. Characterization of DNAPL below the water table is often difficult, due to DNAPL's discrete occurrence in thin layers and complex behavior. Above the water table, residual DNAPL will reside in intergranular pores, held by capillary forces. Overall

characterization of subsurface DNAPL distribution requires application of specifically focused characterization technologies based on contaminant attributes and hydrogeological setting. To minimize the potential for DNAPL spreading, noninvasive or minimally invasive technologies should be employed.

Several technologies were used during the earlier Phase I DNAPL characterization. These included: (1) physical and chemical measurements in existing monitoring wells (e.g., interface probe and bailer samples, and visual examination), (2) cone penetrometer to provide detailed data on the geology (clay layers and lithologic controls), and (3) geophysical logging of existing monitoring wells to examine the well casing and formation outside the well casing for indications of DNAPL. Historical data were used to focus the study on the most promising wells and techniques.

A separate phase was identified in monitoring wells MSB-3D and MSB-22 sumps. Both identifications were made based on direct observation of a bottom filling bailer. Dense phases collected from these two wells were sampled and analyzed at different times to allow testing of various hypotheses for DNAPL occurrence. Observed changes in the volume and composition of the dense phase collected from the two sumps at separate times were specifically related to possible DNAPL behavior scenarios. The data suggest DNAPL has reached the water table only at the largest volume release areas, the M-Area Settling Basin (Settling Basin) and the A-014 Outfall. The relatively thick vadose zone beneath A/M-Area tends to limit the downward flux of DNAPL and capture some DNAPL in layered clays. As expected, DNAPL below the water table has been observed where solvent release exceeded the capacity of the vadose zone to moderate the flux of the pure phase to the groundwater. The clearest evidence of DNAPL below the water table was found at the Settling Basin, where a separate phase was identified in the sumps of two wells. Data collected at separate times suggest the DNAPL below the water table occurs as relatively diffuse ganglia and/or a thin layer on the top of aquitards, and DNAPL collects in well sumps as a result of dynamic processes. One such process is accumulation of dense ganglias in the well sump as the well is actively purged and sampled (similar to accumulation of sediments in the sump).

The cone penetrometer allowed refinement of the delineation of an important clay zone (the "green clay") beneath the water table. Undulations and other structural variations on top of this layer would serve to control movement of a dense phase below the water table. Based on cone penetrometer results, structure controlled pathways for density-dominated transport below the water table were discerned. Two potential pathways were identified. The primary potential pathway of contaminant migration begins near the Settling Basin, where DNAPL was found in monitoring wells MSB-3D and MSB-22, Figure 1. The contour grades toward the west and then north toward MSB-76, where high dissolved constituent concentrations (> 1000ug/L) are reported. Areas along low points of the path described in this interpretation will be locations of future DNAPL investigation. Geophysical logging data indicate the physical integrity of the PVC monitoring well casings in A/M-Area have not been substantially impacted by exposure to chlorinated solvents. Wells, even immediately adjacent to the highest volume release areas, do not show signs of mechanical instability, leakage, or other types of large scale failure. Data from a few monitoring wells, however, provide subtle indications of potential exposure to DNAPL. The most consistent DNAPL indications are provided in monitoring wells MSB-9A and MSB-22, with less probable indications from monitoring wells MSB-10A and MSB-11A.

Phase I of the DNAPL characterization provided significant insight into the nature and location of DNAPL in the SRS subsurface. In particular, the data indicate a substantial amount of DNAPL has been trapped in clays and silts in the vadose zone above the water table. The DNAPL present is composed of approximately 95% TCE and 5% PCE. Remediation of this material by soil vapor extraction (SVE) before it reaches the water table represents the first major DNAPL-targeted remediation technology. SVE demonstrations have been performed in the A/M-Area using both horizontal and vertical wells. A full scale SVE design, installed as a component of the A/M-Area groundwater corrective action program is in place, and additional remediation technology demonstrations are underway. Phase I characterization data also suggest DNAPL below the water table in A/M-Area is present as disconnected ganglia, rather than as a large, solvent-saturated layer. The objectives of Phase II of the DNAPL characterization are: (1) refining

our knowledge of the location and nature of DNAPL in the subsurface, and (2) implementing studies to examine the efficacy of potential remediation techniques for DNAPL below the water table. As in Phase I, non-invasive, or minimally invasive, techniques are stressed.

The injection/extraction test is an important element of the Phase II characterization activities. This characterization test involved injection/extraction of alcohols or surfactants into existing wells (minimizing cost and eliminating the disruptions associated with drilling activities). It was conducted within one quarter mile of the M-Area Settling Basin Hazardous Waste Management Facility. Figure 1 shows locations of the test wells, the area of review, all monitoring wells, surface bodies of water, roads, and other cultural features.

TECHNICAL BASIS

Sequential injection extraction tests were performed at six wells - two known DNAPL wells, and four DNAPL suspect wells. In each test, a small volume of solubilizing solution was injected. The solution was then extracted from the formation . A larger extraction volume was used to improve recovery of the amendments. Two stages were performed at each well. In the first stage, water (with bromide ion tracer) was the solubilizing solution, and in the second stage, alcohol solution was used. According to theory, presence of DNAPL will result in differences between the stages. Presence of DNAPL will be indicated by a difference in concentration of DNAPL present in the alcohol stage of the test from that present in the water stage of the test. Thus the injection/extraction test will provide key information supporting decision making and may provide the basis for modeling and design of future DNAPL remediations based on solubilization by alcohols. Specific details of the test are addressed below.

The technical basis for these tests is described in detail in the Test Plan for Single Well Injection/Extraction Characterization of DNAPL (Looney, et al.). The following is a brief summary of the appropriate sections of the test plan. In designing the test, decisions had to be made concerning injection/extraction volumes and pumping rates, solubilizing solution and concentration, method of determining hydraulic control and extent of testing. Volumes to be injected and extracted, 50 gallons and 150 gallons respectively, were chosen based upon our objective to "probe" 3 inches into the natural formation immediately adjacent to the well screen. An injection and extraction rate of approximately 1 gpm was chosen to minimize hydraulic effects and allow proper mass transfer for solubilization. With the objective of the testing being on solubilization rather than mobilization, lower weight alcohols were identified as candidates for the solubilizing solution. Ethanol was chosen after review of the toxicity of methanol, ethanol, and isopropanol. In choosing the concentration of ethanol to be used, emphasis was on selecting a concentration which would give a significant change in concentration in stage 2 tests over stage 1 tests, but not decrease interfacial tension to a level when DNAPL becomes mobile. The selected concentration was 25%. Use of a conservative tracer in the stage 1 testing was determined to be an effective manner to show hydraulic control of the system being tested. Bromide, an ionic compound commonly employed as a groundwater tracer, was selected. Six wells were selected for testing. These ranged from a control well to 2 confirmed DNAPL wells, with 3 DNAPL suspect but unconfirmed wells.

The theoretical behavior of the injection/extraction test is shown in Figure 2. Relative concentrations of TCE and PCE are predicted to be measurably greater during the ethanol stage tests than the bromide/control stage tests for those wells confirmed to collect DNAPL.

DESCRIPTION OF INJECTION/EXTRACTION TESTS

Six test wells were chosen based on previous data of highest concentrations and selected lower concentration control wells, as described above. A series of short tests where a small volume of fluid is injected, followed by overextraction was conducted. Injection and extraction rates for all tests were approximately 1 gpm. This rate was chosen to minimize hydraulic effects and allow proper mass transfer for

solubilization. The tests were designed to penetrate 4 to 7 inches into the formation. Each test consisted of two stages. The initial stage of each test involved injection and overextraction of a known volume of water containing a sodium bromide tracer at approximately 100 ppm. This was followed by a second stage of injection and overextraction of a known volume of a solubilizing alcohol solution (e.g., 25 % ethanol). All stages were run in batch mode. Presence of DNAPL was indicated by a difference in concentration of DNAPL between the two stages of the test. Levels of liquid in the injection drum were measured pre- and post-injection to provide an accurate account of all injection volumes. During stage 1 testing, a standard hydrogeology tracer (bromide) was added to the injected fluid to allow explicit determination of the water mass balance. (Looney, etal.)

Isolation of the screened zone was accomplished through use of a single packer located above the injection port. The injection port is located at the bottom of the injector assembly. Figure 3 shows the orientation of the packer in isolating the test zone. Equipment is designed to minimize the dead volume of the wells, thus reducing volumes required to reach the natural formation and total volumes removed and managed for waste disposal.

Fluids were removed utilizing a bottom filling lift pump equipped to carefully monitor extracted volumes. Extracted volumes exceeded injected volumes by a factor of three, maximizing recovery of amendments. Extracted fluids were sampled and analyzed for TCE and PCE concentrations, alcohol concentrations, and tracer concentrations. Samples for each stage of each test were collected on ten (10) minute intervals (approximately every 5 gallons pumped) over the first 160 minutes of the test and at twenty (20) minute intervals (approximately every 10 gallons pumped) for the remaining 140 minutes, for a total test period of 300 minutes (5 hours).

No DNAPL was pumped from any of the wells during the extraction process. Wells MSB22 and MSB3D were bailed on August 5 and 12 to determine the presence of DNAPL. Approximately 1.5 liters of a DNAPL-water emulsion was removed from well MSB22 on August 5. Well MSB3D was bailed on August 5 and August 12 resulting in 3.57 liters of DNAPL and 6.16 liters of a DNAPL-water emulsion.

ANALYSIS OF SAMPLES

Samples for these tests were analyzed by several methods. Samples from the tracer test, first stage testing, were analyzed using a Dionex ion chromatograph for the bromide and headspace analysis using a gas chromatograph (GC) with a flame ionization detector (FID) and electron capture detector (ECD) for TCE and PCE. Ten percent of the GC samples were also analyzed by a gas chromatograph with mass spectrometer (GC-MS) with direct injection of the sample. Samples from the alcohol test, second-stage testing, were analyzed by GC-MS with direction injection of the sample. Ten percent of samples from all tests were analyzed for PCBs using a solid phase microextractor to extract and concentrate PCBs from the sample matrix and high resolution gas chromatography using an electron capture detector to isolate and quantify the PCBs. Standards were prepared and run with each batch of samples analyzed. Standard curves were generated and concentrations determined for each analyzed sample.

DATA EVALUATION

Mass balances were determined for all tests. Concentrations and mass balance information are provided in Appendix A for each test. Recovery of the bromide tracer was greater than 77 % for all wells except MSB22, where recovery was approximately 30%. This may be due to preferential flow paths passing through the screened zone of well MSB22. Recovery of the alcohol is less accurate. During testing of the first four wells, uniformity of mixing of the alcohol injectate was not achieved. Modifications to the mixing process led to more uniform mixing for the last two alcohol injection tests. Because of the lack of

uniformity, the accuracy of the mass balance for the first four alcohol tests is highly questionable. The percent recoveries for both bromide and alcohol tests are provided for each well in Table 1.

Table 1 Percent Recovery of Bromide and Alcohol for Injection/Extraction Tests

Test Well	Bromide Recovery (%)	Alcohol Recovery (%)
MHT9D	84	140
MSB11F	96	63
MSB9C	77	118
MSB15D	81	110
MSB22	25 and 36 *	28
MSB3D	80	75

* Bromide test conducted twice due to low recovery of bromide during first test. Second test was to ascertain if first test results were accurate.

All tests were analyzed for concentrations of TCE and PCE. Data for each test is provided in Appendix A. By comparing normalized concentrations of TCE and PCE for the 2 test stages of each well similarities and differences can be identified, this information is graphed for each well below. Each graph is of the same type (x and y axis) as the theoretical graph presented above. You will see, however, that the graphs of the field tests do not resemble the theoretical model. Results for each well are discussed below, starting from the highest concentration and progressing to the lowest concentration. For each well, the behavior of TCE and PCE in the water/bromide solution stage is described, followed by observations of differences in TCE/PCE observed during the alcohol injection extraction stage.

Well MSB3D is a known DNAPL well (based on historical accumulation of DNAPL in the well). As stated above, DNAPL was bailed from this well during the test period. Figure 4 represents the findings of the two stages of testing MSB3D. Despite the fact that this is a confirmed DNAPL well, the graph does not reflect the theoretically predicted curve (shown in Figure 2). Using the theoretical model, the normalized concentrations of TCE and PCE would climb above a C/Co value of 1 shortly after injection of alcohol and within a several hour period return to the baseline condition (C/Co = 1). During the first stage of testing (the bromide tracer/control test), TCE and PCE behaved similarly and in a manner consistent with the first stage of the theoretical curve. By convention, the normalized concentration of TCE and PCE equals "1" prior to injection of the bromide solution. During the injection the normalized concentration dropped to that of the injection fluid (C/Co = 0). Following injection, the normalized concentrations of TCE and PCE rose to approximately 0.4 over the first ten gallons pumped. Normalized concentrations of both contaminants rose more slowly to 0.85 until a total of 50 gallons of water had been pumped. Normalized concentrations of TCE and PCE then hovered between 0.85 and 1.0 through the remainder of the bromide stage (total of 150 gallons pumped). Results during the ethanol stage were qualitatively similar to the bromide stage. They did not show the expected concentration increase due to NAPL solubilization. Interestingly, during the ethanol stage, the normalized TCE concentration increased over TCE in the bromide/control stage while normalized PCE decreased versus the PCE in the bromide/control stage. The normalized TCE concentration in the ethanol stage returned to the initial normalized concentration of 1.0.

Results of testing conducted at MSB22 indicate TCE and PCE behaved similarly in the bromide stage with the same trends as the first stage of the theoretical curve and similar to well MSB3D, Figure 5. At the end of the bromide stage extraction, the normalized concentrations for the TCE and PCE returned to C/Co of 0.6. Results of the ethanol stage showed that normalized TCE concentration decreased in relation to TCE in the bromide stage while normalized PCE concentration acted similar to the PCE in the bromide stage.

Results of well MSB9C, Figure 6, show TCE and PCE levels in the bromide stage increased to a peak level greater than C/Co of 1 and then declined to pretest levels. The peak normalized concentrations of about 2.5 were observed at about 80 gallons extracted; concentrations returned to baseline values (C/Co = 1) at the end of the extraction period (150 gallons extracted). Results of the ethanol stage did not follow this same shape. Results of the ethanol stage showed the normalized TCE and PCE concentrations continued to climb throughout the extraction period. Through the first 90 gallons pumped, the TCE concentration in the ethanol stage mirrored that of the TCE concentration in the bromide stage. The normalized TCE concentration in the ethanol test continuously climbed throughout the test ending in a value of 2.7. The normalized PCE concentration in the ethanol test was less than the normalized PCE concentration in the bromide test through the first 130 gallons of water extracted from the well. The normalized PCE concentration in the ethanol test continuously climbed throughout the test. Normalized PCE concentration in the ethanol test exceeded the normalized PCE concentration in the bromide test after 130 gallons of water have been extracted, ending with a normalized concentration of 1.6.

During the testing of MSB15D, Figure 7, TCE and PCE act similarly during the bromide/control test, following the same trend as the first stage of the theoretical curve and the behavior of well MSB3D. Also, TCE and PCE acted similar to each other during the ethanol stage with relative concentrations of PCE being slightly lower than relative concentrations of TCE. Both rise continuously during the ethanol test to a final relative concentration of approximately 0.9. The relative concentrations of both mirror the concentrations of TCE and PCE in the bromide test which are approximately 1.0.

Results of well MHT9D, Figure 8, follow the expected trend in TCE and PCE concentrations – similar to the first stage theoretical curve and the results as in MSB 3Dand most of the other wells. TCE results during the ethanol stage were similar to the TCE in the bromide/control test while PCE concentrations during the ethanol stage was significantly lower than PCE in the bromide/control test. The relative concentrations of TCE in both tests and PCE in the bromide test approach "1", while the PCE in the ethanol test appears to reach a steady state at approximately 0.4. The pre-test concentration of TCE and PCE recorded for the ethanol test was used as the pre-test concentrations for the bromide/control tests. Well MHT9D had not been pumped for a minimum of a year prior to this testing and we did not do extensive pumping of this well prior to collecting the first pre-test sample. Also, the concentrations of TCE and PCE, during the bromide/control test, approached and appeared to plateau at concentrations near the pre-test concentrations of the ethanol test. Thus, we believe the values obtained for the bromide/control pre-test sample (TCE - 0.13 mg/L, PCE - 0.37 mg/L) were not indicative of the actual formation chemistry. Throughout this test difficulties with maintaining a constant flow were experienced. In order to keep sufficient flow over the pump, the flow rate for testing this well was at half the rate of the other tests. Thus, the duration was double the normal test time of 5 hours.

Well MSB11F, Figure 9, had the lowest concentrations of TCE and PCE. Results indicate this well behaved similarly to well MSB15D. The major difference being normalized concentrations of all contaminants measured for both ethanol and bromide test continued to increase to values significantly above "1" in well MSB 11F (i.e., when pumped, TCE and PCE concentrations increase above background or pre-pumping levels). Normalized concentrations of both TCE and PCE increased to 4.0 in well MSB 11F and both stages behaved similar to each other . Injection times for the two tests conducted at this well were approximately 6 and 4 times longer than injection times for the remainder of the tests. This was due to mechanical problems with the pump.

Data for the alcohol injection/extraction tests were analyzed by two laboratories. One laboratory analyzed samples from the bromide test. A second laboratory analyzed samples from the ethanol test and 10 percent of samples from the bromide test. Comparison of results of the two laboratories indicate for TCE the reported values from the second laboratory varied from 10 percent less to 40 percent greater than values reported by the first laboratory. For PCE, the second laboratory reported values 10 to 40 percent greater

than the first laboratory. This was taken into account when evaluating the test data and it was found to have an insignificant effect on the results.

DISCUSSION OF RESULTS

Based on the theoretical behavior of the alcohol injection extraction test, it was expected that a distinct change would be seen in the results of the six test wells: those with very low concentration versus the known or confirmed DNAPL wells. Review of the six graphs, representing the test results, indicate that no distinct difference in concentration response can be seen. There were several findings of note in these results. Further, the results have important implications for the design and operation of remediation systems that are based on enhanced mobilization using alcohols/cosolvents.

In comparing concentrations measured in the two stages, none of the known DNAPL wells exhibited a period of increased concentration of TCE and PCE associated with extraction of ethanol solution. The data appear to be of high quality because (except as noted below) TCE and PCE concentrations in the two stages behaved similarly. For example, in wells where extracted TCE and PCE concentrations started low and built up to original levels, the pattern was repeated in both stages. The two test stages also tracked in wells where concentrations in the extracted solution peaked above C/Co of "1" and then returned to original levels, and in wells where concentrations in the extracted solution continued to increase to levels above C/Co = 1. The original test objectives were based on a very simple concept. In any well with DNAPL near the screen zone, increased solubility of TCE and PCE in ethanol solutions would result in clear and unambiguous concentration increases during the ethanol stage versus the water/bromide stage. The fact that known DNAPL wells do not exhibit this behavior indicates the injected alcohol solution is not spreading into the subsurface in the DNAPL zone/layer. The alcohol solution is not interrogating the subsurface within the DNAPL zone, even on the small scale of this test. An important factor contributing to the lack of the juxtaposition of alcohol and DNAPL are their relative densities. DNAPL has a density greater than water and will be present in the lowest portion of the aquifer and screen. The alcohol solution has a density less than water and will tend to exit the screen as high as possible and move slightly upward during the test (Figure 10). Thus, even over the scale of one to two meters, the ethanol solution is not effectively contacting DNAPL. This behavior has two important implications. First, it suggests that the scale of alcohol based techniques for characterizing subsurface DNAPL is critical – microscale testing using a cone penetrometer may provide better data because the juxtaposition of the alcohol solution and the DNAPL can be more explicitly controlled. Second, such a behavior indicates that alcohol and cosolvent based remediation system design needs to carefully account for the geometry of the field situation and the tendency of solutions to separate in the subsurface.

A modest, but consistent, difference was observed between the two stages in four of the six wells tested (MHT9D, MSB9C, MSB3D and MSB 22) In these wells, PCE in the ethanol stage decreased slightly in relation to PCE in the bromide/control stage, and/or TCE in the ethanol test increased versus TCE in the bromide/control stage. If this observation proves significant, it may indicate conversion of PCE to TCE during the ethanol stage. One mechanism that would result in such conversion is biological activity stimulated by introduction of ethanol; resulting in, anaerobic dechlorination of PCE to TCE. Such a mechanism is consistent with PCE not reaching the pre-test concentration and for TCE exceeding the pre-test concentration. Further study and replication would be required to confirm this finding and determine a mechanism.

Various observed concentration-time profiles during the water/bromide stage (and the subsequent ethanol stage) did not correlate with initial concentrations or known DNAPL status. This is seen in the behaviors of wells MHT9D (second lowest concentration well) and MSB3D (a known DNAPL well). In these wells, concentrations of TCE and PCE in the extracted water started low and increased to initial concentrations (similar to the water stage of the expected theoretical curve). Two other concentration-time profiles were observed: a) a peak in the concentration graph in the middle of extraction, and b) normalized

concentrations increasing well above "1". These different behaviors did not have any clear relationship to initial TCE and PCE concentration or other measure of DNAPL status (e.g., percent of solubility). Rather than being a direct measure of DNAPL status, qualitative concentration-time profiles are probably general indicators of whether a well is in an area with relatively stable local concentrations or in an area of significant local concentration gradient. Thus, it is possible that known DNAPL wells (which trend toward solubility) and relatively low concentration wells distant from DNAPL sources will both exhibit the expected profile seen in MSB3D and MHT9D.

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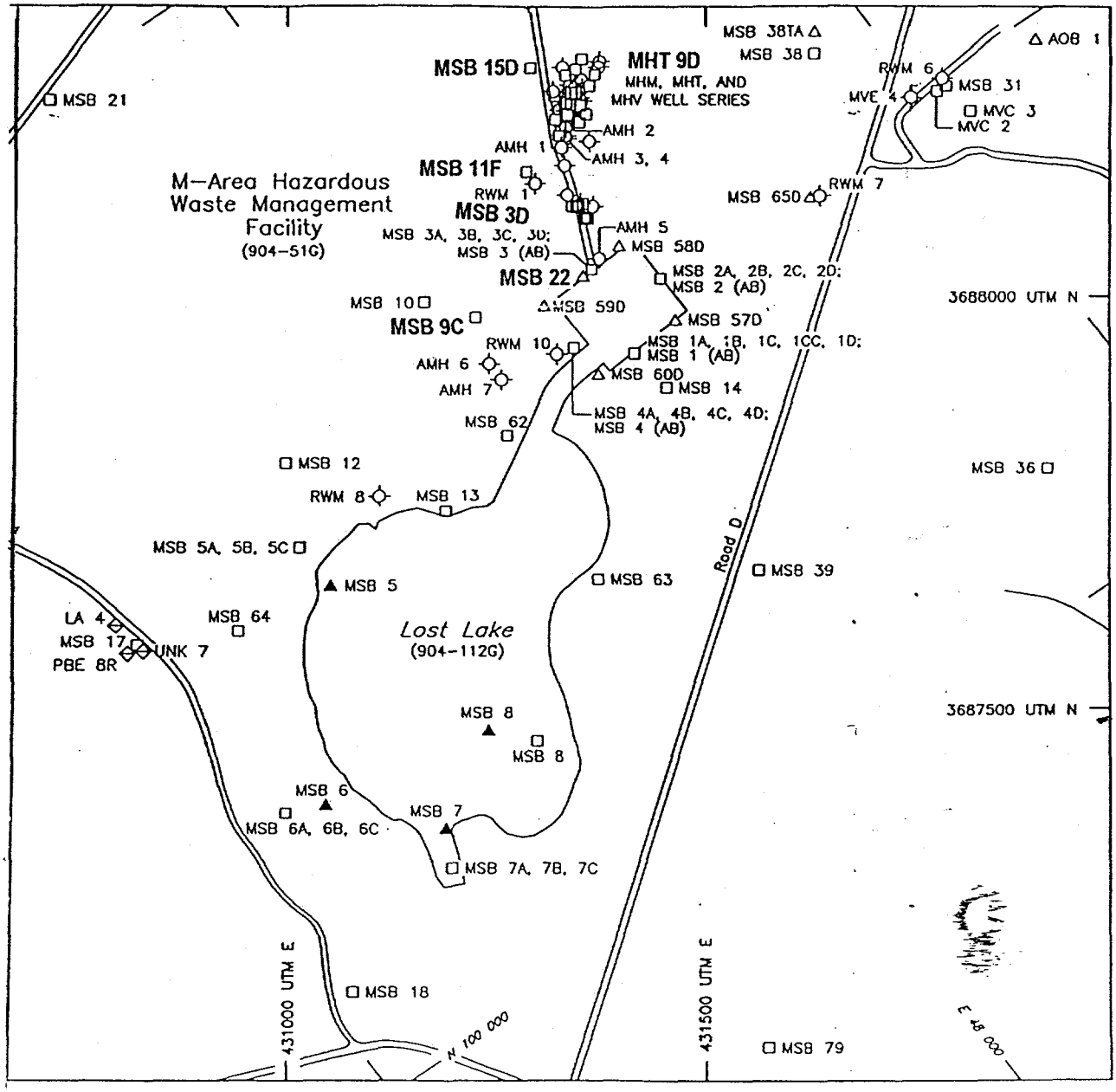
Looney, B.B, K. M. Jerome, S. Burdick, J. Rossabi, T.R. Jarosch, C.A. Eddy-Dilek, Test Plan for Single Well Injection/Extraction Characterization of DNAPL, Prepared for the U.S. Department of Energy under Contract No. DE-AC09-89SR18035, WSRC-RP-95-849.



Test wells are identified in bold text.

Figure 1 Area Map of the Alcohol Injection/Extraction Test Site, Located Adjacent to the M-Area Hazardous Waste Management Facility, including Identification of Test Wells

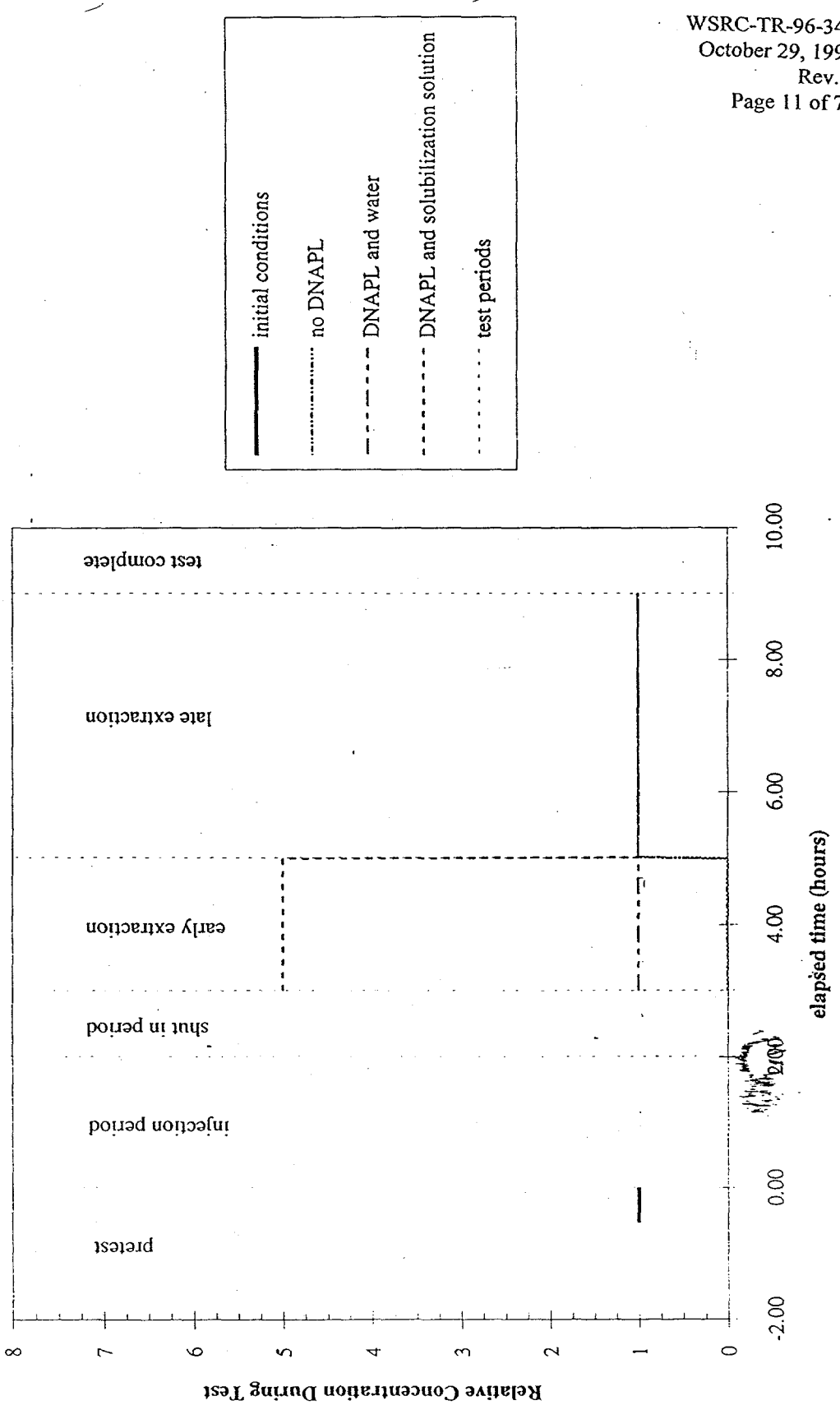


Figure 2 Theoretical Behavior of Small Scale Injection/Extraction Test (DNAPL Characterization)

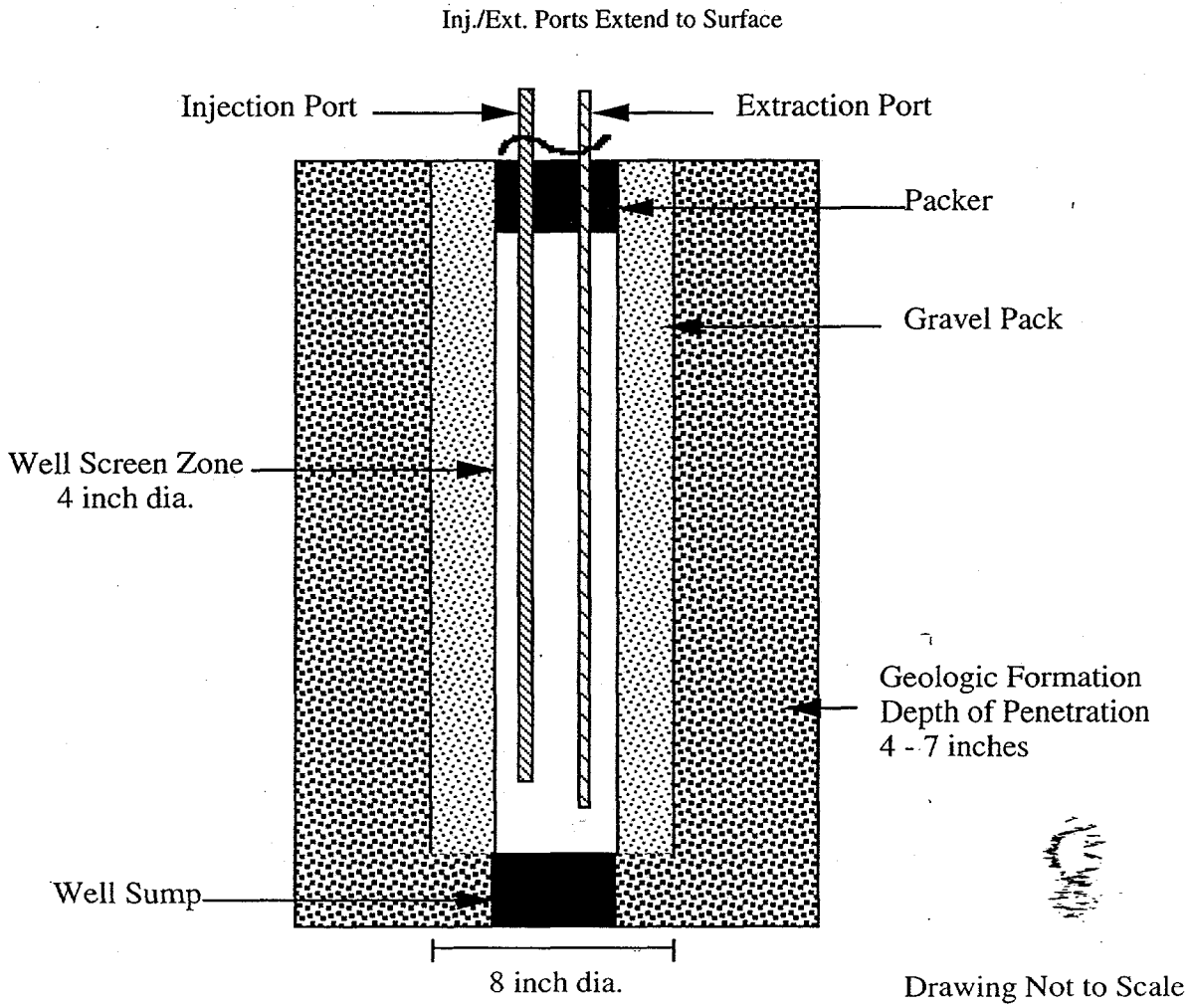


Figure 3 Representation of Test Equipment Inside the Test Wells

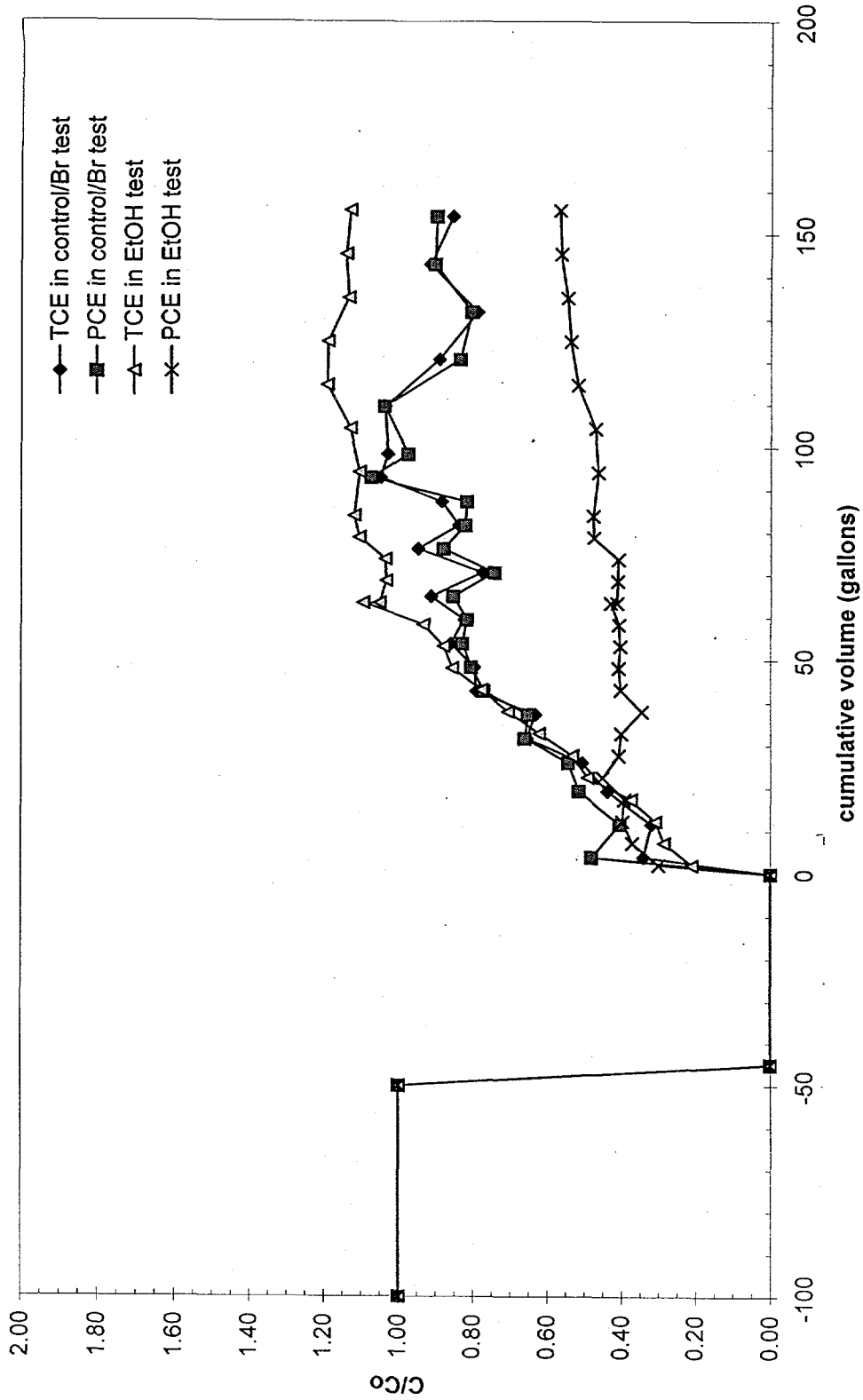


Figure 4 Results of Alcohol Injection/Extraction Test for Well MSB3D, Normalized Concentrations of TCE and PCE versus Gallons of Water Pumped

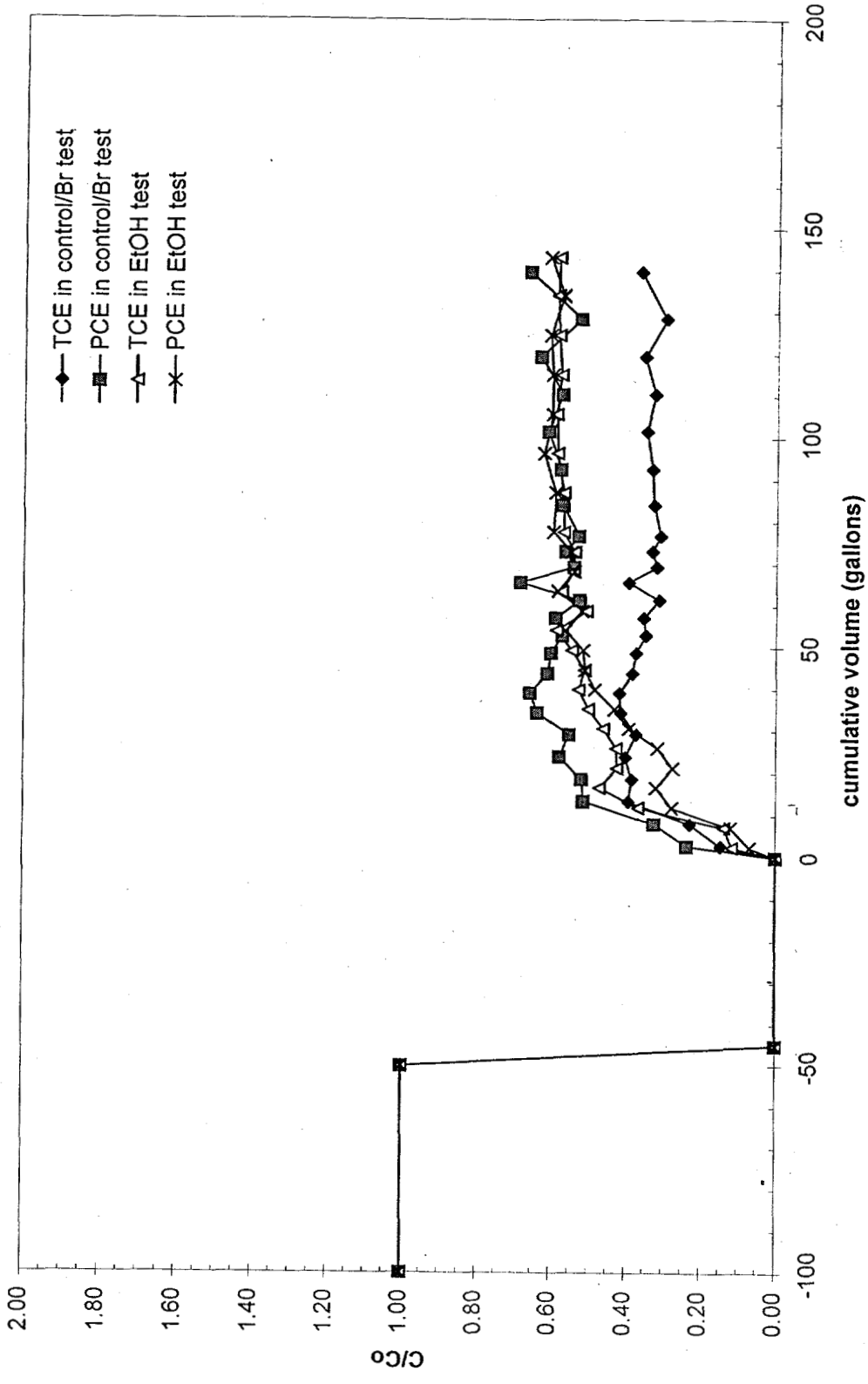


Figure 5 Results of Alcohol Injection/Extraction Test for Well MSB22, Normalized Concentrations of TCE and PCE versus Gallons of Water Pumped

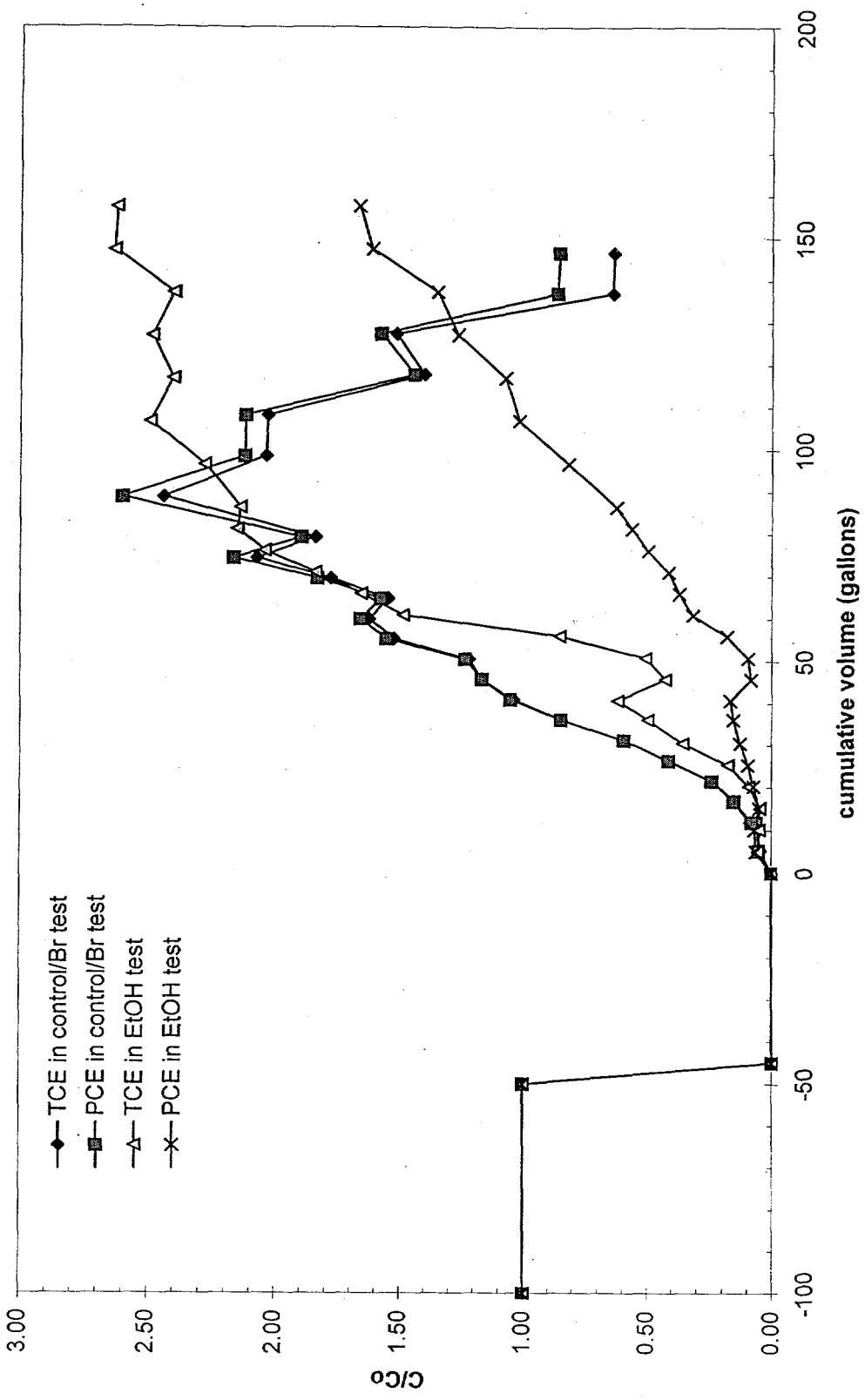


Figure 6 Results of Alcohol Injection/Extraction Test for Well MSB9C, Normalized Concentrations of TCE and PCE versus Gallons of Water Pumped

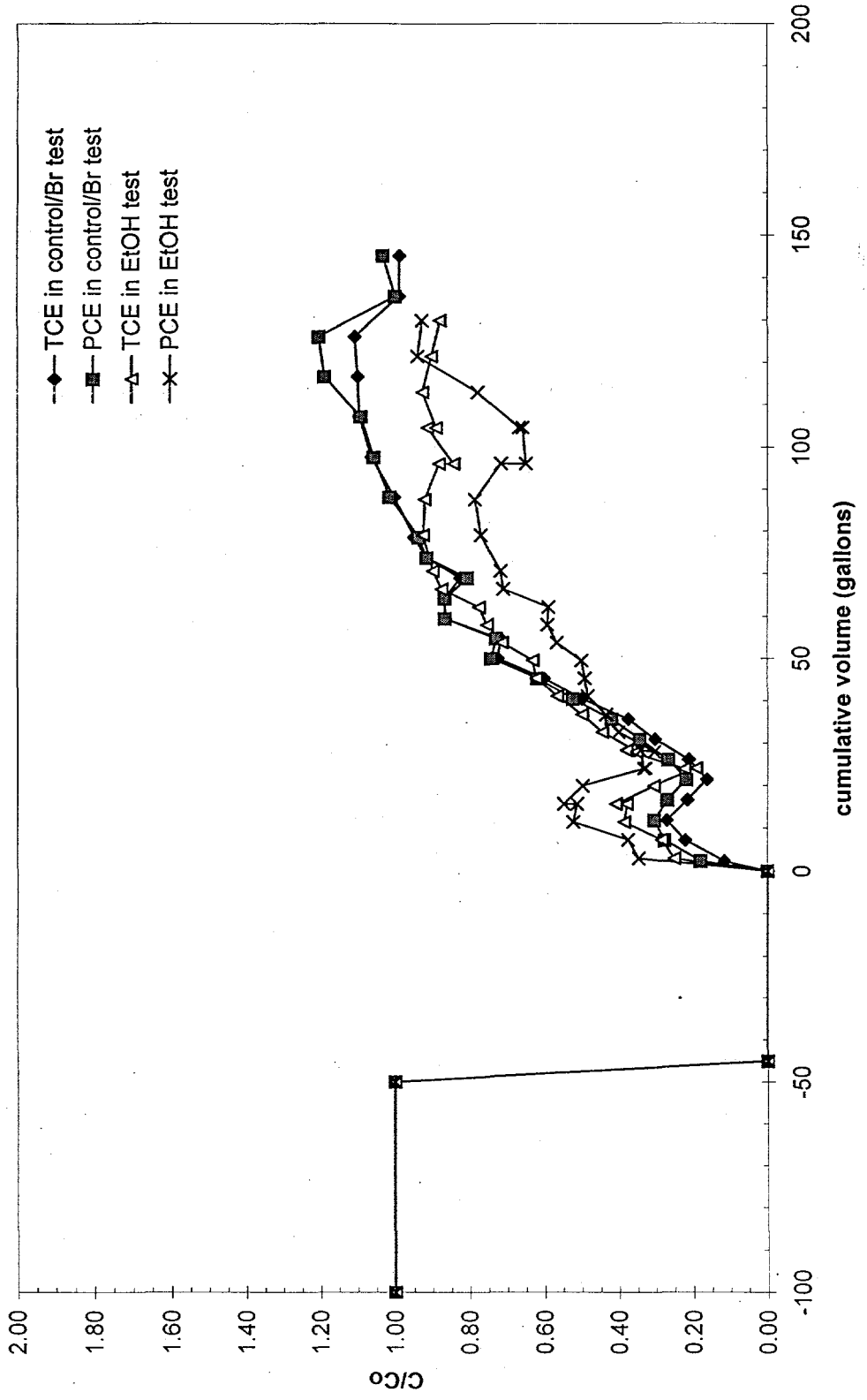


Figure 7 Results of Alcohol Injection/Extraction Test for Well MSB15D, Normalized Concentrations of TCE and PCE versus Gallons of Water Pumped

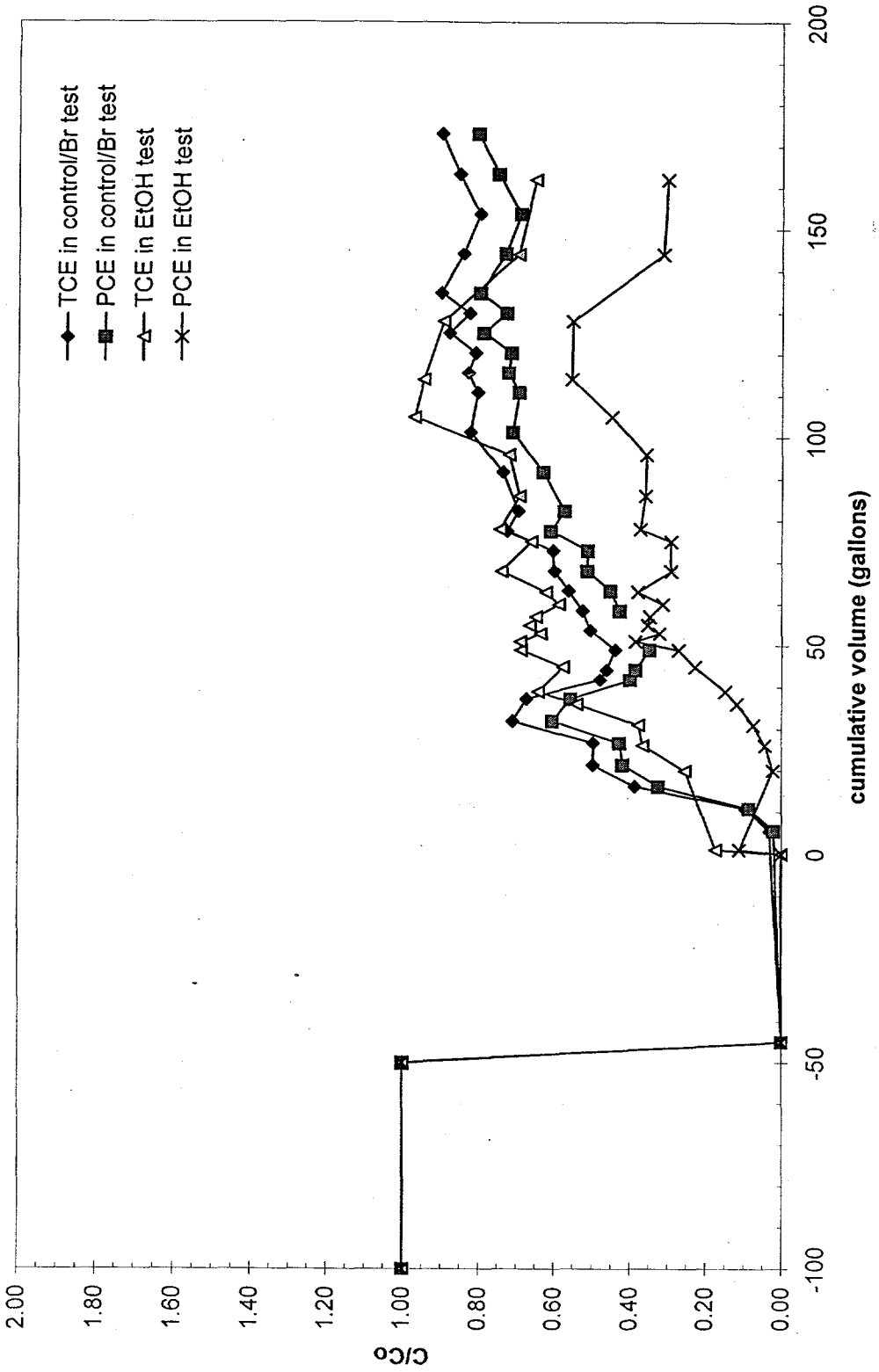


Figure 8 Results of Alcohol Injection/Extraction Test for Well MHT9D, Normalized Concentrations of TCE and PCE versus Gallons of Water Pumped

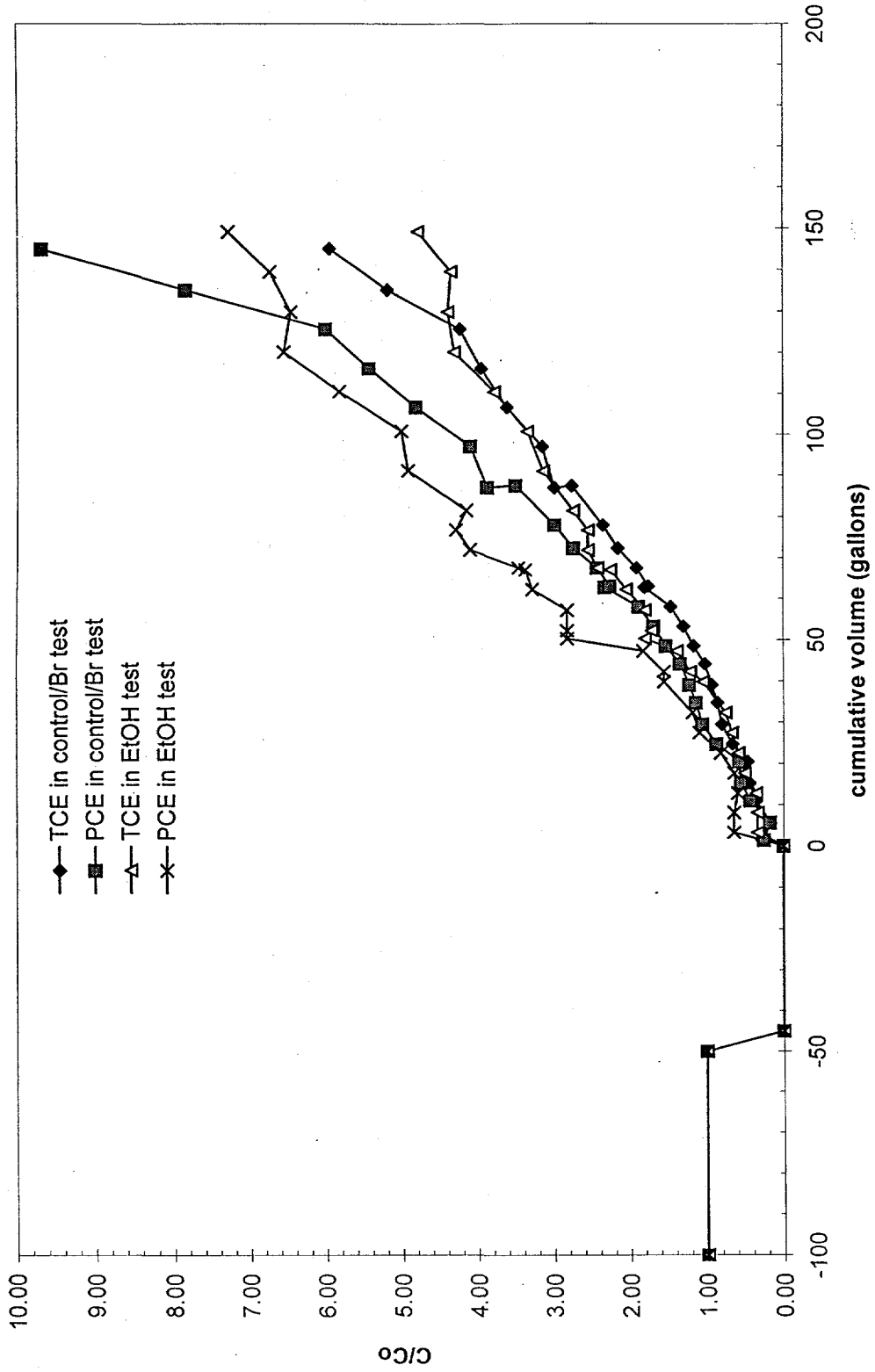


Figure 9 Results of Alcohol Injection/Extraction Test for Well MSB11F, Normalized Concentrations of TCE and PCE versus Gallons of Water Pumped

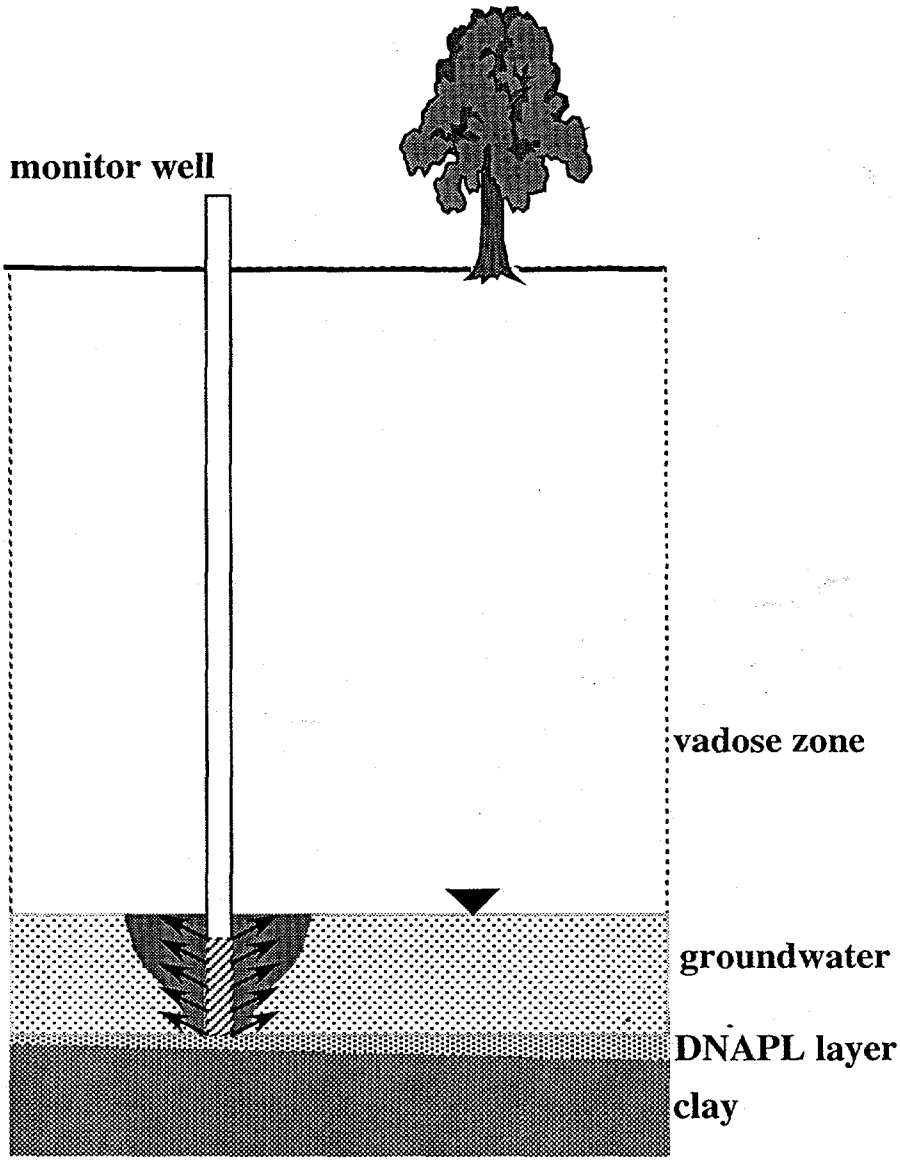


Figure 10 Representation of Behavior of Alcohol and DNAPL in the Subsurface

APPENDIX A

CONCENTRATION AND MASS BALANCE DATA

FOR THE SIX WELLS TESTED

AS PART OF

THE ALCOHOL INJECTION/EXTRACTION TEST

This appendix contains the following information for each of the six wells tested:

- Mass Balance on Bromide for Stage 1 tests
- Mass Balance on Ethanol for Stage 2 tests
- Concentration Data from Bromide Stage tests
- Concentration Data from Ethanol Stage tests
- Table of C/Co data versus volume for both Bromide/Control Stage tests and Ethanol Stage tests
- Graph of PCE and TCE concentrations from Bromide Stage tests
- Graph of PCE and TCE concentrations from Ethanol Stage tests

WELL MSB11F

Injection/ Extraction DNAPL Characterization Study
Test Data for Bromide Tracer at Well MSB11F

Extraction Data

Date	Time	Volume (gallons)	Conc. (mg/L)	Sample	Br- (mg)	Cum. Br- (mg)	Volume Cum. (gallons)
17-Jun	15:48	1.4	109.57	00	592	592	1
	15:57	4.3	76.04	01	1232	1824	6
	16:08	5.2	72.24	02	1430	3254	11
	16:17	4.3	67.65	03	1096	4350	15
	16:28	5.2	61.48	04	1217	5567	20
	16:37	4.3	65.68	05	1064	6631	25
	16:47	4.8	72.76	06	1310	7941	29
	16:58	5.2	63.00	07	1247	9188	35
	17:07	4.3	56.78	08	920	10108	39
	17:18	5.2	55.00	09	1089	11197	44
	17:27	4.3	48.28	10	782	11979	49
	17:37	4.8	42.01	11	756	12735	53
	17:47	4.8	36.43	12	656	13391	58
	17:57	4.8	32.10	13	578	13969	63
	18:07	4.8	26.18	14	471	14440	68
	18:17	4.8	20.86	15	375	14816	72
	18:27	5.7	17.20	16	372	15187	78
	18:47	9.5	10.64	17	383	15570	87
	19:07	9.5	6.84	18	246	15816	97
	19:27	9.5	4.63	19	167	15983	107
	19:47	9.5	3.51	20	126	16109	116
	20:07	9.5	2.54	21	91	16201	126
	20:27	9.5	2.04	22	73	16274	135
	20:48	10.0	1.69	23	64	16338	145

Total gallons removed: 145 gallons
Total Bromide removed: 16338 mg
% Bromide removed: 96.36 %

Extraction Start: 15:45 Extraction Complete: 20:48

Injection Data Injection Start: 9:36 Injection Complete: 15:25

Injected Volume (gallons)	Conc. (mg/L)	Total Br- Added (mg)
55.00	81.44	16956

Injection/ Extraction DNAPL Characterization Study
Test Data for Ethanol Injection at Well MSB11F

Extraction Data

Date	Time	Volume (gallons)	Conc. (vol %)	Sample	EtOH (gallons)	Cum. EtOH (gallons)	Volume Cum. (gallons)
19-Jun	13:30	3.33	22.7	00	0.76	0.76	3.33
	13:40	4.28	14.4	01	0.62	1.37	7.61
	13:50	5.23	12.5	02	0.65	2.03	12.84
	14:00	4.28	11.9	03	0.51	2.53	17.12
	14:10	5.23	9.8	04	0.51	3.05	22.35
	14:20	4.28	10.3	05	0.44	3.49	26.63
	14:30	4.76	9.4	06	0.45	3.94	31.38
	14:45	7.13	8.2	07	0.58	4.52	38.52
	14:50	2.38	9.6	08	0.23	4.75	40.89
	15:00	4.76	7.6	09	0.36	5.11	45.65
	15:10	4.76	6.3	10	0.30	5.41	50.40
	15:20	4.76	5.8	11	0.28	5.69	55.16
	15:30	4.76	5.7	12	0.27	5.96	59.91
	15:40	4.76	4.6	13	0.22	6.17	64.67
	15:50	4.76	4.2	14	0.20	6.37	69.42
	16:00	4.76	4.3	15	0.20	6.58	74.18
	16:10	5.71	3.5	16	0.20	6.78	79.89
	16:30	9.51	3.0	17	0.29	7.06	89.40
	16:50	9.51	2.5	18	0.24	7.30	98.91
	17:10	9.51	1.9	19	0.18	7.48	108.42
	17:30	9.51	1.5	20	0.14	7.63	117.93
	17:50	9.51	1.2	21	0.11	7.74	127.44
	18:10	9.51	1.0	22	0.10	7.83	136.95
	18:30	9.99	0.7	23	0.07	7.90	146.93

Total gallons removed: 146.93 gallons
Total Alcohol removed: 7.90 gallons
% alcohol removed: 62.73 %

Extraction Start: 13:23 Extraction Complete: 18:31

Injection Data Injection Start: 9:48 Injection Complete: 13:20

Injected Volume (gallons)	Conc. (vol%)	Total Alcohol Added (gallons)
50.40	25	12.60

Concentration Data for MSB11F

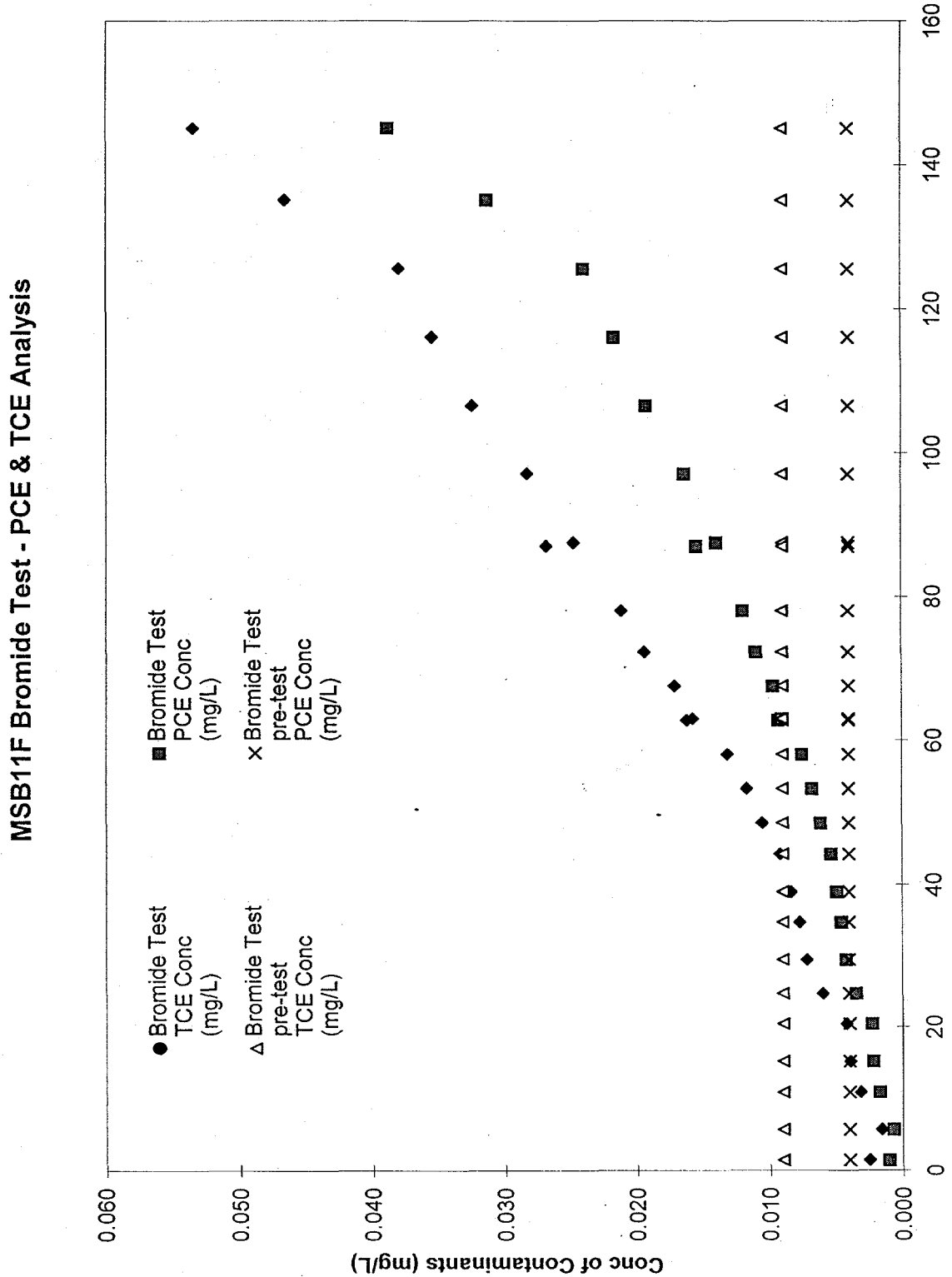
Sample ID	Sample Collection Information	Cumulative Volume (gallons)	Bromide Test TCE Conc (mg/L)	Bromide Test PCE Conc (mg/L)	Bromide Test pre-test TCE Conc (mg/L)	Bromide Test pre-test PCE Conc (mg/L)
MSB - 1100 A	SAMPLE DATE 06-17-96 TIME 15:48	1	0.003	0.001	0.009	0.004
MSB - 1101 A	SAMPLE DATE 06-17-96 TIME 15:57	6	0.002	0.001	0.009	0.004
MSB - 1102 A	SAMPLE DATE 06-17-96 TIME 16:08	11	0.003	0.002	0.009	0.004
MSB - 1103 A	SAMPLE DATE 06-17-96 TIME 16:17	15	0.004	0.002	0.009	0.004
MSB - 1104 A	SAMPLE DATE 06-17-96 TIME 16:28	20	0.004	0.002	0.009	0.004
MSB - 1105 A	SAMPLE DATE 06-17-96 TIME 16:37	25	0.006	0.003	0.009	0.004
MSB - 1106 A	SAMPLE DATE 06-17-96 TIME 16:47	29	0.007	0.004	0.009	0.004
MSB - 1107 A	SAMPLE DATE 06-17-96 TIME 16:58	35	0.008	0.005	0.009	0.004
MSB - 1108 A	SAMPLE DATE 06-17-96 TIME 17:07	39	0.008	0.005	0.009	0.004
MSB - 1109 A	SAMPLE DATE 06-17-96 TIME 17:18	44	0.009	0.005	0.009	0.004
MSB - 1110 A	SAMPLE DATE 06-17-96 TIME 17:27	49	0.010	0.006	0.009	0.004
MSB - 1111 A	SAMPLE DATE 06-17-96 TIME 17:37	53	0.012	0.007	0.009	0.004
MSB - 1112 A	SAMPLE DATE 06-17-96 TIME 17:47	58	0.013	0.008	0.009	0.004
MSB - 1113 A	SAMPLE DATE 06-17-96 TIME 17:57	63	0.016	0.009	0.009	0.004
MSB - 11 D 2 A	SAMPLE DATE 06-17-96 TIME 17:57	63	0.016	0.009	0.009	0.004
MSB - 1114 A	SAMPLE DATE 06-17-96 TIME 18:07	68	0.017	0.010	0.009	0.004
MSB - 1115 A	SAMPLE DATE 06-17-96 TIME 18:17	72	0.019	0.011	0.009	0.004
MSB - 1116 A	SAMPLE DATE 06-17-96 TIME 18:27	78	0.021	0.012	0.009	0.004
MSB - 1117 A	SAMPLE DATE 06-17-96 TIME 18:47	87	0.025	0.014	0.009	0.004
MSB - 11 D 1 A	SAMPLE DATE 06-17-96 TIME 18:47	87	0.027	0.015	0.009	0.004
MSB - 1118 A	SAMPLE DATE 06-17-96 TIME 19:07	97	0.028	0.016	0.009	0.004
MSB - 1119 A	SAMPLE DATE 06-17-96 TIME 19:27	107	0.032	0.019	0.009	0.004
MSB - 1120 A	SAMPLE DATE 06-17-96 TIME 19:47	116	0.035	0.022	0.009	0.004
MSB - 1121 A	SAMPLE DATE 06-17-96 TIME 20:07	126	0.038	0.024	0.009	0.004
MSB - 1122 A	SAMPLE DATE 06-17-96 TIME 20:27	135	0.047	0.031	0.009	0.004
MSB - 1123 A	SAMPLE DATE 06-17-96 TIME 20:47	145	0.053	0.039	0.009	0.004

Concentration Data for MSB11F

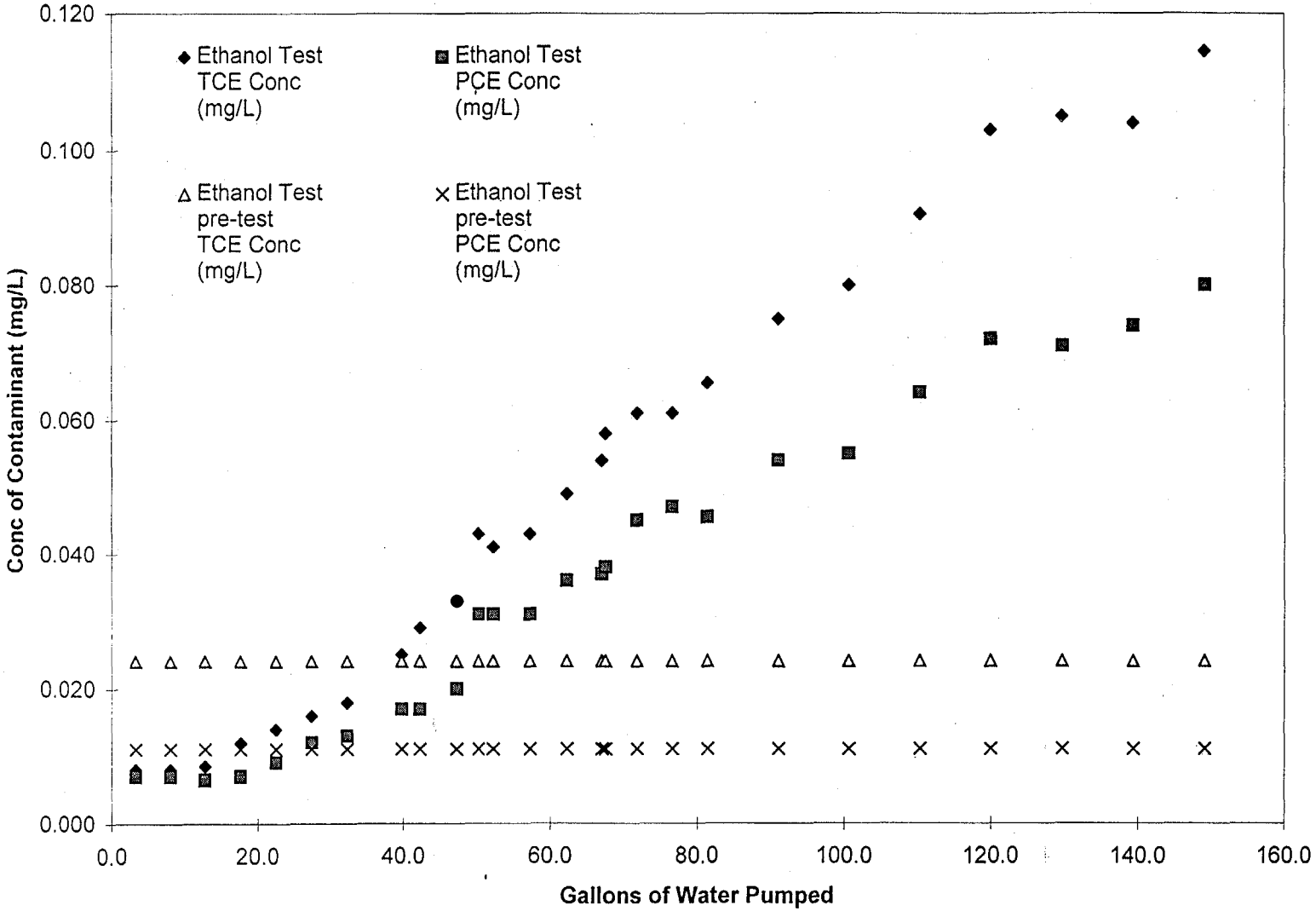
Sample ID	Sample Collection Information	Cumulative Volume (gallons)	Ethanol Test TCE Conc (mg/L)	Ethanol Test PCE Conc (mg/L)	Ethanol Test pre-test TCE Conc (mg/L)	Ethanol Test pre-test PCE Conc (mg/L)
MSB - 1100 A	SAMPLE DATE 06-17-96 TIME 15:48	3.3	0.008	0.007	0.024	0.011
MSB - 1101 A	SAMPLE DATE 06-17-96 TIME 15:57	8.0	0.008	0.007	0.024	0.011
MSB - 1102 A	SAMPLE DATE 06-17-96 TIME 16:08	12.8	0.009	0.007	0.024	0.011
MSB - 1103 A	SAMPLE DATE 06-17-96 TIME 16:17	17.7	0.012	0.007	0.024	0.011
MSB - 1104 A	SAMPLE DATE 06-17-96 TIME 16:28	22.5	0.014	0.009	0.024	0.011
MSB - 1105 A	SAMPLE DATE 06-17-96 TIME 16:37	27.4	0.016	0.012	0.024	0.011
MSB - 1106 A	SAMPLE DATE 06-17-96 TIME 16:47	32.3	0.018	0.013	0.024	0.011
MSB - 1107 A	SAMPLE DATE 06-17-96 TIME 16:58	39.8	0.025	0.017	0.024	0.011
MSB - 1108 A	SAMPLE DATE 06-17-96 TIME 17:07	42.3	0.029	0.017	0.024	0.011
MSB - 1109 A	SAMPLE DATE 06-17-96 TIME 17:18	47.3	0.033	0.020	0.024	0.011
MSB - 11D1	SAMPLE DATE 06-17-96 TIME 17:27	50.3	0.043	0.031	0.024	0.011
MSB - 1110 A	SAMPLE DATE 06-17-96 TIME 17:37	52.3	0.041	0.031	0.024	0.011
MSB - 1111 A	SAMPLE DATE 06-17-96 TIME 17:47	57.2	0.043	0.031	0.024	0.011
MSB - 1112 A	SAMPLE DATE 06-17-96 TIME 17:57	62.2	0.049	0.036	0.024	0.011
MSB - 1113 A	SAMPLE DATE 06-17-96 TIME 17:57	67.0	0.054	0.037	0.024	0.011
MSB - 11D2	SAMPLE DATE 06-17-96 TIME 18:07	67.5	0.058	0.038	0.024	0.011
MSB - 1114 A	SAMPLE DATE 06-17-96 TIME 18:17	71.8	0.061	0.045	0.024	0.011
MSB - 1115 A	SAMPLE DATE 06-17-96 TIME 18:27	76.6	0.061	0.047	0.024	0.011
MSB - 1116 A	SAMPLE DATE 06-17-96 TIME 18:47	81.4	0.066	0.046	0.024	0.011
MSB - 1117 A	SAMPLE DATE 06-17-96 TIME 18:47	91.1	0.075	0.054	0.024	0.011
MSB - 1118 A	SAMPLE DATE 06-17-96 TIME 19:07	100.7	0.080	0.055	0.024	0.011
MSB - 1119 A	SAMPLE DATE 06-17-96 TIME 19:27	110.3	0.091	0.064	0.024	0.011
MSB - 1120 A	SAMPLE DATE 06-17-96 TIME 19:47	120.0	0.103	0.072	0.024	0.011
MSB - 1121 A	SAMPLE DATE 06-17-96 TIME 20:07	129.7	0.105	0.071	0.024	0.011
MSB - 1122 A	SAMPLE DATE 06-17-96 TIME 20:27	139.4	0.104	0.074	0.024	0.011
MSB - 1123 A	SAMPLE DATE 06-17-96 TIME 20:47	149.1	0.115	0.080	0.024	0.011

MSB11F Data Used
in Chart of C/Co vs volume

Results for Control/Bromide Test					Results for Ethanol Inj-Ext Test				
volume (gallons)	TCE (mg/L)	PCE (mg/L)	TCE (C/Co)	PCE (C/Co)	volume (gallons)	TCE (mg/L)	PCE (mg/L)	TCE (C/Co)	PCE (C/Co)
-100	0.009	0.004	1.00	1.00	-100	0.024	0.011	1.00	1.00
-50	0.009	0.004	1.00	1.00	-50	0.024	0.011	1.00	1.00
-45	0	0	0.00	0.00	-45	0	0	0.00	0.00
0	0	0	0.00	0.00	0	0	0	0.00	0.00
1	0.003	0.001	0.28	0.25	3.3	0.008	0.007	0.33	0.64
6	0.002	0.001	0.18	0.17	8.0	0.008	0.007	0.33	0.64
11	0.003	0.002	0.35	0.43	12.8	0.009	0.007	0.35	0.59
15	0.004	0.002	0.44	0.55	17.7	0.012	0.007	0.50	0.64
20	0.004	0.002	0.47	0.57	22.5	0.014	0.009	0.58	0.82
25	0.006	0.003	0.66	0.87	27.4	0.016	0.012	0.67	1.09
29	0.007	0.004	0.80	1.05	32.3	0.018	0.013	0.75	1.18
35	0.008	0.005	0.86	1.14	39.8	0.025	0.017	1.04	1.55
39	0.008	0.005	0.93	1.22	42.3	0.029	0.017	1.21	1.55
44	0.009	0.005	1.02	1.34	47.3	0.033	0.020	1.38	1.82
49	0.010	0.006	1.17	1.52	50.3	0.043	0.031	1.79	2.82
53	0.012	0.007	1.30	1.68	52.3	0.041	0.031	1.71	2.82
58	0.013	0.008	1.46	1.88	57.2	0.043	0.031	1.79	2.82
63	0.016	0.009	1.80	2.32	62.2	0.049	0.036	2.04	3.27
63	0.016	0.009	1.75	2.26	67.0	0.054	0.037	2.25	3.36
68	0.017	0.010	1.90	2.42	67.5	0.058	0.038	2.42	3.45
72	0.019	0.011	2.15	2.73	71.8	0.061	0.045	2.54	4.09
78	0.021	0.012	2.35	2.98	76.6	0.061	0.047	2.54	4.27
87	0.025	0.014	2.75	3.49	81.4	0.066	0.046	2.73	4.14
87	0.027	0.015	2.98	3.86	91.1	0.075	0.054	3.13	4.91
97	0.028	0.016	3.14	4.08	100.7	0.080	0.055	3.33	5.00
107	0.032	0.019	3.60	4.81	110.3	0.091	0.064	3.77	5.82
116	0.035	0.022	3.94	5.43	120.0	0.103	0.072	4.29	6.55
126	0.038	0.024	4.22	6.00	129.7	0.105	0.071	4.38	6.45
135	0.047	0.031	5.18	7.83	139.4	0.104	0.074	4.33	6.73
145	0.053	0.039	5.94	9.69	149.1	0.115	0.080	4.77	7.27


MSB11F Bromide Test - PCE & TCE Analysis
Conc of Contaminants (mg/L)
0.060
0.050
0.040
0.030
0.020
0.010
0.000
0
20
40
60
80
100
120
140
160
Gallons of Water Pumped
● Bromide Test TCE Conc (mg/L)
■ Bromide Test PCE Conc (mg/L)
Δ Bromide Test pre-test TCE Conc (mg/L)
× Bromide Test pre-test PCE Conc (mg/L)

MSB11F Ethanol Test - TCE and PCE Analysis



WELL MHT9D

Injection/ Extraction DNAPL Characterization Study
Test Data for Bromide Tracer at Well MHT9D

Extraction Data

Date	Time	Volume (gallons)	Concentration (mg/L)	Sample	Br- (mg)	Cum. Br- (mg)	Volume Cum. (gallons)
25-Jun	9:50	2.38	99.59	00	896.31	896	2
	10:00	4.76	90.02	01	1620.36	2517	7
	10:10	4.76	67.73	02	1219.14	3736	12
	10:20	4.76	48.33	03	869.94	4606	17
	10:30	4.76	43.53	04	783.54	5389	21
	10:40	4.76	26.35	05	474.30	5864	26
	10:50	4.76	65.15	06	1172.70	7036	31
	11:00	4.76	61.34	07	1104.12	8140	36
	11:10	4.76	59.60	08	1072.80	9213	40
	11:24	2.38	46.21	09	415.89	9629	43
	11:30	2.38	49.73	10	447.57	10077	45
	11:40	2.38	48.04	11	432.36	10509	48
	11:50	2.38	59.24	12	533.16	11042	50
	12:00	2.38	50.55	13	454.95	11497	52
	12:11	2.38	40.51	14	364.59	11862	55
	12:24	2.38	26.42	15	237.78	12100	57
	12:38	2.38	28.12	16	253.08	12353	59
	13:36	0.48	27.55	17	49.59	12402	60

Total gallons removed: 16 gallons
Total Bromide removed: 12402 mg/L
% Bromide removed: 62.10 %

Extraction Start: 9:45 Extraction Complete: 15:15

Injection Data Injection Start: 8:36 Injection Complete: 9:39

Injected Volume (gallons)	Conc. (mg/L)	Total Br- Added (mg)
51	102.99	19970

Note: Due to problems with pump not pumping continuously, discontinued test.

Injection/ Extraction DNAPL Characterization Study
Test Data for Bromide Tracer at Well MHT9D (second test)

Extraction Data

Date	Time	Volume (gallons)	Concentration (mg/L)	Sample	Br- (mg)	Cum. Br- (mg)	Volume Cum. (gallons)
1-Jul	8:33	5.84	88.20	00	1949.68	1950	6
	8:43	5.28	78.59	01	1571.80	3521	11
	8:53	5.28	49.64	02	992.80	4514	16
	9:03	5.28	37.48	03	749.60	5264	22
	9:13	5.28	36.55	04	731.00	5995	27
	9:23	5.28	23.87	05	477.40	6472	32
	9:33	5.28	37.27	06	745.40	7218	38
	9:43	2.40	46.78	07	424.23	7642	40
	9:53	2.88	43.19	08	470.25	8112	43
	10:13	4.90	43.46	09	806.32	8918	48
	10:33	5.69	37.32	10	804.52	9723	53
	10:53	3.92	33.82	11	501.35	10224	57
	11:13	2.41	29.39	12	268.53	10493	60
	11:33	4.06	26.82	13	412.49	10905	64
	11:53	4.65	22.93	14	403.46	11309	68
	12:13	5.04	18.53	15	353.70	11663	73
	12:33	4.72	15.33	16	273.96	11936	78
	13:13	9.29	11.21	17	394.20	12331	88
	13:53	9.49	7.90	18	283.83	12615	97
	14:33	8.85	6.44	19	215.75	12830	106
	14:53	9.68	5.53	20	202.55	13033	116
	15:13	4.60	5.12	21	89.15	13122	120
	15:33	4.60	4.47	22	77.83	13200	125
	15:53	4.60	4.16	23	72.43	13272	129
	16:13	4.71	3.80	24	67.76	13340	134
	16:53	9.68	2.58	25	94.51	13434	144
	17:34	7.99	2.40	26	72.60	13507	152
	18:13	10.36	2.04	27	80.00	13587	162
	18:53	9.45	1.76	28	62.98	13650	172

Total gallons removed: 172 gallons
Total Bromide removed: 13650 mg
% Bromide removed: 84.12 %

Extraction Start: 8:26 Extraction Complete: 18:54

Injection Data Injection Start: 7:21 Injection Complete: 8:25

Injected Volume (gallons)	Conc. (mg/L)	Total Br- Added (mg)
50	84.98	16227

Injection/ Extraction DNAPL Characterization Study
Test Data for Ethanol Injection at Well MHT9D

Extraction Data

Date	Time	Volume (gallons)	Conc. (vol %)	Sample	EtOH (gallons)	Cum. EtOH (gallons)	Volume Cum. (gallons)
9-Jul	9:40	1.63	16.39	00	0.27	0.27	1.63
	10:00	6.29	6.91	01	0.43	0.70	7.92
	10:20	5.97	7.73	02	0.46	1.16	13.89
	10:40	5.60	6.43	03	0.36	1.52	19.49
	11:00	4.83	5.19	04	0.25	1.77	24.32
	11:20	2.72	4.68	05	0.13	1.90	27.04
	11:40	6.03	2.94	06	0.18	2.08	33.07
	12:00	3.80	0.47	07	0.02	2.10	36.87
	12:20	2.10	0.96	08	0.02	2.12	38.97
	12:40	1.88	2.29	09	0.04	2.16	40.85
	13:00	1.89	2.40	10	0.05	2.21	42.74
	13:20	1.94	3.52	11	0.07	2.27	44.68
	13:40	2.15	2.85	12	0.06	2.33	46.83
	14:00	2.34	2.71	13	0.06	2.40	49.17
	14:38	4.81	1.75	14	0.08	2.48	53.98
	15:20	6.55	1.56	15	0.10	2.58	60.53
	16:00	2.99	1.35	16	0.04	2.62	63.52
	17:18	8.69	0.99	17	0.09	2.71	72.21
	18:40	9.18	0.74	18	0.07	2.78	81.39
	20:00	8.80	0.80	19	0.07	2.85	90.19
	21:20	9.60	0.57	20	0.05	2.90	99.79
	22:50	12.84	0.37	21	0.05	2.95	112.63
10-Jul	0:50	16.37	0.30	22	0.05	3.00	129.00
	2:50	17.70	0.20	23	0.04	3.04	146.7

Total gallons removed: 146.7 gallons
Total Alcohol removed: 3.04 gallons
% alcohol removed: 139.76 %

Extraction Start: 9:35 Extraction Complete: 2:50

Injection Data Injection Start: 8:30 Injection Complete: 9:34

Injected Volume (gallons)	Conc. (vol%)	Total Alcohol Added (gallons)
50.4	4.31	2.17

Concentration Data for MHT9D

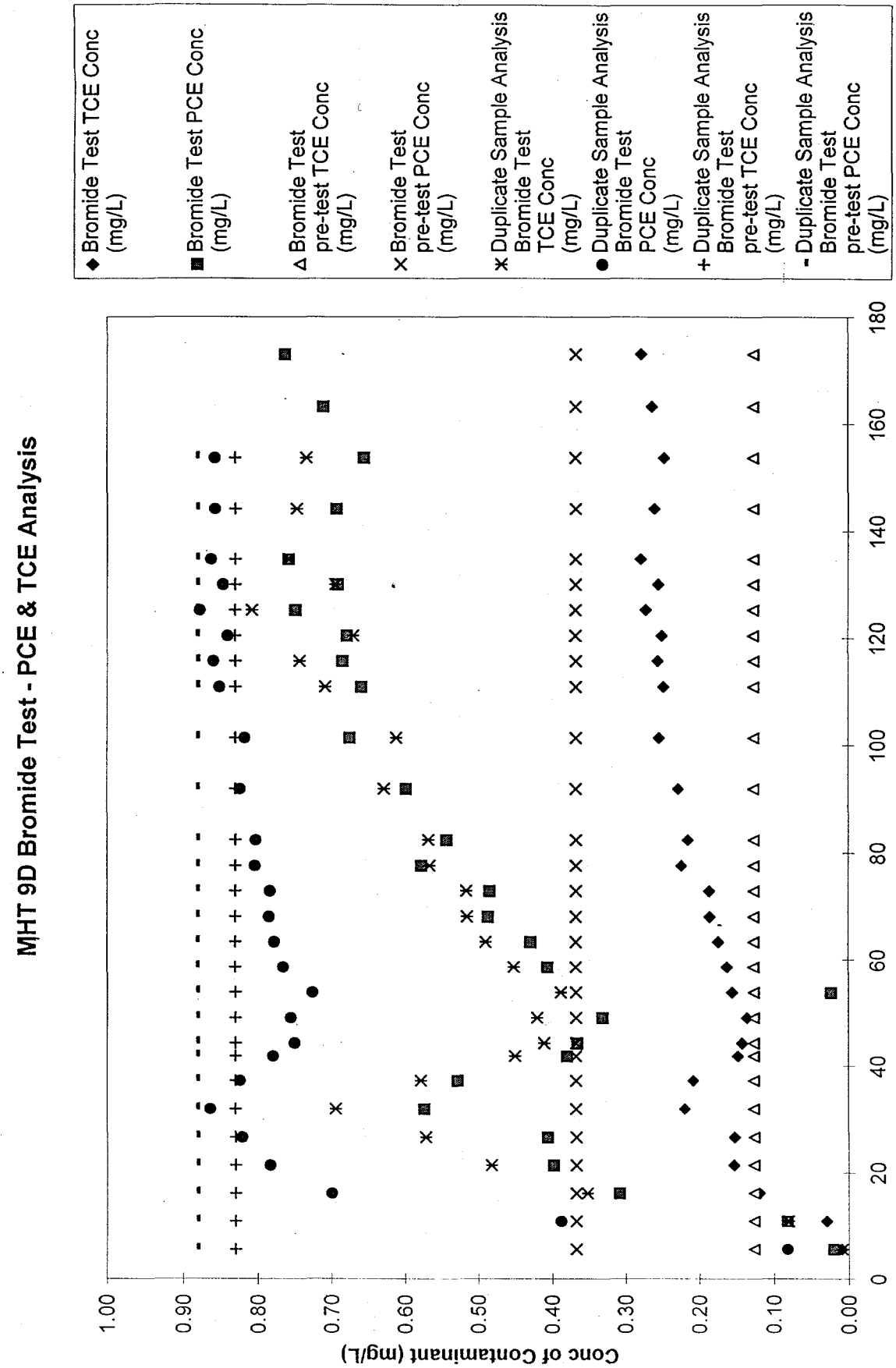
Sample ID	Sample Collection Information	Cumulative Volume (gallons)	Bromide Test TCE Conc (mg/L)	Bromide Test PCE Conc (mg/L)	Bromide Test pre-test TCE Conc (mg/L)	Bromide Test pre-test PCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test TCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test PCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test pre-test TCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test pre-test PCE Conc (mg/L)
MHTO900A	SAMPLE DATE 07-01-96 TIME 8:33	6	0.01	0.02	0.13	0.37	0.01	0.08	0.83	0.88
MHTO901A	SAMPLE DATE 07-01-96 TIME 8:43	11	0.03	0.08	0.13	0.37	0.08	0.39	0.83	0.88
MHTO902A	SAMPLE DATE 07-01-96 TIME 8:53	16	0.12	0.31	0.13	0.37	0.35	0.70	0.83	0.88
MHT0903A	SAMPLE DATE 07-01-96 TIME 9:03	21	0.15	0.40	0.13	0.37	0.48	0.78	0.83	0.88
MHTO904A	SAMPLE DATE 07-01-96 TIME 9:13	27	0.15	0.41	0.13	0.37	0.57	0.82	0.83	0.88
MHTO905A	SAMPLE DATE 07-01-96 TIME 9:23	32	0.22	0.57	0.13	0.37	0.69	0.86	0.83	0.88
MHTO906A	SAMPLE DATE 07-01-96 TIME 9:33	37	0.21	0.53	0.13	0.37	0.58	0.82	0.83	0.88
MHTO907A	SAMPLE DATE 07-01-96 TIME 9:43	42	0.15	0.38	0.13	0.37	0.45	0.78	0.83	0.88
MHTO908A	SAMPLE DATE 07-01-96 TIME 9:53	44	0.14	0.37	0.13	0.37	0.41	0.75	0.83	0.88
MHTO909A	SAMPLE DATE 07-01-96 TIME 10:13	49	0.14	0.33	0.13	0.37	0.42	0.76	0.83	0.88
MHTO910A	SAMPLE DATE 07-01-96 TIME 10:33	54	0.16	0.02	0.13	0.37	0.39	0.73	0.83	0.88
MHTO911A	SAMPLE DATE 07-01-96 TIME 10:53	59	0.16	0.41	0.13	0.37	0.45	0.77	0.83	0.88
MHTO912A	SAMPLE DATE 07-01-96 TIME 11:13	63	0.17	0.43	0.13	0.37	0.49	0.78	0.83	0.88
MHTO913A	SAMPLE DATE 07-01-96 TIME 11:33	68	0.19	0.49	0.13	0.37	0.52	0.78	0.83	0.88
MHTO914A	SAMPLE DATE 07-01-96 TIME 11:53	73	0.19	0.48	0.13	0.37	0.52	0.78	0.83	0.88
MHTO915A	SAMPLE DATE 07-01-96 TIME 12:13	78	0.22	0.58	0.13	0.37	0.57	0.80	0.83	0.88
MHTO916A	SAMPLE DATE 07-01-96 TIME 12:33	82	0.22	0.54	0.13	0.37	0.57	0.80	0.83	0.88
MHTO917A	SAMPLE DATE 07-01-96 TIME 13:13	92	0.23	0.60	0.13	0.37	0.63	0.82	0.83	0.88
MHTO918A	SAMPLE DATE 07-01-96 TIME 13:53	101	0.26	0.68	0.13	0.37	0.61	0.82	0.83	0.88
MHTO919A	SAMPLE DATE 07-01-96 TIME 14:33	111	0.25	0.66	0.13	0.37	0.71	0.85	0.83	0.88
MHTO920A	SAMPLE DATE 07-01-96 TIME 14:53	116	0.26	0.68	0.13	0.37	0.74	0.86	0.83	0.88
MHTO921A	SAMPLE DATE 07-01-96 TIME 15:13	120	0.25	0.68	0.13	0.37	0.67	0.84	0.83	0.88
MHTO922A	SAMPLE DATE 07-01-96 TIME 15:33	125	0.27	0.75	0.13	0.37	0.81	0.88	0.83	0.88
MHTO923A	SAMPLE DATE 07-01-96 TIME 15:53	130	0.26	0.69	0.13	0.37	0.69	0.85	0.83	0.88
MHTO924A	SAMPLE DATE 07-01-96 TIME 16:13	135	0.28	0.76	0.13	0.37	0.76	0.86	0.83	0.88
MHTO925A	SAMPLE DATE 07-01-96 TIME 16:53	144	0.26	0.69	0.13	0.37	0.75	0.86	0.83	0.88
MHTO926A	SAMPLE DATE 07-01-96 TIME 17:34	154	0.25	0.66	0.13	0.37	0.73	0.86	0.83	0.88
MHTO927A	SAMPLE DATE 07-01-96 TIME 18:13	163	0.26	0.71	0.13	0.37				
MHTO928A	SAMPLE DATE 07-01-96 TIME 18:53	173	0.28	0.76	0.13	0.37				

Concentration Data for MHT9D

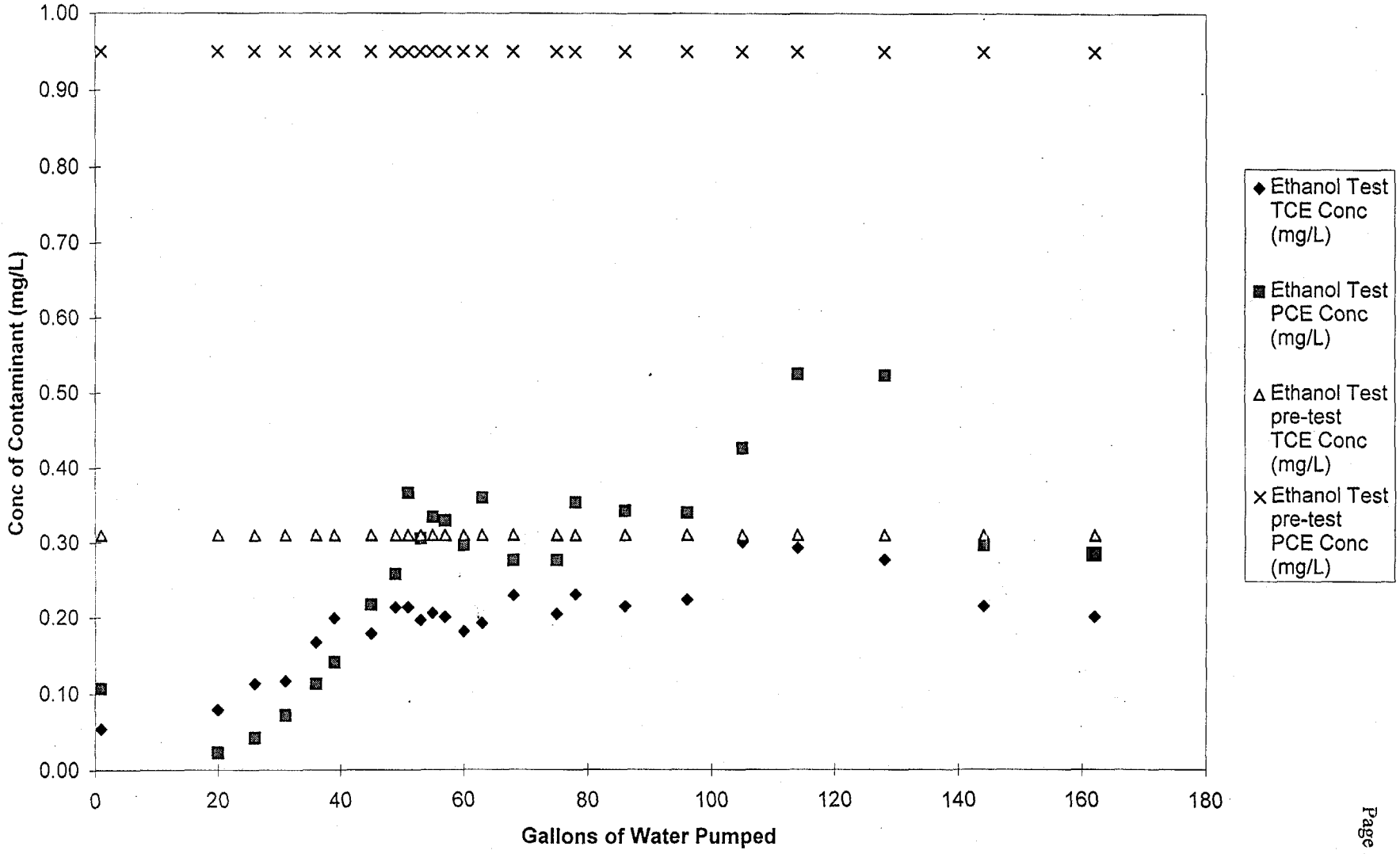
Sample ID	Sample Collection Information	Cumulative Volume (gallons)	Ethanol Test TCE Conc (mg/L)	Ethanol Test PCE Conc (mg/L)	Ethanol Test pre-test TCE Conc (mg/L)	Ethanol Test pre-test PCE Conc (mg/L)
MHT0900B	SAMPLE DATE 07-09-96 TIME 9:40	1	0.05	0.11	0.31	0.95
MHT0901B	SAMPLE DATE 07-09-96 TIME 10:00	20	0.08	0.02	0.31	0.95
MHT0902B	SAMPLE DATE 07-09-96 TIME 10:20	26	0.11	0.04	0.31	0.95
MHT0903B	SAMPLE DATE 07-09-96 TIME 10:40	31	0.12	0.07	0.31	0.95
MHT0904B	SAMPLE DATE 07-09-96 TIME 11:00	36	0.17	0.11	0.31	0.95
MHT0905B	SAMPLE DATE 07-09-96 TIME 11:20	39	0.20	0.14	0.31	0.95
MHT0906B	SAMPLE DATE 07-09-96 TIME 11:40	45	0.18	0.22	0.31	0.95
MHT0907B	SAMPLE DATE 07-09-96 TIME 12:00	49	0.21	0.26	0.31	0.95
MHT0908B	SAMPLE DATE 07-09-96 TIME 12:20	51	0.21	0.37	0.31	0.95
MHT0909B	SAMPLE DATE 07-09-96 TIME 12:40	53	0.20	0.31	0.31	0.95
MHT0910B	SAMPLE DATE 07-09-96 TIME 13:00	55	0.21	0.33	0.31	0.95
MHT0911B	SAMPLE DATE 07-09-96 TIME 13:20	57	0.20	0.33	0.31	0.95
MHT0912B	SAMPLE DATE 07-09-96 TIME 13:40	60	0.18	0.30	0.31	0.95
MHT0913B	SAMPLE DATE 07-09-96 TIME 14:00	63	0.19	0.36	0.31	0.95
MHT0914B	SAMPLE DATE 07-09-96 TIME 14:38	68	0.23	0.28	0.31	0.95
MHT0915B	SAMPLE DATE 07-09-96 TIME 15:20	75	0.20	0.28	0.31	0.95
MHT0916B	SAMPLE DATE 07-09-96 TIME 16:00	78	0.23	0.35	0.31	0.95
MHT0917B	SAMPLE DATE 07-09-96 TIME 17:18	86	0.21	0.34	0.31	0.95
MHT0918B	SAMPLE DATE 07-09-96 TIME 18:40	96	0.22	0.34	0.31	0.95
MHT0919B	SAMPLE DATE 07-09-96 TIME 20:00	105	0.30	0.43	0.31	0.95
MHT0920B	SAMPLE DATE 07-09-96 TIME 21:20	114	0.29	0.53	0.31	0.95
MHT0921B	SAMPLE DATE 07-09-96 TIME 22:50	128	0.28	0.52	0.31	0.95
MHT0922B	SAMPLE DATE 07-10-96 TIME 00:50	144	0.22	0.30	0.31	0.95
MHT0923B	SAMPLE DATE 07-10-96 TIME 02:50	162	0.20	0.29	0.31	0.95
MHT090D1B	SAMPLE DATE 07-09-96 TIME 12:40	53	0.24	0.48	0.31	0.95

MHT9D Data Used
in Chart of C/Co vs volume

Results for Control/Bromide Test						Results for Ethanol Inj-Ext Test				
volume (gallons)	TCE (mg/L)	PCE (mg/L)	TCE (C/Co)	PCE (C/Co)		volume (gallons)	TCE (mg/L)	PCE (mg/L)	TCE (C/Co)	PCE (C/Co)
-100	0.31	0.95	1.00	1.00		-100	0.31	0.95	1.00	1.00
-50	0.31	0.95	1.00	1.00		-50	0.31	0.95	1.00	1.00
-45	0	0	0.00	0.00		-45	0	0	0.00	0.00
6	0.01	0.02	0.03	0.02		0	0	0	0.00	0.00
11	0.03	0.08	0.10	0.09		1	0.05	0.11	0.17	0.11
16	0.12	0.31	0.39	0.32		20	0.08	0.02	0.25	0.02
21	0.15	0.40	0.50	0.42		26	0.11	0.04	0.37	0.04
27	0.15	0.41	0.50	0.43		31	0.12	0.07	0.38	0.07
32	0.22	0.57	0.71	0.60		36	0.17	0.11	0.54	0.12
37	0.21	0.53	0.67	0.56		39	0.20	0.14	0.64	0.15
42	0.15	0.38	0.48	0.40		45	0.18	0.22	0.58	0.23
44	0.14	0.37	0.46	0.38		49	0.21	0.26	0.69	0.27
49	0.14	0.33	0.44	0.35		51	0.21	0.37	0.69	0.39
54	0.16	0.02	0.50			53	0.20	0.31	0.63	0.32
59	0.16	0.41	0.52	0.43		55	0.21	0.33	0.66	0.35
63	0.17	0.43	0.56	0.45		57	0.20	0.33	0.65	0.35
68	0.19	0.49	0.60	0.51		60	0.18	0.30	0.59	0.31
73	0.19	0.48	0.60	0.51		63	0.19	0.36	0.62	0.38
78	0.22	0.58	0.73	0.61		68	0.23	0.28	0.74	0.29
82	0.22	0.54	0.70	0.57		75	0.20	0.28	0.66	0.29
92	0.23	0.60	0.74	0.63		78	0.23	0.35	0.74	0.37
101	0.26	0.68	0.82	0.71		86	0.21	0.34	0.69	0.36
111	0.25	0.66	0.80	0.69		96	0.22	0.34	0.72	0.36
116	0.26	0.68	0.83	0.72		105	0.30	0.43	0.97	0.45
120	0.25	0.68	0.81	0.71		114	0.29	0.53	0.95	0.55
125	0.27	0.75	0.88	0.79		128	0.28	0.52	0.89	0.55
130	0.26	0.69	0.83	0.73		144	0.22	0.30	0.69	0.31
135	0.28	0.76	0.90	0.80		162	0.20	0.29	0.65	0.30
144	0.26	0.69	0.84	0.73						
154	0.25	0.66	0.80	0.69						
163	0.26	0.71	0.85	0.75						
173	0.28	0.76	0.90	0.80						


MHT 9D Bromide Test - PCE & TCE Analysis
◆ Bromide Test TCE Conc (mg/L)
■ Bromide Test PCE Conc (mg/L)
Δ Bromide Test pre-test TCE Conc (mg/L)
× Bromide Test pre-test PCE Conc (mg/L)
✱ Duplicate Sample Analysis Bromide Test TCE Conc (mg/L)
● Duplicate Sample Analysis Bromide Test PCE Conc (mg/L)
+ Duplicate Sample Analysis Bromide Test pre-test TCE Conc (mg/L)
- Duplicate Sample Analysis Bromide Test pre-test PCE Conc (mg/L)
Conc of Contaminant (mg/L)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
20
40
60
80
100
120
140
160
180
Gallons of Water Pumped

MHT 9D Ethanol Test - PCE & TCE Analysis



WELL MSB15D

Injection/ Extraction DNAPL Characterization Study
Test Data for Bromide Tracer at Well MSB15D

Extraction Data

Date	Time	Volume (gallons)	Concentration (mg/L)	Sample	Br- (mg)	Cum. Br- (mg)	Volume Cum. (gallons)
11-Jul	9:40	2	75.42	00	47.37	47	2
	9:50	5	67.07	01	84.25	132	7
	10:00	5	61.28	02	76.98	209	12
	10:10	5	71.60	03	89.94	299	17
	10:20	5	76.26	04	95.79	394	21
	10:30	5	69.59	05	87.42	482	26
	10:40	5	59.97	06	75.33	557	31
	10:50	5	51.95	07	65.26	622	36
	11:00	5	42.07	08	52.85	675	40
	11:10	5	32.04	09	40.25	715	45
	11:20	5	23.00	10	28.89	744	50
	11:30	5	18.71	11	23.50	768	55
	11:40	5	13.89	12	17.45	785	59
	11:50	5	10.98	13	13.79	799	64
	12:00	5	8.88	14	11.15	810	69
	12:10	5	8.10	15	10.17	820	74
	12:20	5	7.13	16	8.96	829	78
	12:40	10	5.52	17	13.87	843	88
	13:00	10	4.70	18	11.81	855	97
	13:20	10	4.00	19	10.05	865	107
	13:40	10	3.58	20	8.99	874	116
	14:00	10	3.32	21	8.34	882	126
	14:20	10	2.91	22	7.31	890	136
	14:40	10	2.67	23	6.71	896	145

Total gallons removed: 145 gallons
Total Bromide removed: 896 mg
% Bromide removed: 81 %

Extraction Start: 9:35 Extraction Complete: 14:43

Injection Data Injection Start: 8:34 Injection Complete: 9:33

Injected Volume (gallons)	Conc. (mg/L)	Total Br- Added (mg)
50	83.24	1104

Injection/ Extraction DNAPL Characterization Study
Test Data for Ethanol Injection at Well MSB15D

Extraction Data

Date	Time	Volume (gallons)	Conc. (vol %)	Sample	EtOH (gallons)	Cum. EtOH (gallons)	Volume Cum. (gallons)
16-Jul	8:48	3.51	9.36	00	0.33	0.33	3.51
	8:58	5.01	9.22	01	0.46	0.79	8.51
	9:08	5.01	9.07	02	0.45	1.24	13.52
	9:18	5.01	9.83	03	0.49	1.74	18.53
	9:28	5.01	9.54	04	0.48	2.21	23.54
	9:38	5.01	10.79	05	0.54	2.75	28.54
	9:48	3.26	11.40	06	0.37	3.13	31.81
	10:00	3.26	7.57	07	0.25	3.37	35.07
	10:10	3.26	7.73	08	0.25	3.63	38.33
	10:20	3.26	6.24	09	0.20	3.83	41.59
	10:30	3.26	6.19	10	0.20	4.03	44.85
	10:40	3.26	5.54	11	0.18	4.21	48.11
	10:50	3.26	4.07	12	0.13	4.34	51.38
	11:00	3.26	3.08	13	0.10	4.44	54.64
	11:10	4.05	2.73	14	0.11	4.55	58.69
	11:20	4.05	2.10	15	0.09	4.64	62.74
	11:30	4.05	1.71	16	0.07	4.71	66.79
	11:50	8.10	1.24	17	0.10	4.81	74.89
	12:10	8.10	1.00	18	0.08	4.89	82.99
	12:30	9.64	1.78	19	0.17	5.06	92.63
	12:50	9.64	1.50	20	0.14	5.21	102.27
	13:10	9.64	0.77	21	0.07	5.28	111.90
	13:30	8.77	0.57	22	0.05	5.33	120.68
	13:50	8.77	0.49	23	0.04	5.37	129.45

Total gallons removed: 129.45 gallons
Total Alcohol removed: 5.37 gallons
% alcohol removed: 109.73 %

Extraction Start: 8:41 Extraction Complete: 15:15

Injection Data Injection Start: 7:36 Injection Complete: 8:39

Injected Volume (gallons)	Conc. (vol%)	Total Alcohol Added (gallons)
50.22	9.75	4.90

Concentration Data for MSB15D

Sample ID	Sample Collection Information	Cumulative Volume (gallons)	Bromide Test TCE Conc (mg/L)	Bromide Test PCE Conc (mg/L)	Bromide Test pre-test TCE Conc (mg/L)	Bromide Test pre-test PCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test TCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test PCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test pre-test TCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test pre-test PCE Conc (mg/L)
MSB 1500A	SAMPLE DATE 07-11-96 TIME 9:40	2	0.49	0.12	4.22	0.66	0.53	0.14	4.34	0.7
MSB 1501A	SAMPLE DATE 07-11-96 TIME 9:50	7	0.93	0.18	4.22	0.66	1.04	0.21	4.34	0.7
MSB 1502A	SAMPLE DATE 07-11-96 TIME 10:00	12	1.14	0.20	4.22	0.66	1.17	0.23	4.34	0.7
MSB 1503A	SAMPLE DATE 07-11-96 TIME 10:10	17	0.91	0.18	4.22	0.66	1.12	0.21	4.34	0.7
MSB 1504A	SAMPLE DATE 07-11-96 TIME 10:20	21	0.69	0.14	4.22	0.66	0.71	0.17	4.34	0.7
MSB 1505A	SAMPLE DATE 07-11-96 TIME 10:30	26	0.90	0.18	4.22	0.66	0.99	0.20	4.34	0.7
MSB 1506A	SAMPLE DATE 07-11-96 TIME 10:40	31	1.28	0.23	4.22	0.66	1.29	0.24	4.34	0.7
MSB 1507A	SAMPLE DATE 07-11-96 TIME 10:50	36	1.58	0.28	4.22	0.66	1.63	0.29	4.34	0.7
MSB 1508A	SAMPLE DATE 07-11-96 TIME 11:00	40	2.11	0.35	4.22	0.66	2.50	0.43	4.34	0.7
MSB 1509A	SAMPLE DATE 07-11-96 TIME 11:10	45	2.53	0.41	4.22	0.66	2.60	0.44	4.34	0.7
MSB 1510A	SAMPLE DATE 07-11-96 TIME 11:20	50	3.05	0.49	4.22	0.66	0.39	0.06	4.34	0.7
MSB 1511A	SAMPLE DATE 07-11-96 TIME 11:30	55	3.02	0.48	4.22	0.66	3.89	0.66	4.34	0.7
MSB 1512A	SAMPLE DATE 07-11-96 TIME 11:40	59	3.64	0.57	4.22	0.66	4.03	0.67	4.34	0.7
MSB 1513A	SAMPLE DATE 07-11-96 TIME 11:50	64	3.66	0.57	4.22	0.66	4.38	0.72	4.34	0.7
MSB 1514A	SAMPLE DATE 07-11-96 TIME 12:00	69	3.48	0.53	4.22	0.66	3.99	0.65	4.34	0.7
MSB 1515A	SAMPLE DATE 07-11-96 TIME 12:10	74	3.86	0.60	4.22	0.66	4.36	0.72	4.34	0.7
MSB 1516A	SAMPLE DATE 07-11-96 TIME 12:20	78	4.00	0.62	4.22	0.66	4.26	0.71	4.34	0.7
MSB 1517A	SAMPLE DATE 07-11-96 TIME 11:20	88	4.22	0.67	4.22	0.66	4.58	0.77	4.34	0.7
MSB 1518A	SAMPLE DATE 07-11-96 TIME 13:00	97	4.48	0.70	4.22	0.66	4.32	0.80	4.34	0.7
MSB 1519A	SAMPLE DATE 07-11-96 TIME 13:20	107					4.62	0.72	4.34	0.7
MSB 1520A	SAMPLE DATE 07-11-96 TIME 13:40	116					4.64	0.78	4.34	0.7
MSB 1521A	SAMPLE DATE 07-11-96 TIME 14:00	126					4.67	0.79	4.34	0.7
MSB 1522A	SAMPLE DATE 07-11-96 TIME 14:20	136					4.17	0.66	4.34	0.7
MSB 1523A	SAMPLE DATE 07-11-96 TIME 14:40	145					4.16	0.68	4.34	0.7

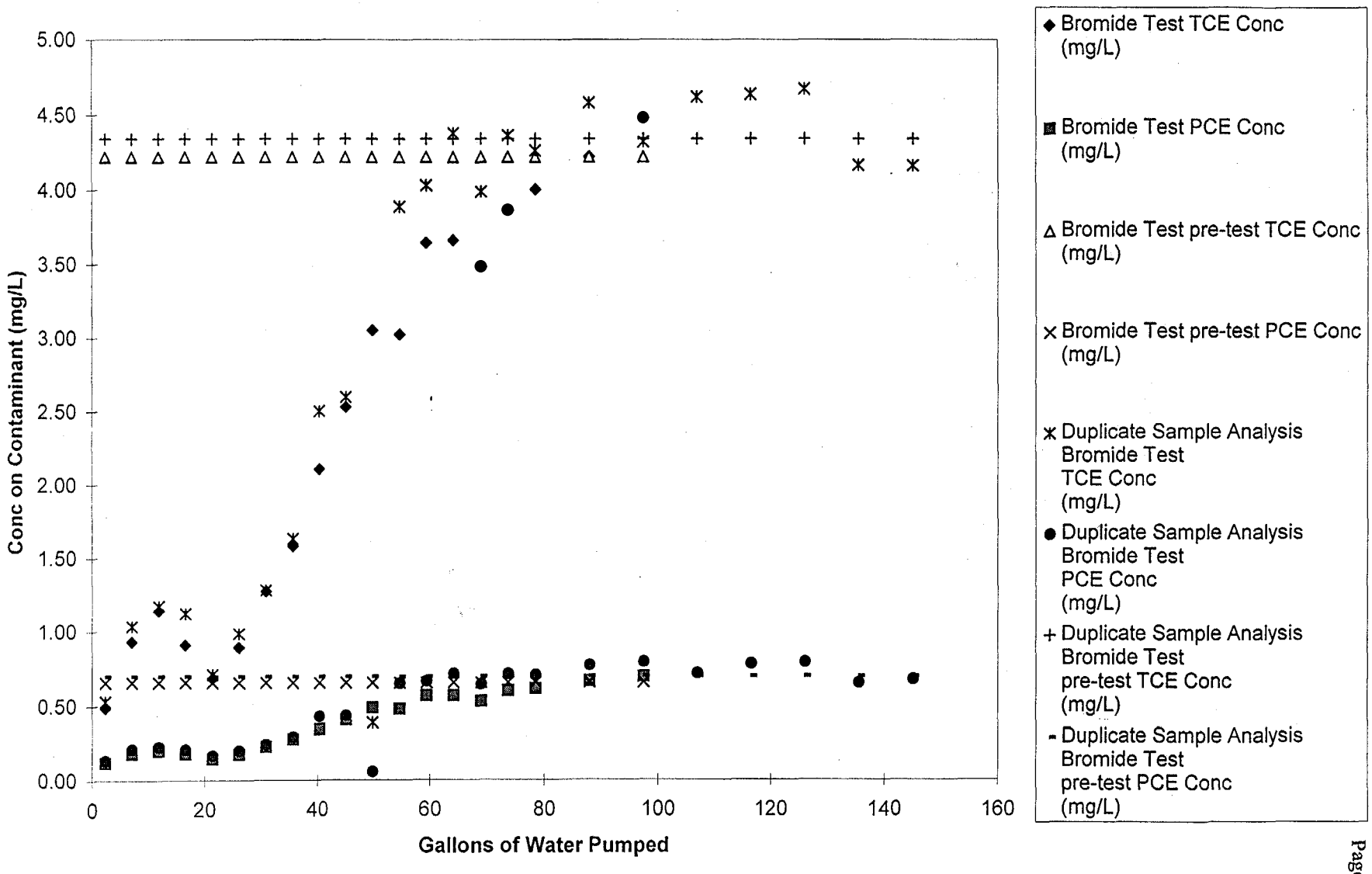
Concentration Data for MSB15D

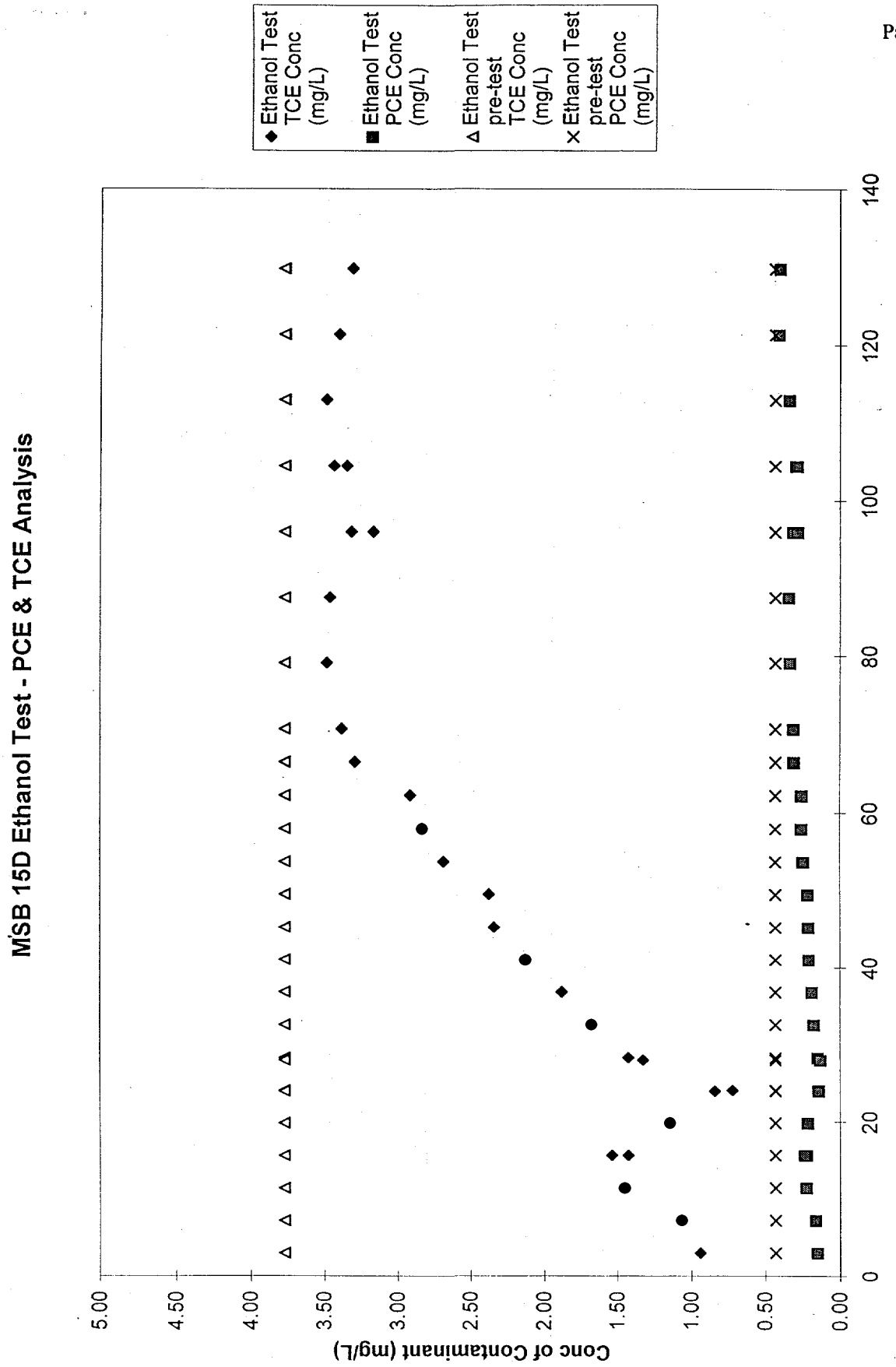
Sample ID	Sample Collection Information	Cumulative Volume (gallons)	Ethanol Test TCE Conc (mg/L)	Ethanol Test PCE Conc (mg/L)	Ethanol Test pre-test TCE Conc (mg/L)	Ethanol Test pre-test PCE Conc (mg/L)
MSB1500B	SAMPLE DATE 07-16-96 TIME 8:48	3	0.94	0.15	3.77	0.43
MSB1501B	SAMPLE DATE 07-16-96 TIME 8:58	7	1.07	0.16	3.77	0.43
MSB1502B	SAMPLE DATE 07-16-96 TIME 9:08	11	1.45	0.22	3.77	0.43
MSB1503B	SAMPLE DATE 07-16-96 TIME 9:18	16	1.43	0.22	3.77	0.43
MSB1503B	SAMPLE DATE 07-16-96 TIME 9:18	16	1.54	0.24	3.77	0.43
MSB1504B	SAMPLE DATE 07-16-96 TIME 9:28	20	1.15	0.21	3.77	0.43
MSB1505B	SAMPLE DATE 07-16-96 TIME 9:38	24	0.72	0.14	3.77	0.43
MSB1505B	SAMPLE DATE 07-16-96 TIME 9:38	24	0.84	0.14	3.77	0.43
MSB1506B	SAMPLE DATE 07-16-96 TIME 9:48	28	1.43	0.15	3.77	0.43
MSB1506B	SAMPLE DATE 07-16-96 TIME 9:48	28	1.33	0.13	3.77	0.43
MSB1507B	SAMPLE DATE 07-16-96 TIME 10:00	33	1.68	0.17	3.77	0.43
MSB1508B	SAMPLE DATE 07-16-96 TIME 10:10	37	1.88	0.19	3.77	0.43
MSB1509B	SAMPLE DATE 07-16-96 TIME 10:20	41	2.13	0.21	3.77	0.43
MSB1510B	SAMPLE DATE 07-16-96 TIME 10:30	45	2.34	0.21	3.77	0.43
MSB1511B	SAMPLE DATE 07-16-96 TIME 10:40	49	2.38	0.21	3.77	0.43
MSB1512B	SAMPLE DATE 07-16-96 TIME 10:50	54	2.69	0.24	3.77	0.43
MSB1513B	SAMPLE DATE 07-16-96 TIME 11:00	58	2.83	0.25	3.77	0.43
MSB1514B	SAMPLE DATE 07-16-96 TIME 11:10	62	2.92	0.25	3.77	0.43
MSB1515B	SAMPLE DATE 07-16-96 TIME 11:20	66	3.30	0.31	3.77	0.43
MSB1516B	SAMPLE DATE 07-16-96 TIME 11:30	71	3.39	0.31	3.77	0.43
MSB1517B	SAMPLE DATE 07-16-96 TIME 11:50	79	3.49	0.33	3.77	0.43
MSB1518B	SAMPLE DATE 07-16-96 TIME 12:10	87	3.47	0.34	3.77	0.43
MSB1519B	SAMPLE DATE 07-16-96 TIME 12:30	96	3.32	0.31	3.77	0.43
MSB1519B	SAMPLE DATE 07-16-96 TIME 12:30	96	3.17	0.28	3.77	0.43
MSB1520B	SAMPLE DATE 07-16-96 TIME 12:50	104	3.44	0.28	3.77	0.43
MSB1520B	SAMPLE DATE 07-16-96 TIME 12:50	104	3.35	0.29	3.77	0.43
MSB1521B	SAMPLE DATE 07-16-96 TIME 13:10	113	3.49	0.33	3.77	0.43
MSB1522B	SAMPLE DATE 07-16-96 TIME 13:30	121	3.40	0.40	3.77	0.43
MSB1523B	SAMPLE DATE 07-16-96 TIME 13:50	130	3.31	0.40	3.77	0.43

MSB15D Data Used
in Chart of C/Co vs volume

Results for Control/Bromide Test				
volume (gallons)	TCE (mg/L)	PCE (mg/L)	TCE (C/Co)	PCE (C/Co)
-100	4.22	0.66	1.00	1.00
-50	4.22	0.66	1.00	1.00
-45	0	0	0.00	0.00
0	0	0	0.00	0.00
2	0.49	0.12	0.12	0.18
7	0.93	0.18	0.22	0.28
12	1.14	0.20	0.27	0.30
17	0.91	0.18	0.22	0.27
21	0.69	0.14	0.16	0.22
26	0.90	0.18	0.21	0.27
31	1.28	0.23	0.30	0.34
36	1.58	0.28	0.38	0.42
40	2.11	0.35	0.50	0.52
45	2.53	0.41	0.60	0.62
50	3.05	0.49	0.72	0.74
55	3.02	0.48	0.72	0.73
59	3.64	0.57	0.86	0.87
64	3.66	0.57	0.87	0.87
69	3.48	0.53	0.82	0.81
74	3.86	0.60	0.92	0.91
78	4.00	0.62	0.95	0.94
88	4.22	0.67	1.00	1.01
97	4.48	0.70	1.06	1.06
107	4.62	0.72	1.09	1.09
116	4.64	0.78	1.10	1.19
126	4.67	0.79	1.11	1.20
136	4.17	0.66	0.99	1.00
145	4.16	0.68	0.99	1.03

Results for Ethanol Inj-Ext Test				
volume (gallons)	TCE (mg/L)	PCE (mg/L)	TCE (C/Co)	PCE (C/Co)
-100	3.77	0.43	1.00	1.00
-50	3.77	0.43	1.00	1.00
-45	0	0	0.00	0.00
0	0	0	0.00	0.00
3	0.94	0.15	0.25	0.35
7	1.07	0.16	0.28	0.37
11	1.45	0.22	0.39	0.52
16	1.43	0.22	0.38	0.51
16	1.54	0.24	0.41	0.55
20	1.15	0.21	0.30	0.50
24	0.72	0.14	0.19	0.33
24	0.84	0.14	0.22	0.33
28	1.43	0.15	0.38	0.34
28	1.33	0.13	0.35	0.30
33	1.68	0.17	0.44	0.40
37	1.88	0.19	0.50	0.43
41	2.13	0.21	0.57	0.48
45	2.34	0.21	0.62	0.49
49	2.38	0.21	0.63	0.50
54	2.69	0.24	0.71	0.57
58	2.83	0.25	0.75	0.59
62	2.92	0.25	0.77	0.59
66	3.30	0.31	0.87	0.71
71	3.39	0.31	0.90	0.72
79	3.49	0.33	0.92	0.77
87	3.47	0.34	0.92	0.78
96	3.32	0.31	0.88	0.71
96	3.17	0.28	0.84	0.65
104	3.44	0.28	0.91	0.66
104	3.35	0.29	0.89	0.67
113	3.49	0.33	0.93	0.78
121	3.40	0.40	0.90	0.94
130	3.31	0.40	0.88	0.93


MSB 15D Bromide Test - PCE & TCE Analysis
Conc on Contaminant (mg/L)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
20
40
60
80
100
120
140
160
Gallons of Water Pumped
Bromide Test TCE Conc (mg/L)
Bromide Test PCE Conc (mg/L)
Bromide Test pre-test TCE Conc (mg/L)
Bromide Test pre-test PCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test TCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test PCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test pre-test TCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test pre-test PCE Conc (mg/L)


MSB 15D Ethanol Test - PCE & TCE Analysis
◆ Ethanol Test TCE Conc (mg/L)
■ Ethanol Test PCE Conc (mg/L)
Δ Ethanol Test pre-test TCE Conc (mg/L)
× Ethanol Test pre-test PCE Conc (mg/L)
Conc of Contaminant (mg/L)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
20
40
60
80
100
120
140
Gallons of Water Pumped

WELL MSB9C

Injection/ Extraction DNAPL Characterization Study
Test Data for Bromide Tracer at Well MSB9C

Extraction Data

Date	Time	Volume (gallons)	Concentration (mg/L)	Sample	Br- (mg)	Cum. Br- (mg)	Volume Cum. (gallons)
18-Jul	9:05	6	92.78	00	149.57	150	6
	9:15	5	97.80	01	124.90	274	11
	9:25	5	97.09	02	123.99	398	16
	9:35	5	84.50	03	107.91	506	21
	9:45	5	76.72	04	97.98	604	25
	9:55	5	59.46	05	75.94	680	30
	10:05	5	44.18	06	56.42	737	35
	10:15	5	36.23	07	46.27	783	40
	10:25	5	28.78	08	36.75	820	45
	10:35	5	20.59	09	26.30	846	50
	10:45	5	17.21	10	21.98	868	54
	10:55	5	13.80	11	17.62	886	59
	11:05	5	11.65	12	14.88	901	64
	11:15	5	10.48	13	13.38	914	69
	11:25	5	8.79	14	11.23	925	74
	11:35	5	8.50	15	10.86	936	79
	11:45	5	7.16	16	9.14	945	83
	12:05	10	6.51	17	16.63	962	93
	12:25	10	4.81	18	12.29	974	103
	12:45	10	3.96	19	10.11	984	112
	13:05	10	3.28	20	8.38	993	122
	13:25	10	3.97	21	10.14	1003	132
	13:45	10	2.52	22	6.44	1009	141
	14:05	10	2.28	23	5.82	1015	151

Total gallons removed: 151 gallons
Total Bromide removed: 1015 mg
% Bromide removed: 77 %

Extraction Start: 9:00 Extraction Complete: 14:07

Injection Data Injection Start: 8:02 Injection Complete: 8:58

Injected Volume (gallons)	Conc. (mg/L)	Total Br- Added (mg)
50	100.1	1322

Injection/ Extraction DNAPL Characterization Study
Test Data for Ethanol Injection at Well MSB09C

Extraction Data

Date	Time	Volume (gallons)	Conc. (vol %)	Sample	EtOH (gallons)	Cum. EtOH (gallons)	Volume Cum. (gallons)
23-Jul	8:40	4.89	9.97	00	0.49	0.49	4.89
	8:50	4.89	9.92	01	0.49	0.97	9.78
	9:00	5.30	9.61	02	0.51	1.48	15.08
	9:10	5.30	8.48	03	0.45	1.93	20.38
	9:20	5.30	8.51	04	0.45	2.38	25.68
	9:30	5.30	7.85	05	0.42	2.80	30.98
	9:41	5.55	7.05	06	0.39	3.19	36.54
	9:50	4.54	5.42	07	0.25	3.44	41.08
	10:00	3.03	4.89	08	0.15	3.58	44.11
	10:10	4.54	4.15	09	0.19	3.77	48.65
	10:20	5.05	3.45	10	0.17	3.95	53.70
	10:30	5.30	2.63	11	0.14	4.09	59.00
	10:40	5.30	2.21	12	0.12	4.20	64.30
	10:50	5.30	2.11	13	0.11	4.32	69.60
	11:00	5.30	1.95	14	0.10	4.42	74.90
	11:10	5.30	1.80	15	0.10	4.51	80.20
	11:20	5.30	1.63	16	0.09	4.60	85.50
	11:40	10.34	1.31	17	0.14	4.74	95.84
	12:00	10.34	1.17	18	0.12	4.86	106.18
	12:20	10.34	0.98	19	0.10	4.96	116.52
	12:40	10.26	0.90	20	0.09	5.05	126.78
	13:00	10.26	0.72	21	0.07	5.12	137.04
	13:20	10.43	0.66	22	0.07	5.19	147.47
	13:40	13.03	0.58	23	0.08	5.27	160.50

Total gallons removed: 160.50 gallons
Total Alcohol removed: 5.27 gallons
% alcohol removed: 117.61 %

Extraction Start: 8:30 Extraction Complete: 13:45

Injection Data Injection Start: 7:15 Injection Complete: 8:20

Injected Volume (gallons)	Conc. (vol%)	Total Alcohol Added (gallons)
50.00	8.96	4.48

Concentration Data for MSB09C

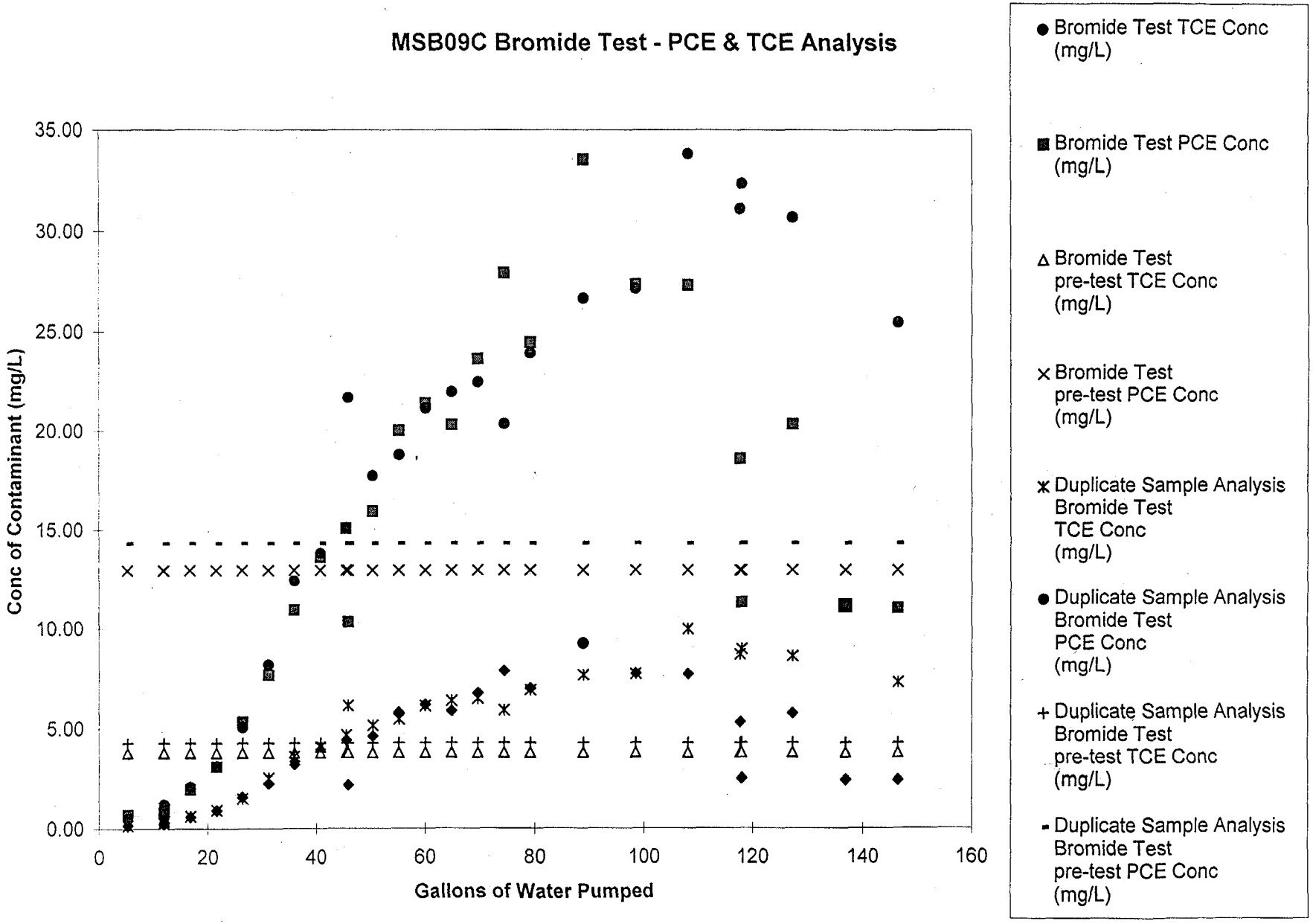
Sample ID	Sample Collection Information	Cumulative Volume (gallons)	Bromide Test TCE Conc (mg/L)	Bromide Test PCE Conc (mg/L)	Bromide Test pre-test TCE Conc (mg/L)	Bromide Test pre-test PCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test TCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test PCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test pre-test TCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test pre-test PCE Conc (mg/L)
MSB0900A	SAMPLE DATE 07-18-96 TIME 9:05	5	0.17	0.66	3.79	12.92	0.14	0.50	4.27	14.30
MSB0901A	SAMPLE DATE 07-18-96 TIME 9:15	12	0.25	0.79	3.79	12.92	0.27	0.86	4.27	14.30
MSBO902A	SAMPLE DATE 07-18-96 TIME 9:25	12	0.33	1.02	3.79	12.92	0.39	1.20	4.27	14.30
MSBO903A	SAMPLE DATE 07-18-96 TIME 9:35	17	0.59	1.96	3.79	12.92	0.62	2.08	4.27	14.30
MSB0904A	SAMPLE DATE 07-18-96 TIME 9:45	22	0.91	3.08	3.79	12.92	0.92	3.12	4.27	14.30
MSBO905A	SAMPLE DATE 07-18-96 TIME 9:55	26	1.57	5.31	3.79	12.92	1.50	5.06	4.27	14.30
MSBO906A	SAMPLE DATE 07-18-96 TIME 10:05	31	2.25	7.64	3.79	12.92	2.52	8.18	4.27	14.30
MSBO907A	SAMPLE DATE 07-18-96 TIME 10:15	36	3.19	10.90	3.79	12.92	3.61	12.39	4.27	14.30
MSBO908A	SAMPLE DATE 07-18-96 TIME 10:25	41	3.94	13.57	3.79	12.92	4.08	13.80	4.27	14.30
MSBO909A	SAMPLE DATE 07-18-96 TIME 10:35	46	4.42	15.04	3.79	12.92	4.67	15.09	4.27	14.30
MSBO910A	SAMPLE DATE 07-18-96 TIME 10:45	50	4.62	15.91	3.79	12.92	5.14	17.73	4.27	14.30
MSBO911A	SAMPLE DATE 07-18-96 TIME 10:55	55	5.77	20.02	3.79	12.92	5.44	18.80	4.27	14.30
MSBO912A	SAMPLE DATE 07-18-96 TIME 11:05	60	6.15	21.39	3.79	12.92	6.10	21.14	4.27	14.30
MSBO913A	SAMPLE DATE 07-18-96 TIME 11:15	65	5.86	20.30	3.79	12.92	6.34	21.97	4.27	14.30
MSBO914A	SAMPLE DATE 07-18-96 TIME 11:25	70	6.74	23.61	3.79	12.92	6.46	22.47	4.27	14.30
MSBO915A	SAMPLE DATE 07-18-96 TIME 11:35	74	7.85	27.91	3.79	12.92	5.88	20.35	4.27	14.30
MSBO916A	SAMPLE DATE 07-18-96 TIME 11:45	79	6.97	24.45	3.79	12.92	6.88	23.94	4.27	14.30
MSBO917A	SAMPLE DATE 07-18-96 TIME 12:05	89	9.25	33.54	3.79	12.92	7.63	26.67	4.27	14.30
MSBO918A	SAMPLE DATE 07-18-96 TIME 12:25	98	7.72	27.36	3.79	12.92	7.69	27.15	4.27	14.30
MSBO919A	SAMPLE DATE 07-18-96 TIME 12:45	108	7.69	27.32	3.79	12.92	9.97	33.83	4.27	14.30
MSBO920A	SAMPLE DATE 07-18-96 TIME 1:05	118	5.31	18.58	3.79	12.92	8.68	31.13	4.27	14.30
MSBO921A	SAMPLE DATE 07-18-96 TIME 1:25	127	5.74	20.32	3.79	12.92	8.59	30.70	4.27	14.30
MSB0922A	SAMPLE DATE 07-18-96 TIME 1:45	137	2.42	11.11	3.79	12.92			4.27	14.30
MSB0923A	SAMPLE DATE 07-18-96 TIME 2:05	146	2.41	11.00	3.79	12.92	7.27	25.46	4.27	14.30
MSB09D1A	SAMPLE DATE 07-18-96 TIME 11:05	46	2.18	10.32	3.79	12.92	6.11	21.69	4.27	14.30
MSB09D2A	SAMPLE DATE 07-18-96 TIME 12:45	118	2.50	11.28	3.79	12.92	8.96	32.37	4.27	14.30

Concentration Data for MSB09C

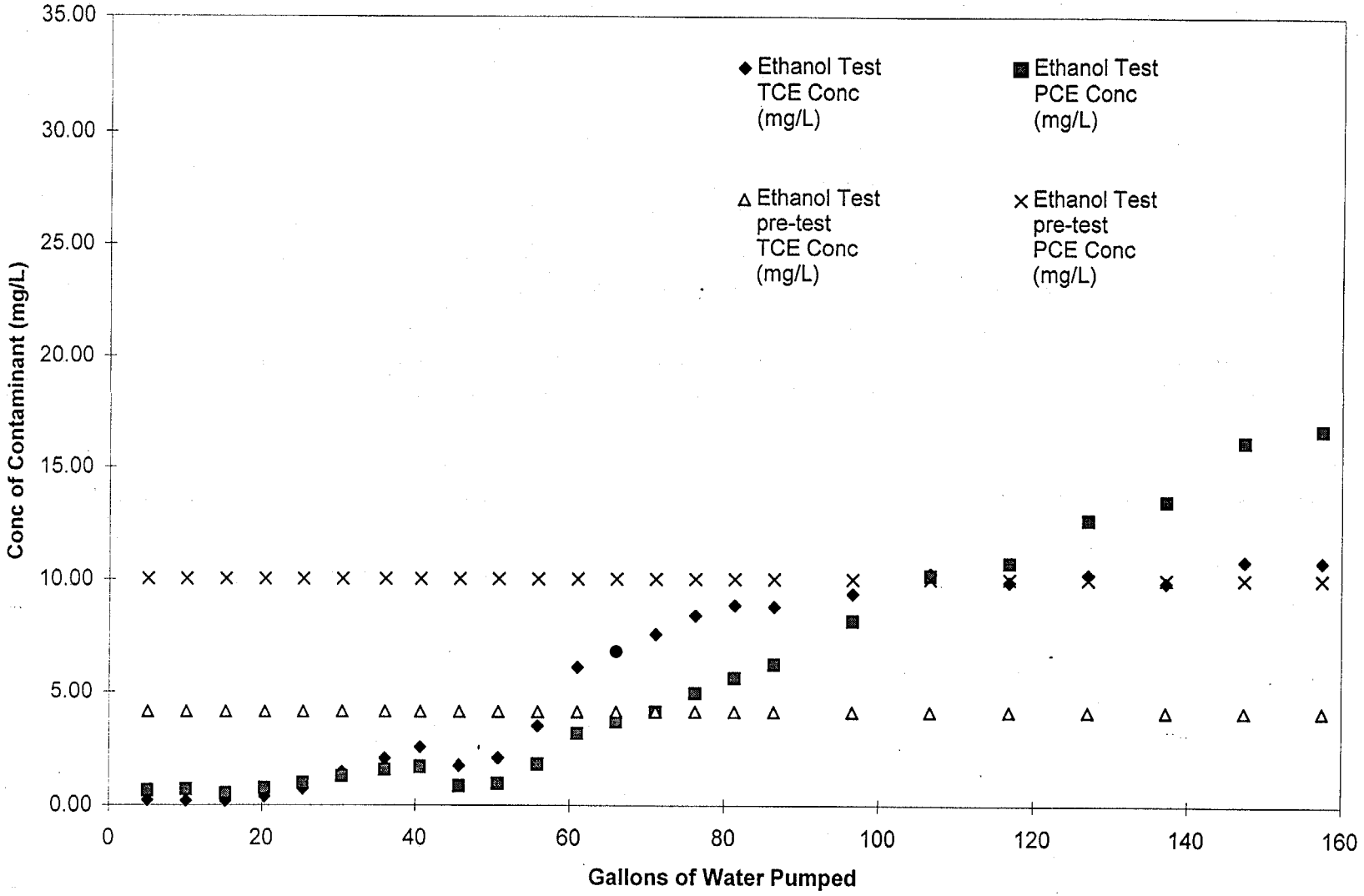
Sample ID	Sample Collection Information		Cumulative Volume (gallons)	Ethanol Test TCE Conc (mg/L)	Ethanol Test PCE Conc (mg/L)	Ethanol Test pre-test TCE Conc (mg/L)	Ethanol Test pre-test PCE Conc (mg/L)
MSB0900A	SAMPLE DATE 07-23-96	TIME 8:40	5	0.23	0.64	4.12	10.02
MSB0901A	SAMPLE DATE 07-23-96	TIME 8:50	10	0.21	0.70	4.12	10.02
MSBO902A	SAMPLE DATE 07-23-96	TIME 9:00	15	0.19	0.51	4.12	10.02
MSBO903A	SAMPLE DATE 07-23-96	TIME 9:10	20	0.38	0.74	4.12	10.02
MSB0904A	SAMPLE DATE 07-23-96	TIME 9:20	25	0.72	0.96	4.12	10.02
MSBO905A	SAMPLE DATE 07-23-96	TIME 9:30	30	1.46	1.28	4.12	10.02
MSBO906A	SAMPLE DATE 07-23-96	TIME 9:40	36	2.04	1.55	4.12	10.02
MSBO907A	SAMPLE DATE 07-23-96	TIME 9:50	41	2.55	1.67	4.12	10.02
MSBO908A	SAMPLE DATE 07-23-96	TIME 10:00	46	1.75	0.84	4.12	10.02
MSBO909A	SAMPLE DATE 07-23-96	TIME 10:10	51	2.08	0.96	4.12	10.02
MSBO910A	SAMPLE DATE 07-23-96	TIME 10:20	56	3.50	1.80	4.12	10.02
MSBO911A	SAMPLE DATE 07-23-96	TIME 10:30	61	6.12	3.15	4.12	10.02
MSBO912A	SAMPLE DATE 07-23-96	TIME 10:40	66	6.81	3.68	4.12	10.02
MSBO913A	SAMPLE DATE 07-23-96	TIME 10:50	71	7.57	4.12	4.12	10.02
MSBO914A	SAMPLE DATE 07-23-96	TIME 11:00	76	8.41	4.95	4.12	10.02
MSBO915A	SAMPLE DATE 07-23-96	TIME 11:10	81	8.87	5.63	4.12	10.02
MSBO916A	SAMPLE DATE 07-23-96	TIME 11:20	86	8.81	6.24	4.12	10.02
MSBO917A	SAMPLE DATE 07-23-96	TIME 11:40	97	9.39	8.16	4.12	10.02
MSBO918A	SAMPLE DATE 07-23-96	TIME 12:00	107	10.27	10.18	4.12	10.02
MSBO919A	SAMPLE DATE 07-23-96	TIME 12:20	117	9.90	10.74	4.12	10.02
MSBO920A	SAMPLE DATE 07-23-96	TIME 12:40	127	10.23	12.66	4.12	10.02
MSBO921A	SAMPLE DATE 07-23-96	TIME 13:00	137	9.89	13.51	4.12	10.02
MSB0922A	SAMPLE DATE 07-23-96	TIME 13:20	147	10.85	16.15	4.12	10.02
MSB0923A	SAMPLE DATE 07-23-96	TIME 13:40	157	10.81	16.69	4.12	10.02
MSB09D1A	SAMPLE DATE 07-23-96	TIME 10:10	51	4.26	2.52	4.12	10.02

MSB9C Data Used
in Chart of C/Co vs volume

Results for Control/Bromide Test					Results for Ethanol Inj-Ext Test				
volume (gallons)	TCE (mg/L)	PCE (mg/L)	TCE (C/Co)	PCE (C/Co)	volume (gallons)	TCE (mg/L)	PCE (mg/L)	TCE (C/Co)	PCE (C/Co)
-100	3.79	12.90	1.00	1.00	-100	4.12	10.02	1.00	1.00
-50	3.79	12.90	1.00	1.00	-50	4.12	10.02	1.00	1.00
-45	0	0	0.00	0.00	-45	0	0	0.00	0.00
0	0	0	0.00	0.00	0	0	0	0.00	0.00
5	0.17	0.66	0.05	0.05	5	0.23	0.64	0.06	0.06
12	0.25	0.79	0.07	0.06	10	0.21	0.70	0.05	0.07
12	0.33	1.02	0.09	0.08	15	0.19	0.51	0.05	0.05
17	0.59	1.96	0.15	0.15	20	0.38	0.74	0.09	0.07
22	0.91	3.08	0.24	0.24	25	0.72	0.96	0.18	0.10
26	1.57	5.31	0.42	0.41	30	1.46	1.28	0.35	0.13
31	2.25	7.64	0.59	0.59	36	2.04	1.55	0.50	0.16
36	3.19	10.90	0.84	0.85	41	2.55	1.67	0.62	0.17
41	3.94	13.57	1.04	1.05	46	1.75	0.84	0.42	0.08
46	4.42	15.04	1.17	1.17	51	2.08	0.96	0.51	0.10
50	4.62	15.91	1.22	1.23	56	3.50	1.80	0.85	0.18
55	5.77	20.02	1.52	1.55	61	6.12	3.15	1.48	0.31
60	6.15	21.39	1.62	1.66	66	6.81	3.68	1.65	0.37
65	5.86	20.30	1.54	1.57	71	7.57	4.12	1.84	0.41
70	6.74	23.61	1.78	1.83	76	8.41	4.95	2.04	0.49
74	7.85	27.91	2.07	2.16	81	8.87	5.63	2.15	0.56
79	6.97	24.45	1.84	1.90	86	8.81	6.24	2.14	0.62
89	9.25	33.54	2.44	2.60	97	9.39	8.16	2.28	0.81
98	7.72	27.36	2.04	2.12	107	10.27	10.18	2.49	1.02
108	7.69	27.32	2.03	2.12	117	9.90	10.74	2.40	1.07
118	5.31	18.58	1.40	1.44	127	10.23	12.66	2.48	1.26
127	5.74	20.32	1.51	1.57	137	9.89	13.51	2.40	1.35
137	2.42	11.11	0.64	0.86	147	10.85	16.15	2.63	1.61
146	2.41	11.00	0.64	0.85	157	10.81	16.69	2.62	1.67


MSB09C Bromide Test - PCE & TCE Analysis
Conc of Contaminant (mg/L)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
20
40
60
80
100
120
140
160
Gallons of Water Pumped
Bromide Test TCE Conc (mg/L)
Bromide Test PCE Conc (mg/L)
Bromide Test pre-test TCE Conc (mg/L)
Bromide Test pre-test PCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test TCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test PCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test pre-test TCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test pre-test PCE Conc (mg/L)

MSB09C Ethanol Test - PCE & TCE Analysis



WELL MSB22

Injection/ Extraction DNAPL Characterization Study
Test Data for Bromide Tracer at Well MSB22

Extraction Data

Date	Time	Volume (gallons)	Concentration (mg/L)	Sample	Br- (mg)	Cum. Br- (mg)	Volume Cum. (gallons)
26-Jul	9:40	2.64	86.57	00	866	866	3
	9:50	5.28	78.52	01	1570	2436	8
	10:00	5.28	47.21	02	944	3380	13
	10:10	5.28	18.96	03	379	3760	18
	10:20	5.28	13.48	04	270	4029	24
	10:30	5.28	8.34	05	167	4196	29
	10:40	5.28	8.52	06	170	4366	34
	10:50	4.76	7.04	07	127	4493	39
	11:00	4.76	5.78	08	104	4597	44
	11:10	4.76	4.00	09	72	4669	49
	11:20	4.23	3.50	10	56	4725	53
	11:30	4.23	3.02	11	48	4773	57
	11:40	4.23	2.60	12	42	4815	61
	11:50	4.23	2.42	13	39	4854	66
	12:00	3.70	2.27	14	32	4885	69
	12:10	3.70	2.23	15	31	4917	73
	12:20	3.70	2.01	16	28	4945	77
	12:40	7.40	1.90	17	53	4998	84
	13:00	8.45	1.85	18	59	5057	92
	13:20	8.98	1.48	19	50	5108	101
	13:40	8.98	1.47	20	50	5158	110
	14:00	8.98	1.46	21	50	5207	119
	14:20	8.98	1.46	22	50	5257	128
	14:40	11.23	1.48	23	63	5320	140

Total gallons removed: 140 gallons
Total Bromide removed: 5320 mg
% Bromide removed: 25.31 %

Extraction Start: 9:15 Extraction Complete: 14:25

Injection Data Injection Start: 8:10 Injection Complete: 9:13

Injected Volume (gallons)	Conc. (mg/L)	Total Br- Added (mg)
50.89	109.13	21022

Injection/ Extraction DNAPL Characterization Study
Test Data for Bromide Tracer at Well MSB22 (second test)

Extraction Data

Date	Time	Volume (gallons)	Concentration (mg/L)	Sample	Br- (mg)	Cum. Br- (mg)	Volume Cum. (gallons)
1-Aug	8:55	3.1	98.7	00	1150	1150	3
	9:05	6.2	69.1	01	1610	2760	9
	9:15	6.2	71.3	02	1661	4421	15
	9:25	4.6	39.1	03	685	5106	20
	9:35	4.6	24.0	04	420	5527	25
	9:45	4.6	18.7	05	328	5854	29
	9:55	4.6	13.3	06	233	6087	34
	10:05	4.6	12.4	07	217	6305	39
	10:15	4.6	7.6	08	133	6438	43
	10:25	4.6	6.2	09	109	6546	48
	10:35	4.6	5.5	10	96	6643	52
	10:45	4.6	4.7	11	82	6725	57
	10:55	4.6	4.4	12	77	6802	62
	11:05	4.6	3.7	13	65	6867	66
	11:15	4.6	3.4	14	60	6926	71
	11:25	4.6	3.2	15	56	6983	76
	11:35	4.6	3.1	16	54	7037	80
	11:55	9.3	3.0	17	105	7142	89
	12:15	9.3	3.1	18	109	7251	99
	12:35	9.3	3.1	19	109	7359	108
	12:55	9.3	3.8	20	133	7492	117
	13:15	9.3	4.0	21	140	7632	126
	13:35	9.3	4.0	22	140	7773	136
	13:55	9.3	4.6	23	161	7934	145

Total gallons removed: 145 gallons
Total Bromide removed: 7934 mg
% Bromide removed: 35.56 %

Extraction Start: 8:50 Extraction Complete: 13:58

Injection Data Injection Start: 7:35 Injection Complete: 8:45

Injected Volume (gallons)	Conc. (mg/L)	Total Br- Added (mg)
53.1	111	22312

Injection/ Extraction DNAPL Characterization Study
Test Data for Ethanol Injection at Well MSB22

Extraction Data

Date	Time	Volume (gallons)	Conc. (vol %)	Sample	EtOH (gallons)	Cum. EtOH (gallons)	Volume Cum. (gallons)
30-Jul	8:55	1.96	20.07	00	0.39	0.39	1.96
	9:05	3.93	18.95	01	0.74	1.14	5.89
	9:15	3.93	13.21	02	0.52	1.66	9.81
	9:25	3.93	7.38	03	0.29	1.95	13.74
	9:35	3.93	4.99	04	0.20	2.14	17.67
	9:45	3.93	3.12	05	0.12	2.26	21.59
	9:55	5.17	3.18	06	0.16	2.43	26.76
	10:05	5.17	2.47	07	0.13	2.56	31.93
	10:15	5.17	2.66	08	0.14	2.69	37.10
	10:25	5.17	1.53	09	0.08	2.77	42.28
	10:35	5.17	1.42	10	0.07	2.85	47.45
	10:45	5.17	1.34	11	0.07	2.92	52.62
	10:55	5.17	1.12	12	0.06	2.97	57.79
	11:05	5.17	0.98	13	0.05	3.02	62.96
	11:15	4.71	0.79	14	0.04	3.06	67.67
	11:25	4.71	0.01	15	0.00	3.06	72.38
	11:35	4.71	0.77	16	0.04	3.10	77.09
	11:55	9.42	0.65	17	0.06	3.16	86.51
	12:15	8.10	0.60	18	0.05	3.21	94.62
	12:35	9.56	0.59	19	0.06	3.27	104.18
	12:55	9.56	0.55	20	0.05	3.32	113.74
	13:15	9.56	0.62	21	0.06	3.38	123.31
	13:35	9.56	0.50	22	0.05	3.42	132.87
	13:55	11.00	0.49	23	0.05	3.48	143.87

Total gallons removed: 143.87 gallons
Total Alcohol removed: 3.48 gallons
% alcohol removed: 28.52 %

Extraction Start: 8:50 Extraction Complete: 13:58

Injection Data Injection Start: 7:37 Injection Complete: 8:46

Injected Volume (gallons)	Conc. (vol%)	Total Alcohol Added (gallons)
50.67	24.07	12.20

Concentration Data for MSB22

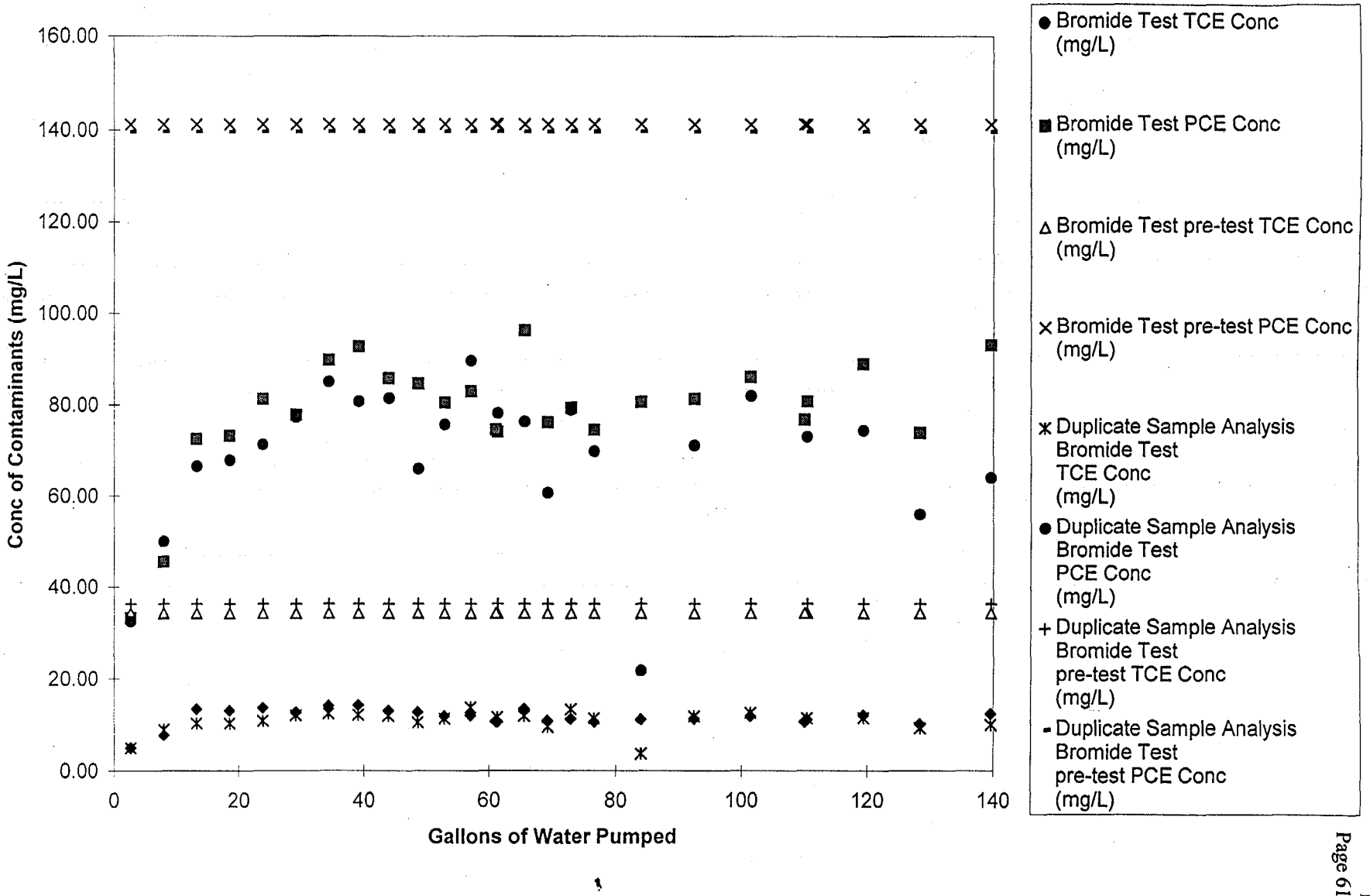
Sample ID	Sample Collection Information	Cumulative Volume (gallons)	Bromide Test TCE Conc (mg/L)	Bromide Test PCE Conc (mg/L)	Bromide Test pre-test TCE Conc (mg/L)	Bromide Test pre-test PCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test TCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test PCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test pre-test TCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test pre-test PCE Conc (mg/L)
MSB2200A	SAMPLE DATE 07-26-96 TIME 9:20	3	4.98	33.21	34.23	141.17	4.96	32.46	36.29	139.61
MSB2201A	SAMPLE DATE 07-26-96 TIME 9:30	8	7.77	45.54	34.23	141.17	8.88	49.99	36.29	139.61
MSB2202A	SAMPLE DATE 07-26-96 TIME 9:40	13	13.36	72.47	34.23	141.17	10.21	66.57	36.29	139.61
MSB2203A	SAMPLE DATE 07-26-96 TIME 9:50	18	13.07	73.19	34.23	141.17	10.22	67.85	36.29	139.61
MSB2204A	SAMPLE DATE 07-26-96 TIME 10:00	24	13.62	81.30	34.23	141.17	10.78	71.28	36.29	139.61
MSB2205A	SAMPLE DATE 07-26-96 TIME 10:10	29	12.65	77.77	34.23	141.17	11.99	77.29	36.29	139.61
MSB2206A	SAMPLE DATE 07-26-96 TIME 10:20	34	14.08	89.78	34.23	141.17	12.36	85.03	36.29	139.61
MSB2207A	SAMPLE DATE 07-26-96 TIME 10:30	39	14.20	92.69	34.23	141.17	12.05	80.72	36.29	139.61
MSB2208A	SAMPLE DATE 07-26-96 TIME 10:40	44	12.99	85.75	34.23	141.17	11.87	81.45	36.29	139.61
MSB2209A	SAMPLE DATE 07-26-96 TIME 10:50	49	12.65	84.53	34.23	141.17	10.36	65.93	36.29	139.61
MSB2210A	SAMPLE DATE 07-26-96 TIME 11:00	53	11.78	80.42	34.23	141.17	11.23	75.61	36.29	139.61
MSB2211A	SAMPLE DATE 07-26-96 TIME 11:10	57	11.98	82.88	34.23	141.17	13.71	89.57	36.29	139.61
MSB2212A	SAMPLE DATE 07-26-96 TIME 11:20	61	10.62	73.99	34.23	141.17	11.51	78.14	36.29	139.61
MSB2213A	SAMPLE DATE 07-26-96 TIME 11:30	66	13.35	96.24	34.23	141.17	11.77	76.30	36.29	139.61
MSB2214A	SAMPLE DATE 07-26-96 TIME 11:40	69	10.83	76.11	34.23	141.17	9.50	60.75	36.29	139.61
MSB2215A	SAMPLE DATE 07-26-96 TIME 11:50	73	11.22	79.25	34.23	141.17	13.27	78.83	36.29	139.61
MSB2216A	SAMPLE DATE 07-26-96 TIME 12:00	77	10.52	74.43	34.23	141.17	11.25	69.76	36.29	139.61
MSB2217A	SAMPLE DATE 07-26-96 TIME 12:20	84	11.09	80.55	34.23	141.17	3.68	21.81	36.29	139.61
MSB2218A	SAMPLE DATE 07-26-96 TIME 12:40	92	11.24	81.26	34.23	141.17	11.74	71.07	36.29	139.61
MSB2219A	SAMPLE DATE 07-26-96 TIME 1:00	101	11.77	86.01	34.23	141.17	12.53	81.95	36.29	139.61
MSB2220A	SAMPLE DATE 07-26-96 TIME 1:20	110	11.01	80.67	34.23	141.17	11.33	72.95	36.29	139.61
MSB2221A	SAMPLE DATE 07-26-96 TIME 1:40	119	11.97	88.82	34.23	141.17	11.37	74.30	36.29	139.61
MSB2222A	SAMPLE DATE 07-26-96 TIME 2:00	128	10.05	73.82	34.23	141.17	9.24	55.96	36.29	139.61
MSB2223A	SAMPLE DATE 07-26-96 TIME 2:20	140	12.35	93.03	34.23	141.17	9.92	64.04	36.29	139.61
MSB22D2A	SAMPLE DATE 07-26-96 TIME 1:20	110	10.55	76.64	34.23	141.17				
MSB22D1A	SAMPLE DATE 07-26-96 TIME 11:20	61	10.58	74.49	34.23	141.17				

Concentration Data for MSB22

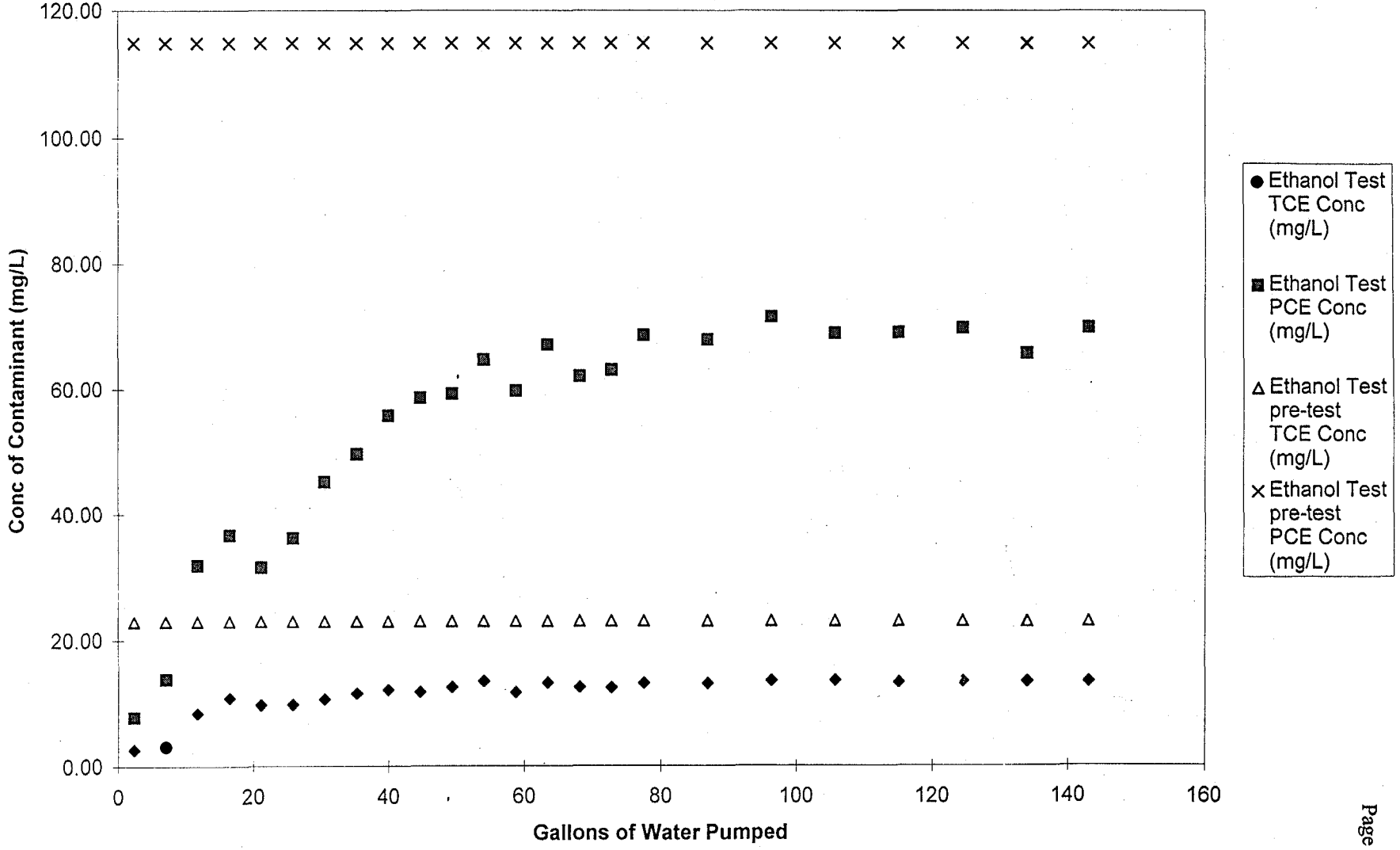
Sample ID	Sample Collection Information		Cumulative Volume (gallons)	Ethanol Test TCE Conc (mg/L)	Ethanol Test PCE Conc (mg/L)	Ethanol Test pre-test TCE Conc (mg/L)	Ethanol Test pre-test PCE Conc (mg/L)
MSB2200B	SAMPLE DATE 07-30-96	TIME 8:55	2	2.66	7.81	22.93	114.84
MSB2201B	SAMPLE DATE 07-30-96	TIME 9:05	7	3.15	13.81	22.93	114.84
MSB2202B	SAMPLE DATE 07-30-96	TIME 9:15	12	8.42	31.86	22.93	114.84
MSB2203B	SAMPLE DATE 07-30-96	TIME 9:25	16	10.84	36.63	22.93	114.84
MSB2204B	SAMPLE DATE 07-30-96	TIME 9:35	21	9.73	31.52	22.93	114.84
MSB2205B	SAMPLE DATE 07-30-96	TIME 9:45	26	9.79	36.13	22.93	114.84
MSB2206B	SAMPLE DATE 07-30-96	TIME 9:55	31	10.60	45.13	22.93	114.84
MSB2207B	SAMPLE DATE 07-30-96	TIME 10:05	35	11.52	49.60	22.93	114.84
MSB2208B	SAMPLE DATE 07-30-96	TIME 10:15	40	12.13	55.70	22.93	114.84
MSB2209B	SAMPLE DATE 07-30-96	TIME 10:25	45	11.73	58.55	22.93	114.84
MSB2210B	SAMPLE DATE 07-30-96	TIME 10:35	49	12.53	59.15	22.93	114.84
MSB2211B	SAMPLE DATE 07-30-96	TIME 10:45	54	13.47	64.64	22.93	114.84
MSB2212B	SAMPLE DATE 07-30-96	TIME 10:55	59	11.67	59.63	22.93	114.84
MSB2213B	SAMPLE DATE 07-30-96	TIME 11:05	63	13.15	66.97	22.93	114.84
MSB2214B	SAMPLE DATE 07-30-96	TIME 11:15	68	12.46	61.98	22.93	114.84
MSB2215B	SAMPLE DATE 07-30-96	TIME 11:25	73	12.39	62.94	22.93	114.84
MSB2216B	SAMPLE DATE 07-30-96	TIME 11:35	77	13.07	68.49	22.93	114.84
MSB2217B	SAMPLE DATE 07-30-96	TIME 11:55	87	13.06	67.78	22.93	114.84
MSB2218B	SAMPLE DATE 07-30-96	TIME 12:15	96	13.48	71.44	22.93	114.84
MSB2219B	SAMPLE DATE 07-30-96	TIME 12:35	106	13.52	68.83	22.93	114.84
MSB2220B	SAMPLE DATE 07-30-96	TIME 12:55	115	13.25	68.90	22.93	114.84
MSB2221B	SAMPLE DATE 07-30-96	TIME 13:15	124	13.40	69.62	22.93	114.84
MSB2222B	SAMPLE DATE 07-30-96	TIME 13:35	134	13.45	65.60	22.93	114.84
MSB2222B	SAMPLE DATE 07-30-96	TIME 13:35	134	13.45	65.60	22.93	114.84
MSB2223B	SAMPLE DATE 07-30-96	TIME 13:55	143	13.41	69.72	22.93	114.84

MSB22 Data Used
in Chart of C/Co vs volume

Results for Control/Bromide Test						Results for Ethanol Inj-Ext Test				
volume (gallons)	TCE (mg/L)	PCE (mg/L)	TCE (C/Co)	PCE (C/Co)		volume (gallons)	TCE (mg/L)	PCE (mg/L)	TCE (C/Co)	PCE (C/Co)
-100	34.00	141.00	1.00	1.00		-100	23.00	115.00	1.00	1.00
-50	34.00	141.00	1.00	1.00		-50	23.00	115.00	1.00	1.00
-45	0	0	0.00	0.00		-45	0	0	0.00	0.00
0	0	0	0.00	0.00		0	0	0	0.00	0.00
3	4.98	33.21	0.15	0.24		2	2.66	7.81	0.12	0.07
8	7.77	45.54	0.23	0.32		7	3.15	13.81	0.14	0.12
13	13.36	72.47	0.39	0.51		12	8.42	31.86	0.37	0.28
18	13.07	73.19	0.38	0.52		16	10.84	36.63	0.47	0.32
24	13.62	81.30	0.40	0.58		21	9.73	31.52	0.42	0.27
29	12.65	77.77	0.37	0.55		26	9.79	36.13	0.43	0.31
34	14.08	89.78	0.41	0.64		31	10.60	45.13	0.46	0.39
39	14.20	92.69	0.42	0.66		35	11.52	49.60	0.50	0.43
44	12.99	85.75	0.38	0.61		40	12.13	55.70	0.53	0.48
49	12.65	84.53	0.37	0.60		45	11.73	58.55	0.51	0.51
53	11.78	80.42	0.35	0.57		49	12.53	59.15	0.54	0.51
57	11.98	82.88	0.35	0.59		54	13.47	64.64	0.59	0.56
61	10.62	73.99	0.31	0.52		59	11.67	59.63	0.51	0.52
66	13.35	96.24	0.39	0.68		63	13.15	66.97	0.57	0.58
69	10.83	76.11	0.32	0.54		68	12.46	61.98	0.54	0.54
73	11.22	79.25	0.33	0.56		73	12.39	62.94	0.54	0.55
77	10.52	74.43	0.31	0.53		77	13.07	68.49	0.57	0.60
84	11.09	80.55	0.33	0.57		87	13.06	67.78	0.57	0.59
92	11.24	81.26	0.33	0.58		96	13.48	71.44	0.59	0.62
101	11.77	86.01	0.35	0.61		106	13.52	68.83	0.59	0.60
110	11.01	80.67	0.32	0.57		115	13.25	68.90	0.58	0.60
119	11.97	88.82	0.35	0.63		124	13.40	69.62	0.58	0.61
128	10.05	73.82	0.30	0.52		134	13.45	65.60	0.58	0.57
140	12.35	93.03	0.36	0.66		134	13.45	65.60	0.58	0.57
						143	13.41	69.72	0.58	0.61


MSB22 Bromide Test - TCE & PCE Analysis
Conc of Contaminants (mg/L)
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0
20
40
60
80
100
120
140
Gallons of Water Pumped
Bromide Test TCE Conc (mg/L)
Bromide Test PCE Conc (mg/L)
Bromide Test pre-test TCE Conc (mg/L)
Bromide Test pre-test PCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test TCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test PCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test pre-test TCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test pre-test PCE Conc (mg/L)

MSB22 Ethanol Test - PCE & TCE Analysis



WELL MSB3D

Injection/ Extraction DNAPL Characterization Study
Test Data for Bromide Tracer at Well MSB3D

Extraction Data

Date	Time	Volume (gallons)	Concentration (mg/L)	Sample	Br- (mg)	Cum. Br- (mg)	Volume Cum. (gallons)
9-Aug	8:51	3.9	68.5	00	1002	1002	4
	9:01	7.7	71.0	01	2078	3080	12
	9:11	7.7	62.1	02	1818	4898	19
	9:21	6.7	54.0	03	1364	6262	26
	9:31	5.6	49.8	04	1048	7311	32
	9:41	5.6	41.7	05	878	8189	37
	9:51	5.6	35.2	06	741	8930	43
	10:01	5.6	29.7	07	625	9555	48
	10:11	5.6	24.2	08	509	10064	54
	10:21	5.6	12.1	09	255	10319	59
	10:31	5.6	11.4	10	240	10559	65
	10:41	5.6	9.7	11	204	10763	70
	10:51	5.6	8.0	12	168	10932	76
	11:01	5.6	7.3	13	154	11085	82
	11:11	5.6	7.3	14	154	11239	87
	11:21	5.6	5.3	15	112	11351	93
	11:31	5.6	5.0	16	105	11456	98
	11:51	11.1	4.1	17	173	11629	109
	12:11	11.1	3.6	18	152	11780	121
	12:31	11.1	2.9	19	122	11902	132
	12:51	11.1	3.4	20	143	12045	143
	13:11	11.1	2.3	21	97	12142	154
	13:31	11.1	1.9	22	80	12222	165
	13:51	11.1	1.8	23	76	12298	176

Total gallons removed: 176 gallons
Total Bromide removed: 12298 mg
% Bromide removed: 80.21 %

Extraction Start: 8:46 Extraction Complete: 13:53

Injection Data Injection Start: 7:41 Injection Complete: 8:41

Injected Volume (gallons)	Conc. (mg/L)	Total Br- Added (mg)
50	81	15332

Injection/ Extraction DNAPL Characterization Study
Test Data for Ethanol Injection at Well MSB3D

Extraction Data

Date	Time	Volume (gallons)	Conc. (vol %)	Sample	EtOH (gallons)	Cum. EtOH (gallons)	Volume Cum. (gallons)
13-Aug	8:50	1.99	15.35	00	0.31	0.31	1.99
	9:00	4.97	16.18	01	0.80	1.11	6.96
	9:10	4.97	14.31	02	0.71	1.82	11.93
	9:20	4.97	13.89	03	0.69	2.51	16.89
	9:30	4.97	12.20	04	0.61	3.12	21.86
	9:40	5.17	12.93	05	0.67	3.78	27.03
	9:50	5.17	11.62	06	0.60	4.39	32.20
	10:00	5.17	12.28	07	0.63	5.02	37.37
	10:10	5.17	8.89	08	0.46	5.48	42.55
	10:20	5.17	7.64	09	0.40	5.88	47.72
	10:30	5.17	6.31	10	0.33	6.20	52.89
	10:40	5.17	5.36	11	0.28	6.48	58.06
	10:50	5.09	5.40	12	0.27	6.75	63.15
	11:00	5.09	3.97	13	0.20	6.96	68.23
	11:10	5.09	3.46	14	0.18	7.13	73.32
	11:20	5.09	3.36	15	0.17	7.30	78.41
	11:30	5.09	2.91	16	0.15	7.45	83.50
	11:50	10.18	2.14	17	0.22	7.67	93.67
	12:10	10.18	2.00	18	0.20	7.87	103.85
	12:30	10.18	2.32	19	0.24	8.11	114.03
	12:50	10.18	1.36	20	0.14	8.25	124.20
	13:10	10.18	1.15	21	0.12	8.36	134.38
	13:30	10.18	0.98	22	0.10	8.46	144.55
	13:50	10.18	0.80	23	0.08	8.54	154.73

Total gallons removed: 154.73 gallons
Total Alcohol removed: 8.54 gallons
% alcohol removed: 75.18 %

Extraction Start: 8:46 Extraction Complete: 13:57

Injection Data Injection Start: 7:35 Injection Complete: 8:44

Injected Volume (gallons)	Conc. (vol%)	Total Alcohol Added (gallons)
50.00	22.73	11.37

Concentration Data for MSB3D

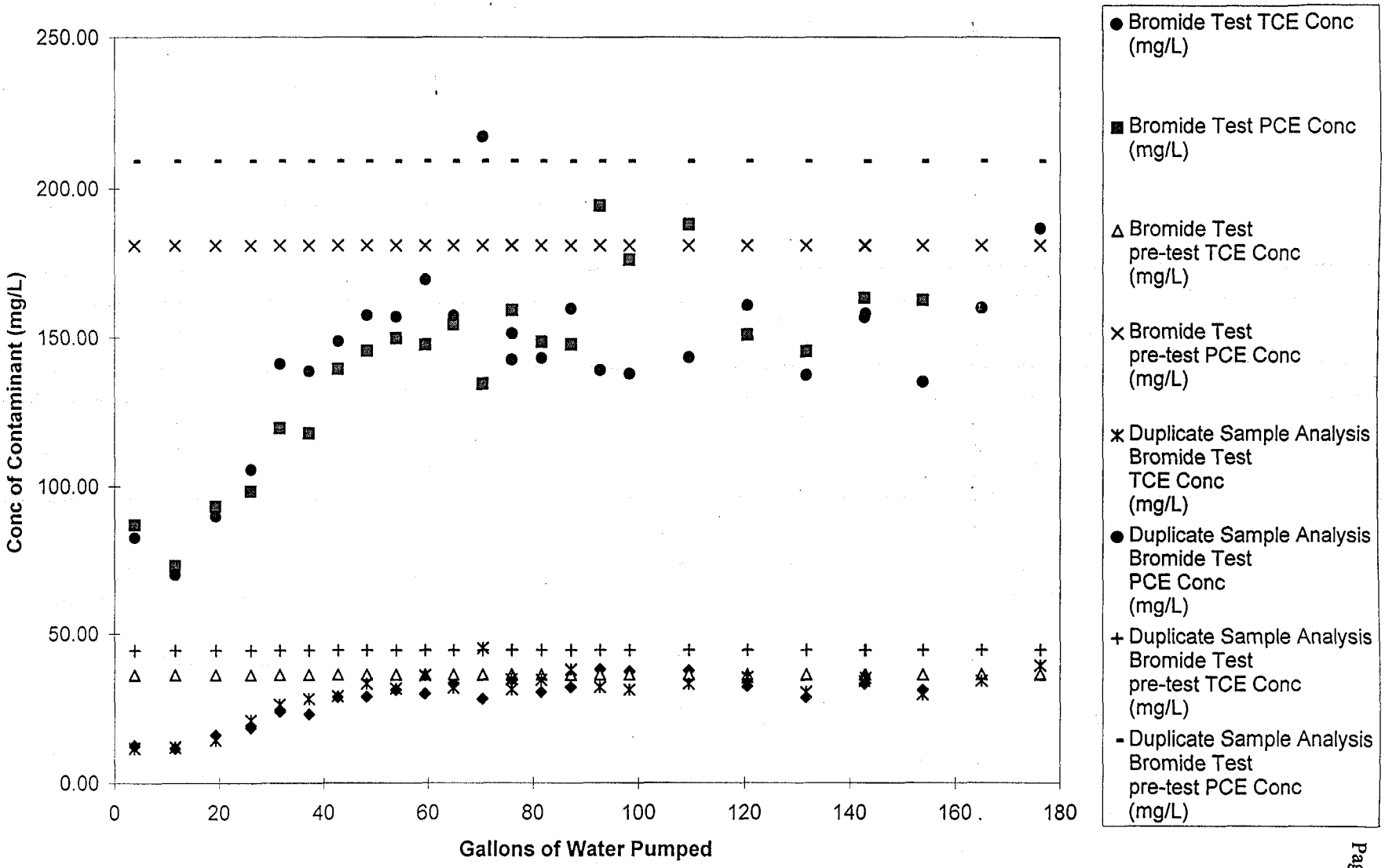
Sample ID	Sample Collection Information	Cumulative Volume (gallons)	Bromide Test TCE Conc (mg/L)	Bromide Test PCE Conc (mg/L)	Bromide Test pre-test TCE Conc (mg/L)	Bromide Test pre-test PCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test TCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test PCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test pre-test TCE Conc (mg/L)	Duplicate Sample Analysis Bromide Test pre-test PCE Conc (mg/L)
MSBO300A	SAMPLE DATE 08-09-96 TIME 8:51	4	12.37	86.91	36.30	180.97	11.52	82.62	44.46	209.08
MSBO301A	SAMPLE DATE 08-09-96 TIME 9:01	12	11.56	73.00	36.30	180.97	11.88	70.12	44.46	209.08
MSB0302A	SAMPLE DATE 08-09-96 TIME 9:11	19	15.89	93.15	36.30	180.97	14.28	89.88	44.46	209.08
MSBO303A	SAMPLE DATE 08-09-96 TIME 9:21	26	18.37	98.31	36.30	180.97	20.86	105.66	44.46	209.08
MSBO304A	SAMPLE DATE 08-09-96 TIME 9:31	32	23.79	119.57	36.30	180.97	26.25	141.23	44.46	209.08
MSBO305A	SAMPLE DATE 08-09-96 TIME 9:41	37	22.96	117.91	36.30	180.97	28.16	138.78	44.46	209.08
MSBO306A	SAMPLE DATE 08-09-96 TIME 9:51	43	28.67	139.36	36.30	180.97	28.93	148.85	44.46	209.08
MSBO307A	SAMPLE DATE 08-09-96 TIME 10:01	48	28.92	145.50	36.30	180.97	33.21	157.54	44.46	209.08
MSBO308A	SAMPLE DATE 08-09-96 TIME 10:11	54	31.17	149.85	36.30	180.97	31.58	157.06	44.46	209.08
MSBO309A	SAMPLE DATE 08-09-96 TIME 10:21	59	29.91	147.67	36.30	180.97	36.09	169.52	44.46	209.08
MSBO310A	SAMPLE DATE 08-09-96 TIME 10:31	65	33.14	154.44	36.30	180.97	31.89	157.42	44.46	209.08
MSBO311A	SAMPLE DATE 08-09-96 TIME 10:41	70	28.11	134.40	36.30	180.97	45.11	217.32	44.46	209.08
MSBO312A	SAMPLE DATE 08-09-96 TIME 10:51	76	34.39	159.19	36.30	180.97	31.24	151.39	44.46	209.08
MSBO313A	SAMPLE DATE 08-09-96 TIME 11:01	82	30.43	148.58	36.30	180.97	34.46	143.11	44.46	209.08
MSBO314A	SAMPLE DATE 08-09-96 TIME 11:11	87	32.10	147.73	36.30	180.97	37.97	159.75	44.46	209.08
MSB0315A	SAMPLE DATE 08-09-96 TIME 11:21	93	38.05	194.24	36.30	180.97	32.00	139.02	44.46	209.08
MSB0316A	SAMPLE DATE 08-09-96 TIME 11:31	98	37.34	176.18	36.30	180.97	31.15	137.88	44.46	209.08
MSBO317A	SAMPLE DATE 08-09-96 TIME 11:51	109	37.63	187.96	36.30	180.97	33.13	143.37	44.46	209.08
MSBO318A	SAMPLE DATE 08-09-96 TIME 12:11	121	32.35	151.06	36.30	180.97	35.31	160.91	44.46	209.08
MSBO319A	SAMPLE DATE 08-09-96 TIME 12:31	132	28.60	145.34	36.30	180.97	30.32	137.42	44.46	209.08
MSBO320A	SAMPLE DATE 08-09-96 TIME 12:51	143	33.21	163.39	36.30	180.97	34.08	156.91	44.46	209.08
MSBO321A	SAMPLE DATE 08-09-96 TIME 13:11	154	31.06	162.68	36.30	180.97	29.53	135.13	44.46	209.08
MSBO322A	SAMPLE DATE 08-09-96 TIME 13:31	165			36.30	180.97	34.18	160.02	44.46	209.08
MSBO323A	SAMPLE DATE 08-09-96 TIME 13:51	176			36.30	180.97	39.21	186.68	44.46	209.08
MSBO3D2A	SAMPLE DATE 08-09-96 TIME 12:51	143			36.30	180.97	35.13	158.17	44.46	209.08
MSBO3D1A	SAMPLE DATE 08-09-96 TIME 10:51	76			36.30	180.97	34.65	142.56	44.46	209.08

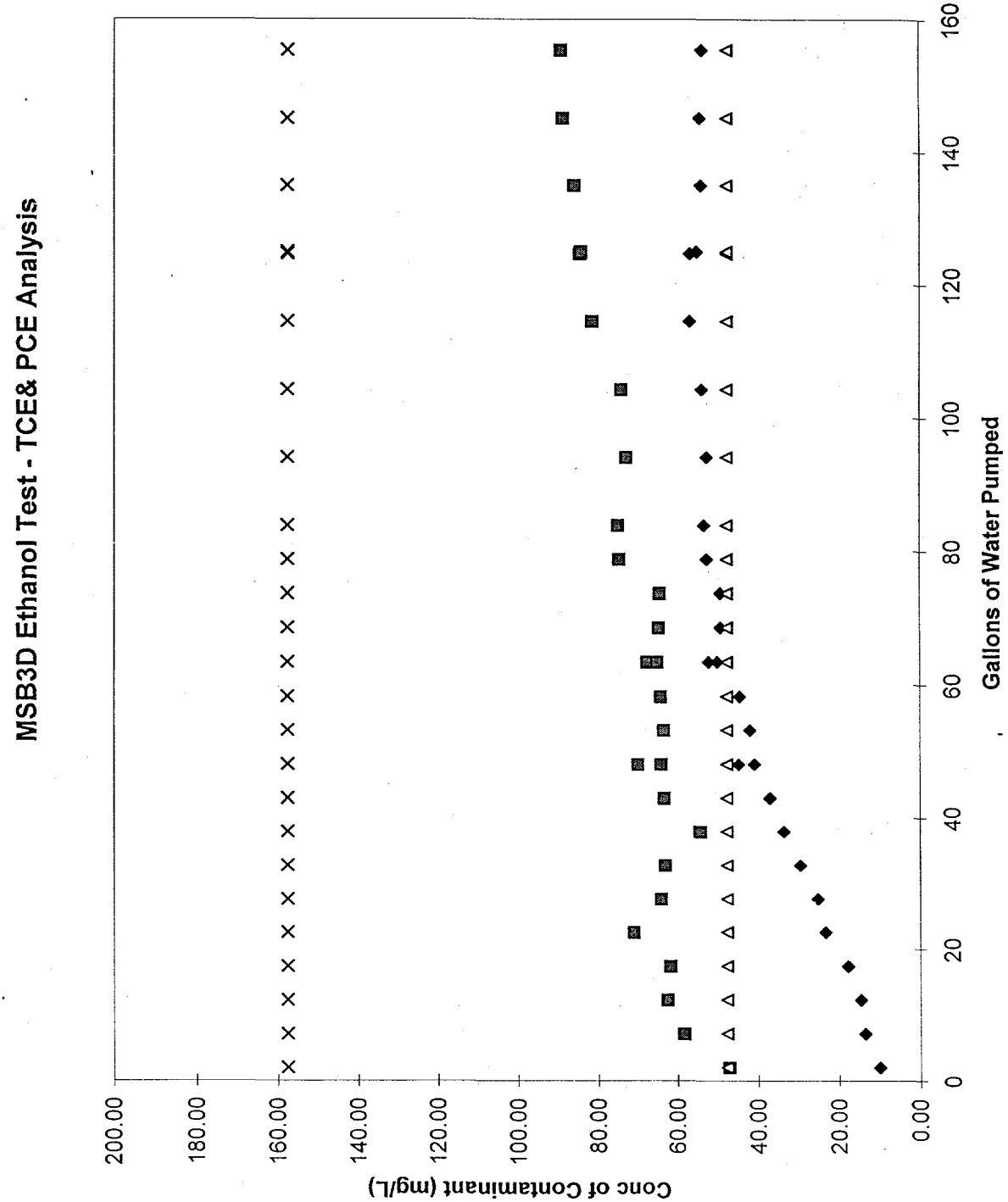
Concentration Data for MSB3D

Sample ID	Sample Collection Information	Cumulative Volume (gallons)	Ethanol Test TCE Conc (mg/L)	Ethanol Test PCE Conc (mg/L)	Ethanol Test pre-test TCE Conc (mg/L)	Ethanol Test pre-test PCE Conc (mg/L)
MSB0300B	SAMPLE DATE 08-13-96 TIME 8:50	2	10.03	47.33	47.76	157.53
MSB0301B	SAMPLE DATE 08-13-96 TIME 9:00	7	13.63	58.37	47.76	157.53
MSB0302B	SAMPLE DATE 08-13-96 TIME 9:10	12	14.71	62.52	47.76	157.53
MSB0303B	SAMPLE DATE 08-13-96 TIME 9:20	17	17.88	61.81	47.76	157.53
MSB0304B	SAMPLE DATE 08-13-96 TIME 9:30	22	23.45	71.08	47.76	157.53
MSB0305B	SAMPLE DATE 08-13-96 TIME 9:40	28	25.42	64.13	47.76	157.53
MSB0306B	SAMPLE DATE 08-13-96 TIME 9:50	33	29.72	63.05	47.76	157.53
MSB0307B	SAMPLE DATE 08-13-96 TIME 10:00	38	33.69	54.41	47.76	157.53
MSB0308B	SAMPLE DATE 08-13-96 TIME 10:10	43	37.10	63.32	47.76	157.53
MSB0309B	SAMPLE DATE 08-13-96 TIME 10:20	48	40.86	64.12	47.76	157.53
MSB0310B	SAMPLE DATE 08-13-96 TIME 10:30	53	41.95	63.44	47.76	157.53
MSB0311B	SAMPLE DATE 08-13-96 TIME 10:40	58	44.57	64.13	47.76	157.53
MSB0312B	SAMPLE DATE 08-13-96 TIME 10:50	63	52.32	67.62	47.76	157.53
MSB0312B	SAMPLE DATE 08-13-96 TIME 10:50	63	50.17	64.99	47.76	157.53
MSB0313B	SAMPLE DATE 08-13-96 TIME 11:00	69	49.33	64.61	47.76	157.53
MSB0314B	SAMPLE DATE 08-13-96 TIME 11:10	74	49.45	64.41	47.76	157.53
MSB0315B	SAMPLE DATE 08-13-96 TIME 11:20	79	52.79	74.76	47.76	157.53
MSB0316B	SAMPLE DATE 08-13-96 TIME 11:30	84	53.45	74.99	47.76	157.53
MSB0317B	SAMPLE DATE 08-13-96 TIME 11:50	94	52.76	72.87	47.76	157.53
MSB0318B	SAMPLE DATE 08-13-96 TIME 12:10	104	53.98	74.13	47.76	157.53
MSB0319B	SAMPLE DATE 08-13-96 TIME 12:30	115	56.95	81.45	47.76	157.53
MSB0320B	SAMPLE DATE 08-13-96 TIME 12:50	125	56.85	84.49	47.76	157.53
MSB0321B	SAMPLE DATE 08-13-96 TIME 13:10	135	54.18	85.85	47.76	157.53
MSB0322B	SAMPLE DATE 08-13-96 TIME 13:30	145	54.55	88.75	47.76	157.53
MSB0323B	SAMPLE DATE 08-13-96 TIME 13:50	155	54.03	89.30	47.76	157.53
MSB03D1B	SAMPLE DATE 08-13-96 TIME 10:20	48	44.86	69.95	47.76	157.53
MSB03D2B	SAMPLE DATE 08-13-96 TIME 12:50	125	55.23	84.21	47.76	157.53

MSB3D Data Used
in Chart of C/Co vs volume

Results for Control/Bromide Test					Results for Ethanol Inj-Ext Test				
volume (gallons)	TCE (mg/L)	PCE (mg/L)	TCE (C/Co)	PCE (C/Co)	volume (gallons)	TCE (mg/L)	PCE (mg/L)	TCE (C/Co)	PCE (C/Co)
-100	36.30	180.97	1.00	1.00	-100	47.76	157.53	1.00	1.00
-50	36.30	180.97	1.00	1.00	-50	47.76	157.53	1.00	1.00
-45	0	0	0.00	0.00	-45	0	0	0.00	0.00
0	0	0	0.00	0.00	0	0	0	0.00	0.00
4	12.37	86.91	0.34	0.48	2	10.03	47.33	0.21	0.30
12	11.56	73.00	0.32	0.40	7	13.63	58.37	0.29	0.37
19	15.89	93.15	0.44	0.51	12	14.71	62.52	0.31	0.40
26	18.37	98.31	0.51	0.54	17	17.88	61.81	0.37	0.39
32	23.79	119.57	0.66	0.66	22	23.45	71.08	0.49	0.45
37	22.96	117.91	0.63	0.65	28	25.42	64.13	0.53	0.41
43	28.67	139.36	0.79	0.77	33	29.72	63.05	0.62	0.40
48	28.92	145.50	0.80	0.80	38	33.69	54.41	0.71	0.35
54	31.17	149.85	0.86	0.83	43	37.10	63.32	0.78	0.40
59	29.91	147.67	0.82	0.82	48	40.86	64.12	0.86	0.41
65	33.14	154.44	0.91	0.85	53	41.95	63.44	0.88	0.40
70	28.11	134.40	0.77	0.74	58	44.57	64.13	0.93	0.41
76	34.39	159.19	0.95	0.88	63	52.32	67.62	1.10	0.43
82	30.43	148.58	0.84	0.82	63	50.17	64.99	1.05	0.41
87	32.10	147.73	0.88	0.82	69	49.33	64.61	1.03	0.41
93	38.05	194.24	1.05	1.07	74	49.45	64.41	1.04	0.41
98	37.34	176.18	1.03	0.97	79	52.79	74.76	1.11	0.47
109	37.63	187.96	1.04	1.04	84	53.45	74.99	1.12	0.48
121	32.35	151.06	0.89	0.83	94	52.76	72.87	1.10	0.46
132	28.60	145.34	0.79	0.80	104	53.98	74.13	1.13	0.47
143	33.21	163.39	0.91	0.90	115	56.95	81.45	1.19	0.52
154	31.06	162.68	0.86	0.90	125	56.85	84.49	1.19	0.54
					135	54.18	85.85	1.13	0.54
					145	54.55	88.75	1.14	0.56
					155	54.03	89.30	1.13	0.57


MSB3D Bromide Test - TCE & PCE Analysis
Conc of Contaminant (mg/L)
250.00
200.00
150.00
100.00
50.00
0.00
0
20
40
60
80
100
120
140
160
180
Gallons of Water Pumped
Bromide Test TCE Conc (mg/L)
Bromide Test PCE Conc (mg/L)
Bromide Test pre-test TCE Conc (mg/L)
Bromide Test pre-test PCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test TCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test PCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test pre-test TCE Conc (mg/L)
Duplicate Sample Analysis Bromide Test pre-test PCE Conc (mg/L)


MSB3D Ethanol Test - TCE& PCE Analysis
◆ Ethanol Test TCE Conc (mg/L)
■ Ethanol Test PCE Conc (mg/L)
Δ Ethanol Test pre-test TCE Conc (mg/L)
× Ethanol Test pre-test PCE Conc (mg/L)
Conc of Contaminant (mg/L)
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0
20
40
60
80
100
120
140
160
Gallons of Water Pumped