Minnesota Pollution Control Agency

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

May 19, 2004

Commanding Officer
Southern Division
Naval Facilities Engineering Command
Attn: Dan Owens, Code ES32
P.O. Box 190010
North Charleston, SC 29419-9010

RE: Naval Industrial Reserve Ordnance Plant Superfund Site

Dear Mr. Owens:

The Minnesota Pollution Control Agency (MPCA) staff has reviewed the report entitled, "Draft Report for A Field Application to Enhance In-Situ Bioremediation of Chlorinated Solvents via Vegetable Oil Injection at Naval Industrial Ordinance Plant Fridley, Minnesota," ("Report") dated March 2004. The Report is for the Naval Industrial Reserve Ordnance Plant (NIROP) Superfund Site and was submitted pursuant to the Federal Facility Agreement, dated March 27, 1991, between the MPCA, the U.S. Environmental Protection Agency (U.S. EPA), and the U.S. Navy (Navy).

The MPCA commends the Navy for investigating innovative technologies to address the environmental problems that the NIROP Partnering Team is dealing with at the NIROP. The vegetable oil injection pilot study to enhance in-situ bioremediation of chlorinated solvents is an innovative technology that may have promise in Anoka County Park and possibly in other areas of the NIROP Site.

The analysis of the pilot study includes valuable information that is important to understanding the fate of the chlorinated contaminants in pilot study area. The geochemistry, oil fermentation products, microbial identification, and assays are thorough and nicely presented in the Report. However, the MPCA staff review of the Report has identified a number of factors that may have affected the pilot study results and have presented challenges for the interpretation of the results. These factors, which are more fully articulated in Attachment I, include:

- small-scale variations in lithology in the pilot study area;
- incomplete characterization of the horizontal and vertical flow regimes in the pilot study area;
- addition of iron (in two forms) to the vegetable oil;
- reduction in ground water contamination in the pilot study area due to the improved ground water capture system; and
- impacts to ground water contamination concentrations in the pilot study area due to significant capture system down-time during 2003.

At our April 15, 2004 NIROP Partnering Team Meeting, the team made a decision to not proceed with full scale implementation of the pilot study until some of the issues identified in the review of the Report were resolved.

The decisions were as follows:

- 0404D01 - Venky/Parsons will develop a draft workplan addendum for the Phase I pilot study. The data collected from the initial pilot study and Phase I will be used as input for the DQOs for potential expanded pilot study.

- 0404D02 - The results from Phase I and the trends in the Anoka County Park will determine future remedial action(s).

The MPCA staff believes that continued ground water monitoring is needed in the pilot study. The Phase I monitoring should result in a better understanding of the performance of the vegetable oil technology at the NIROP Site. Also the Phase I pilot study monitoring will give the Navy the opportunity to clarify some of the unanswered questions that remain problematic for the interpretation of the pilot study results. The information will allow the Partnering Team to make a better decision regarding the potential of vegetable oil technology to achieve protection of the Mississippi River.

With the above-cited issues in mind, the MPCA staff hereby modifies the Report pursuant to Attachment I of this letter.

If you have any questions regarding this letter, please call me at (651) 296-7818.

Sincerely,

David N. Douglas, Project Manager
Superfund Unit 2
Superfund Section
Majors and Remediation Division

DND:csa

Enclosures

cc: Thomas Smith, U.S. EPA (w/enclosures)
Venky Venkatesh, CH2M Hill Constructors, Inc. (w/enclosures)
Mark Sladic, Tetra Tech NUS, Inc. (w/enclosures)

Attachment I

Modifications to "Draft Report for A Field Application to Enhance In-Situ Bioremediation of Chlorinated Solvents via Vegetable Oil Injection at Naval Industrial Ordinance Plant Fridley, Minnesota," Dated March 2004

Part I. Modifications Based on an MPCA Staff Review of an Interim Report

The Report was reviewed regarding how the Navy addressed the MPCA staff responses to a technical review of a memorandum entitled "Preliminary Results for the Anoka County Park Substrate Addition Pilot Test," (Preliminary Report) dated July 1, 2003 sent to the Navy by e-mail on December 5, 2003. The responses to the Preliminary Report are in italics below and the MPCA staff follow-up responses are in non-italicized script:

Biofouling due to microbial growth has been identified as a problem around the oil injection wells. Oil delivery has been identified as a problem and at meetings it has been said that more numerous injection points may be need. How will permeability reductions due to biofouling impact the movement of ground water through the oil to achieve treatment?

The MPCA staff believes that this question was not answered in the Report. The MPCA staff requests that the Navy answer this question.

It has been stated that organic carbon is not migrating as expected and that organic carbon may be degrading before reaching downgradient wells. How will this problem be addressed?

The MPCA staff believes that the Report adequately answers the question.

It is stated that Dehalococciodes ethenogenes has not been found at the site even in wells with high biomass. Ethane is present which would indicate conflicting information that the microbe should be present. How will this be resolved?

The MPCA staff believes that the Report adequately answers this question.

It is stated that the local hydrogeologic system in the vicinity of the pilot test area is not adequately defined. Parsons recommends expanding the monitoring well network and conducting additional process monitoring rounds to make these determinations. How will this issue be resolved? What are Parsons' recommendations?

Please see the follow-up MPCA staff response in Part II of this attachment.

The issue of upward flow of ground water from deeper zones was not resolved at the Technical Subcommittee meeting regarding the USGS report. The pilot test was designed assuming horizontal ground water flow. How important is it that this be resolved for the pilot scale test? How does this impact the results?

Please see the follow-up MPCA staff response in Part II of this attachment.

How will the issue of partitioning of TCE to the oil be evaluated in the TCE reductions observed? Are we creating an LNAPL? What will happen to this material over time?

The MPCA staff believes that the Report adequately answers the questions.

It seems that the imaging work, proposed to determine how the oil was distributed, is important to the evaluation of the test results (oil delivery and carbon distribution has been identified as a problem). Will the final report include the USGS imaging evaluation?

The MPCA staff believes that the Report adequately answers the question.

Is it likely that the iron added to image to oil distribution is reactive with TCE? Is it reactive? Is it fair to assume that it was added to enhance TCE reduction? Will it be possible to determine what reduction is from the oil and biological activity and what reduction is due to the iron addition (see comments to MS-53PC work plan). How valid is the evaluation of organic substrate addition now that iron has been added to the aquifer?

Please see the follow-up MPCA staff response in Part II of this attachment.

How will you evaluate the TCE reductions in Anoka County Park due to the addition of additional capture wells upgradient and how will you separate this from the other potential treatment mechanisms at work including biological activity from the oil injection and the introduction of iron?

Please see the follow-up MPCA staff response in Part II of this attachment.

The results of the monitoring downgradient of the oil injection points are equivocal. While a couple of the wells appear to show the effect of the oil injection (primary fermentation products, an increase in cis-DCE and vinyl chloride) other monitoring wells do not. It is unclear whether this indicates:

- *An incorrect initial conceptual model of the ground water flow at the site;*
- *That the vegetable oil has altered ground water flow patterns;*
- *And an actual spatial variation in the aquifer and microbial response to the oil inject*

The MPCA staff believes that the Report adequately addresses the bulleted items above.

Understanding what effect the oil has had on the chlorinated solvents is compromised by the injection of the iron into the ground water.

The MPCA staff believes that this item was discussed in the Report; however, the recommendations/conclusion section does not allude to it. The MPCA staff requests that this item be addressed in the recommendations/conclusions section.

The appearance of hydrogen in CW wells 1, 2, and 3 at 1 nanomolar or higher is confusing. These concentrations of hydrogen indicate a highly reducing environment. However, these wells are downgradient of the injection wells in an aquifer that was characterized before the oil injection study as aerobic, and we should not expect to see hydrogen increases that far away from the test area as a result of the oil injection.

The MPCA staff believes that this apparent contradiction was not answered in the Report. The MPCA staff requests that the Navy explain this apparent contradiction.

Earlier discussion centered on the fact that monitoring wells 1 and 6 have not yet exhibited a convincing downward trend, and wells 2, 3, and 4 are showing very little effect of the oil injection on contaminant concentrations. As was discussed last July, declaring success and moving to a full scale system may be premature.

The MPCA staff believes that this comment is addressed Report; however, the MPCA staff believes that the interpretation of how successful the pilot study has been is still being debated.

II. Current Report Modifications

General Comment

While the analysis and presentation of the pilot study results are excellent, the results are confounded by the co-injection of the zero-valent iron and magnetite with the oil. Magnetite has been reported to break down chlorinated aliphatic compounds non-biologically (see *Lee, W., and B. Batchelor, 2002. Abiotic reductive dechlorination of chlorinated ethylenes by iron bearing soil minerals. 1. Pyrite and magnetite. Environ. Sci. Technol. 36:5147-5154*), and the reaction of chlorinated ethylenes with zero-valent iron is well-known. The impact of the vegetable oil on the chlorinated compounds apart from the iron compounds is very difficult to determine, and remains an unknown factor as the scale-up options are considered.

Studies at the nearby Twin City Arms and Ammunition Plant (TCAAP) also indicate that the disappearance of dichloroethylene (DCE) isomers without the appearance of vinyl chloride is likely due to the presence of magnetite in the ground water sediments (see *Ferrey, et al., 2004. Non-biological removal of cis-dichloroethylene and 1,1-dichloroethylene in aquifer sediment containing magnetite. Environ. Sci. Technol., 38:1746-1752*). This may account for the absence of DCE isomers in the downgradient wells from the pilot study. The MPCA staff requests that the discussion be amended to include the possibility that magnetite may be responsible for DCE isomer degradation at this Site as well.

The effect of iron addition needs more discussion in the Report, particularly in Section 5 where conclusions and recommendations are presented. Because the influence of the iron compounds is unknown, it is not clear how to proceed with the planning and implementation of Phase II and possibly Phase III (conclusions and recommendations section).

As a general comment, it is confusing why concentrations of trichloroethylene (TCE) increased dramatically in well MW-5 and remained relatively stable in MW-4. If the effect of the oil was to decrease concentrations of this contaminant near the injection wells, the subsequent monitoring data for wells MW-4 and MW-5 either indicate that these wells are not downgradient of the injection wells or that the impact of the oil is limited to a very narrow band near the injection area.

Section ES.1 Field Results, page ES-4, first paragraph, last sentence

Please see MPCA staff comment to Section 4.1.1 regarding ground water flow.

Section 2.2, Site Geology, page 2-3, paragraph 3

The natural material beneath the fill in the pilot study area also includes silty sand and sandy clay (see Figure 4.1). The significance of these various deposits is that they have a varying degree of ability to transmit water due to hydraulic conductivity differences. Silty sand has much lower hydraulic conductivity than sand and may have an effect on the local ground water flow regime. Lithologic variation of such materials may affect the pilot test results by influencing the ground water flow regime and the distribution of the desired reactants. The MPCA staff requests that the Navy acknowledge this in the Report.

Section 2.3.1, Ground Water Flow Under Pumping Conditions, pages 2-4 to 2-9

This section discusses the ground water flow conditions that have been determined on a large scale that includes Anoka County Park (ACP). There is general agreement on the "big picture" two-dimensional flow scenario in ACP. It is possible that on a smaller scale there are local variations in the flow regime where horizontal flow may differ due to smaller scale changes in lithology that are not apparent on a larger scale. These variations in flow may impact any evaluations or tests that are carried out on a smaller scale. The MPCA staff requests that the Navy acknowledge this fact in the Report.

There is less agreement on the role of vertical hydraulic head gradients and the vertical movement of ground water from one zone to another, i.e., the three-dimensional flow regime that may have an impact on ACP. How these lithologic variations in the test area affect the three dimensional flow in ACP is not fully understood. The MPCA staff requests that this be noted in the Report.

Section 2.3.1, Ground Water Flow Under Pumping Conditions, pages 2-4 to 2-9

The ground water flow regime in ACP is three-dimensional given the presence of vertical head gradients in the park. The pilot test largely assumes a two-dimensional flow regime in which ground water flow is primarily horizontal. It is important to understand the ground water flow regime prior to evaluating the pilot study and prior to developing any remedial options. As stated elsewhere in this letter, the lack of homogeneous lithology and the role of vertical gradients and how these affect ground water flow in ACP is not generally agreed upon. The MPCA staff requests that this be noted in the Report.

Section 2.3.1, Ground Water Flow Under Pumping Conditions, page 2-7, paragraph 4

The discussion of the vertical movement of water from the Prairie du Chien/Jordan (PC) aquifer is most likely oversimplified. The Report suggests that PC water migrates from depth to the shallow zone. In reality the flow is most likely much more complicated and is not fully understood. Variations in the strength of horizontal gradients and lithologic variations in various zones between the PC and the shallow subsurface will dictate how ground water moves from one zone to another. In some zones there are strong horizontal gradients and more permeable materials. Water traveling up to these zones may tend to be preferentially carried horizontally rather than continue upward or there may be a component of both horizontal and vertical flow. PC water may not travel all of the way up into the shallow subsurface. Instead deep and intermediate zone water may be pushed up into shallow zones.

In addition, there is variation in the contaminant concentrations from zone to zone. The intermediate and shallow zones generally have higher concentrations. It is important to know the vertical flow relationships because the movement of water between zones may impact the concentrations in other zones. At the present time this is poorly understood and there is not general agreement on this issue. The concept that PC water or low contaminant concentration and differing geochemical character flows freely from the PC into the shallow subsurface may not be valid. The MPCA staff requests that the Navy emphasize the uncertainty of this type of flow occurring in the Report.

Section 2.3.1, Ground Water Flow Under Pumping Conditions, page 2-7, paragraph 4

The silt layer identified in the United States Geological Survey (USGS) report has been interpreted to be leaky, allowing some water to move upward as indicated in discussions with the USGS at NIROP Technical Subcommittee meetings. How ground water travels vertically through this interval is not fully understood. The MPCA staff requests that the Navy acknowledge this uncertainty in the Report.

Section 2.3.2, Non-Pumping Conditions and Effect of Extraction Wells, page 2-9

The Report states that geochemical and contaminant conditions within the pilot study area do not appear to be directly impacted by the extraction system. Although the pilot study area does not appear to be in the capture zone of the system, it is impacted by the system. The system intercepts contaminated ground water that would otherwise flow into ACP. Trends in some ACP wells do show a downward trend in contaminant concentration. This section needs to be reworded to acknowledge that ACP has been impacted in a positive way by the extraction system. How much ACP and the pilot study area COC levels in ground water have been impacted by the extraction system is not discussed in this section. The 2003 Annual Monitoring Report (AMR) indicates that in much of ACP the TCE trends have been downward since the additional shallow pumping was added to the system. In ACP wells, where increases in TCE were observed, it is possible that the extended shutdown of the extractions system could have resulted in these increases. This information could be referenced from the 2003 AMR. The MPCA staff requests that the Navy discuss the effects of extraction system operation and shutdown on the study results in the Report.

Section 2.5 Chlorinated Ethenes Over Time at Anoka County Park, seventh sentence, third paragraph, page 2-13

The Report states that MS-46S was directly impacted by the pilot study. However, in Section 4.5.4, the Report states that the geophysical data indicate that geochemical changes related to vegetable oil injection extends downgradient, not up gradient. Also Figure 9 of the USGS tracer study report, "Application of Cross-Borehole Radar to Monitor Field-Scale Vegetable Oil Injection Experiments for Biostimulation," ("Tracer Study Report"), undated, emailed to the MPCA staff on January 8, 2004, does not show that the subsurface oil emulsion reached MS-46S. Instead Figure 9 shows the oil-affected ground water flowing in the opposite direction. The MPCA staff requests that this contradiction be explained in the Report.

The Report also identifies MS-45S as being accidentally impacted by vegetable oil back-flushing. Although the Navy has identified MS-53P as being impacted by back-flushing, the Navy has not previously identified MS-45S as being similarly impacted. To the MPCA's knowledge, no effort has been made to remove oil from MS-45S as was done for MS-53P. The MPCA staff requests more information about the back-flushing contamination of MS-45S, efforts made to remove oil from this well, and the effect of this oil addition on pilot study results in the Report.

Section 2.5, Chlorinated Ethenes Over Time at Anoka County Park, pages 2-12 to 2-13

In its responses to the 2002 NIROP AMR, the MPCA staff requested that a statistical method be investigated to determine trends of chemical concentrations with time. The 2003 NIROP AMR used the Mann-Kendall trend analysis to look at trends in TCE trends in NIROP wells. The MPCA staff requests that the general trends in ACP wells be discussed in this section; that the 2003 AMR be referenced; and a general summary of ACP well trends be included in this section.

Section 2.5, Chlorinated Ethenes Over Time at Anoka County Park, page 2-13, paragraph 3

This section mentions that monitoring well MS-45S was directly impacted by oil injection. This is not indicated in the figures in the Tracer Study Report that show vegetable oil distribution. Chemical parameters discussed in subsequent sections of the Report do not seem to corroborate that MS-45S was impacted by oil injection. The MPCA staff requests that the Navy clarify the apparent contradiction. If the well was not impacted by oil injection please, provide possible reasons why the TCE concentration has been dramatically declined in this well.

Section 3.1.4 Departure from the Final Project Work Plan

Please see MPCA staff response to Section 4.5.4 regarding the addition of colloidal iron and dissolved magnetite.

Section 4.1.1 Ground Water Flow Direction, pages 4-2 to 4-16, Figures 4.1 to 4.7

A review of the water level data is presented in the discussion. The data is presented in a series of figures that is used to construct equipotential maps for the pilot area. The maps show hydraulic head distribution prior to oil injection and during various seasons (spring, summer, fall and winter) during the pilot study. The MPCA staff has reviewed the data and maps and makes the general observations and requests:

- A hydraulic head difference exists from higher head to lower head along the line of monitoring wells including MS-27S, PES-CW-1, PES-CW-2, PES-CW-3 and MS-47S. This difference indicates that there is a component of north to south flow that is not accounted for in the maps as presented. The data indicates that, in reality, ground water flow is most likely not perpendicular to the Mississippi River, as is assumed, but flows towards the river in a more south westerly direction. In many of the maps, it appears that ground water flow could be interpreted to be nearly south. In some of the maps some water levels were not collected in certain wells, which makes evaluation more difficult due to lack of data control (an example is Figure 4.2).

- An area of relatively flat gradient is present represented by data from monitoring wells PES-MW-4, PES-MW-5, PES-CW-1 and PES-CW-2. It appears that this area of flat gradients is present in all of the maps with the possible exception of the winter of 2002 (Figure 4.2, February 2002) although several water levels were not collected at that time. Some data is not available to complete the map. Hydraulic heads north of this area and south of this area seem to show a drop in hydraulic head from north to south that shows the potential for ground water flow through this area. If high permeability sediments are located in the area of "flat" hydraulic gradients, sufficient horizontal gradient change between north and south of this area may transmit ground water readily from north to south through the "flat" area.

- Ground water flow reversals are shown on many of the Report figures, which show ground water flow away from the river towards the pilot area. In most of these figures, the hydraulic head differences are only a mater of several hundredths of a foot. These differences are likely well within measurement error and in reality are too small to cause reverses in ground water flow. Although seasonal changes can occur in ground water flow, the ground water flow regime in this area is most likely well established and flow directions are unlikely to change significantly. The area is beyond the direct hydraulic influence of the pumping system and the Report indicates that the area is not affected by the river stages. Precipitation events, the spring recharge event, and winter freeze up may affect some seasonal changes on the hydraulic heads in monitoring wells, but these effects most likely do not cause flow reversals or great changes in flow direction. Many of these influences are transient and may be short lived and ultimately not result in significant changes in flow directions. A different interpretation of the equipotential maps eliminates the need for reversing flow (see next comment).

- A different interpretation of ground water equipotentials can be made using the same head data. The interpretation involves taking into account the north to south change from high head to low head in the last row of wells towards the river and resolves the flow through the area of relatively flat gradients. The interpretation is show in the attached modified figures that show ground water flow from north to south through the area of flat gradient. The horizontal flow regime may be much different than the assumed flow regime upon which the test was based. It is possible that the addition of monitoring wells during the next monitoring phase of the pilot could refine the ground water flow regime.

- The effect of any vertical gradients on the flow regime in the test area is unknown. It is possible that the addition of several intermediate monitoring wells, nested with shallow unconfined wells, could verify the vertical ground water flow regime. A review of the vertical flow evaluation in the 2003 AMR might shed light on this issue.

- The impact of the lack of homogeneity of lithology in the pilot area and how that might effect the flow regime is not fully understood and discussed. It is possible that additional lithologic information could be collected during the addition of monitoring wells to verify the impact of lithologic changes on the ground water flow regime in the pilot area.

It is uncertain how this variation on the assumed flow regime might effect the interpretation of the pilot study, but it is unlikely that the ground flow as interpreted in the Report is correct. The MPCA staff requests that the Navy evaluate the alternative flow presented by the MPCA staff and determine how that flow scenario might impact the interpretation of the pilot study data. The flow scenario may help to explain some of the study results. As discussed in previous comments, the possible effect of vertical gradients has not been quantified or evaluated. A vertical flow component might also impact the pilot study results. Much of this information could be collected during field work for the extended monitoring of the pilot study.

Section 4.1.2, Hydraulic Conductivity and Ground Water Flow Velocities, page 4-16

The Report indicates that wells PES-MW-3, PES-MW-8 and PES-MW-9 are screened in low permeability materials. There is apparently lithologic variability in the area of these wells that may have prevented or impeded the flow of ground water in a downgradient direction from the injection points. This variability may have impacted the distribution of the desired reactants to these wells from the injection points and may also explain the seeming lack of impact from the vegetable oil injection on some of these wells. (It appears that PES-MW-3 was impacted from the test but that PES-MW-3 and PES-MW-8 were not impacted much.) The MPCA staff requests that the Navy review and discuss how this may have impacted the pilot.

Section 4.1.2, Hydraulic Conductivity and Ground Water Flow Velocities, page 4-17

The Report states that "the observed impact to hydraulic conductivity is likely a long-term effect of the vegetable oil injection and will likely last until the vegetable oil and associated biomass have been depleted". This is an important consideration for evaluation of a scale-up effort at the site. Based on this observation, the impact on ground water flow on a larger scale may be significant. The MPCA staff requests that the Navy's plans for scaling up the project take this into consideration.

Section 4.1.2, Hydraulic Conductivity and Ground Water Flow Velocities, page 4-20, paragraph 3

The MPCA has discussed the potential flow reversal scenario in a comment to Section 4.1.1. The MPCA staff requests that the Navy refer to this comment for this section.

Section 4.1.1, Ground Water Flow Direction

In this section, the Navy identifies periodic changes in ground water flow direction during the pilot study. The Figures 4.1 through 4.7 show that the predominant ground water flow direction in the study area is to the southwest. In Figure 4.3, the Navy shows that the ground water flow direction in May 2002 in the area of the injection wells is toward MS-46S. However, Figure 9 of the Tracer Study Report shows that the direction of movement of the oil-affected ground water is to the southwest toward the river, away from MS-46S. The MPCA staff requests that the Navy explain this apparent contradiction.

Section 4.4.1, Chlorinated Ethenes Over Time, page 4-29, paragraph 2

This section states that upgradient well GWMS-46S is impacted by vegetable oil injection activities. This is neither indicated in the figures in the Tracer Study Report that show vegetable oil distribution nor is this supported by various chemical parameters observed in the well. The MPCA staff requests that the Navy clarify the apparent contradiction.

Section 4.4.1, Chlorinated Ethenes Over Time, page 4-30, paragraph 1

The Report states that the variation in TCE concentration in well MS-46S is perhaps due to variable ground water flow direction. In Figures 4.1- 4.7, MS-46S is upgradient of the pilot test wells with the possible exception of the May 2002 map (Figure 4.3). It is questionable that small differences in hydraulic head shown on this map are significant and long lasting enough to cause flow to reverse from the regional trend of flow towards the river. It may be possible that vegetable oil moved, under injection pressures, in an upgradient direct to MS-46S, but the Tracer Study Report on the study to investigate the distribution of vegetable oil using iron additives does not seem to indicate that oil traveled to that well. Chemical parameters discussed in subsequent sections of the Report do not seem to corroborate that MS-45S was impacted by oil injection. It may also be possible that modifications to the pumpout system may have caused changes in concentration in the well. The MPCA staff requests that the Navy further discuss this contradiction.

Section 4.4.1 Chlorinated Ethenes Over Time, second paragraph, page 4-29

The Navy attributes the dramatic decline in the TCE concentration in MS-46S to "vegetable oil injection activities," presumably meaning that injected oil reached the area around this well. However, as cited above, the Tracer Study Report shows that the ground water flow direction is away from MS-46S.

Also unlike MW-7, which shows an increasing level of DCEs associates with a decrease in TCE concentrations over the study period, the decline in TCE in MS-46S is occurring with a concurrent decline in DCEs even though the starting TCE concentration in MS-46S is over an order of magnitude higher than that of MW-7. Also in Section 4.5.1, the Navy argues that total organic carbon (TOC) is an indicator of the impact of oil injection in MWs 7 and 9, these wells showing the highest TOCs in the study, up to 26,000 mg/L in MW-7 and up to 240 mg/L in MW-9. The TOC in MS-46S never exceeds 18 mg/L. These contradictory data suggest that the decline in TCE concentration in MS-46S may not be associated with vegetable oil injection activities. The MPCA staff requests that the Navy explain the apparent contradiction in the data cited above. Also the MPCA staff requests that the Navy identify what "vegetable oil injection activities" it believes are resulting in the decline in the TCE concentration in MS-46S.

Section 4.4.1 Chlorinated Ethenes Over Time, first paragraph, page 4-36

The MPCA staff requests that the Navy acknowledge that the TCE levels in MW-9 increased in the last two sampling events after falling dramatically during a period that showed the expected associated rise in DCEs.

Section 4.4.2, Presence of Daughter Products and CAH Ratios, page 4-39, paragraph 2

It is not clear from Figure 4.10B that the molar fraction of vinyl chloride increased over the time interval from April, 2003-August, 2003. From the figure, concentrations of vinyl chloride appear near 0 percent throughout the entire time of the study. The MPCA staff requests that the Navy explain this apparent contradiction.

Section 4.5.1, Total Organic Carbon as an Indicator of Substrate Addition and Area of Influence, pages 4-43 to 4-47

This section discusses the use of TOC to determine distribution of substrate. An increase in TOC concentration is used to interpret distribution of substrate. In other sections, the Report indicates that well MS-46S has been impacted by vegetable oil injection activities. There is not a significant sustained increase in TOC concentration in well MS-46S observed in the data. It would seem that the lack of increase in TOC does not support that this well is impacted by vegetable oil injection activities. The MPCA staff requests that the Navy discuss this apparent contradiction.

Section 4.5.1, Total Organic Carbon as an Indicator of Substrate Addition and Area of Influence

The data in Table 4.6 appears to indicate that most TOC is found around MWs 7 and 9, with most of the study area, including the area around MWs 6, 1, and 2, having TOC levels an order of magnitude or more lower in other areas of the study area. However, Figure 9 of the Tracer Study Report implies that the oil-affected ground water uniformly covers the area around MWs 6, 1, 7, and 2. The MPCA staff requests that the Navy explain the apparent contradiction regarding the area of influence of the vegetable oil injection.

Section 4.5.1, Total Organic Carbon as an Indicator of Substrate Addition and Area of Influence, page 4-43, first paragraph

The texts states that the USGS results of the radius of influence testing are summarized in Section 4.5.3; however, the USGS results are discussed in Section 4.5.4. The MPCA staff requests that the text be changed accordingly.

Section 4.5.1, Total Organic Carbon as an Indicator of Substrate Addition and Area of Influence, page 4-47

It does not appear that the data on Table 4.6 supports the statement that "TOC data indicate that the zone of influence of the vegetable oil injection within the first few months following injection was limited primarily to the area of wells PESMW-1, PES-MW-6, PES-MW-7 and PES-MW-9". The TOC data for wells PES-MW-1 and PES-MW-6 does not appear to be elevated, particularly in comparison to PES-MW-7 and PES-MW-9. The MPCA staff requests that the Navy resolve the apparent contradiction in the Report.

Section 4.5.2, Dissolved Hydrogen as an Indicator of Substrate Addition and Area of Influence, page 4-47

The presence of hydrogen at 4 nanomolar (nM) in wells 27S and 47S indicate that conditions at these locations are naturally conducive to the reductive dechlorination of chlorinated compounds. How does this observation affect the overall interpretation of the influence of the vegetable oil? If hydrogen is present at locations where we are assuming there is no significant reductive dehalogenation, is it an adequate indicator of the reductive processes at the site?

Section 4.5.4 Cross-Borehole Radar Data, page 4-56

This section does not indicate distribution of vegetable oil in an upgradient direction to well MS-46S. This situation contradicts information in the Report that suggests that vegetable oil injection has impacted the well. The MPCA staff requests that the Navy discuss this apparent contradiction.

Table 4.5

Calculation of a slope on the data is informative, but must be accompanied by a standard deviation or variance on the slope to provide perspective on the variability of the data. The MPCA staff requests that the analysis be completed accordingly and that the corresponding discussion make reference to these statistics.

Section 4.6.1.1, Dissolved Oxygen, page 4-58, paragraph 2

The Report states that there is a change in dissolved oxygen (DO), oxidation-reduction potential (ORP) and dissolved hydrogen data. It should be noted that in April, the spring recharge event occurs in Minnesota. During this event, frozen water stored in the frost zone, snowmelt and any significant spring precipitation may recharge to the water table.

It is possible that the influx of this recharge water may impact some of the parameters that are discussed in this section. The MPCA staff requests that the Navy evaluate the recharge event in the Report.

Section 4.8, Summary of Enhanced Biodegradation, page 4-82

A number of factors are indicated that were present for reductive dechlorination to occur. The MPCA staff request that the Navy add a map to the Report that shows the area where these factors were present and where dechlorination occurred.

Section 4.8, Summary of Enhanced Biodegradation, page 4-82

The Report notes the sub-optimal distribution of organic carbon, which is attributed to low hydraulic gradient and transient ground water flow reversals. In previous responses to the Report, the MPCA staff noted that it is unlikely that transient flow reversals occur in the pilot area and that alternative interpretations of ground water flow indicate that hydraulic gradients in the area denoted as a "flat area" of gradient may be influenced by stronger gradients than previously thought. It should be noted that variable lithology may also be a factor in the uneven distribution of organic carbon. The MPCA staff requests that the Navy resolve these issues in the next phase of pilot monitoring.

Section 4.9, Iron Addition and the Role of Abiotic Degradation, page 4-84, paragraph 2

The text states "it cannot be determined if the iron injected into PES-INJ-3 had any effect on the chlorinated solvents in the vicinity of PES-INJ-3." As pointed out earlier in the attachment, magnetite is known to degrade chlorinated solvents. Based on the pilot study DQOs, pilot success could be achieved with the success of only one of the three monitoring wells. Pilot success was achieved only in MW-7. Therefore, it is critical to know why success was achieved in only MW-7. The MPCA staff requests that the Navy evaluate the effect of magnetite on the results seen in MW-7. If uncertainty remains after the requested evaluation, the MPCA staff requests that the Navy indicate in the Report what will be done to account for the impact of added iron in further work associated with the pilot study.

Section 5.1.2, Observed Changes in Site Geochemistry, page 5-1

The Report states that geochemical changes from the oil injection are "neither spatially uniform or [sic] temporally consistent" within the pilot study area. The MPCA staff requests that the Navy further explain the factors that might have contributed to this observation.

Section 5.1.3, Actual/Significant Changes in Contaminant Concentrations, page 5-2

The Report states that after vegetable oil injection, there were significant decreases in TCE concentration in well MS-46S. The Tracer Study Report does not indicate that oil was distributed to this well. Chemical parameters that would indicate that the well was impacted by oil did not seem to be present in the data. Although a significant decrease in TCE did occur, it appears that it cannot be attributed to reductive dechlorination due to vegetable oil injection.

The MPCA staff requests that the Navy identify and discuss other mechanisms that could have led to the TCE concentration reduction in this well.

Section 5.1.3, Actual/Significant Changes in Contaminant Concentrations, page 5-3

The Report states that there were increasing TCE concentration trends in four monitoring wells between baseline sampling and the most recent monitoring event. It may be possible that the increases were the result of the extended downtime of the extraction system. The MPCA staff requests that the Navy compare periods of system downtime to TCE concentration increases in ACP wells.

Section 5.1.5, Degree of Electron Donor Utilization for Reductive Dechlorination, page 5-4

The Report states that organic carbon concentrations greater than 20 milligrams per liter (mg/l) are required to meet both the natural demand for electron donor and to provide sufficient electron donor for the dechlorination of chlorinated aliphatic hydrocarbon (CAH) mass. The MPCA staff requests that the Navy list the monitoring wells where this was achieved in the pilot study area and show a map of the area where these conditions were met.

Section 5.1.6, Substrate Distribution and Potential for Future Reductive Dechlorination, page 5-5

The Report states that the lack of reductive dechlorination at ACP is primarily a function of inadequate substrate distribution. This factor seems to have greatly limited the success of the pilot study. The MPCA staff does not agree that the failure of distribution is the result of cyclical reversals of ground water flow. There are other more likely factors that have prevented the distribution of substrate. They include variations in lithology that prevent the flow of ground water to certain areas, lack of dissolution of oil into ground water, lack of characterization of the ground water flow regime in the horizontal direction and lack of characterization of the impact of vertical ground water flow into the pilot study area. There may be other factors. The MPCA staff requests that the Navy discuss these other factors and their possible impact on the pilot study.

Section 5.2, Recommendations, page 5.5

A number of recommendations are discussed for further monitoring of the existing pilot study wells and for a phased expansion to full scale in ACP. The limited success of the pilot study and a number of uncertainties regarding the horizontal ground water flow regime, vertical ground water flow and variations in lithology were previously noted in the MPCA staff response to the Report. The MPCA staff is not certain how these factors have limited the distribution of substrate and impacted the results. Due to the uncertainties identified by the MPCA staff (and others to the pilot study) at the April 15, 2004 meeting, the NIROP Partnering Team decided that full scale implementation and additional injection not proceed at this time. Instead the team decided to conduct continued monitoring of the existing pilot study area and to install some additional monitoring wells to address some of the uncertainties that have been identified. A Technical Subcommittee meeting will be convened to scope the level of effort for the next monitoring phase and to determine the number and location of additional monitoring wells.

For the time being, the MPCA staff cannot approve the phased full-scale implementation. The MPCA staff requests that the Navy revise the Report to reflect the actions adopted by the NIROP Partnering Team at its April 15, 2004 meeting.

5.2.2. Recommendations for a Full Scale Application at Anoka County Park, General Modification

Since the Navy is not proposing to add iron to the vegetable oil for full scale implementation, before the MPCA staff can approve moving ahead with full scale implementation (phased or otherwise), the staff requests that the Navy determine the role played by the addition of iron to success of the pilot study.

Since the Navy has asserted that MS-46S was impacted by the vegetable oil injection of the pilot study and the Navy plans to install six monitoring well pairs in the vicinity of this well, the MPCA staff requests that the Navy identify how far upgradient the vegetable oil traveled during the pilot study before choosing the area for Phase I of the full implementation.

5.2.2. Recommendations for a Full Scale Application at Anoka County Park, last bullet, page 5-7

Since the objective of the pumpout wells is to capture the ground water plume leaving NIROP at a TCE concentration of 100 ppb or higher (see the DQO decision rules of Step 5 for Problem C, dated August 21, 2001), the area covered by the full scale should be chosen to be consistent with treating ground water at a TCE concentration of 100 ppb or higher. The number and placement of injection wells needs to be based on this objective so at this juncture the MPCA staff cannot agree on the number of injection wells needed for any full scale remedy.

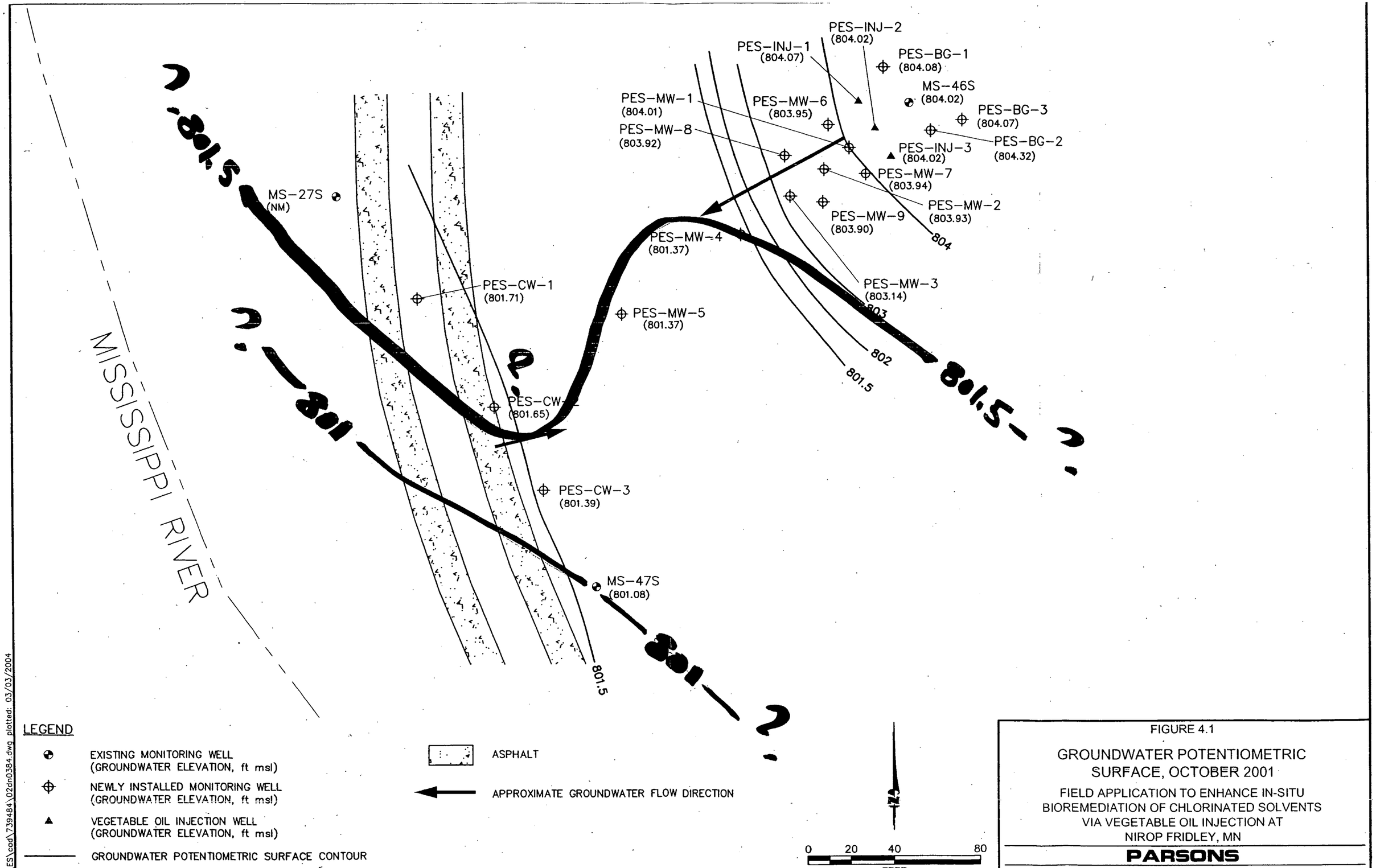

FIGURE 4.1

GROUNDWATER POTENTIOMETRIC SURFACE, OCTOBER 2001

FIELD APPLICATION TO ENHANCE IN-SITU BIOREMEDIATION OF CHLORINATED SOLVENTS VIA VEGETABLE OIL INJECTION AT NIROP FRIDLEY, MN

PARSONS

Denver, Colorado (303) 831-8100

S:\ES\cad\739484\02dn0384.dwg plotted: 03/03/2004

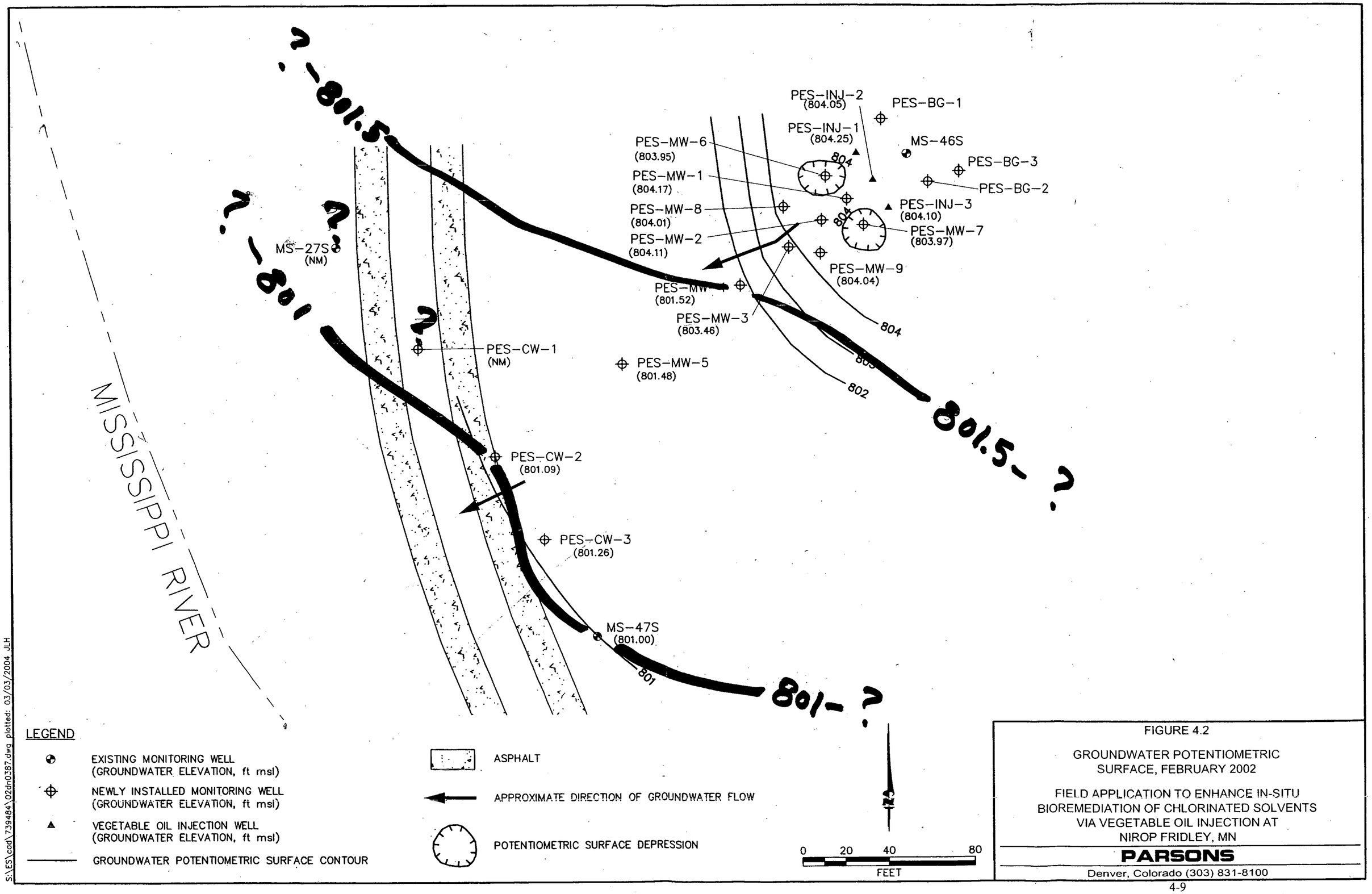

FIGURE 4.2

GROUNDWATER POTENTIOMETRIC SURFACE, FEBRUARY 2002

FIELD APPLICATION TO ENHANCE IN-SITU BIOREMEDIATION OF CHLORINATED SOLVENTS VIA VEGETABLE OIL INJECTION AT NIROP FRIDLEY, MN

PARSONS

Denver, Colorado (303) 831-8100

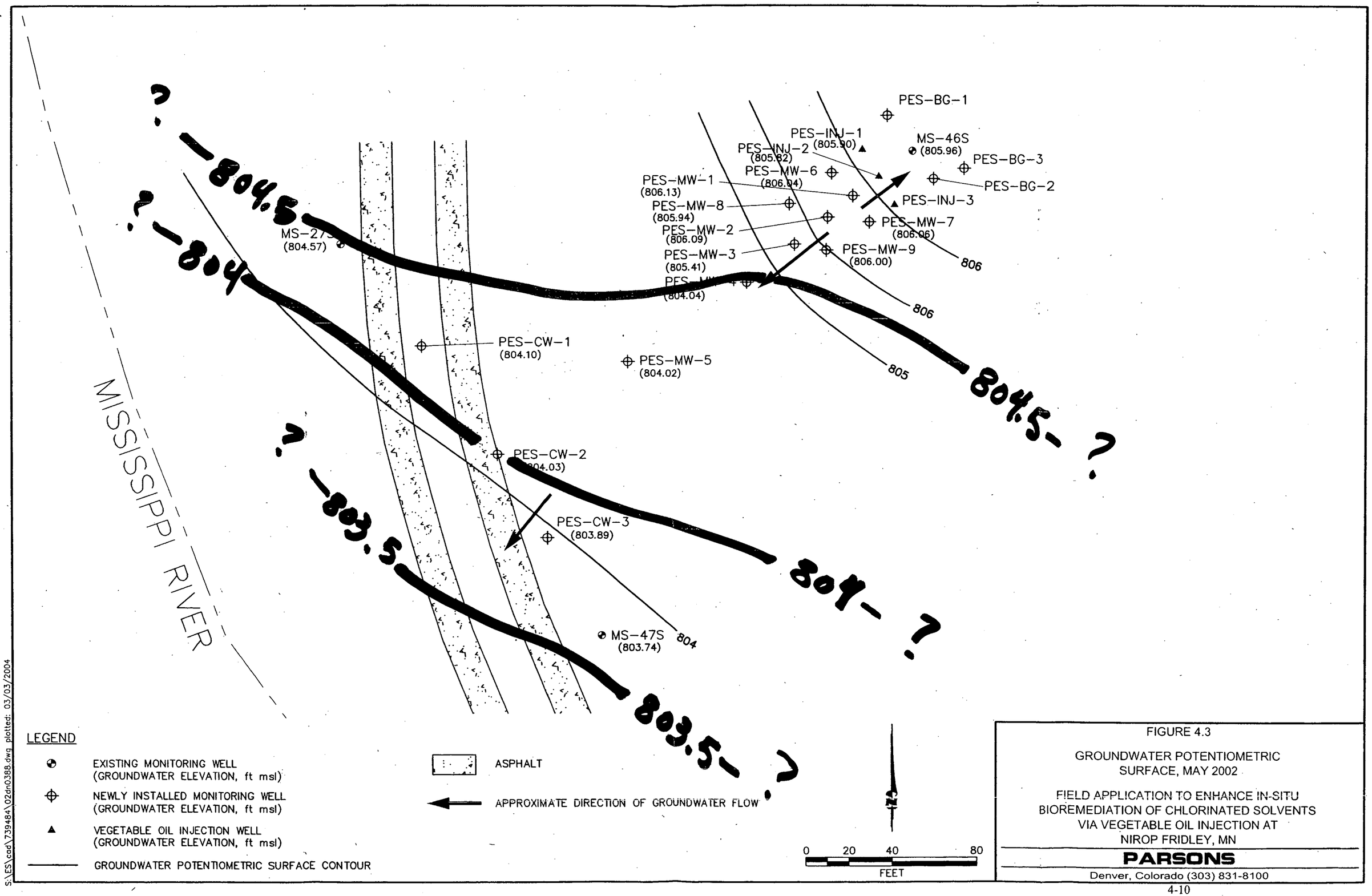

FIGURE 4.3

GROUNDWATER POTENTIOMETRIC SURFACE, MAY 2002

FIELD APPLICATION TO ENHANCE IN-SITU BIOREMEDIATION OF CHLORINATED SOLVENTS VIA VEGETABLE OIL INJECTION AT NIROP FRIDLEY, MN

PARSONS

Denver, Colorado (303) 831-8100

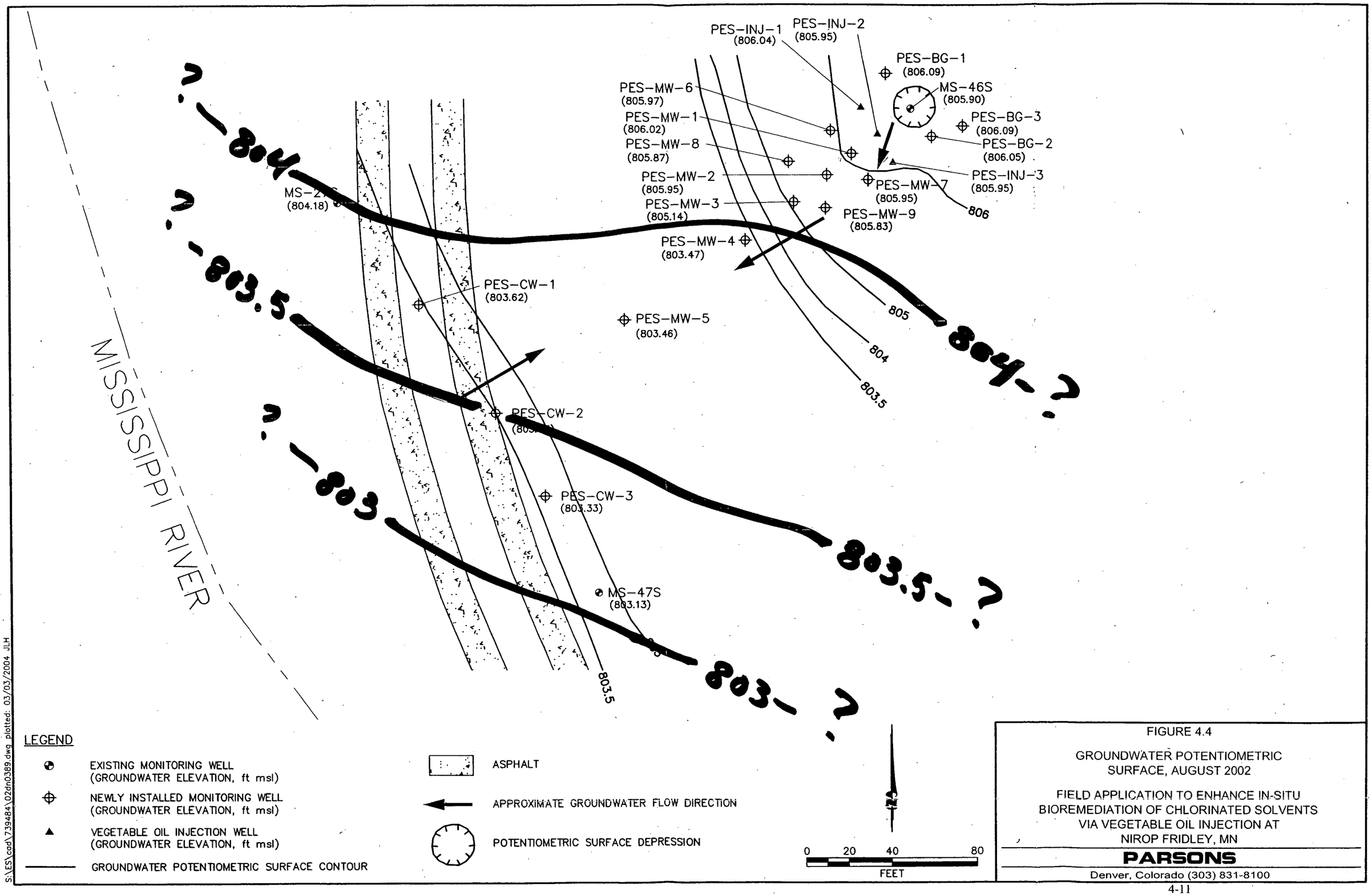

FIGURE 4.4

GROUNDWATER POTENTIOMETRIC SURFACE, AUGUST 2002

FIELD APPLICATION TO ENHANCE IN-SITU BIOREMEDIATION OF CHLORINATED SOLVENTS VIA VEGETABLE OIL INJECTION AT NIROP FRIDLEY, MN

PARSONS

Denver, Colorado (303) 831-8100

S:\ES\cad\739484\02dn0389.dwg plotted: 03/03/2004 JLH

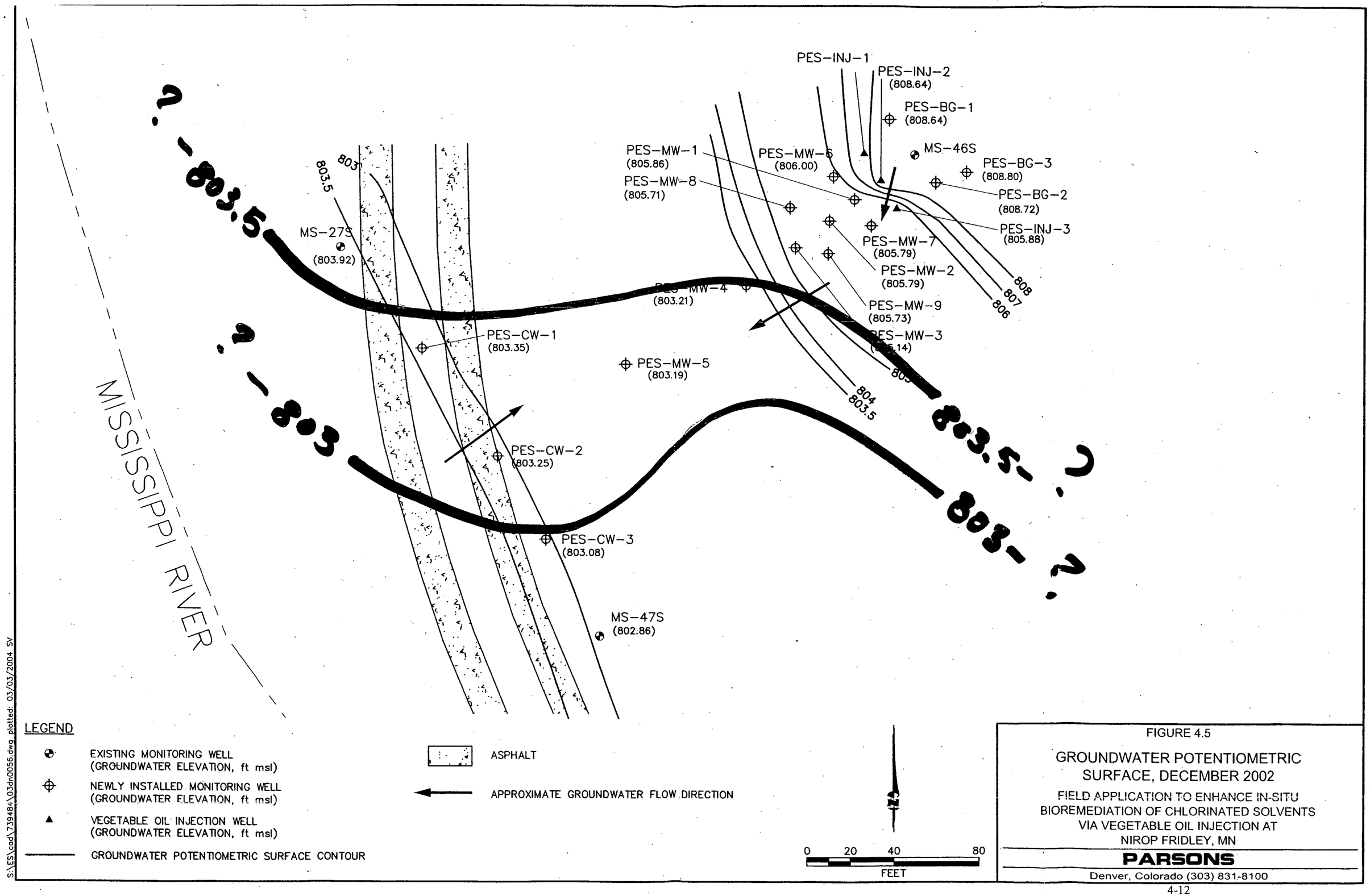

FIGURE 4.5

GROUNDWATER POTENTIOMETRIC SURFACE, DECEMBER 2002

FIELD APPLICATION TO ENHANCE IN-SITU BIOREMEDIATION OF CHLORINATED SOLVENTS VIA VEGETABLE OIL INJECTION AT NIROP FRIDLEY, MN

PARSONS

Denver, Colorado (303) 831-8100

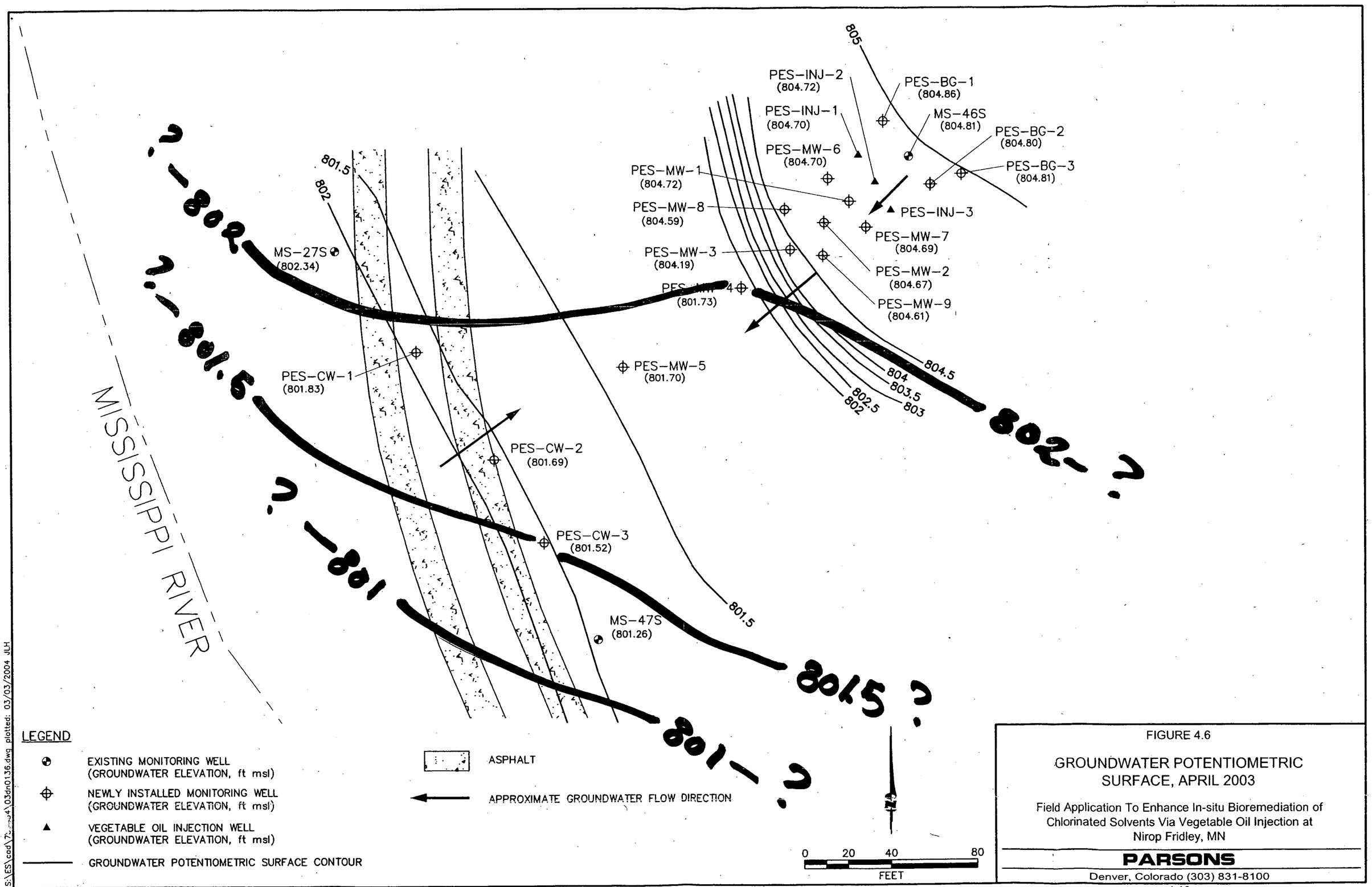

FIGURE 4.6

GROUNDWATER POTENTIOMETRIC SURFACE, APRIL 2003

Field Application To Enhance In-situ Bioremediation of Chlorinated Solvents Via Vegetable Oil Injection at Nirop Fridley, MN

PARSONS

Denver, Colorado (303) 831-8100

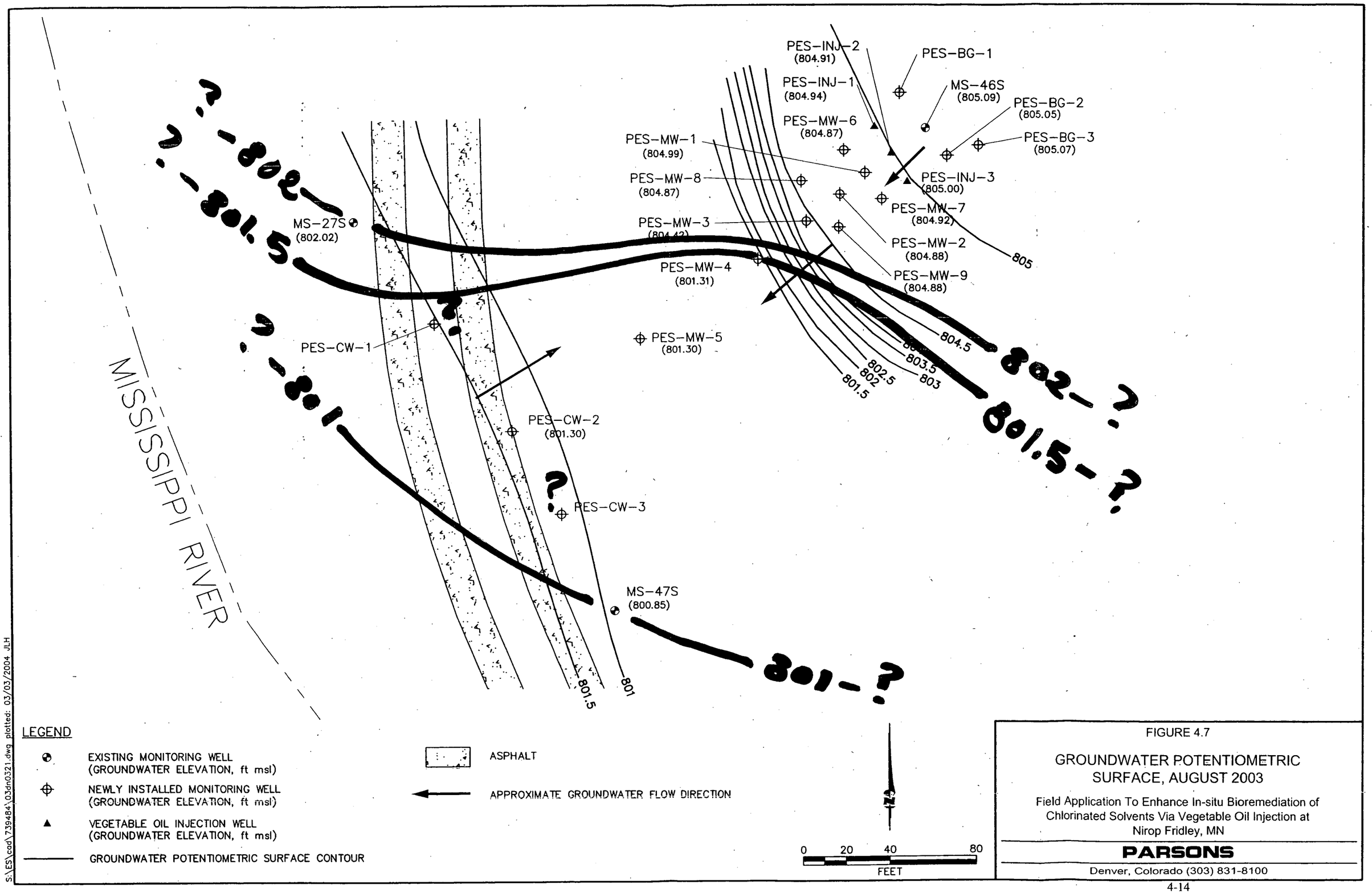

FIGURE 4.7

GROUNDWATER POTENTIOMETRIC SURFACE, AUGUST 2003

Field Application To Enhance In-situ Bioremediation of Chlorinated Solvents Via Vegetable Oil Injection at Nirop Fridley, MN

PARSONS

Denver, Colorado (303) 831-8100