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Mr. Tom Williams
Work Assignment Manager (SR-6J)
U.S. Environmental Protection Agency
77 West Jackson Boulevard
Chicago, IL 60604-3507

Subject: Review and Recommendations for the LNAPL Recovery and Bioventing
Penta Wood Products Site, Siren, WI
WA No. 004-LRLR-05WE, Contract No. EP-S5-06-01

Dear Mr. Williams:

Enclosed for your review, please find 3 copies of the Review and Recommendations for the LNAPL Recovery and Bioventing Document. A copy of the document has also been sent to the Wisconsin Department of Natural Resources (WDNR) Project Manager, Bill Schultz.

If you have any questions, please feel free to call me at 414-847-0341.

Sincerely,

CH2M HILL

Bill Andrae

Bill Andrae
Site Manager

Enclosures

c: Stephen Nathan, PO/U.S. EPA, Region 5 (w/o enclosure)
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Review and Recommendations for LNAPL Recovery and Bioventing at Penta Wood Products (PWP) Site, Town of Daniels, Wisconsin

Introduction

The purpose of this review was twofold: (1) to evaluate the existing light nonaqueous-phase liquids (LNAPL) recovery system at the site and provide recommendations to improve its performance, and (2) to assess whether initiating bioventing system operation would be appropriate while LNAPL is still present in the subsurface. Site background information, including investigation, design, and construction of soil and groundwater remedial actions has been documented elsewhere and is not repeated here. Historic information applicable to the LNAPL recovery system and its performance is briefly summarized below. The LNAPL-impacted area within the unconfined groundwater unit beneath the site is approximately 4 acres. LNAPL is not present in the confined groundwater unit underlying the unconfined unit.

Groundwater remediation has been ongoing since the fall of 2000. The remediation system consists of eight groundwater recovery wells (6-inch-diameter stainless steel). The system was designed to contain dissolved-phase contamination of pentachlorophenol (PCP) onsite, prevent offsite migration, and reduce PCP concentrations to below 1,000 μg/L. Diesel oil was used during site operations as the carrier oil for PCP. Diesel oil originally contained approximately 5 percent PCP.

Electric submersible pumps were installed in eight groundwater recovery wells to recover groundwater at approximately 20 feet below the groundwater table. Ten bioventing wells (4-inch-diameter Schedule 80 PVC) were also installed to remediate PCP vadose zone soil contamination and residual LNAPL/PCP contamination following LNAPL recovery. The LNAPL contamination consisting of PCP dissolved in diesel oil is recovered using skimmer pumps installed within eight of the ten bioventing wells. These eight bioventing wells have been installed within the same borehole as the groundwater recovery well. The eight extraction wells (EW), therefore, consist of the groundwater recovery well and the bioventing wells with LNAPL skimmer pumps. Based on the design for the bioventing system, approximately 500 cubic feet per minute (cfm) of air per well (or 5 cfm per foot of screen length) will be pumped in the formation for residual PCP remediation after LNAPL is recovered.

Groundwater remediation system startup took place on September 29, 2000, and the system operated intermittently until September 27, 2001, at which time system upgrades were needed to consistently achieve the 0.1 μg/L PCP effluent discharge limit. Modifications were designed and implemented; the system was restarted February 27, 2004, and has operated since. As of December 31, 2005, the system had operated for a total of 430 (240 days in 2004 and 190 days in 2005) days since modifications were implemented.

Estimated LNAPL Volume and PCP Mass

According to Tables 1 and 2 of the 2005 Annual Report, the estimated average mass of PCP in groundwater prior to groundwater remedial system startup was about 9,800 pounds (lb). As of December 31, 2005, the estimated mass of PCP removed from groundwater was 5,900 lb. As of December 31, 2005, the remaining PCP mass in groundwater was, therefore, approximately 3,900 lb. Also, as of December 31, 2005, about 7,360 gallons of LNAPL have been removed since remedial system operation began in September 2000. During 2005, the estimated LNAPL removal rate was 13 gallons per day of operation from four extraction wells. This has not changed appreciably throughout the period of system operation. The recovery rate in individual extraction wells has been limited by the maximum pump flow rate. The estimated volume of LNAPL removed is based on volumes provided in Table 4 of the 2005 Annual Report, and assumes that 50 percent of the volume recovered was diesel and its weight is 7 lb per gallon (specific gravity equal to 0.84).

The attached figures show the LNAPL thickness and groundwater elevations as a function of time since 1997 (prior to system startup) to May 2006. LNAPL thickness typically varies as the groundwater elevation varies. In this case, LNAPL thickness and groundwater elevation is affected by the operation of the remedial system, ceased operations, and system restart after modifications were implemented. Similar trends in LNAPL thickness (increase) and groundwater elevation (decrease) were observed at monitoring wells MW-10S and MW-20 since the system restart in February 2004, while more erratic trends were observed in monitoring wells MW-18 and MW-19. In summary, operation of the LNAPL recovery system has not resulted in clear declining trends in LNAPL thickness to date.

Based on LNAPL thickness measurements following remedial system modifications, approximately 0.5 foot of LNAPL thickness on average (based on measurements made in wells MW-10S, MW-18, MW-19, and MW-20) is present in the monitoring wells. Translating LNAPL thickness in monitoring wells to the amount that is floating on the water table and is recoverable is difficult. This is because LNAPL thickness in monitoring wells is often greater than that actually present in the formation. In one study, a sample of sandy soil similar to that at PWP, the actual thickness of mobile free-phase LNAPL was near zero for measured thickness up to 3 inches in observation wells. In a sandy soil with a measured LNAPL thickness of 6 inches in an observation well, the actual volume of free-phase LNAPL was 0.4 inch. A similar sandy soil had less than 0.2 inch LNAPL at a measured observation well thickness of 9 inches (Farr et al., 1990). As a result, the actual thickness of recoverable floating LNAPL may be considerably less than the average of 0.5 ft in the monitoring wells.

Assuming the worse case that LNAPL is present within a 0.5-foot-thick zone of soil at the water table, LNAPL is present over the 4-acre area and the soil has a porosity of 0.3, an estimated 200,000 gallons of floating LNAPL is still remaining at the site. Using the literature value of 0.2 inch of LNAPL in a sandy soil where the monitoring well showed 9 inches referenced above, the volume of free-phase LNAPL could be as little as 6,500 gallons remaining. Typically, only a fraction of the floating LNAPL is recoverable. Assuming about 50 percent of the floating LNAPL is recoverable, the estimated range of recoverable LNAPL is 3,250 to 100,000 gallons.

Assuming the upper end of the range, 100,000 gallons of LNAPL is remaining to be recovered, only about 7 percent has been recovered through 2005. At the current 13 gal/day rate of recovery, 21 more years of recovery would be needed to remove 100,000 gallons of LNAPL. Given the lack of declining recovery rates and no discernable downward trend in LNAPL thickness measurements in monitoring wells, it is more likely that many years of recovery will be needed to remove the remaining recoverable LNAPL. As a result, methods to improve LNAPL recovery should be investigated.

Methods for Improved LNAPL Recovery

The LNAPL/groundwater recovery system has achieved substantial reductions in PCP concentrations and has removed at least 7 percent of recoverable LNAPL. It appears, however, that significant quantities of PCP and LNAPL still remain at the site. As the amount of LNAPL present in the subsurface decreases with continued pumping at the site, the rate of LNAPL recovery will also decrease. Improvements in LNAPL recovery will be investigated by increasing the LNAPL recovery pump capacity and, if necessary, increasing the groundwater extraction flow rate at selected recovery wells. Other higher cost methods potentially applicable to the site, such as use of surfactants, may be considered in the future if the initial tests are unsuccessful in improving LNAPL recovery rates

The first recommended test is to evaluate the LNAPL recovery rate using a higher capacity LNAPL recovery pump under current groundwater pumping conditions. An electric submersible pump capable of pumping 2 pounds per square inch will be used to replace the current LNAPL recovery pumps in two extraction wells. Selection of the recovery wells to be used in the testing will be based on the historic thickness of LNAPL observed.

If the results of the first test indicate that the overall LNAPL recovery rate can be increased substantially more than the current overall rate of 13 gallons per day (gpd), the test will be repeated with the current groundwater recovery rate reduced by 50 percent. This is proposed to be evaluated because reducing the groundwater flow rate offers operational cost savings and may not effect the overall duration of active pump and treat. The duration may not change because LNAPL appears to be maintaining relatively constant dissolved-phase PCP groundwater concentrations. Reducing the volume of extracted groundwater (without affecting dissolved-phase recovery of PCP) is also consistent with the recommendation of the Remedial System Evaluation team.

If the results of the first test indicate that the overall LNAPL recovery rate is not significantly different than the current overall rate of 13 gpd, the test will be repeated at twice the current groundwater recovery rate. This is proposed to be evaluated because increasing the groundwater flow rate increases the hydraulic gradient to the extraction wells and should induce more rapid LNPAL flow into the well.

LNAPL Pump Tests

The two types of tests (note that the second test will either increase or decrease the groundwater extraction system flow rate) described above will be performed at the two selected extraction wells for a total of four LNAPL recovery tests at the site.

Baseline conditions will be measured prior to starting the tests. LNAPL thicknesses and water levels will be measured in the four extraction wells (EW-03, EW-05, EW-06, and

EW-10) and the four monitoring wells with LNAPL (MW-18, MW-19, MW-20, and MW-10S). Also, prior to commencing the first test, the current LNAPL recovery rate at the current groundwater extraction flow rate will be measured in each of the two test wells. LNAPL recovery will be measured by discharging the LNAPL to a graduated container over a 1-day period. The LNAPL recovery rate along with the groundwater flow rate (using the flow meters in the treatment building) at each of the two test wells will be recorded.

The first test will be conducted by replacing the existing LNAPL recovery pump with a 2-inch-diameter electric, submersible pump (Grundfos Redi-Flo 2). This first test will be run with the groundwater recovery rate maintained at the current rate. The depth to water and LNAPL thickness will be measured prior to starting the test. The new LNAPL recovery pump will be started and the LNAPL will be removed from the well until all has been removed. Care will be taken to minimize the removal of groundwater with this pump. LNAPL will be discharged to a graduated container to facilitate accurate volume measurement of the LNAPL. The LNAPL will be allowed to recover to at least 50 percent of the initial thickness and the LNAPL will again be removed. This will continue until the maximum sustainable recovery rate is determined. This may require anywhere from a few hours to a full day. Extracted LNAPL will be transferred to the onsite 8,000-gallon LNAPL storage tank. A pressure transducer and data logger or water level indicator will be used to gauge depth to water at the extraction well. In addition, depth to water measurements will be made at two to three other nearby monitoring wells to assess hydraulic influence during the LNAPL recovery test. Depth to water and LNAPL thickness will be measured at the completion of the test at each test well, and again 2 to 3 days following the completion of the test.

The second test will be similar to the first with the exception that the groundwater recovery pumping rate will be set either at 50 percent or twice the current flow rate, dependent on the results of the first test as discussed earlier.

Initiating Bioventing System Operation

After the proposed tests are completed and any modifications are made to the existing LNAPL recovery system, the bioventing system can be started. Initiating the bioventing system is not expected to adversely affect LNAPL recovery because: (1) the extraction system influence encompasses the entire LNAPL and dissolved-phase PCP contamination area, (2) air flow rate in each bioventing well will be increased gradually to the target design level of 5 cfm per foot of screen length, and (3) monitoring of LNAPL thickness and depth to water in the extraction wells and nearby monitoring wells will be performed frequently to assess potential impacts on LNAPL dispersal and/or water level mounding during bioventing. LNAPL recovery rates will also be monitored to determine if rates decline after bioventing startup because of dispersal of LNAPL.

Reference

Farr, A.M., Houghtalen and McWhorter. 1990. Volume Estimation of Light Nonaqueous Phase Liquids in Porous Media. Vol.28, No. 1, Groundwater, January–February.

FIGURE 1
LNAPL at Monitoring Wells

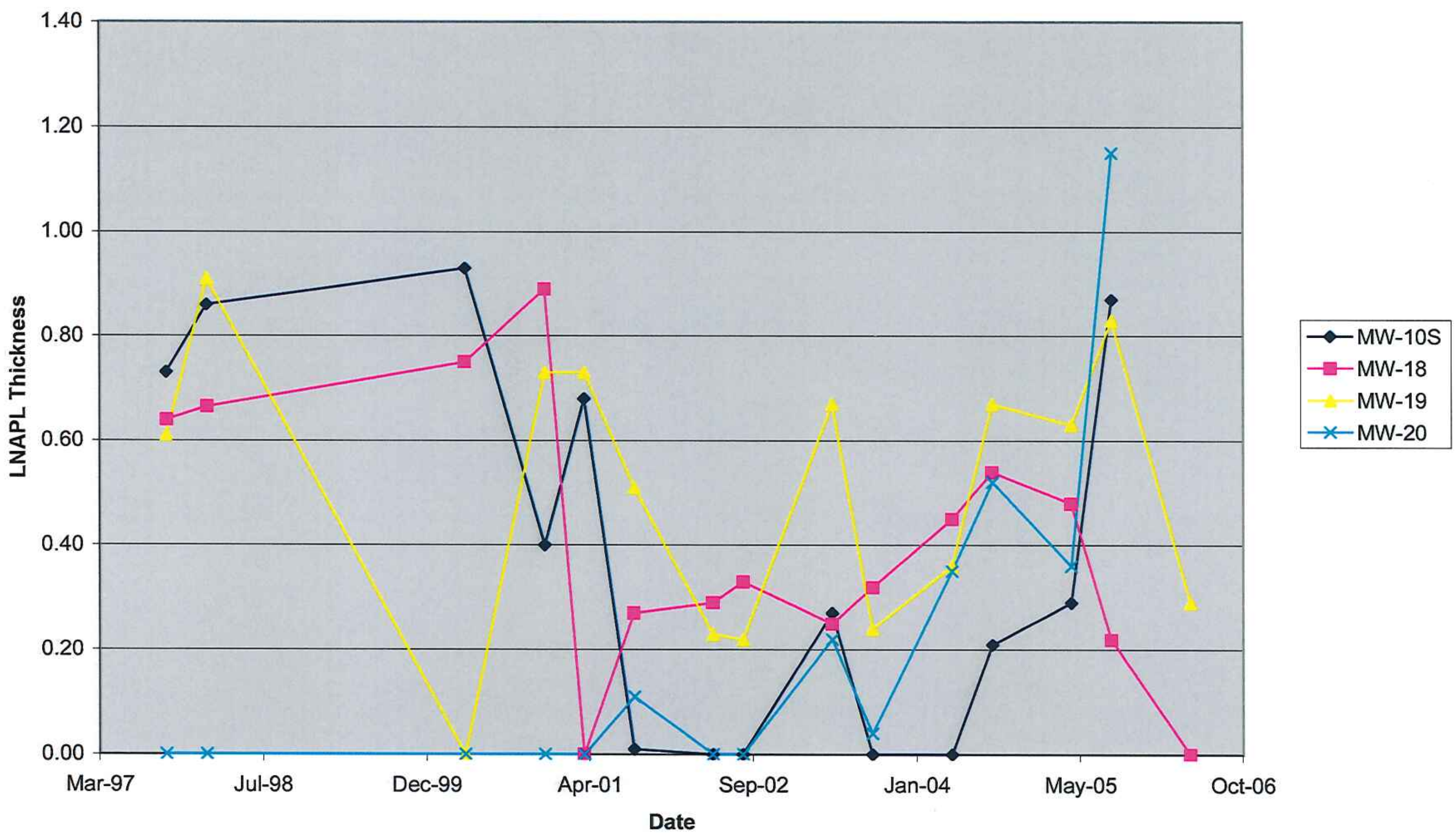

FIGURE 2
Groundwater Elevations

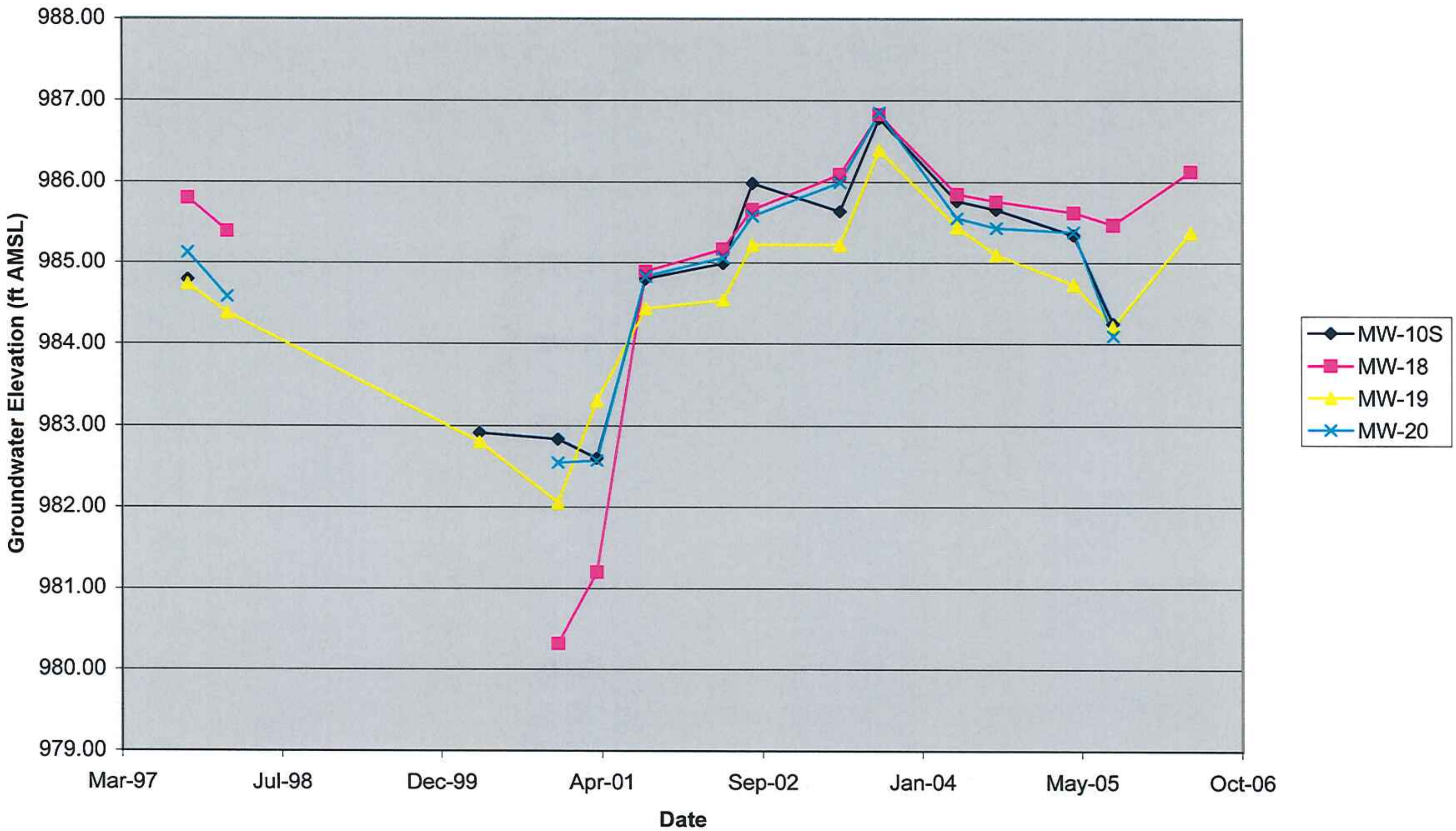

FIGURE 3
LNAPL Thickness & GW Elevation at MW-10S

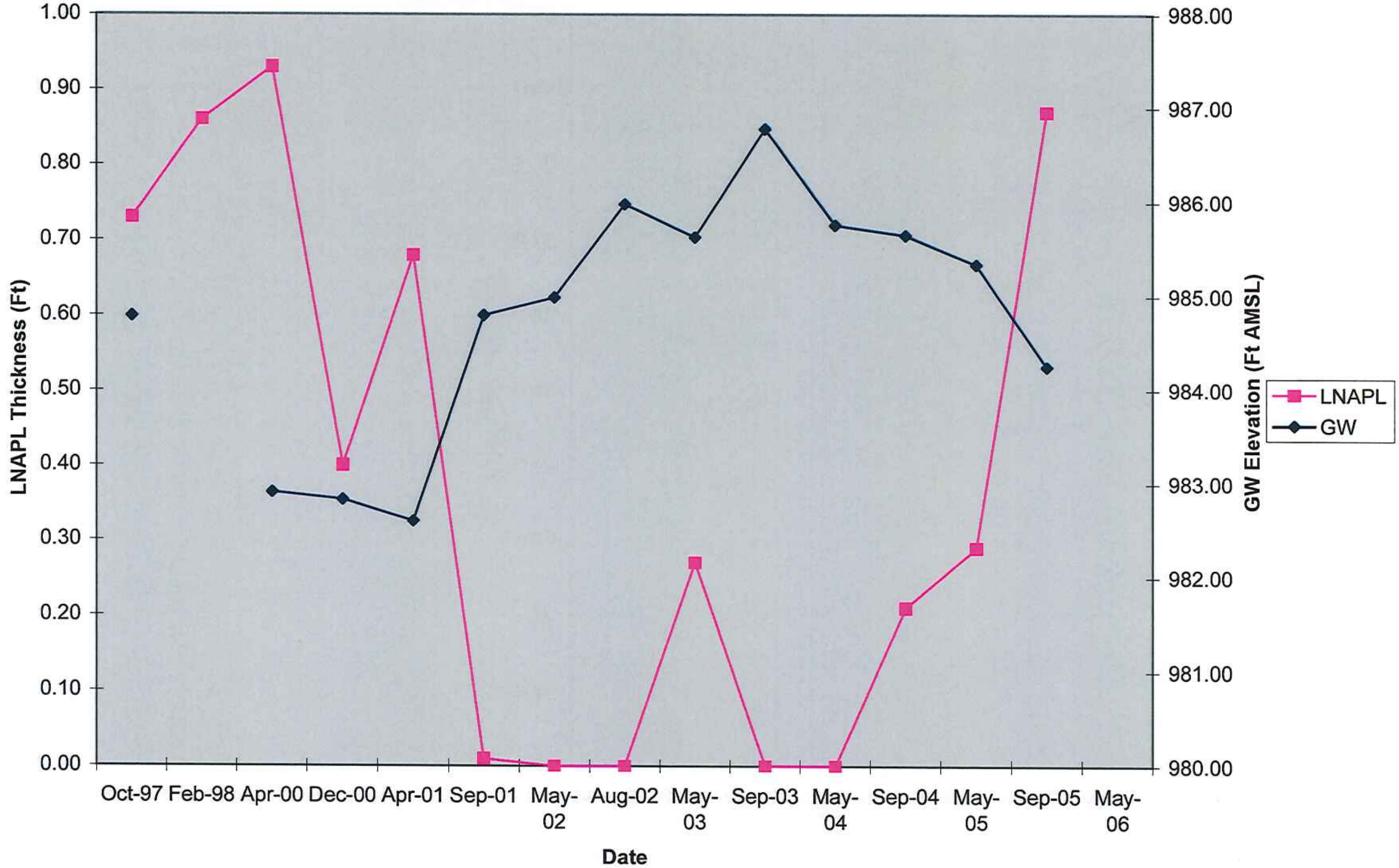

FIGURE 4
LNAPL Thickness & GW Elevation at MW-18

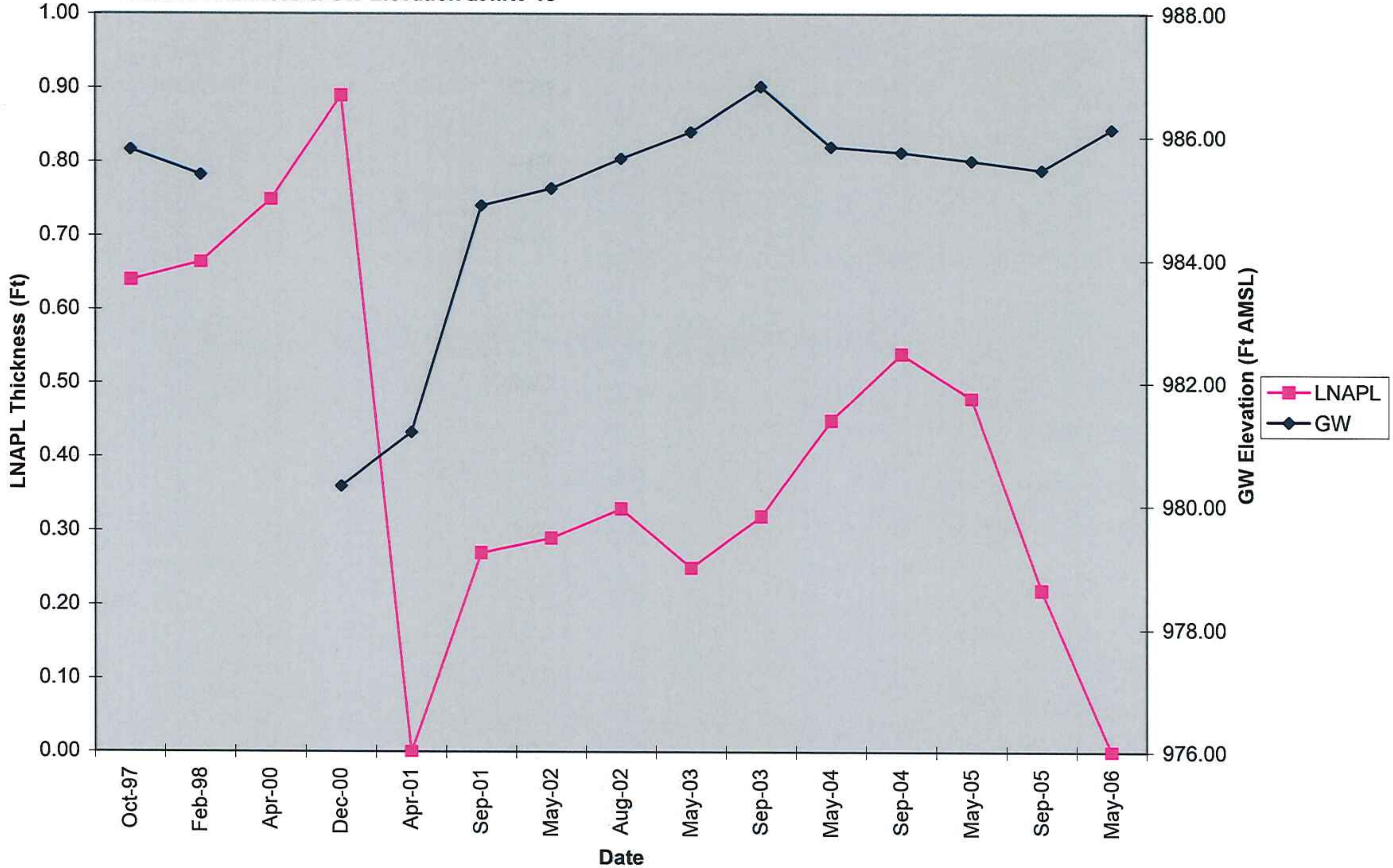

FIGURE 5
LNAPL Thickness & GW Elevation at MW-19

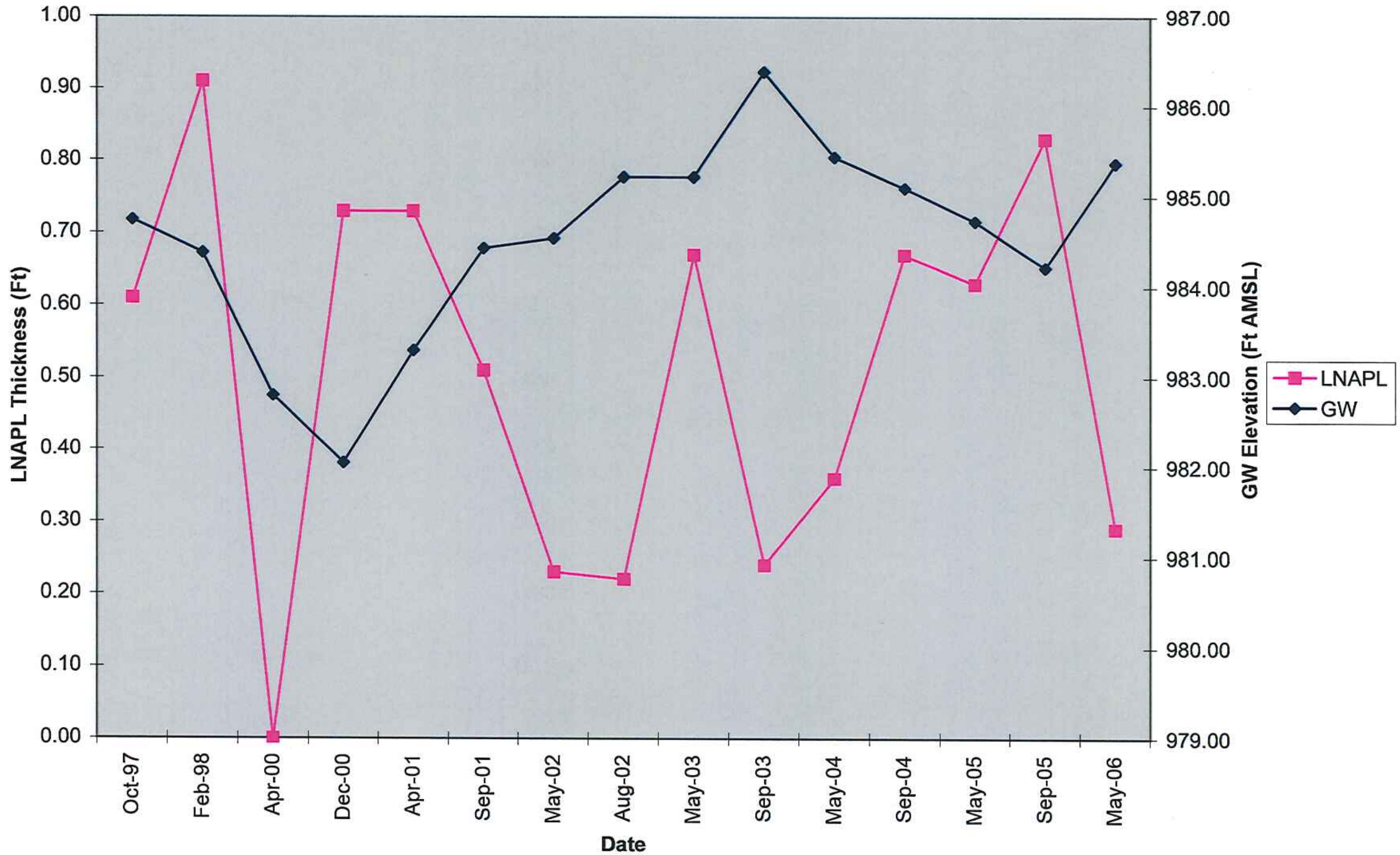

FIGURE 6
LNAPL Thickness & GW Elevation at MW-20