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Subject: Fridley Capture Zone Proposal

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Attached is the proposal for determining the capture zones at the NIROP facility that was discussed at the DQO meeting in Charleston. The proposal has been reviewed by the Navy and Tetra Tech, and their comments have been incorporated. In addition, I had Ed Weeks, an aquifer test expert at the USGS, review the proposal. He liked the approach and estimated that it had a 70%- 80% chance of working as expected. Please feel free to make any comments. If you have any questions please email me or give me a call at 850 942 9500 x3038.

-Hal Davis

Proposal for Determining the Capture Area of Recovery Wells at the NIROP Facility, Fridley, Minnesota

Introduction

On May 7, 2001, the ground-water pumping and recovery system at the NIROP facility will be turned off until May 20, 2001. During this period some wells will be removed from the system and new (already drilled) wells will be connected. On May 20, the recovery system will be turned back on with all wells pumping. Figure 1 shows the location of the recovery wells and the general direction of ground-water flow; figure 2 shows a cross-section of the aquifer (recovery wells are shown in red on figures 1 and 2). The geology at the site consists of a complex mixture of gravels, sands, silts and clays as seen in figure 2. The BIG question is: Will the combined capture zones of all the pumping wells be sufficiently large to fully capture the ground-water contamination plume or will contaminated ground water "blow through" the system.

Purpose of Proposal

The purpose of this proposal is to suggest a method for determining if the recovery wells installed at the NIROP facility will capture contaminated ground water before it leaves the facility property. The details of the method are discussed in the Approach and Study Methods section.

Background

When the recovery wells are turned on, pumping will cause drawdown of water levels in the aquifer, and the ground-water gradients in the

vicinity of the wells will reverse from sloping toward the Mississippi River to sloping back toward the wells. If the cones of depression are large and deep enough, then the capture zones of the wells should overlap and capture all the water moving between the wells. If the reversal of the ground-water gradients can be quantified, then the extent of ground-water capture can be determined. It should be noted that the capture zones will be somewhat smaller than the cones of depressions, and capture will only occur where the ground-water gradients have changed so that they and are sloping toward the pumping wells.

Approach and Study Methods

It is the intention of the Navy to determine the water levels at the NIROP facility during both pumping and non-pumping conditions. The establishment of these water levels was previously planned and is independent of this proposal. However, these water levels will be used for the work described in this proposal and will be supplemented by additional water level data collection described below. For the Navy to determine the pumping water levels it is anticipated that the following series of events will occur: 1) the recovery system will be turned back on on May 20 and will run until steady-state flow conditions occur, this will require sufficient time for the aquifer to adjust to the pumping and the Mississippi river return to base-flow conditions. The first mass round of water-level measurements will be taken at this time to establish the pumping water levels. 2) Immediately after the first round of water-level measurements, the recovery system will be turned off and the aquifer allowed to return to steady-state non-pumping conditions (estimated to take about 2-3 weeks). The second round of water level measurements will be taken at this time to establish non-pumping conditions.

The work proposed in this study will consist of taking additional water-level measurements in the period between the 2 mass round of measurements. The purpose of the additional work is to measure the recovery of water levels in the monitoring wells surrounding the pumping wells so that the combined cone of depression from all the wells in the recovery system can be determined. From this the capture zone of the recovery system will be estimated. The specifics tasks and methods that will be used are described below.

The proposed study consists of the following specific tasks:

1) Install pressure transducers at the site prior to the first round of water level measurements. These transducers will remain in place to measure water levels that occur when the pumping system is turned off; they should remain in place until the aquifer reaches equilibrium at the non-pumping conditions (about 2-3 weeks). In addition to measuring draw-down, the data form the pressure transducers will be used to eliminated background water level effects not related to pumping (e.g. effects of river fluctuation, barometric pressure changes.) Hand measurements will be taken at specified intervals in all the monitoring wells surrounding the pumping wells to supplement the pressure transducer data.

2) Subtract the pumping water levels from the non-pumping water levels to determine the cumulative drawdown created by all the extraction wells.

3) The cumulative drawdown can then be subtracted from the non-pumping surface to determine where the ground-water gradients are reversed and capture is occurring.

Analytical Methods

Analytical solutions were used as a test to determine how well the proposed method will actually delineate the capture area of the recovery system in the critical intermediate zone from which wells AT3A, AT9A, and AT10A are withdrawing water. To do this the following tasks were done:

1) Using the Theis equation, the designed pumping rates, and transmissivity values for the each of the pumping wells the drawdown in nearby monitoring wells was calculated. The Theis equation assumes a non-varying hydraulic conductivity between the pumping and observation wells. The pumping rates and hydraulic conductivity values used were: AT3A: pumping rate 245 gpm, conductivity 70 ft/day: AT9A: pumping rate 100gpm, conductivity 500 ft/day, and AT10A: pumping rate 30 gpm, conductivity 16 ft/day.

2) Using the law of superposition the calculated drawdowns were added together to get the total drawdown (simulating the system when all three of these wells are pumping). This total calculated drawdown is shown in figure 3.

3) The drawdown values were subtracted from the non-pumping water levels measured on January 4, 2000. The resulting predicted potentiometric surface in the intermediate zone (assuming wells AT3A, AT9A, and AT10A are pumping) is shown in figure 4.

4) Figure 5 is the same potentiometric map shown in figure 4 with ground-water flow lines added. This map indicates that the wells will fully capture ground-water flowing between the wells.

Consideration of Assumptions

The analytical analysis above was based on the Theis equation, which assumes that the aquifer is homogenous, isotropic, and that all wells are fully penetrating. Figure 2 shows that none of these conditions truly exist, which has also been shown in results from previous aquifer tests. Figure 6 shows the drawdowns that occurred during the aquifer test conducted at well AT3A. If Theis conditions had existed then all the drawdown curves would have over-lain. As seen in figure 6 not even 2 curves overlaid each other because the aquifer is heterogeneous, anisotropic, and all wells were partially penetrating. In addition there is about a 2-foot upward water-level difference between the top of the intermediate zone and the bottom of the intermediate zone which may have complicated the interpretation.

The effect of the aquifer properties on the measured drawdown and thus on the results of this study is difficult to predict ahead of time. It is possible that the aquifer properties will cause greater drawdowns and increase the probably of showing capture. However, much of the prediction of capture will depend on water-level measurements in the down-gradient wells, of which there are relatively few. Complications in the interpretation is this area could add to the uncertainty of prediction.

In the analysis discussed above, only the effect of wells AT3A, AT9A, and AT10A was considered. However, wells AT7, AT8, AT5A, and AT5B will also be pumping and these wells will probably increase the drawdown in the intermediate zone. The magnitude of the increase is difficult to predict, but it will probably be modest. It is also possible that due to preferential pathways the drawdown in the intermediate zone may decrease from what is predicted.

Field Work

The purpose of the field work is to collect water-level data in the vicinity of the pumping wells, starting at the time the initial round of

measurements are taken (for pumping conditions) and continuing until the aquifer has come to equilibrium during non-pumping conditions. The following tasks will need to be done.

1) Install the pressure transducers at the same time that the pumping water-level measurements are made. Pressure transducers should be installed in as many wells as possible. The most favorable wells are circled in purple on figure 7, however there probably will not be will be enough transducers to cover this many wells.

2) When the system is turned off, hand measurements should be taken in all the wells shown in figure 7. The measurements should be taken as rapidly as possible for about 12 hours. This will probably take about 4 people. After the first 12 hours, water levels should be in all the wells twice a day for 2 days. After this water levels should be taken once a day for 11 days, or until the water levels stabilize at the non-pumping conditions.

(See attached file: Figure 7.jpg)(See attached file: Figure 2.jpg)(See attached file: Figure 3.jpg)(See attached file: Figure 4.jpg)(See attached file: Figure 5.jpg)(See attached file: Figure 6.jpg)(See attached file: Figure 1.jpg)