# TW-19 AQUIFER PERFORMANCE TEST

## PALL LIFE SCIENCES

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**TABLES**



**APPENDICES**



**FIGURES**

## 1.0 INTRODUCTION AND BACKGROUND

This report summarizes an aquifer performance test conducted by Fishbeck, Thompson, Carr & Huber, Inc. (FTC&H) for Pall Life Sciences, Inc. (PLS) using the TW-19 well (TW-19). TW-19 was installed by Stearns Drilling of Dutton, Michigan, in November and December 2005 for the purpose of aquifer testing and an extraction well for the Maple Road Interim Response.

### 1.1 Site Location

TW-19 was installed on the west side of Maple Road between Dexter and Jackson Roads, approximately 150 feet ENE of MW-85. Figure 1 depicts the location of TW-19 and other geographic features relevant to this report.

### 1.2 Hydrogeological Setting

TW-19 is installed in an aquifer generally referred to as Unit E. This aquifer has been the subject of investigations by PLS. The investigations have included the installation of numerous test borings/monitoring wells, water level measurements, water quality monitoring, and the installation and aquifer testing of extraction wells TW-15, TW-16, TW-18 and TW-19. These data have assisted in developing a conceptual understanding of the hydrogeology of this aquifer.

Geological cross section A-A' (Figure 2) illustrates the geological setting in the TW-19 area. Figure 1 shows the location of the cross-section line. TW-19 is completed in a primarily coarse-grained deposit, which has a saturated thickness of approximately 97 feet. The deposit varies in thickness and composition away from the TW-19 area.

## 2.0 DATA COLLECTION

### 2.1 Test Dates and Duration

The aquifer performance test was conducted from December 20 to December 22, 2005. The test included collecting pretest water level data for more than three days. Following this period, TW-19 was pumped for a period of 24 hours at a rate of 204 gallons per minute (gpm). After the 24-hour pumping period, the pump was shut off, and water levels in the pumping well and other observation wells were measured for a recovery period of approximately 8 hours. All data collected during the testing is provided digitally in Appendix 1.

### 2.2 Well Information and Water Level Measurement Instruments

Water levels were measured in the pumping well and 14 observation wells. In five of the observation wells (MW-72d, MW-79, MW-85, MW-88 and MW-84s) and an existing test well (TW-16), water levels were monitored using In-Situ Mini Trolls® (pressure transducer/data logging systems). Water levels in the remaining observation wells and the pumping well (TW-19) were measured using an electronic water level meter. The other monitored wells included MW-72s, MW-81, MW-84d, MW-87s, MW-87d, MW-89, and MW-90. Relevant data for the observation wells used for the test are summarized in Table 1. Details regarding the construction of TW-19 are provided in Appendix 2.

### 2.3 Flow Measurements and Management of Water During the Test

Flow measurements were collected using an in-line flow meter and totalizer. The measurements were periodically recorded during the pumping portion of the test by onsite representatives. The totalizer indicated at total of 294,410 gallons over 24 hours for an average discharge rate of 204 gpm. Water from the test was transferred into a frac tank. To prevent pressure changes in the discharge line due to water level changes in the frac tank, water entered the tank at the top. Tanker trucks were used to unload water from the tanks during the test. The water was transported to the PLS Wagner Road facility for treatment. No water infiltration occurred in the test area as a result of the aquifer testing.

### 2.4 Climatological Data

Barometric pressure and other climatological data for the testing period were obtained from the National Oceanic and Atmospheric Administration for the Ann Arbor, Michigan, station (ARB), WBAN Number 94889. These data are provided in digital format in Appendix 1.

## 3.0 ANALYSIS OF AQUIFER TEST DATA

### 3.1 Pretest Background Data Analysis and Barometric Efficiency

Background water level data prior to the aquifer test were evaluated to estimate the barometric efficiency of the aquifer. Changes in barometric pressure during an aquifer test can influence water levels in confined and semi-confined aquifers and result in inaccurate estimates of aquifer coefficients. Analysis of water level and barometric pressure data prior to pumping can be used to correct the test data for barometric effects, if necessary. Figure 3 displays water level hydrographs combined with barometric pressure. The barometric and water level data for the pretest period are included in Appendix 3.

Barometric pressure ranged between a minimum of 32.616 and a maximum of 33.034 feet of water over the pretest period. Table 2 shows the barometric efficiency calculated for each well. As shown by the table, monitoring wells MW-72d, MW-79, MW-85, and MW-88 had similar barometric efficiencies with an average of 67%. In contrast, MW-84s and TW-16 had much lower barometric efficiencies (22 and 32%, respectively) suggesting these wells are completed in deposits isolated from the production aquifer.

Based on pretest data from most of the wells, the barometric efficiency of the aquifer is approximately 67%, i.e., the head in the aquifer will change 0.67 foot for every foot of change in barometric pressure (measured in feet of water). The change in atmospheric pressure that occurred during the test was calculated to have an affect on the measured water levels. As such, the data were adjusted for atmospheric pressure change. From the changes in atmospheric pressure observed during a test and the known relationship between change in pressure and change in head, the water-level changes due to changes in atmospheric pressure along ($\Delta hp$) can be calculated for the test period for the well (Kruseman, deRidder, 1991).

The data were corrected as follows:
For falling atmospheric pressures: $s' = s + \Delta hp$
For rising atmospheric pressures: $s' = s - \Delta hp$

The corrected and uncorrected data were plotted for each well and are included in Appendix 3. Although a minimal affect was shown, the pumping and recovery portions of the test were analyzed using the adjusted data.

## 3.2 Pumping and Recovery Data Analysis

The pumping of TW-19 induced a hydraulic response in several of the observation wells monitored during the test. Table 3 summarizes the response of the observation wells to the aquifer performance testing, along with the approximate maximum amount of drawdown each well experienced. As shown on Table 3, drawdown ranged from 0.11 foot at MW-90 to 2.41 feet at MW-85. The maximum drawdown at TW-19 was 18.42 feet.

Drawdown data for selected wells were entered into the aquifer test analysis software, AquiferWin32, Version 2.33 (Environmental Solutions, Inc.). The software was used to analyze the data using type curve matching techniques. Recovery data for selected wells were also entered into the program for analysis. Resulting drawdown curves and recovery plots are provided in Appendix 4.

The aquifer coefficients of transmissivity (T) and storativity (S) were calculated using drawdown and recovery data from MW-72d, MW-79, MW-85, MW-88, MW-84s and TW-16. The drawdown data from these six wells were matched to several type curves, including the Hantush Leaky Confined Partial Penetration type curve for partially penetrating wells in a confined aquifer (Hantush, 1964) and the Cooper and Jacob straight-line method (Cooper and Jacob, 1946). Recovery data were analyzed using the Theis Recovery Method (Theis, 1946). Derivative analysis plots for the Hantush method were also used to help with the type curve fitting. The type curve graphs are included in Appendix 4.

The coefficients derived from the aquifer test are summarized on Table 4. The transmissivity (T) results from the various analysis methods generally range from 44,750 to 60,900 gallons per day per foot (gpd/ft) (5982 to 8141 $ft^2$/day), excluding wells MW-84s and TW-16, which responded significantly different than the remaining observation wells. The Hantush confined partial penetration method and the Theis Recovery analysis are the most appropriate methods for estimating T for the given scenario. The average T for the four observation wells (MW-72d, MW-79, MW-85, and MW-88) for the Hantush analysis is 48,964 gpd/ft (6,545 $ft^2$/day), and the average T for the Theis Recovery analysis is 58,215 gpd/ft (7,782 $ft^2$/day), excluding MW-72d. Results from MW-72 are substantially higher than the remaining wells for both the Theis Recovery and the Cooper-Jacob methods, possibly due to a boundary or inaccuracy due to a greater distance from the pumped well, for which the Cooper-Jacob method becomes invalid. The data for the four observation wells were also analyzed using a multiple-well analysis with the Hantush (1964) method. Curve matching optimization of data from the four observation wells together results in a T of 54,544 gpd/ft (7,291 $ft^2$/day). A group optimization of the four observation wells included individual results in a T of 54,253 gpd/ft (7,252 $ft^2$/day). The average for all of the Hantush (1964) method analyses, including multiple-well analyses, is 51,010 gpd/ft (6,819 $ft^2$/day). Assuming an aquifer thickness at the pumping well of 97 feet results in a hydraulic conductivity (K) of 70 ft/day.

The storativites ranged between 8.17E-05 to 2.71E-04. The average storativity value for the observation wells, excluding MW-84s and TW-16, is 1.36E-04. This storativity value is within the typical range for a confined aquifer type.

## 4.0 SUMMARY AND DISCUSSION

TW-19 is completed in a confined aquifer. The aquifer varies in thickness and composition in the investigated area. The transmissivity calculated in the area of TW-19 is approximately 51,010 gpd/ft (6,819 $ft^2$/day) with average hydraulic conductivity values in the range of 70 ft/day. The aquifer test resulted in an average storativity value of 1.36E-04.

TW-19 has the available drawdown to support a sustained flow rate of at least 200 gpm. As such, TW-19 appears more than capable of pumping water at flow rates sufficient to meet the objective of the Maple Road Interim Response. The transmissivity and average hydraulic conductivity value calculated from the TW-19 aquifer test is on the low end of values derived from other Unit E aquifer tests, including the TW-16 test. The lower hydraulic conductivity suggests operation of TW-19 at a flow rate of 200 gpm may create a capture zone larger than necessary to achieve the objective of capturing concentrations of 1,4-dioxane greater than 2,800 ug/L. Such a large capture zone may also promote the unwanted circulation of water between one or more of the injection wells and TW-19. Pall proposes an initial extraction rate of 200 gpm and injection of 100 gpm into each of the injection wells. The flow field around extraction/injection zones will be closely monitored to determine if the objectives of the system are being met and whether their needs to be extraction or injection well flow rate adjustments. Preliminary groundwater modeling by Pall suggests a flow rate as low as 75 gpm may be capable of meeting system objectives.

Data from this test suggest TW-19 is in good hydraulic communication with portions of the Unit E plume exhibiting the highest 1,4-dioxane concentrations (MW-72s, MW-85 and MW-88 areas). This aquifer testing also suggests the potential for hydraulic communication/interaction between TW-19 and IW-3 will be significantly less than between TW-19 and IW-4. As such, it may be prudent to adjust the distribution of injection water volumes in the future to optimize system operations.

## 5.0 REFERENCES

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