Geo-Logic ASSOCIATES

October 14, 2016
Project No. 2015.0171

Mr. Jim Bennett, CHG
County of San Diego
Planning and Development Services
5510 Overland Avenue
San Diego, CA 92123

RECOMMENDATION FOR GROUNDWATER SHUTDOWN REQUIREMENTS DURING CONSTRUCTION OF THE TULE WIND FARM PROJECT EAST SAN DIEGO COUNTY, CALIFORNIA

On behalf of Avangrid, Geo-Logic Associates (GLA) is pleased to provide this letter to address a condition of the groundwater monitoring and mitigation plan presented in the County of San Diego approved Major Use Permit 3300-09-019 (MUP) and assist the County Department of Planning and Land Use (DPLU) in establishing groundwater shutdown requirements for Rough Acres Ranch (RAR) water supply Wells 6 and 6a during the Tule wind farm construction project. The MUP states that off-site well interference from project groundwater pumping may not fall more than 20 feet in off-site wells. For this project, since the exact location of the nearest well is unknown, the 20-foot drawdown threshold is assumed to occur at the nearest residential property line, approximately 1,129 feet west-southwest of RAR Wells 6 and 6a. Water level monitoring will be conducted in a recently constructed piezometer (PZ-1) to assess changes in the water level and trigger shutdown of Wells 6 and 6a, if the water level data indicate pumping has caused the static water level to fall 20 feet or more at the nearest property line during Tule Project construction. The following sections present the proposed initial baseline water level in PZ-1, and a recommendation that the County may consider in establishing the groundwater shutdown requirements. In addition, if groundwater shutdown does occur, recommendations are provided for groundwater recharge and water level recovery that would allow the production wells to be re-started.

Static Water Level

Water level data are being monitored and recorded using dedicated pressure transducers in several wells in the vicinity of RAR Wells 6 and 6a. Specifically, for the Tule construction project, water level data are collected at Well 6, adjacent to Well 6a, and piezometer PZ-1, installed in May 2016 and located 250 feet southwest of Wells 6 and 6a. Using the water level data obtained on September 27, 2016, the water level in piezometer PZ-1 is 31.00 feet below the top of the well casing (TOC; 29.71 feet below ground surface [bgs]). The water level in Well 6 on the same day was measured at a depth of 32.57 feet below TOC (about 31.49 feet bgs). It is proposed that a depth of 31 feet below TOC (29.71 feet bgs) be designated as the baseline

water level in PZ-1, on which changes in water level (drawdown) will be evaluated during Tule Project construction.

Calculation of Drawdown with Distance from the Pumping Wells

Based on an analysis of aquifer test data obtained during a 72-hour aquifer pumping test at Well 6a, performed for the Tule project and presented in the final Groundwater Investigation Report (GLA, January, 2012), it is possible to calculate the expected drawdown at the nearest property line (1,129 feet from pumping Well 6a). The analysis of potential drawdown is presented in the May 12, 2011 memorandum provided in Appendix B (B-3) of the report.

As presented in the May 12, 2011 memorandum, the results of a 72-hour aquifer pumping test, pumping at an average rate of 50 gallons per minute (gpm), yielded the drawdown data from observation Well 6 used to assess the aquifer's response to pumping from Well 6a. The results were presented on a time versus drawdown plot, and a change in slope ($\triangle s$) over one log cycle of 0.44 was calculated. On this time-drawdown plot, the slope of the line is extrapolated to 388,800 minutes (nine months) to project a drawdown of 4.59 feet in the observation well, if well 6a is pumped continuously at a rate of 50 gpm. Employing Cooper-Jacob methods (1946), described by Driscoll (1986), the following time-drawdown equation was used to calculate the transmissivity, T (the rate at which water flows through a vertical strip of the aquifer, 1-foot wide and extending though the full saturated thickness under a hydraulic gradient of 1) in gallons per day (gpd) per foot:

$$T = \frac{264Q}{\triangle s}$$

Where:

Q = pumping rate in gpm.

In this case the aquifer test was performed at a rate of 50 gpm, and the Transmissivity (T), is then calculated to be 30,000 gpd/ft, or 4,010 square feet per day (ft^2/day). To then evaluate the drawdown with distance, the distance-drawdown formula is used:

$$T = \frac{528Q}{\triangle s}$$

Where T remains 30,000 gpd/ft, resulting in $\triangle s$ calculated to be 0.88 (double the value measured on the time-drawdown plot) when the pumping rate (Q) is 50 gpm. With the drawdown of 4.67 feet extrapolated from the time-drawdown plot, and a slope, $\triangle s$, of 0.88, the drawdown can be projected any distance from the pumping center. For example, as presented in Figure 1 (revised from Figure 3 in the memorandum to reflect the distances to PZ-1 and the nearest residential property line), the drawdown is about 3.9 feet at piezometer PZ-1, and 3.3 feet at the property line. Changes in the drawdown are proportional with the pumping rate. Therefore, if the pumping rate is doubled to 100 gpm (the maximum capacity of the pumping systems), the drawdown exhibited is doubled to 7.8 feet and 6.6 feet, respectively.

Under the above scenario, when pumping at the maximum rate of 100 gpm over the nine-month construction period, the drawdown below the baseline water level would not approach the 20-foot threshold limit.

Recommendations for Groundwater Shutdown and Water Level Recovery/Production Restart

Although the aquifer test data indicate that the drawdown will not exceed the 20-foot threshold at the nearest residential property line, to be protective of the nearest off-site water users and comply with the off-site well interference requirements, GLA recommends that groundwater shutdown occur at Wells 6 and 6a when the water level in piezometer PZ-1 drops 20 feet below the baseline level of 31 feet (to a depth of 51 feet below TOC [49.71 feet bgs]). At that time, the County will be notified. Groundwater production would cease until the water level in PZ-1 has recovered 5 feet (to a depth of 46 feet below TOC), at which time, in accordance with the MUP, written permission would be requested from the County to restart the production wells.

CLOSING

This letter and analysis of aquifer test data pertains to the Tule Project. It may not be appropriate for other projects or for other sites. GLA requests that the County of San Diego Department of Planning and Development Services notify GLA and/or our client, Avangrid, LLC of any changes that the County would like to see made prior to the start of Tule project construction.

Sincerely,
Geo-Logic Associates

Sarah J. Battelle, CHG 609
Principal Geologist

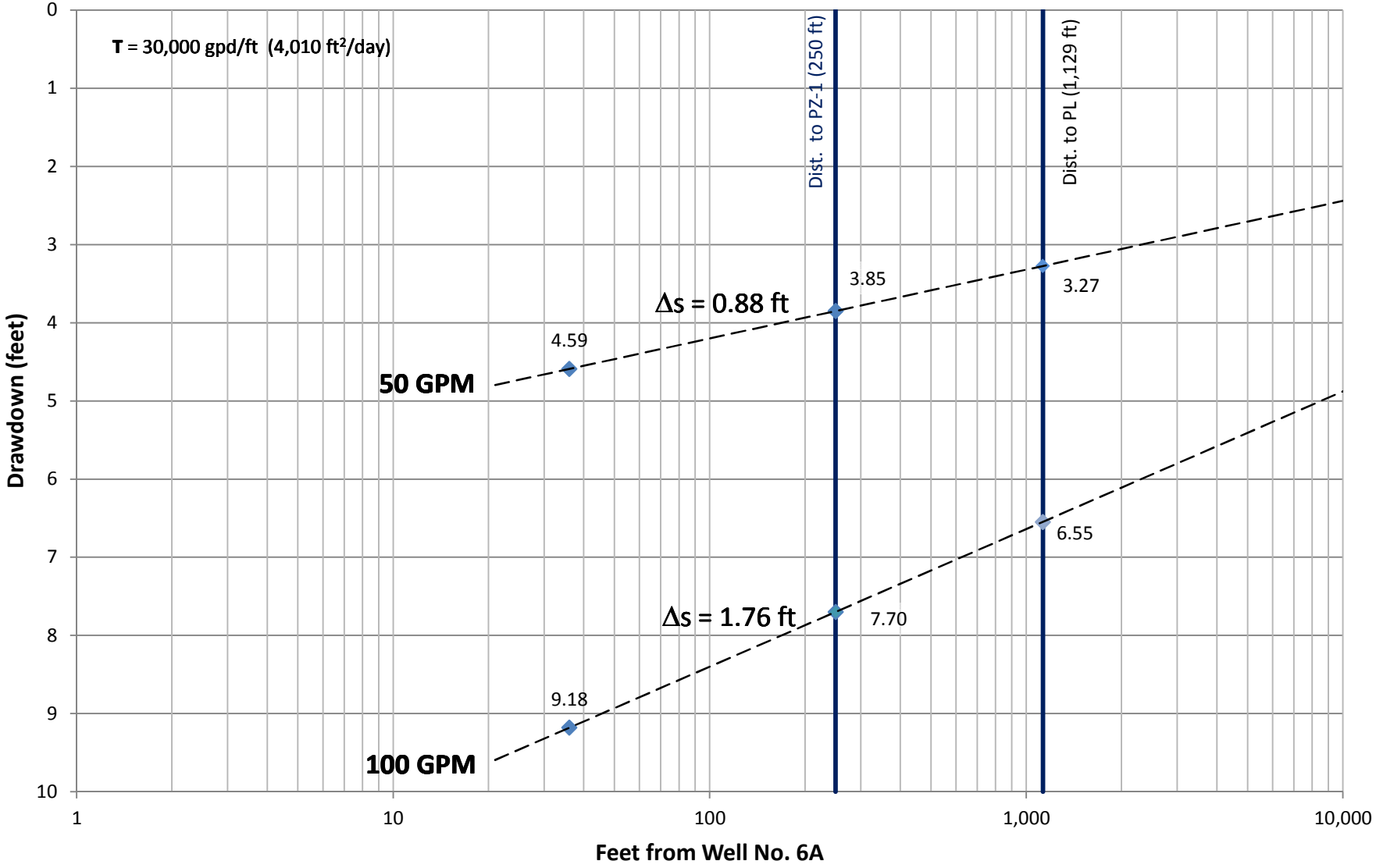
REFERENCES

Cooper, H.H., Jr. and Jacob, C.E., 1946, A Generalized Graphical Method for Evaluation Formation Constants and Summarizing Well Field History, *Transactions*, *American Geophysical Union*, Vol. 27. No. 4.

Driscoll, D.G., 1986, Groundwater and Wells, Johnson Filtration Systems, Inc., St. Paul, Minnesota.

Geo-Logic Associates, 2012, Revised Groundwater Investigation Report, Tule Wind Project, East San Diego County, California, January 24.

Figure 1
9-Month Projected Drawdown at PZ-1 and Property Line
T Calculated From Observation Well No. 6



Geo-Logic
ASSOCIATES
Geologists, Hydrogeologists and Engineers

Date: May 12, 2011

Project No.: 2010-0005

To: Sarah Battelle, CHg.

From: Jason Sapp, CHg.

Re: **Additional Well Interference Analyses for Rough Acres Ranch Well No. 6A, San Diego County, California**

INTRODUCTION

This memorandum presents the results of additional aquifer pumping test analyses that were completed to evaluate the potential for well interference effects at the proposed Tule Wind Project at Rough Acres Ranch (RAR) in the McCain Valley, eastern San Diego County, California. The analyses estimate the aquifer drawdown that could result from continuously pumping groundwater from RAR Well No. 6A during the estimated 9 month construction period expected for the project. The data presented herein are based on the results of a 72-hour aquifer test that was conducted at RAR on August 24, 2010 (Geo-Logic Associates [GLA], 2010).

AQUIFER DRAWDOWN FORECAST

As requested by the County of San Diego, the aquifer drawdown that could occur after continuously pumping RAR Well No. 6A for 9 months at a rate (Q) of 50 gallons per minute (gpm) was initially evaluated using the Cooper-Jacob method (1946) and the hydraulic properties of the aquifer as determined from the pumping well drawdown data obtained during the three day August 2010 aquifer pumping test at RAR (GLA, 2010). This forecast scenario used an aquifer transmissivity (T) value of 4,212 gallons per day per foot (gpd/ft; i.e., 563 square feet per day [ft^2/day]) and the aquifer drawdown measured at observation well RAR Well No. 6 during the August 2010 pumping test. [1]

Because pumping well drawdown data also reflect well inefficiencies and other losses in hydraulic head (i.e., drawdown that exceeds the aquifer drawdown immediately adjacent to it), pumping well data is considered inaccurate and typically results in smaller calculated transmissivity values. Since they are not typically subject to turbulent flow and other flow inefficiencies, observation well drawdown data are generally considered more accurate and provide for a better assessment of an aquifer's responses to pumping.

[1] RAR Well No. 6 is located approximately 36 feet from RAR Well No. 6A, and is the closest well to Well No. 6A.

Recognizing this condition, and in an abundance of caution, a second, more conservative, forecast scenario was also evaluated using the transmissivity value calculated from observation Well 6 drawdown data (Figure 1: T = 30,000 gpd/ft [4,010 ft^2/day]).

As shown on Figures 1 through 3, the analyses presented herein employed the Cooper-Jacob (CJ) method, graphical methods identified by Driscoll (1986), and the following equations for time-drawdown and distance-drawdown data respectively:

$$T = \frac{264\ Q}{\Delta s} \quad , \qquad T = \frac{528\ Q}{\Delta s}$$

The Δs in the denominator represents the change in drawdown (in feet) over one log-cycle when the drawdown data is plotted on a semi-log graph.

ANALYTICAL RESULTS

Scenario 1 - Pumping Well Data Analysis: Figure 1 depicts the drawdown that was measured in RAR Observation Well No. 6 during the 3 day (4,320 minutes) August 2010 pumping aquifer test when Well No. 6A was pumped at 50 gpm. As noted, when the late-time, equilibrated drawdown is projected for a longer 9 month pumping duration, the predicted drawdown at observation Well 6, which is 36 feet away from well 6A, would be 4.59 feet. Using the T value derived from the RAR No. 6A pumping well drawdown data (4,212 gpd/ft; GLA 2010), the CJ formula for T can be solved to yield a Δs value of 6.27 feet.

As shown on Figure 2, to determine the radius of influence that might be realized by pumping Well No. 6A for 9 months, the time-drawdown Δs line value is doubled and plotted on a semi-log graph. The x-axis intercept (i.e., zero drawdown) marks the calculated radius of influence of pumping at approximately 195 feet, a distance well inside the RAR property line (assumed to be approximately 439 feet from the pumping well). Moreover, because the calculation estimating the radius of influence (r_0 on Figure 2) is independent of the pumping rate (Q), the radius of influence for pumping Well No. 6A at 50 gpm or 100 gpm would be approximately the same (Figure 2). Accordingly, this analysis would anticipate no drawdown at the property line under either 50 or 100 gpm pumping scenario.

Scenario 2 – Observation Well Data Analysis: Unlike the first scenario which used a T value calculated from pumping Well 6A, the second scenario evaluated employed a Δs value calculated from the time-drawdown data for observation Well No. 6 (Figure 1). As shown on Figure 1, the observation well Δs value for one time-drawdown logarithmic cycle is 0.44 feet, which yields a calculated T value of approximately 30,000 gpd/ft. To evaluate aquifer drawdown near the property line, this time-drawdown Δs value (0.44 feet) is doubled and plotted on a semi-log graph through the projected 9 month drawdown level predicted for the observation well (Figure 3). As can be seen, this more conservative analysis predicts that drawdown at the property line after pumping Well No. 6A for 9 months at 50 gpm will be approximately 3.64 feet. If pumping is doubled to 100 gpm, calculated drawdown at the property line amounts to approximately 7.28 feet.

Under this most conservative analysis, if a well were to exist on the closest property line, and the project construction included pumping from Well 6A at 100 gpm for nine months (64 days is the anticipated duration), in accordance with County initial screening guidelines for significance, less than a 5 percent reduction in saturated aquifer thickness must be maintained. Under these guidelines, the fractured bedrock aquifer beneath the RAR property would need to be a minimum of 146 feet thick in order for the nine month drawdown of 7.28 feet forecasted at RAR property line (from pumping Well No. 6A at 100 gpm) to satisfy the County 5 percent criterion. Given that the aquifer near Well No. 6A appears to be at least 357 feet thick however (as shown on State Well Completion Report No. 1089956; GLA, 2010), County guidelines regarding minimum saturated aquifer thickness are expected to be maintained during the project.

CONCLUSIONS AND RECOMMENDATIONS

This additional well interference analysis concludes that there will be no significant impact to offsite wells if the Tule Wind Project pumps at rates between 50 and 100 gpm for a nine month period. Using aquifer transmissivity data from pumping Well 6A, as directed by the County Groundwater Geologist, results in a conclusion that there will be no impact at the nearest property line because the cone of depression will only extend 195 feet from Well 6A under either pumping scenario.

Conservatively employing observation well drawdown data from Well 6, however, and assuming that Well No. 6A pumps at rates ranging from 50 to 100 gpm, after 9 months aquifer drawdown is calculated to between 3.64 and 7.28 feet at the RAR property line, respectively. Of note, the Cooper-Jacob (1946) method employed for these analyses assumes that the aquifer is confined, consists of granular porous media, and has an infinite aerial extent. Since the aquifer that will be pumped by Well No. 6A consists of fractured rock, is unconfined, and has a limited aerial extent, the predicted aquifer drawdown identified herein may differ from those that actually occur. However, recognizing the conservative character of the analyses, we expect that actual drawdown at the property line will not exceed 5 percent of the anticipated saturated thickness (the County initial screening guideline for significance) if Well No. 6A is pumped at 100 gpm for 9 months.

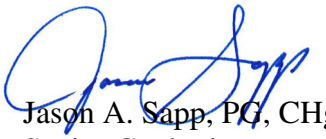
In an abundance of caution, we recommend installation of a pressure transducer in observation Well No. 6 to monitor actual drawdown overtime and to permit a better projection of aquifer drawdown at the property line through the 9 month construction project. Periodic downloads of the transducer data will allow for re-evaluation of the aquifer response predictions presented herein and modification of pumping rates if necessary.

CLOSURE

The analyses presented herein were completed in general accordance with accepted professional and hydrogeologic principles and practices. We make make no other warranties, either expressed or implied, relating to the professional advice or information included herein. Our firm should be notified of any pertinent change in the project work scope, or if conditions are found to differ from those described herein, as this may require further evaluation of the conclusions. This report has not been prepared for use by parties or

projects other than those named or described herein. It may not contain sufficient information for other parties or purposes.

Geo-**L**ogic **A**ssociates



Jason A. Sapp, PG, CHg.
Senior Geologist

Attachments:

References

Figure 1 – 50 GPM Time-Drawdown Plot, Rough Acres Observation Well No. 6
Figure 2 – 9 Month Projected Drawdown at Well No. 6, County Requested Analyses, T Calculated From Pumping Well No. 6A
Figure 3 – 9 Month Projected Drawdown, T Calculated From Observation Well No. 6

REFERENCES

Cooper, H.H., Jr. and Jacob, C.E., 1946, A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well Field History, *Transactions, American Geophysical Union*, Vol. 27, No. 4.

Driscoll, D.G., 1986, Groundwater and Wells, Johnson Filtration Systems Inc., St. Paul, Minnesota.

Geo-Logic Assoicates, 2010, Observations and Analyses of Aquifer Characteristics, Rough Acres Ranch, San Diego County, California, December 1.

Theis, C.V., 1935, The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Groundwater Storage, *American Geophysical Union Transactions*, Vol. 16, pp. 519-524.

Waterloo Hydrogeologic (co-developed with Thomas Roerich), 2002, AquiferTest version 3.5, Advanced Pumping Test and Slug Test Analytical Software.

Figure 1
50 GPM Time-Drawdown Plot
Rough Acres Observation Well No. 6

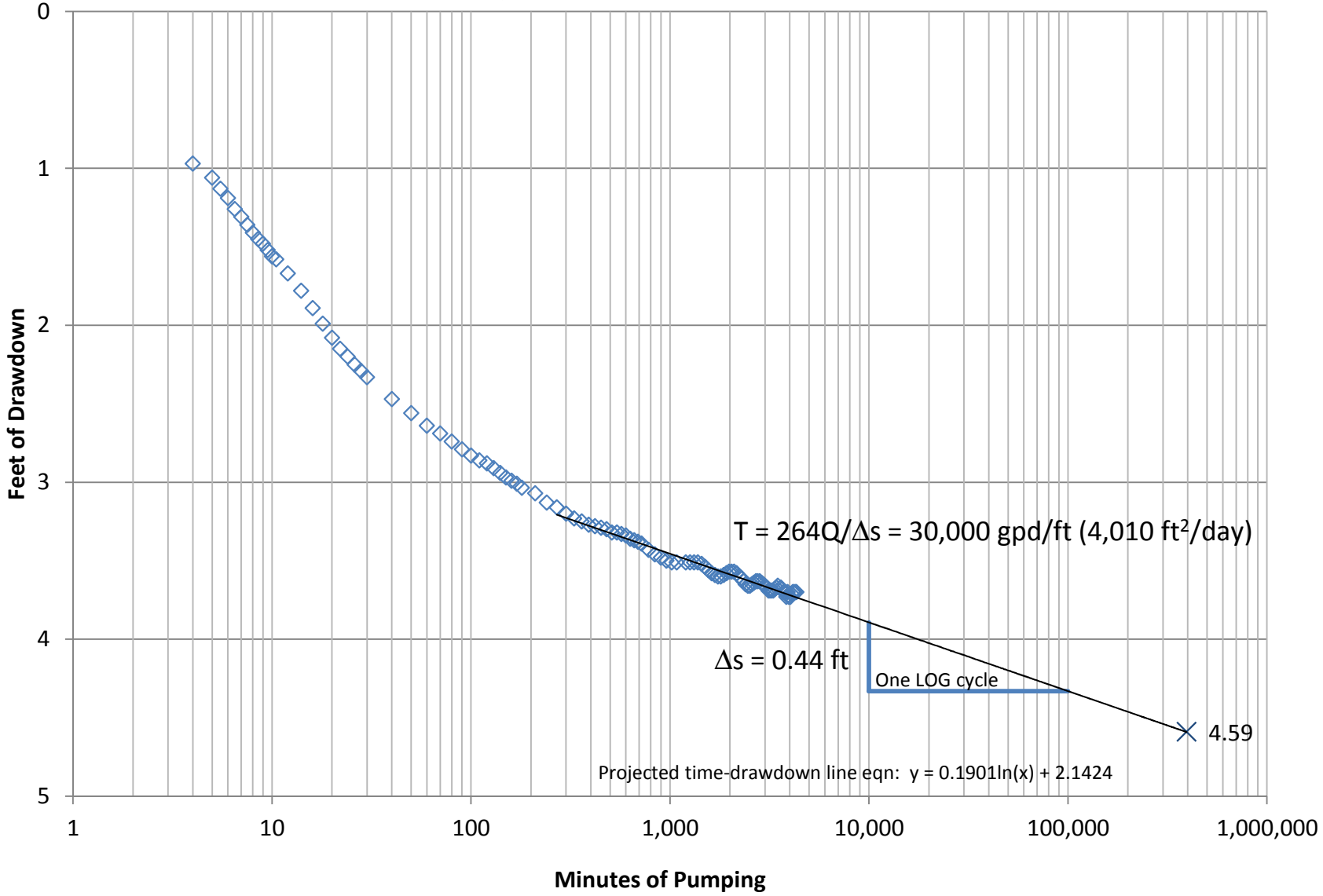


Figure 2
9 Month Projected Drawdown at Well No. 6
County Requested Analyses
T Calculated From Pumping Well No. 6A

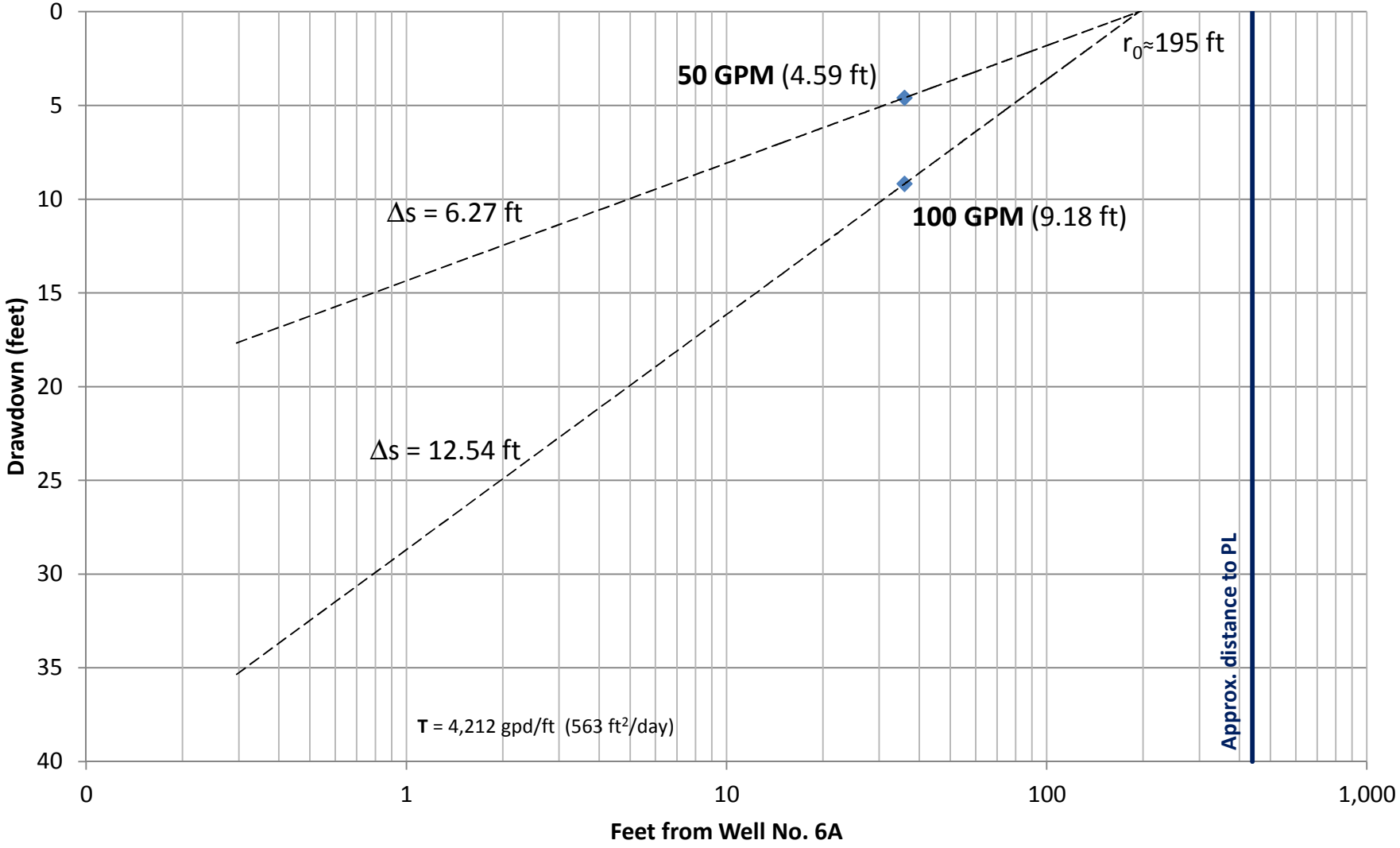


Figure 3
9 Month Projected Drawdown at Property Line
T Calculated From Observation Well No. 6