Guidelines for Hydrogeologic Reports and Aquifer Tests Conducted Within the Jurisdictional Boundaries of the Barton Springs / Edwards Aquifer Conservation District

Aquifer Science Staff, January 2007

I. Introduction

In accordance with the District's Rules and Bylaws and the District's Well Construction Standards, a hydrogeologic report may be required as part of the application for a pumping permit or increase in the permit, constructing, drilling, or modifying nonexempt wells. These guidelines are intended to assist professionals involved in conducting hydrogeologic studies (and the associated aquifer test) of existing and proposed groundwater pumping systems in the Barton Springs segment of the Edwards Aquifer. These guidelines provide some standards and District expectations of the hydrogeologic studies, and have been prepared with consideration for the local hydrogeologic conditions typically experienced in the region. Planning and implementation of the aquifer test shall be closely coordinated with the District to insure that the proposed study is consistent with District standards, however, the groundwater professional conducting the investigation is solely responsible for the accuracy and validity of the report. Prior to the commencement of the hydrogeologic investigation the District shall approve a written work plan that describes the design, approach, potential uncertainties, and remedies to those uncertainties. An approved work plan shall include all components of the District guidelines for hydrogeologic reports and aquifer tests in the Barton Springs Segment of the Edwards Aquifer, but is not limited only to these guidelines. Deviation from these guidelines may occur with District approval and should be addressed in the work plan. District staff may recommend that permit requests be rejected due to hydrogeologic reports that do not meet the District standards outlined below.

II. Purpose and goals of the Hydrogeologic Study

Hydrogeologic studies provide essential information for water-resource management for both the District and the permittee. As new water-use systems and increased demands are added to the Edwards Aquifer, hydrogeologic studies (and aquifer tests) are an essential tool to assess and document the potential influences on local wells and to understand the local aquifer characteristics.

The primary goals of the hydrogeologic report that must be addressed in the report are summarized below:

1. **Aquifer Properties**: Hydrogeologic parameters including *transmissivity* and *storage* need to be calculated from an aquifer test. From these parameters, the report should estimate the effects of current and projected pumpage on the water levels on surrounding wells for a one and three year period, unless otherwise specified by the District. Additionally, the report should also identify the presence of nearby hydrogeologic barriers, specific recharge features, public water supplies, or other factors that may influence this pumpage over time.

2. **Impacts To Wells**: The study should produce a map of the maximum drawdown from the aquifer test for the surrounding monitored wells.

3. **Changes in Water Quality**: The study should indicate if water quality changes are likely to occur as a result of future pumping demands. In cases where pumping wells are located near the bad-water line or in an area where significant contribution may be received from the Glen Rose

or other aquifers of differing and distinguishable water quality, field and lab measurements shall be performed in conjunction with an aquifer test to assess possible water quality changes.

III. Aspects of the Hydrogeologic Report and Aquifer Test Guidelines

Below are some aspects of the hydrogeologic report that must be addressed for the District to adequately assess the report. Aquifer test guidelines (collection and analyses of data) should follow those discussed in Driscoll (1986) and Kruseman and de Ritter (1991), or other published sources.

A. Description of the Well Site and Water System

The report must present a description of the project and indicate, using text and maps, the location of the well site(s) and site-system configuration. A description of the current and anticipated annual pumping demands should be addressed along with typical pumping schedules, such as, frequency, duration, peak demand hours, and pumping rates of the pumped well. The location and volume of water-storage facilities on and adjacent to the well site should be discussed.

B. Geology & Aquifer Description

The geologist or hydrogeologist should provide a description of their hydrogeologic conceptual model. This should include discussion on hydrogeologic aspects of the aquifer, such as the aquifer conditions (e.g. confined, semi-confined, unconfined), thickness and lateral continuity. Evidence to support this model must include a geologic and hydrogeologic stratigraphic description of the well site and surrounding area prepared by the geologist or hydrogeologist. A geologic map and cross sections illustrating the outcropping geologic units well bore geology, structural features (faults), and potential recharge influences on groundwater flow must be provided. In general, the cross sections should be aligned perpendicular and parallel to the direction of regional faulting. Pre-pump test potentiometric surfaces, maximum drawdown, and theoretical maximum drawdown for 3 years should be shown on the cross sections. Geologic and hydrogeologic information may be derived from drilling logs, state well records, geotechnical borings, geophysical logs, site mapping of outcrops (by a qualified geologist), surface geophysical methods, and in conjunction with published geological maps. A potentiometric map should be prepared showing the elevations of the potentiometric surface of the aquifer proposed for usage. The potentiometric map should be based on water-level measurements taken within a 2-week period prior to the aquifer test. The water- level measurements should be limited to wells screened in the same aquifer, unless impacts between aquifers are being assessed.

C. Inventory of potential recharge and discharge locations

The report must include an inventory of all known wells (private and public water source), surface ponds or reservoirs, major karst features, springs, or any other source of water recharge and discharge for the project well site and surrounding area. The area this inventory covers will vary according to each test, and the District Assessment staff shall be consulted as to the area of the survey prior to the test. However, it should be noted that previous pump tests in confined portions of the aquifer have demonstrated that large pumping rates over several days can result in measurable drawdown for over a 2-mile distance. Drilling and geophysical logs, and state well records from area wells should be included in the appendices of the report.

D. Public Notice

Collecting data in sufficient amounts and of the highest quality during the aquifer test is critical for accurate assessment of the results. The applicant must ensure that adjacent well owners who are interested in participating in the aquifer test (for example, as observation well locations) are aware of the test and that their participation is included in the test if it provides useful additional data and information. Therefore, a public notice approved by the District and sent certified mail is required for all hydrogeologic studies (aquifer tests) and shall be provided to all adjacent property owners within a ½ mile radius of the well to be tested. Notification of any property owner served by a retail water utility is not required if notice is provided to the water utility. The applicant will provide public notice via certified mail to all adjacent recipients and publish in a newspaper of general circulation within the District twenty (20) days before conducting the hydrogeologic study (aquifer test).

E. Aquifer Test: Design and Operation

The report should describe the configuration and methodology of the aquifer test. All aquifer test data, including date and time, measured discharge rate, drawdown, and field comments should be presented in the Appendices (and a copy provided in digital spreadsheet form). Any problems encountered in the field must be discussed and documented. Guidelines for various aspects of aquifer testing in the District are presented below:

Duration and Pumping Rate of the Aquifer Test: The date and time of starting, stopping, and pumping rate of the test must be clearly stated in the work plan and in the report. The duration and rate of pumping of the aquifer test should be sufficient to predict the long-term aquifer response to pumping and impacts to wells. (Driscoll, 1986) The District determines the duration of the test by the volume of water requested on the permit and the flow rate capability of the pumping well. To adequately stress the aquifer, the test shall be designed to pump a minimum of three times the daily equivalent of the requested annual permitted volume. For example, if the requested permitted volume of groundwater is 50,000,000 gallons; the daily equivalent of pumped groundwater would be 136,986 gallons. Therefore, the amount of water pumped during the test should be three times that volume, or 410, 958 gallons. For an aquifer test conducted over a 24-hour period, the flow rate would be about 285 gallons per minute. Note that the pumping rates chosen for the test should not be the maximum allowed by the system so as to ensure that the pump can be adjusted to maintain a constant pumping rate as the water level drops in the well.

During the aquifer test, discharge should be measured accurately and frequently enough to verify that a constant discharge rate is being achieved. If a flow meter is used to measure flow, it should be calibrated prior to the test and verified using another calculation method, such as an orifice weir, or by the time required to fill a storage facility of known volume. Waste of the discharge should be avoided as much as possible, particularly during low water-level conditions in the aquifer and should be routed to storage tanks or to other water systems when possible. If the water must be discharged to surface drainages off-site, the pumped water should be routed so that it does not recharge into the tested aquifer in the vicinity of the pumping well during the test.

***Aggregate Well Fields*:** If the study involves the assessment of two or more pumping wells, each well may be pumped separately to measure their combined effects. If the wells are sufficiently close, it may be possible to pump the wells simultaneously. Pumping each well separately, and allowing sufficient time for recovery between tests, can more accurately measure aquifer parameters.

1. ***Number and Location of observation wells*:** Observation wells should be selected radially around the pumping well, although drawdown measurements should be focused on wells where the greatest drawdown is anticipated, such as following along strike of the dominant fault trend. The location of observation wells will vary depending if aquifer conditions are confined or unconfined. The number of monitor wells will vary depending on the scale of the aquifer test and accessibility. Note that the district can help locate monitor wells and acquire access when applicable.

2. ***Water-Level Data*:** Pre- and post-aquifer test water-level measurements should be collected to adequately document local background conditions in the aquifer. All water-level measurements should be within 0.01 feet precision. Precipitation and stream flow on the recharge zone (from USGS flow stations) should be reported during the test. Aquifer tests should not be conducted during or immediately after significant rain events, because of the rapid change in water levels that often follows in this aquifer. Because water levels are dropping rapidly within the first several hours of pumping, water level measurements should be taken frequently. The use of automated data loggers and pressure transducers should be used whenever possible and verified with frequent manual e-line measurements Arrangements need to be made and testing schedules should be coordinated with other area pumping wells to avoid pumpage interferences that could result in misleading or uncertain results. The District can help coordinate these efforts.

3. ***Recovery:*** The recovery of water levels in the pumping and observation wells should be monitored immediately following the pumping period until all of the wells reach at least 90% of their original water level or have achieved a constant level for 2 hours. Data from the recovery phase should be nearly a mirror image of the pumping phase data when plotted arithmetically.

   Note: Incomplete recovery and deviations from the theoretical recovery trends should be addressed. Several of the monitored wells should be measured beyond the recovery period of the pumping phase to establish regional and local water level trends.

F. Analyses of Aquifer Test Data

This section should be prepared by a groundwater professional describing the hydrologic information and the methods used to characterize the aquifer and discuss the limitations of the data and analyses. Aquifer parameters are generally measured using an aquifer test. However, other methods of estimating aquifer parameters exist, such as, those based on grain size or geophysical response of the rock matrix, or the specific capacity of the well. These methods are generally insufficient alone to provide accurate measurement of the aquifer properties, but may be used to provide supplemental information.

1. Presentation of the water-level data should include a graph of the arithmetic (non-log) water-level elevation versus time for all the data from each well. From these graphs, long- and short-term trends, the lack of full recovery of water levels, and evidence of aquifer boundaries can be addressed.

2. Discussion of the analyses and methods used to calculate transmissivity and storage coefficients must be presented. Most commonly, curve-matching techniques are applied to achieve the optimal fit between theoretical relationships (e.g. Theis) and measured field data. Numerical

modeling of pumptest data has also been developed (e.g. MODFLOW and RADFLOW), and can be used in conjunction with curve-matching techniques (see Johnson et al., 2001).

Semi-log and log-log graphs of drawdown versus time must show the measured data and the theoretical curve used to calculate the parameters. All data manipulation should be clearly described. Most importantly, deviations from these theoretical curves must be addressed and may include issues, or violations of assumptions, such as: recharge, partial penetration of wells, fluctuating pumping rate, delayed yield, leakage, atmospheric responses, regional water-level trends, and interference from other wells.

G. Evaluation of Potential Water-Level and Quality Impacts

The effects of pumpage from the investigated wells on the aquifer and surrounding wells must be evaluated.

1. A map of the maximum measured drawdown and discussion about how those numbers were determined must be provided. If more than one well is pumped, the maximum drawdown from each test should be shown separately, and the drawdown effects of each test may be summed, if appropriate, in each observation well and presented in a separate map. Regional water-level trends and spring flow at Barton Springs should be discussed. These data can be obtained from the District. Maximum drawdown determinations may need to be adjusted for regional water level trends.

2. The calculation of aquifer transmissivity and storage coefficients can be used to predict future water-level declines for a given time period and pumping rate. These theoretical graphs showing drawdown over distance, such as the modified Cooper-Jacob Equation, are a useful tool to evaluate the effects of future pumping on surrounding well owners and public water supplies. A map of this theoretical drawdown shall be presented in the report for given time periods.

3. Additionally, the report should document and discuss any water-quality trends that may have occurred due to the groundwater withdrawals. Analytical results should be provided in the appendices. Arrangements can be made with the District to take field and some basic laboratory measurements in conjunction with an aquifer test.

H. Supplemental Information

Due to the test-specific nature of these investigations, additional information can significantly enhance the results of the investigation. Below are some items that should be considered within the scope of work for the hydrogeologic studies:

1. In the absence of good geological and geophysical control data, a suite of geophysical logs (and down-hole camera) should be performed on the pumping well.
2. In the absence of sufficient observation wells, a scientific monitor well (borehole) should be completed in the well field.

References

Driscoll, Fletcher R., 1986, Groundwater and Wells. Second Edition. Johnson Screens, St. Paul, Minnesota. Pp. 1089.

Johnson, G.S., D.M. Cosgrove, and D.B. Frederick, 2001. A Numerical Model and Spreadsheet Interface for Pumping Test Analysis, Groundwater, July-August 2001, Vol. 39, No. 4, Pp. 582-592.

Kruseman, G.P., and N.A. de Ridder, 1991, Analysis and Evaluation of Pump Test Data, Second Edition, ILRI, Netherlands. Pp. 377

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