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ECF-Hanford-15-0040
Revision 0

Analysis of Well Development Data in the 100 Areas

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

ch2m

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APPROVED
By G. E. Bratton at 1:55 pm, Sep 01, 2016

Release Approval   Date

CH2MHILL Plateau Remediation Company

Environmental Calculation Cover Page

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Terms

CHPRC	CH2M HILL Plateau Remediation Company
FAR	field activity report
gpm	gallons per minute
SC	specific capacity

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1 Purpose

The purpose of this environmental calculation brief is to present the analysis of well development data at several wells in the Hanford 100 Area. Well development data sets for more than 500 wells were provided by CH2M HILL Plateau Remediation Company (CHPRC) (CHPRC, 2013, Well Development Data).

After reviewing the data sets provided, data from 71 wells were identified as suitable for detailed assessment using methods developed specifically for drawdown and recovery data analysis. These 71 wells were selected based on the duration and quality of the pumping history and the quality of the drawdown/recovery responses. Estimates of aquifer transmissivity and hydraulic conductivity were then developed for these wells using one or a variety of methods described in this brief. Data sets for an additional 120 wells were considered unsuitable for analysis using methods developed specifically for drawdown and recovery analysis because of noisy pumping/drawdown/recovery responses but suitable for estimation of specific capacity (SC). Estimates of aquifer transmissivity were also developed for these 120 wells based on the methodology described in Appendix A.

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2 Methodology

Drawdown and recovery phase data were analyzed using the methods described in this section.

Well development data were not evaluated for the purpose of estimating aquifer properties, which is best accomplished using longer term testing. There were the only available data in this case and were used until better analysis can be conducted. The methods of analysis used, as described in this section, all rest upon simplifying assumptions that are violated, to one extent or another, by the conditions of the well development data sets. However, under many circumstances, analysis of well development data can provide an indication of the properties of the surrounding aquifer, particularly transmissivity.

A wide variety of drawdown and recovery responses were observed in the well development data sets provided for this analysis. Drawdown data during pumping were generally irregular because of variable pumping rates that are characteristic of well development activities, whereas recovery data, when available, were generally more regular and suggest, in many instances, the S-shape recovery pattern that is characteristic of an unconfined aquifer. It is evident from the recovery data that at least some of the recovery data were impacted by the backflow of water immediately following cessation of pumping (i.e., during early time recovery) due to the absence of in-line check valves. For some wells, water levels dropped below the transducer during the drawdown portion of the test, producing an artificially flat drawdown response.

In general, it might be expected that estimates of transmissivity derived from SC values measured during well development will underestimate aquifer transmissivity because well losses are unaccounted for (i.e., it is assumed that well is an ideal sink), and the well is generally undergoing development during the drawdown phase which complicates the interpretation of the drawdown results. In contrast, it might be expected that recovery data would provide a more accurate indication of aquifer transmissivity since the recovery period should represent post-development conditions and since the recovery phase is less dependent upon the variations in pumping rate during the drawdown phase. However, given the short-term duration of well development tests, the impact of variable extraction rates and (intentional) well development during the drawdown phase and the occurrence of early time backflow during the recovery phase, data from both the drawdown and recovery phase were evaluated, and estimates for aquifer transmissivity were based on assessment of both results obtained. Well-specific analyses completed are presented in individual subsections of this brief, and the results obtained from these analyses are presented in two comprehensive tables. In some instances, the estimated value for aquifer transmissivity that is obtained from analysis of the drawdown data is substantially different from that obtained through analysis of the recovery data. In these circumstances, deference has generally been given to estimates based upon drawdown and SC data, rather than the recovery data, because in many instances the recovery data appear to provide transmissivity estimates that are systematically higher than other sources of information available at the time this brief was prepared. Nonetheless, readers of this calculation are encouraged to review and compare values obtained from both methods.

Analyses of drawdown and recovery data were performed using AQTESOLV Version 4.5 (www.aqtesolv.com), a program that incorporates a large number of methods for analysis of drawdown and recovery data such as obtained during aquifer tests. At wells where drawdown or recovery data could not be analyzed using more rigorous methods, transmissivity estimates were obtained solely from SC values calculated at the end of the drawdown period, as described in the following subsection.

2.1 Specific Capacity Estimation

SC values are obtained by dividing the final pumping rate in gallons per minute (gpm) by the drawdown (in ft) as observed at the end of the pumping period. SC values obtained were converted from units of gpm/ft to m^3/day/m of drawdown by multiplying by the conversion factor (5.45099/0.3048). First-cut estimates of the corresponding aquifer transmissivity, in units of m^2/d, were then developed by multiplying the SC estimate by a factor of 1.3, following the approach described in Appendix A. These calculations were performed using 2013 Microsoft Excel®, Version 15.0.4675.1003.

2.2 Theis Drawdown Data Analysis as Modified by Hantush (1961)

The Theis, 1952, "The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage," nonequilibrium solution for fully penetrating pumping wells in nonleaky confined aquifers was extended by Hantush, 1961, "Drawdown Around a Partially Penetrating Well," for partially penetrating wells. In this solution, drawdown is a function of aquifer transmissivity (T), storage coefficient (S), and hydraulic conductivity anisotropy ratio (K_z/K_x), where K_z is the vertical hydraulic conductivity and K_x is the horizontal hydraulic conductivity. Best fit values for these aquifer parameters are estimated by visually adjusting the values, so that the calculated drawdown matches the observations to the extent possible.

2.3 Cooper-Jacob Drawdown Data Analysis

The Cooper-Jacob, 1953, "A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History," solution is an approximation of the Theis nonequilibrium solution for nonleaky confined aquifers. In the Cooper-Jacob method, drawdown data (signified by s) are plotted against the logarithm of the time elapsed since the commencement of pumping. A straight line is fit to the later portion of the drawdown data: aquifer transmissivity is inversely proportional to the slope of the straight line, and the storage coefficient is directly proportional to the x-intercept of the straight line. The Cooper-Jacob straight line should be fit to the portion of the drawdown data where the drawdown response is representative of the response of the aquifer and not wellbore storage change. Mathematically, this is the portion of the data where the derivative, $\frac{\partial s}{\partial \ln(t)}$, of the drawdown with respect to the logarithm of elapsed time (ln(t)) is constant. The drawdown derivative has been added to the Cooper-Jacob plots presented in this brief to assist in identifying the appropriate portion of the response for analysis.

2.4 Theis Recovery Data Analysis

Recovery data are analyzed using the straight line solution proposed by Theis. In this method, recovery data are plotted on a semilog plot. The recovery data (i.e., residual drawdown, s) at time (t) are plotted against $t/(t-t_{off})$, where t is the time elapsed since pumping commenced and t_{off} is the time at which pumping ceased (i.e., start of recovery period). A straight line is fit through the later part of the recovery data, and transmissivity is estimated from the slope of the straight line. The x-intercept of the straight line is equal to the ratio of the storage coefficient during pumping to the storage coefficient during recovery. For ideal conditions, the straight line through the late-time recovery data should project back to zero drawdown as $t/(t-t_{off})$ approaches a value of 1 and the ratio of storage coefficients should equal 1. In some cases, a negative y-intercept is obtained, indicating that complete recovery is achieved earlier than the ideal response. In other cases, a positive y-intercept is obtained, indicating that the water level in the well never recovers to the original water level. Deviations from ideal conditions can be very diagnostic: in the case of premature recovery, the response suggests that the drawdown cone is replenished by a source of water in addition to confined storage. For example, this response may be observed in a well that is adjacent to surface water. In the case of permanent drawdown, the response suggests that the drawdown

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® Excel is a registered trademark of Microsoft Corporation, Redmond, Washington.

cone will only be replenished through slow recharge or leakage across confining units. Further diagnoses of the departures from ideal conditions were not possible within the scope of this calculation brief.

2.5 Papadopulos and Cooper (1967) Drawdown Data Analysis

The Papadopulos and Cooper, 1967, "Drawdown in a Well of Large Diameter," solution is another method for estimating transmissivity and the storage coefficient of non-leaky confined aquifers. In contrast with the Theis method and its Cooper-Jacob approximation, which each assume that the pumped well is a zero diameter perfect line sink (or source), the Papadopulos-Cooper method explicitly accounts for wellbore storage within a large diameter (finite-diameter) pumped well. Obtaining estimates for aquifer parameters using the Papadopulos-Cooper analysis involves matching a calculated solution to drawdown data measured during pumping.

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3 Assumptions and Inputs

The following assumptions are made in the calculation of SC and estimation of the corresponding transmissivity:

- The well has been pumped sufficiently long enough for well bore storage effects to dissipate and drawdown to stabilize. For wells where the drawdown did not stabilize, a conservative estimate of drawdown was used for calculating SC.
- In estimating transmissivity from SC, it is assumed that the only source of drawdown is head losses in the aquifer formation. All other possible sources of drawdown (e.g., skin losses, nonlinear head losses in the well, turbulent head losses in the aquifer formation, and partial penetration effects) are neglected.

The following assumptions apply to use of the Theis (drawdown and recovery), Cooper-Jacob (drawdown), and Papadopulos and Cooper (drawdown) analytical solutions:

- The aquifer is confined, has an infinite areal extent, and is homogeneous, isotropic, and of uniform thickness.
- The pumping well is fully screened in the aquifer, and the pumping rate is constant for the duration of the test. Additionally, the flow to the pumping well is horizontal and unsteady (transient).
- The Papadopulos and Cooper solution does not neglect the well diameter and accounts for wellbore storage. The other three analytical solutions assume that the diameter of the pumping well is small enough to neglect wellbore storage.
- Water is released instantaneously from storage with a decline in hydraulic head.
- The background hydraulic head is known everywhere prior to the start of pumping, and there are no variations in water levels that are not due to the pumping well.
- The Cooper-Jacob drawdown analysis requires the analytical solution to be fit to the portion of the drawdown responses caused only by the aquifer.
- The Theis recovery and Cooper-Jacob drawdown solutions assume that the well radius is very small compared to the time of interest.
- In applying analytical solutions developed for wells in confined aquifers to wells screened in the unconfined aquifer, it is assumed that flow to the well is horizontal, and pumping at the well does not lower the water table. These assumptions are reasonable because most of the pumping tests lasted only a few hours and did not cause significant drops in the water table.

In recognition that the aquifer parameter estimates obtained from the well development data sets are approximations, subject to the assumptions listed above and other deviations from ideal conditions, precision of the parameter estimates is generally reduced to two significant figures for reporting purposes.

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4 Software Applications, Descriptions, Installation and Checkout, and Statements of Validity

Software packages that were used to perform the calculations in this report are described in the following sections.

4.1 AQTESOLV (Calculation Software)

- Software title is AQTESOLV by HydroSolve Inc. (www.aqtesolv.com) for design and analysis of aquifer tests in confined, unconfined, leaky, and fractured aquifers.
- Software version is 4.5 for Windows; Hanford Information System Inventory identification number 3219.
- The AQTESOLV code has been graded as Level D software in accordance with PRC-PRO-IRM-309, *Controlled Software Management*.
- AQTESOLV is not designated as a Safety System Software. Use of this software was consistent with its purpose, within its limitations, and valid as an application of AQTESOLV consistent with the functional requirements identified in CHPRC-01814, *AQTESOLV(TM) Software Management Plan*.
- Workstation type and property number used to run software were S.S. Papadopulos and Associates, Inc. (FE483).

4.2 Excel 2013 (Calculation Software)

- Software title is Excel 2013 spreadsheet software by Microsoft Inc. (www.microsoft.com).
- Software version is 2013 (15.0.4675.1003) for Windows.
- The software was consistent with its intended use for, and is a valid use of this software for, the problem addressed in this application.
- The software was used within its limitations.
- Workstation type and property number used to run software were S.S. Papadopulos and Associates, Inc. (FE483).

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5 Calculation

Well development data for 71 wells in the Hanford 100 Area is analyzed in this chapter.

5.1 Analysis of Well Development Data at Well 199-B2-13

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *A4551_WD_199-B2-13_1992-06-10.xls.*

5.1.1 Summary of available data

The well was developed on June 10, 1992. The well was pumped at 6.87 gpm for 78 minutes, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period. Changes in the water level with time are shown in Figure 5-1. The well recovers to a higher level than the value measured at the start of pumping.

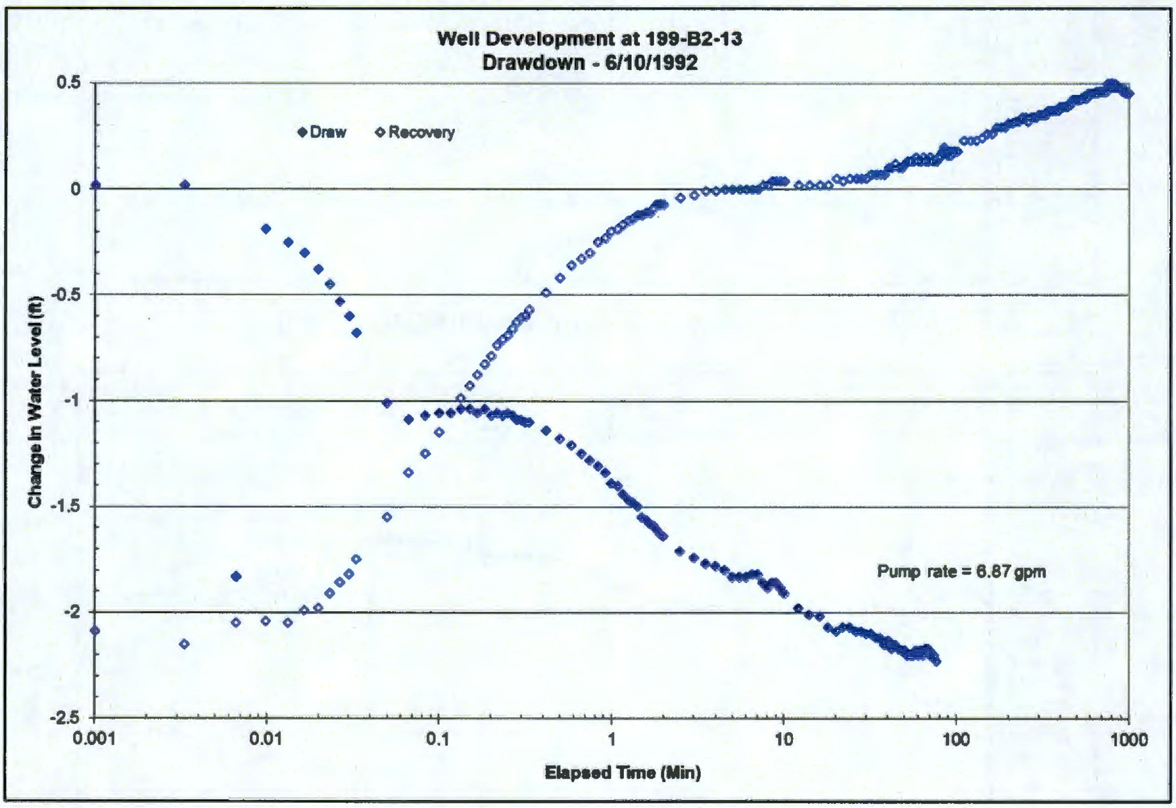


Figure 5-1. Drawdown and Recovery Data at 199-B2-13

5.1.2 Analysis

The Theis recovery method was used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-2, aquifer transmissivity is estimated to be 80 m^2/d. The estimated ratio of the storage coefficients is 20.9. A ratio in excess of 1 points to premature recovery, that is, the drawdown cone is replenished by a process external to the pumping test. Consistent transmissivity estimates were also obtained from the analysis of the drawdown data, with the Theis and Cooper-Jacob methods, as shown in Figure 5-2.

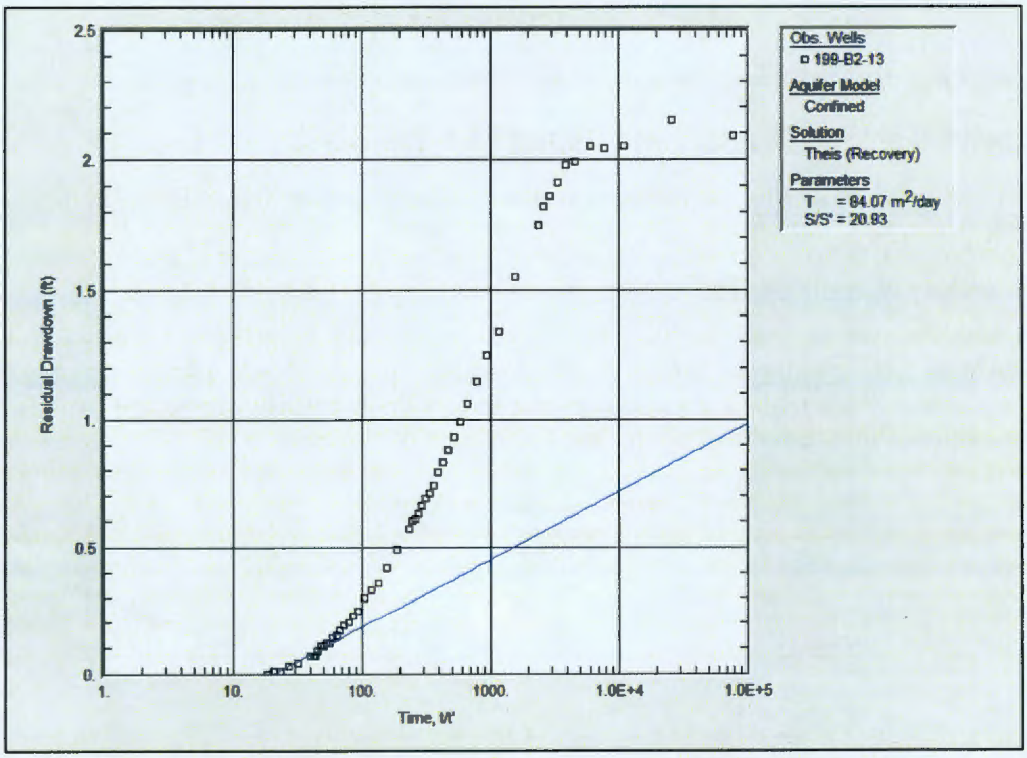


Figure 5-2. Theis Recovery Analysis at 199-B2-13 (1 of 3)

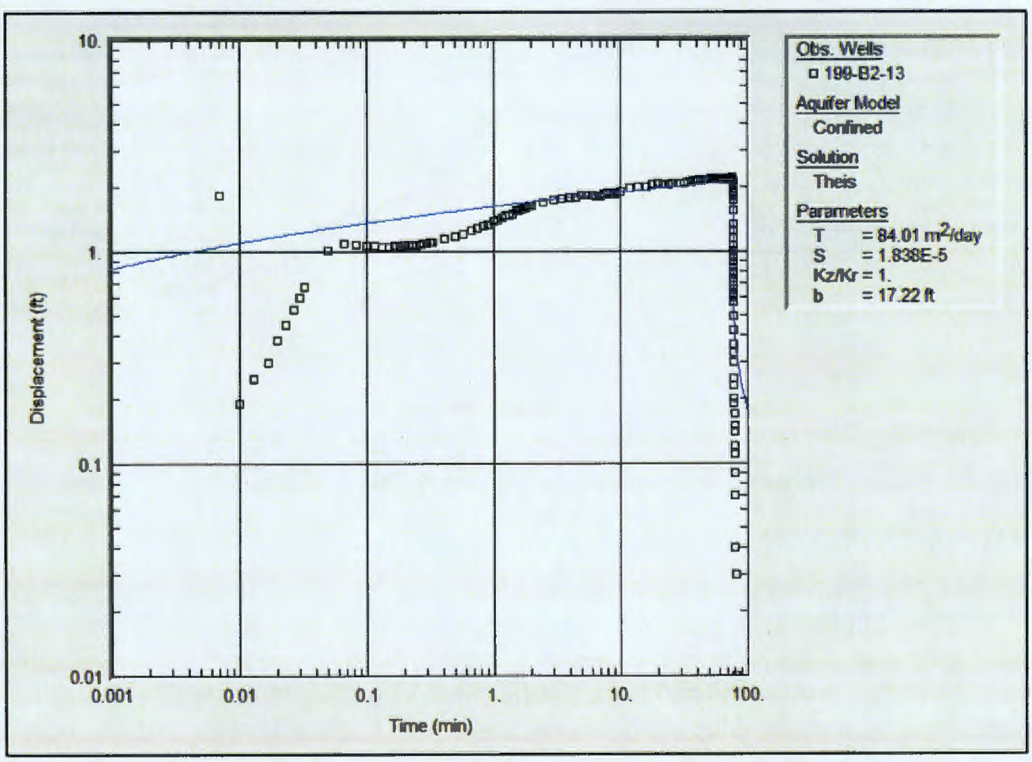


Figure 5-2. Theis Drawdown Analysis at 199-B2-13 (2 of 3)

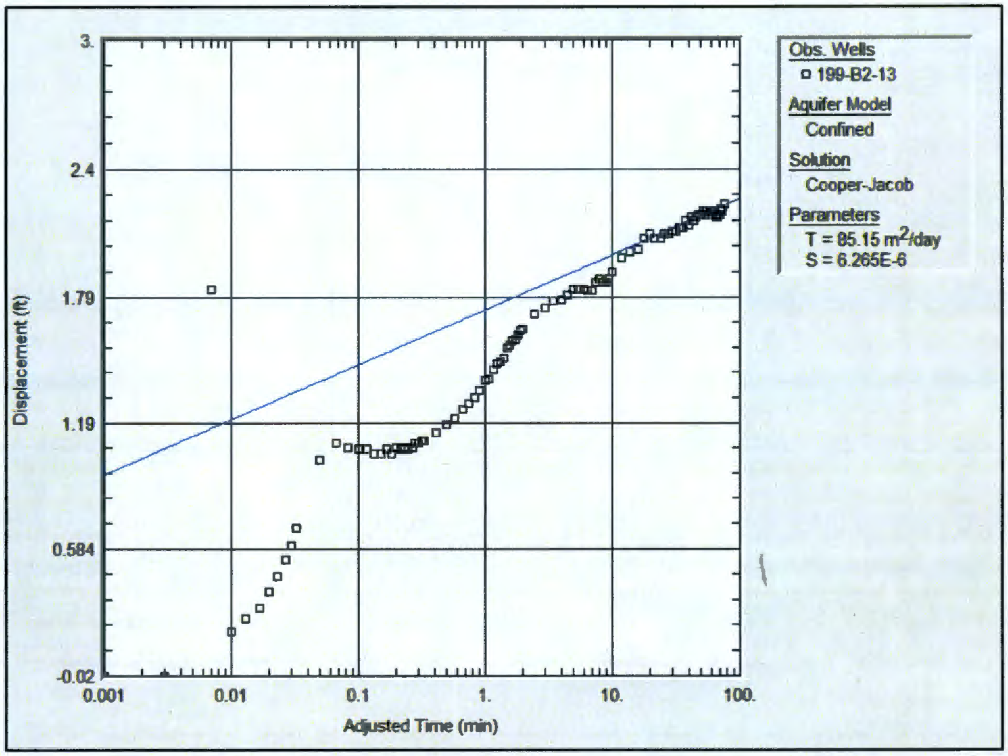


Figure 5-2. Cooper-Jacob Drawdown Analysis at 199-B2-13 (3 of 3)

5.2 Analysis of Well Development Data at Well 199-B3-46

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *A4552_WD_199-B3-46_1992-06-03.xls*.

5.2.1 Summary of available data

Three well development data sets are included in the Excel file. The well was initially developed on May 26, 1992. The well was pumped at 14.86 gpm for 291 minutes, followed by recovery. The well was pumped at 15.15 gpm for 90 minutes on June 2, 1992. On June 3, 1992, the well was pumped at 9.26 gpm for 157 minutes. The May 26 event was chosen for analysis because the other two events exhibited irregular responses during pumping and recovery. The changes in the water level with time for the May 26 event are shown in Figure 5-3.

5.2.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-4, aquifer transmissivity is estimated to be 310 m^2/d. The late-time recovery data are consistent with the response of an ideal aquifer. Drawdown data were not analyzed because the water levels dropped below the transducer during the test.

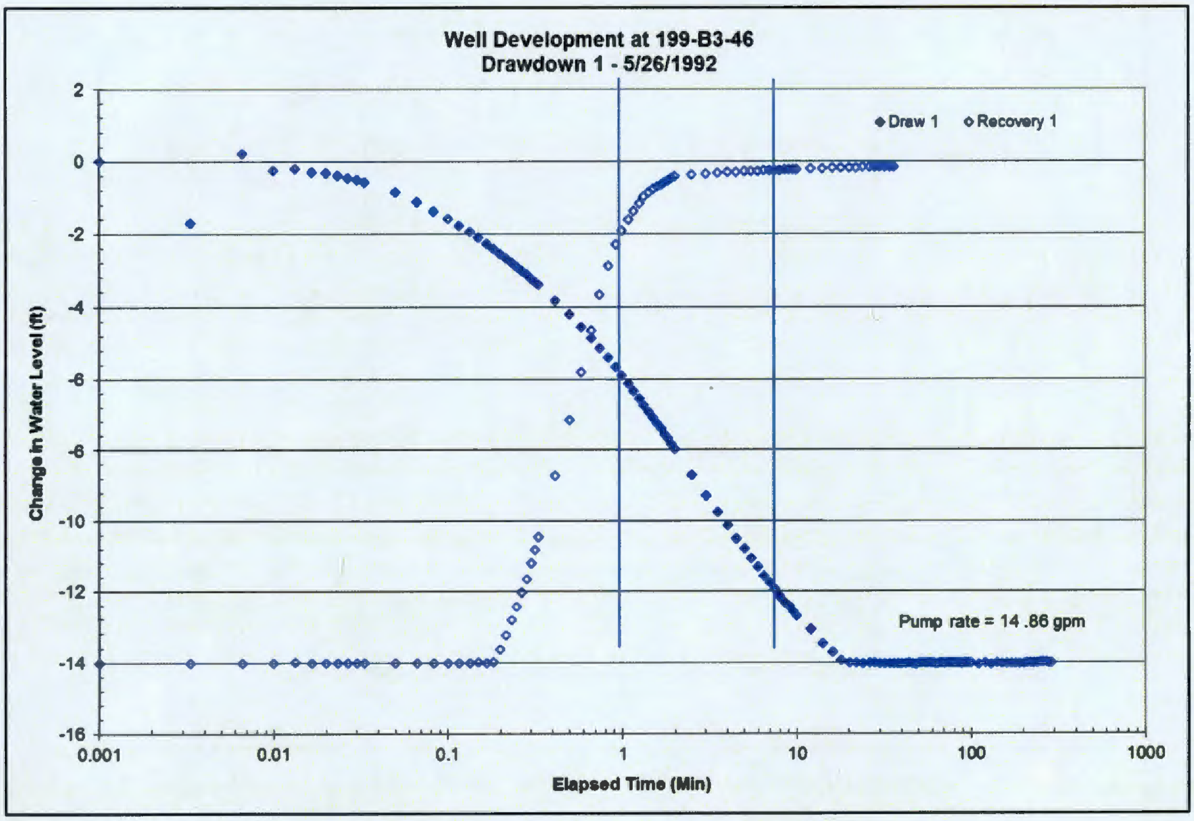


Figure 5-3. Drawdown and Recovery Data at 199-B3-46

5.3 Analysis of Well Development Data at Well 199-D2-10

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C7089_WD_199-D2-10_2001-01-25.xls*.

5.3.1 Summary of available data

The well was developed on January 25, 2001. The well was initially pumped at 22 gpm. Two minutes into the test, the pumping rate was reduced to 15 gpm. Pumping continued for another 65 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-5.

5.3.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-6, aquifer transmissivity is estimated to be 300 m^2/d. The late-time recovery data are consistent with the response of an ideal aquifer. Drawdown data were not analyzed because the pumping history was complicated.

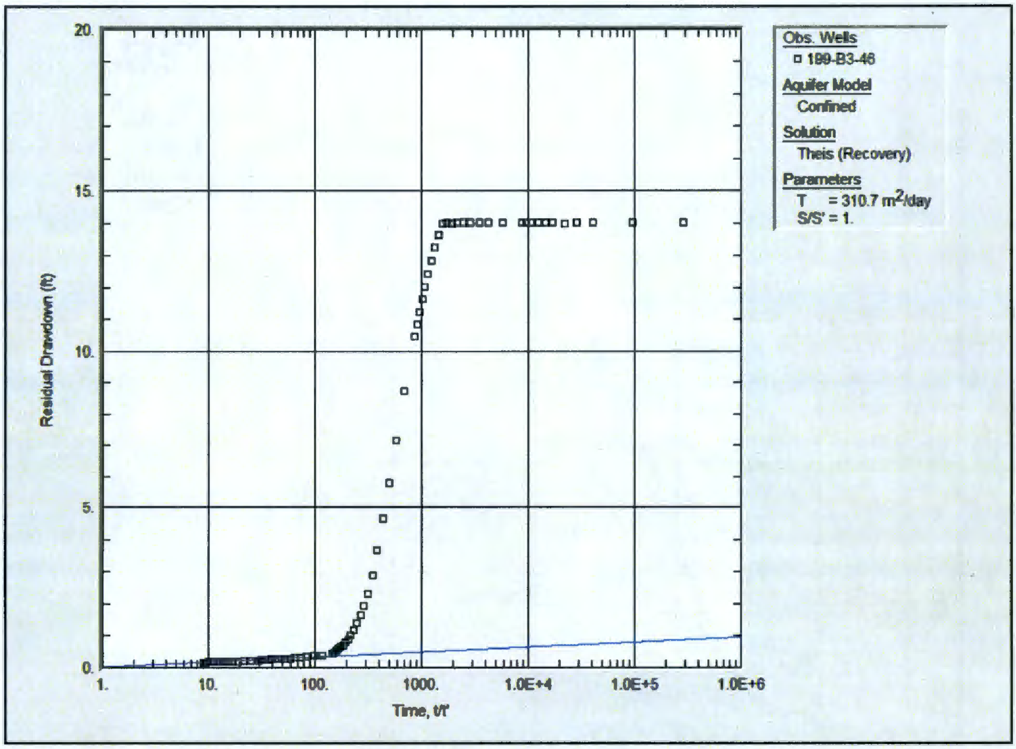


Figure 5-4. Theis Recovery Analysis at 199-B3-46

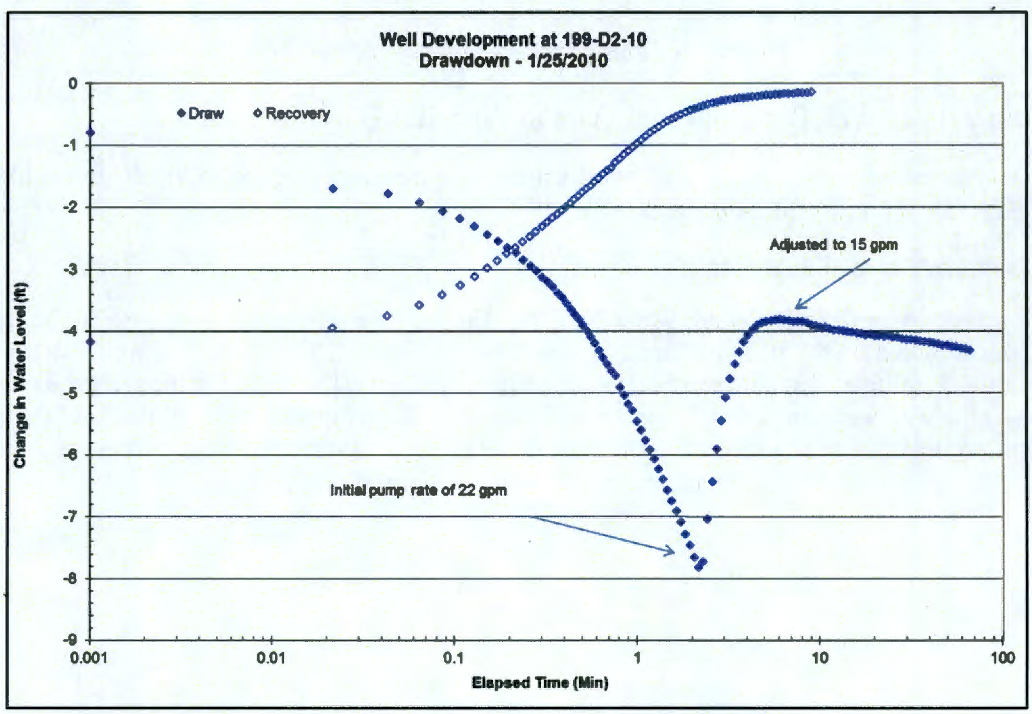


Figure 5-5. Drawdown and Recovery Data at 199-D2-10

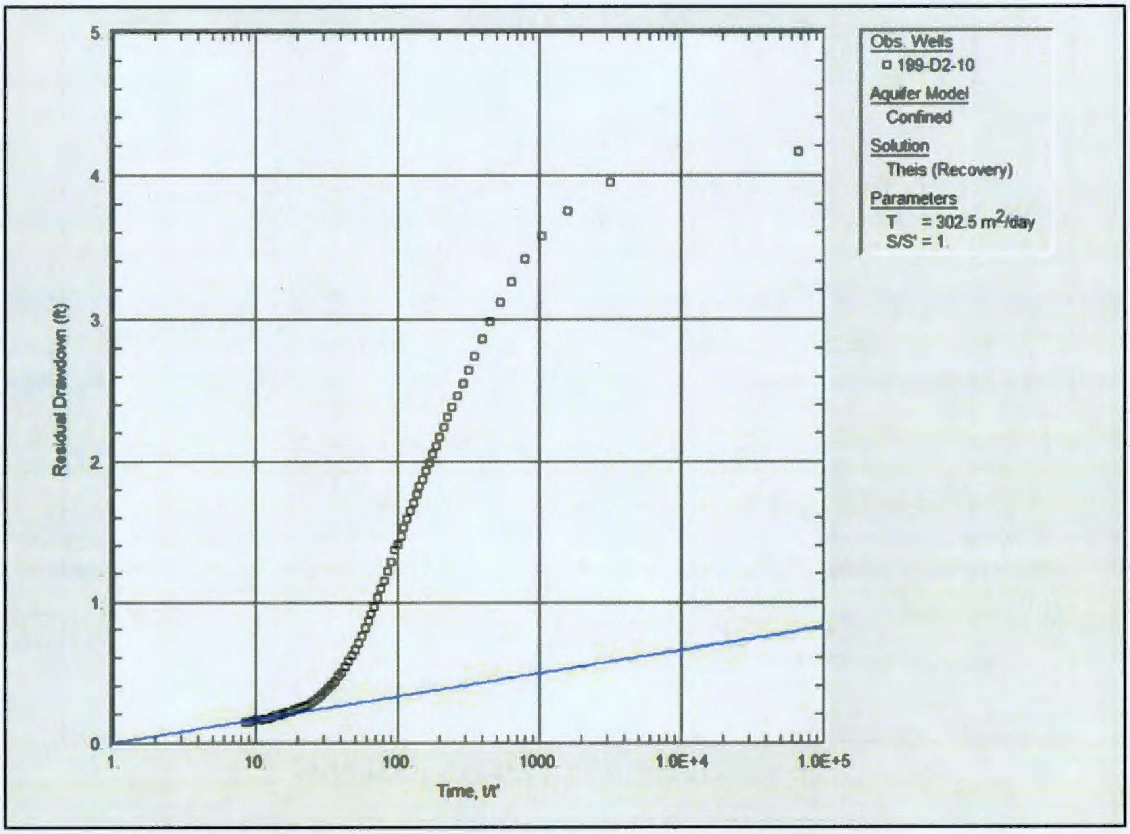


Figure 5-6. Theis Recovery Analysis at 199-D2-10

5.4 Analysis of Well Development Data at Well 199-D3-4

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C3314_WD_199-D3-4_2002-02-20.xls*.

5.4.1 Summary of available data

The well was developed on February 19 and 20, 2002. The well was rawhided[†] at 15 gpm for 30 minutes with the pump intake at 98.5 ft. Then the pump intake was moved to 109.5 ft, and the well was rawhided at 31 gpm for 98 minutes. No data were collected on the first day (2/19/2002). On the second day (2/20/2002) the well was pumped at 31 gpm for 42 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-7.

† *"Rawhiding consists of pumping a well until the discharge is relatively sand free. The pump is then stopped allowing the water in the column pipe to drop down into the well where it backsurges the formation to break any sand bridges in the formation that were stable under the unidirectional flow of water"*
Source: http://info.ngwa.org/GWOL/pdf/701901648.pdf

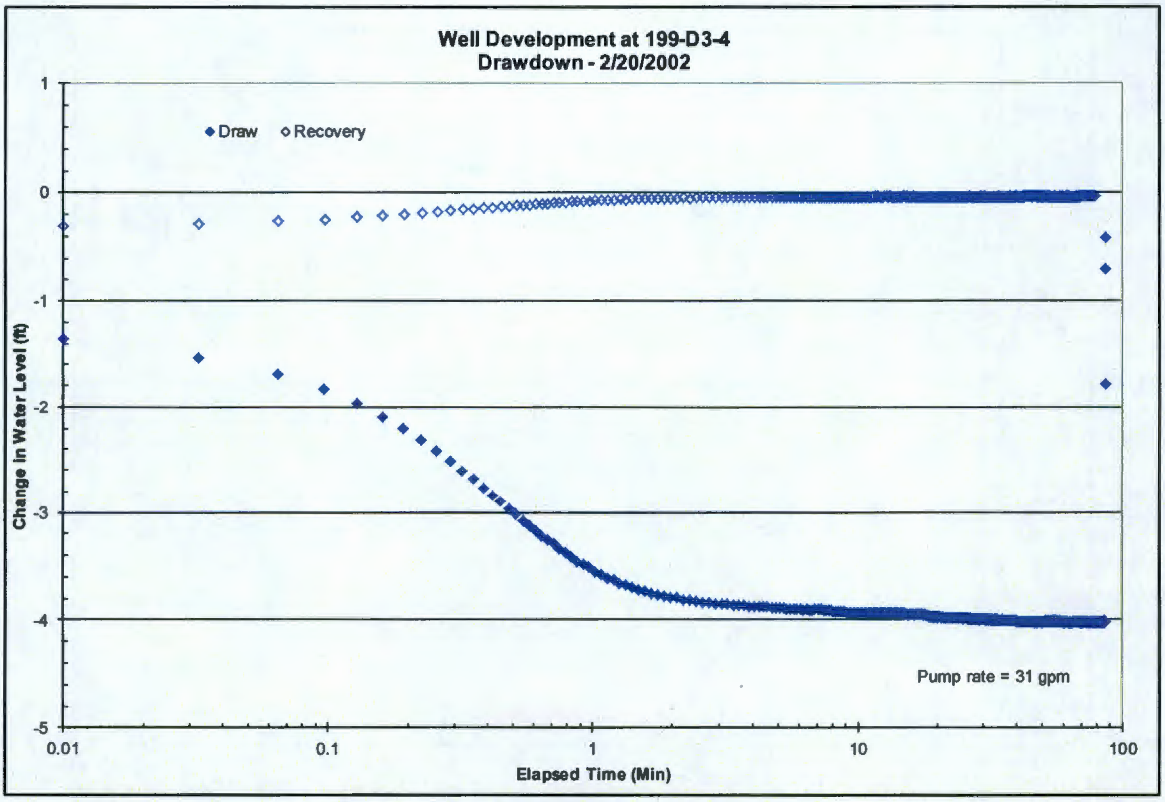


Figure 5-7. Drawdown and Recovery Data at 199-D3-4

5.4.2 Analysis

A transmissivity estimate of 630 m^2/d is obtained from Cooper-Jacob analysis of the drawdown data. A plot of the Cooper-Jacob analysis for the drawdown test is shown in Figure 5-8. The derivative of the drawdown with respect to time, $\partial s/\partial \ln(t)$, is shown at the bottom. The Cooper-Jacob straight line analysis is conducted over the period where the derivative flattens, confirming that the Cooper-Jacob straight line is fit to the portion of the drawdown responses caused only by the aquifer. The unrealistically small storage coefficient (*S*) is caused by wellbore storage effects lasting for several minutes. From Section 2.2, the estimate of the storage coefficient *S* is known to be directly proportional to t_0 (time extrapolated to zero drawdown). The Cooper-Jacob straight line from Figure 5-8 is extrapolated to a very small value for t_0, yielding a very small storage coefficient. Since the well recovered faster than expected, the recovery data were not analyzed.

5.5 Analysis of Well Development Data at Well 199-D4-14

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *B8072_WD_199-D4-14_1997-08-27.xls.*

5.5.1 Summary of Available Data

The well was developed on August 27, 1997. The well was initially pumped at 26 gpm for about 31 minutes. The pumping rate was then increased to 35 gpm and pumped for 26 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-9.

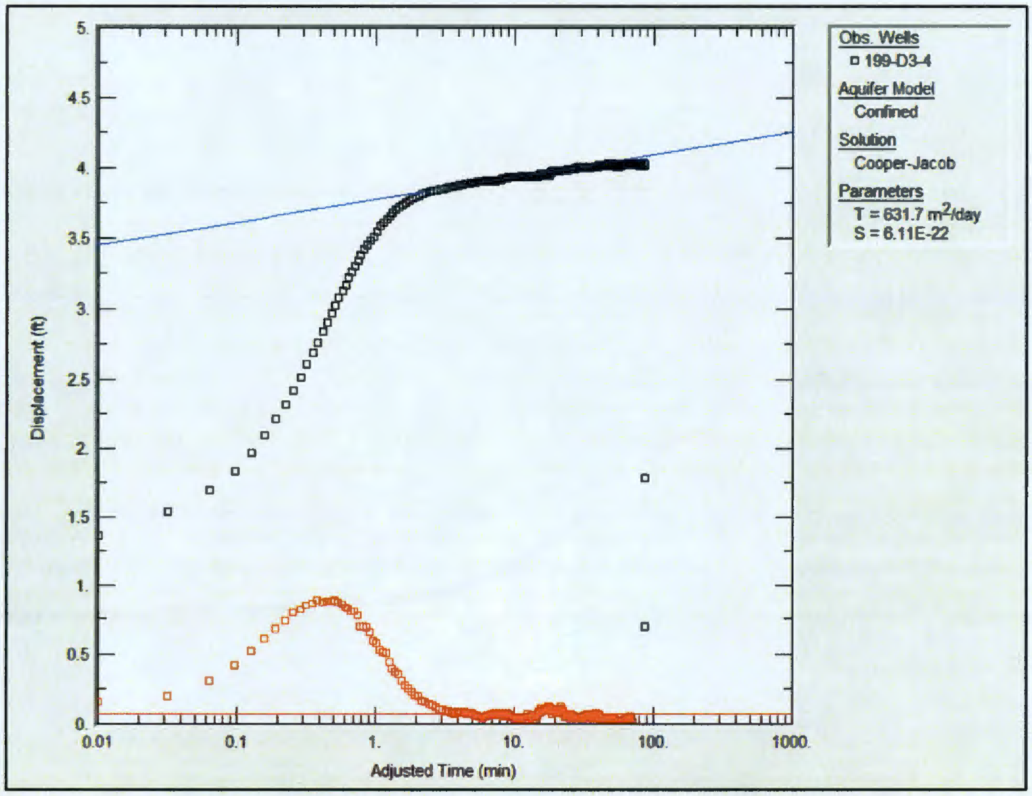


Figure 5-8. Cooper-Jacob Drawdown Analysis at 199-D3-4

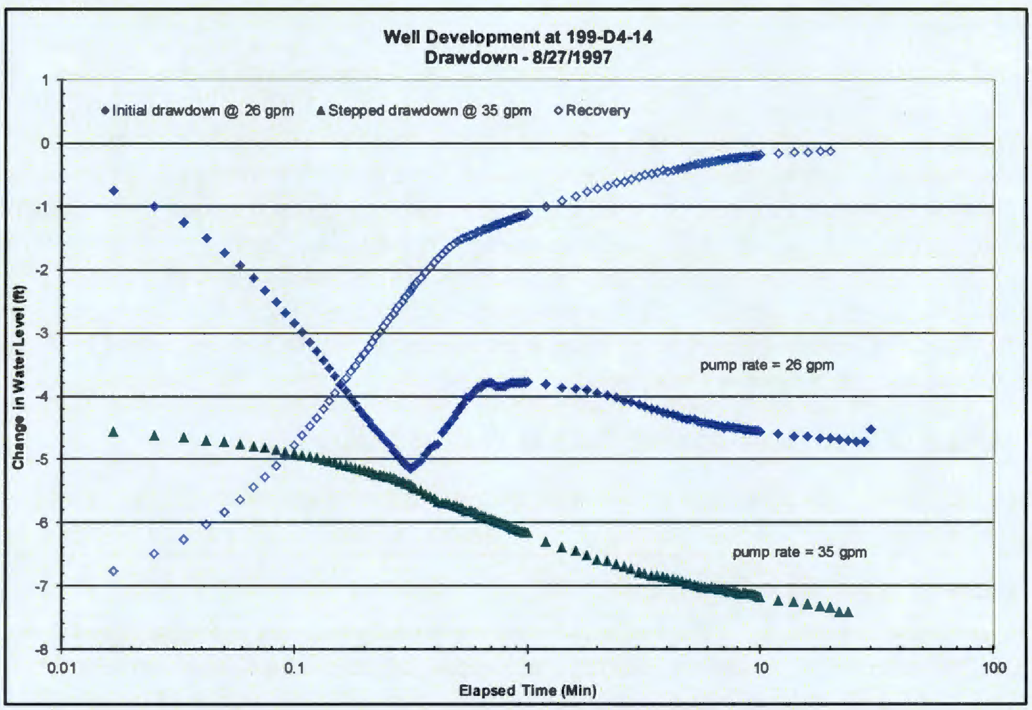


Figure 5-9. Drawdown and Recovery Data at 199-D4-14

5.5.2 Analysis

A best estimate of transmissivity (110 m^2/d) is obtained from the match of the Theis solution to the drawdown data shown in Figure 5-10. Analysis of the recovery data yielded a value that was 6 times the estimate from the drawdown data and was not considered reliable for the 100-D Area.

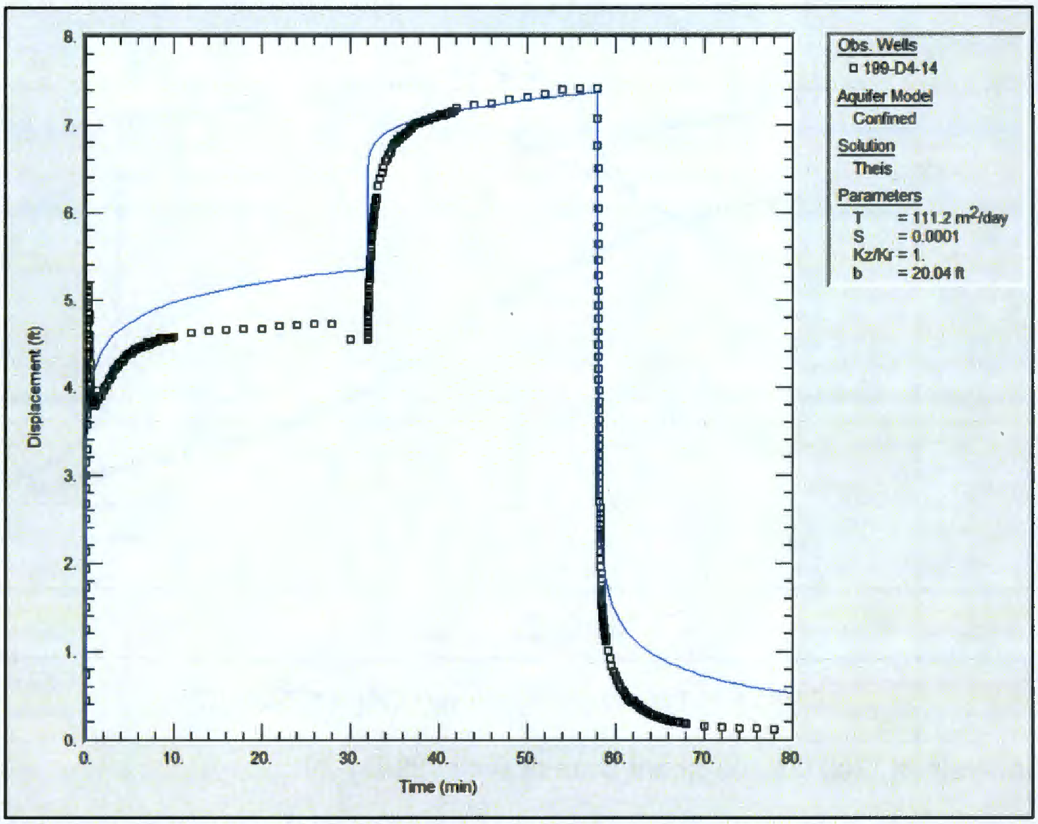


Figure 5-10. Theis Drawdown Analysis at 199-D4-14

5.6 Analysis of Well Development Data at Well 199-D4-15

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *B8073_WD_199-D4-15_1997-08-27.xls*.

5.6.1 Summary of Available Data

The well was developed on August 27, 1997. The well was initially pumped at 25 gpm for about 23 minutes. The pumping rate was increased to 60 for an additional 52 minutes. The pump was then stopped, and the water level in the well was allowed to recover. Water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-11.

5.6.2 Analysis

Aquifer transmissivity is estimated to be 1,200 m^2/d, based on analysis of the recovery data with the Theis recovery method. The Theis recovery analysis is shown in Figure 5-12. Consistent estimates of transmissivity are also obtained from a match of the Theis solution to the drawdown data and a Cooper-Jacob analysis.

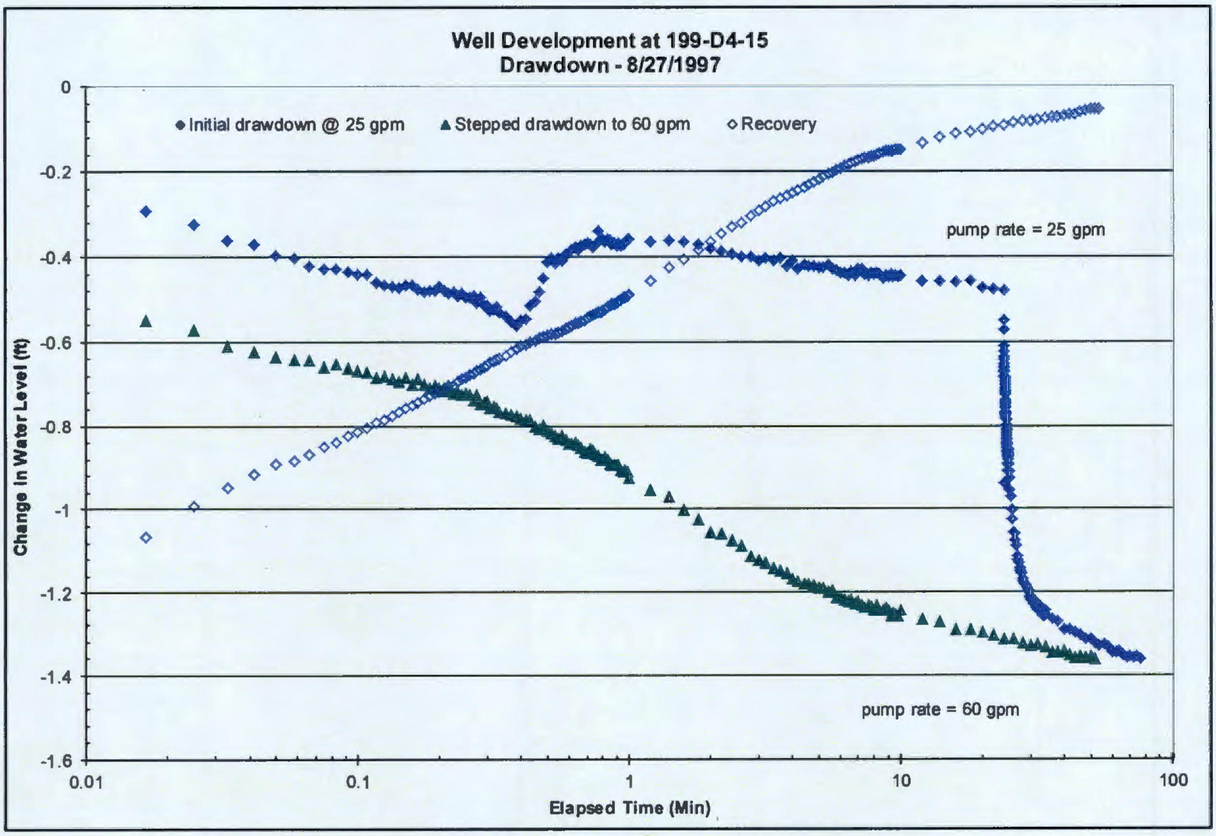


Figure 5-11. Drawdown and Recovery Data at 199-D4-15

5.7 Analysis of Well Development Data at Well 199-D4-29

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *B8980_WD-199-D4-29_2000-04-17.xls*.

5.7.1 Summary of Available Data

The well was developed on April 17, 2000. The well was initially pumped at 22 gpm for about 4 minutes, then the pumping rate was reduced to 15 gpm and run for 3 minutes, and then to 13 gpm for 37 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-13.

5.7.2 Analysis

Aquifer transmissivity is estimated to be 30 m^2/d, based on analysis of the recovery data with the Theis recovery. The Theis recovery fit is shown in Figure 5-14. Consistent estimates of transmissivity are also obtained from a match of the Theis solution to the drawdown data and a Cooper-Jacob analysis. The well is observed to recover more rapidly than expected for an ideal aquifer, suggesting that an additional source of water is replenishing the drawdown cone.

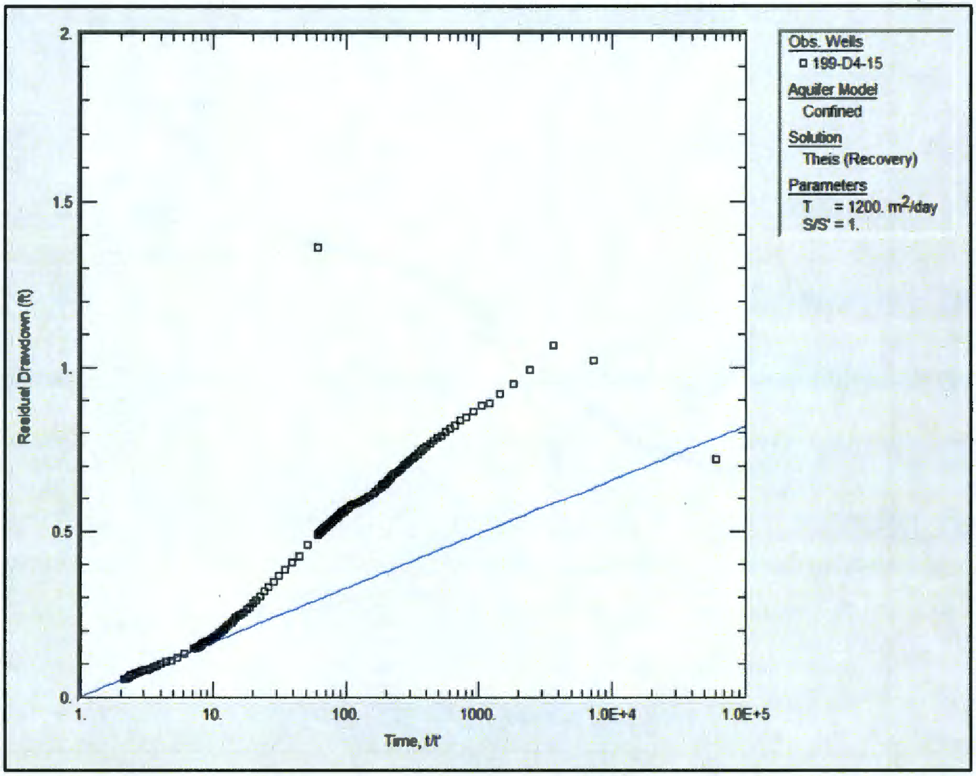


Figure 5-12. Theis Recovery Analysis at 199-D4-15 (1 of 3)

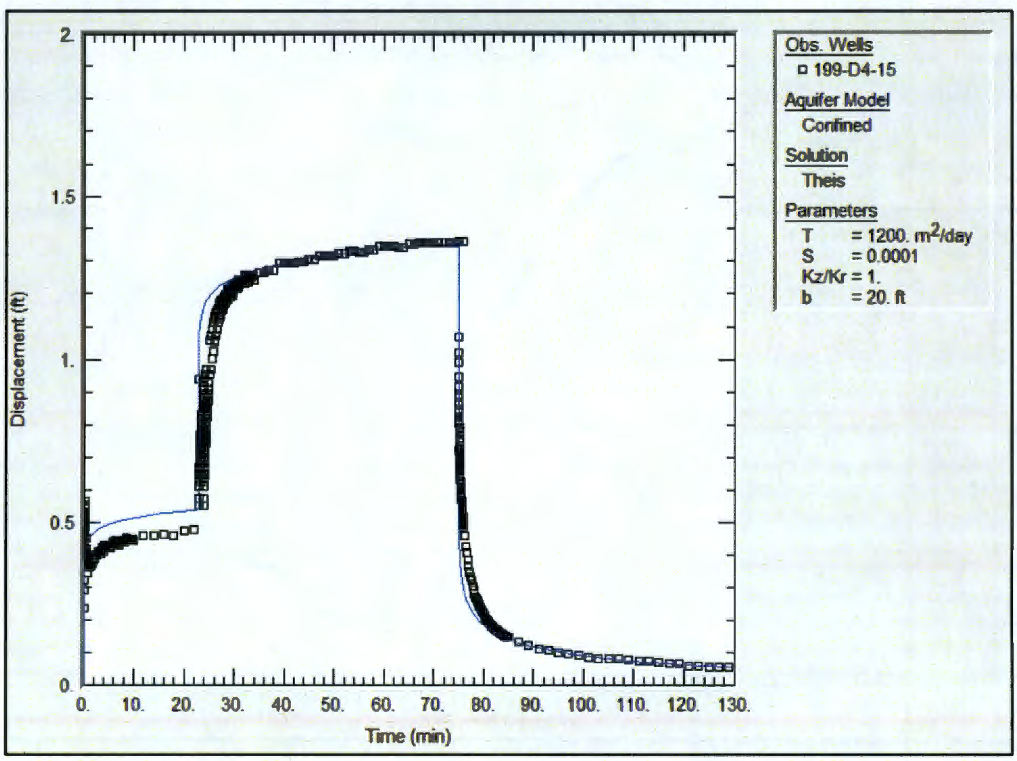


Figure 5-12. Theis Drawdown Analysis at 199-D4-15 (2 of 3)

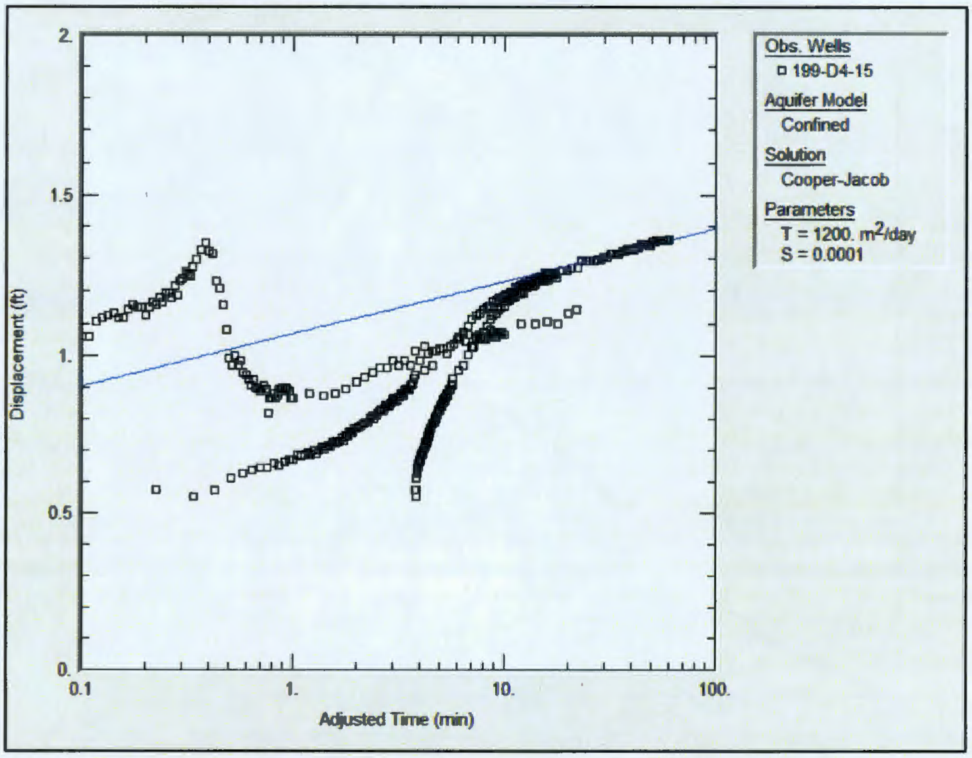


Figure 5-12. Cooper-Jacob Drawdown Analysis at 199-D4-15 (3 of 3)

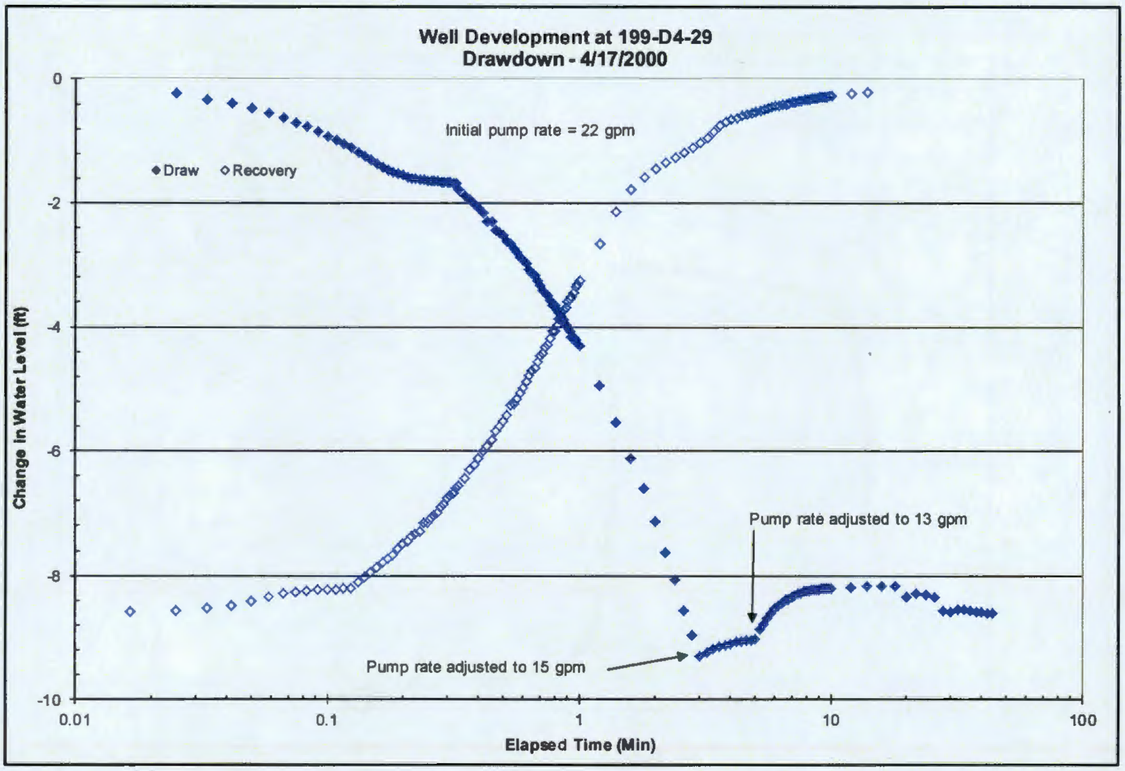


Figure 5-13. Drawdown and Recovery Data at 199-D4-29

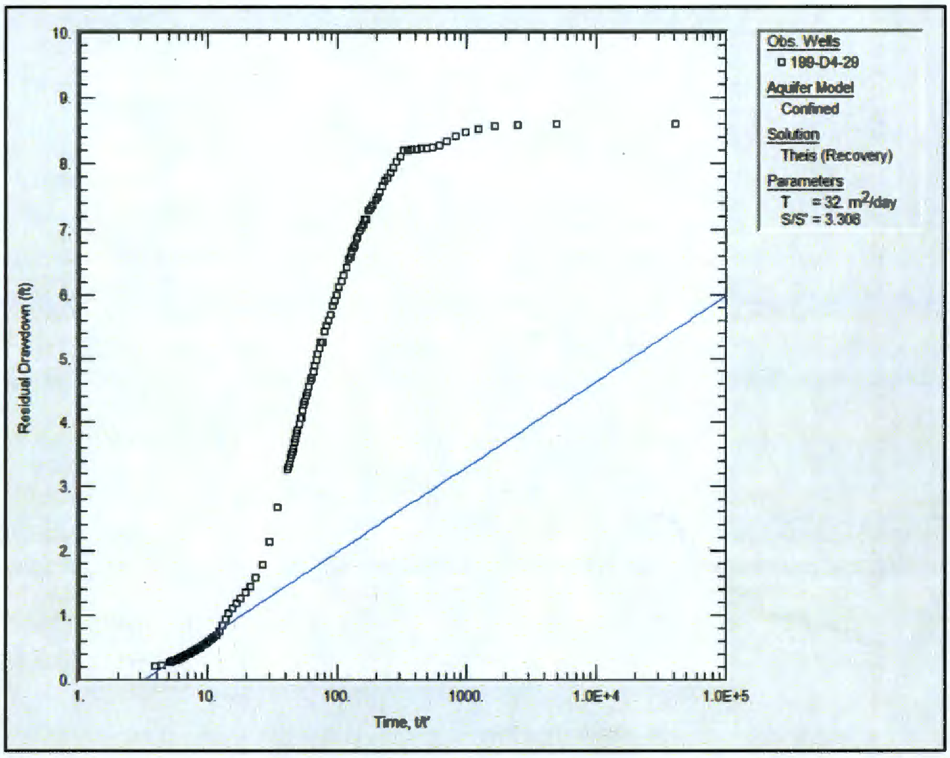


Figure 5-14. Theis Recovery Analysis at 199-D4-29 (1 of 3)

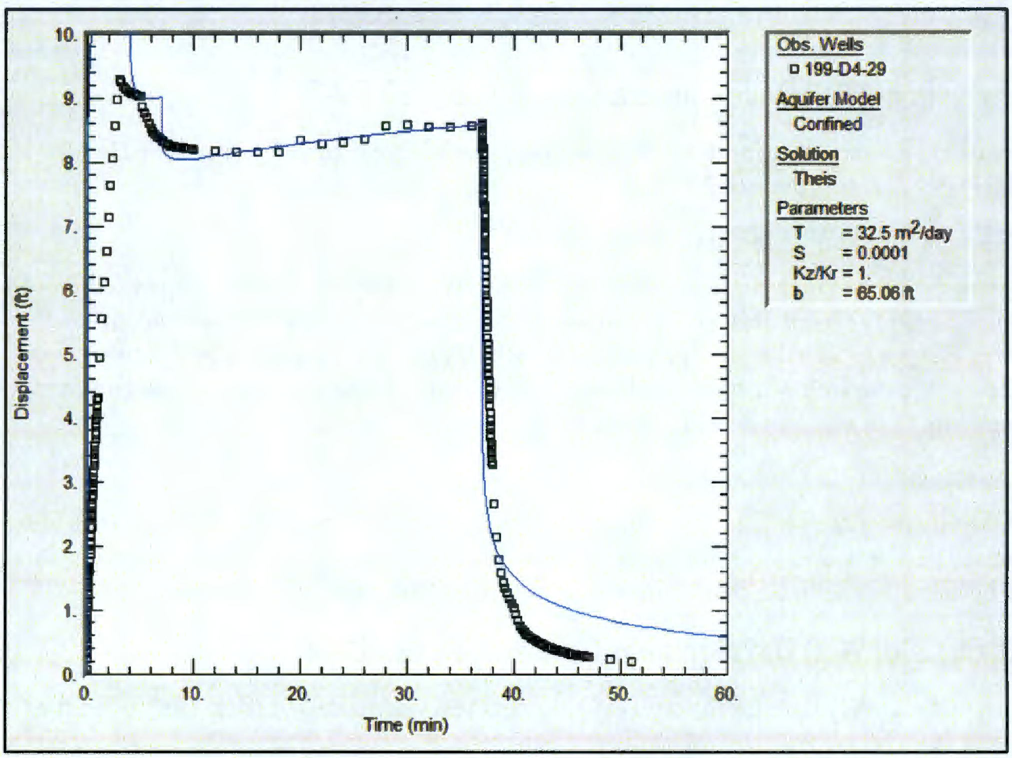


Figure 5-14. Theis Drawdown Analysis at 199-D4-29 (2 of 3)

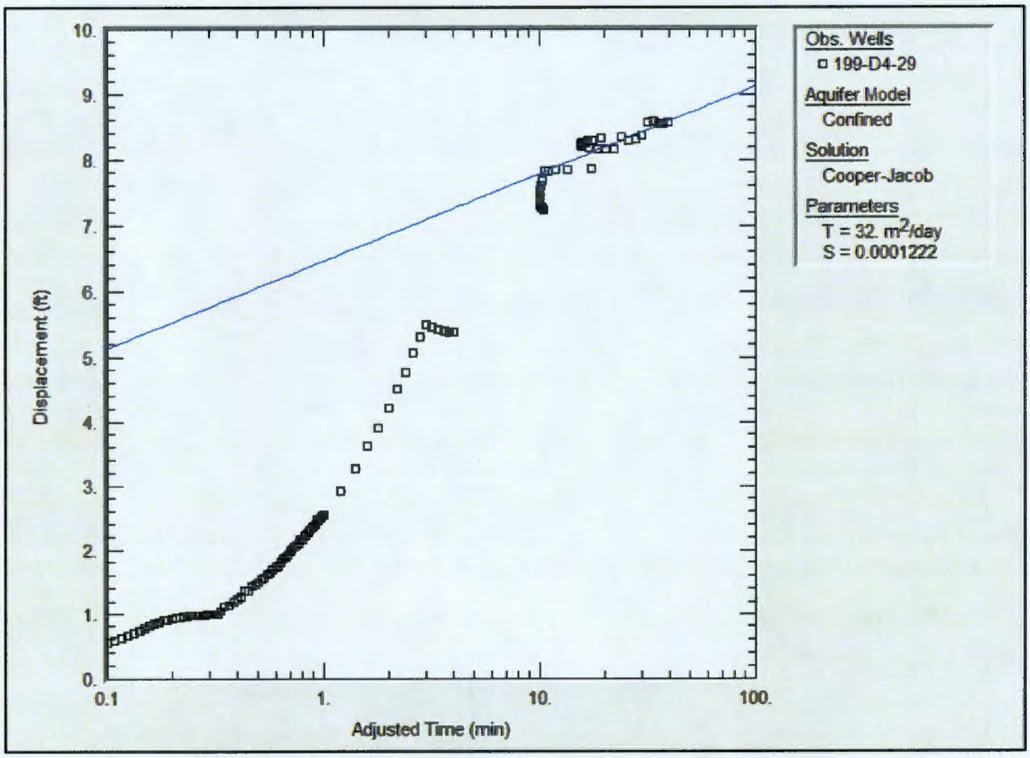


Figure 5-14. Cooper-Jacob Drawdown Analysis at 199-D4-29 (3 of 3)

5.8 Analysis of Well Development Data at Well 199-D4-39

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *B8990_WD_199-D4-39_2000-03-29.xls*.

5.8.1 Summary of available data

The well was developed on March 29, 2000. The well was initially pumped at 16 gpm for about 1 minute, adjusted to 22 gpm for 9 minutes, and then reduced to 20 gpm due to drawdown concerns and run for 19 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-15.

5.8.2 Analysis

A transmissivity estimate of 45 m^2/d is obtained from the match of the Theis solution to the observed drawdowns. The Theis solution fit to the drawdown data is shown in Figure 5-16. Recovery data were not analyzed because they indicate premature recovery arising from riser pipe drainage.

5.9 Analysis of Well Development Data at Well 199-D4-41

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C3271_WD_199-D4-41_2001-03-06.xls*.

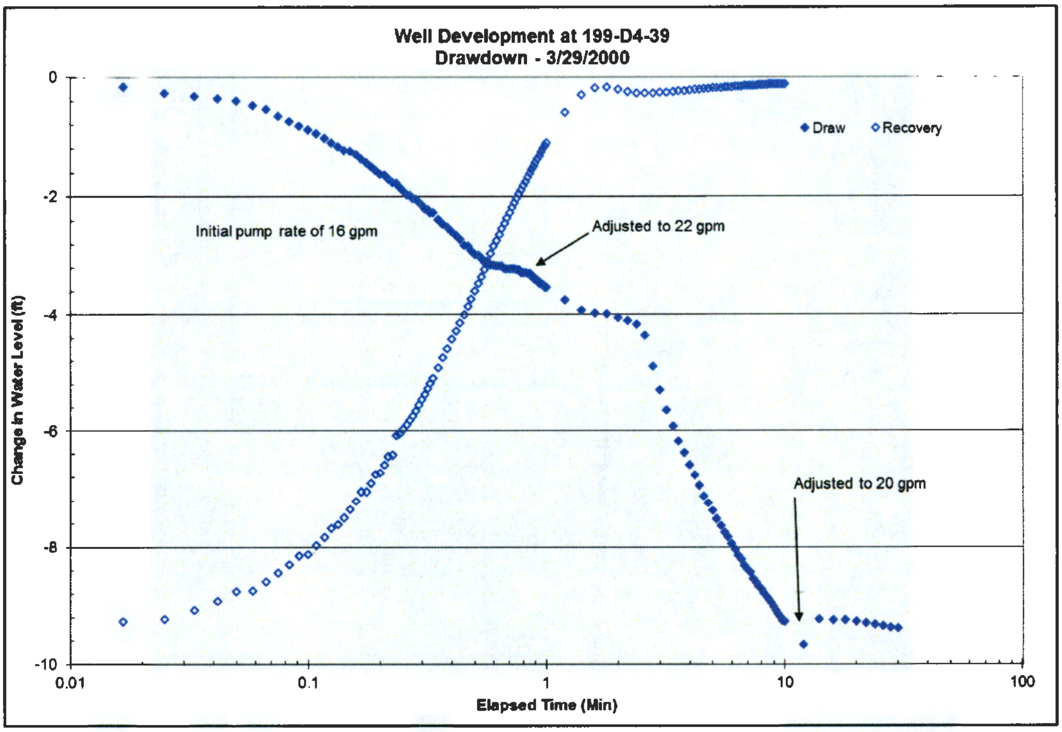


Figure 5-15. Drawdown and Recovery Data at 199-D4-39

5.9.1 Summary of Available Data

The well was developed on March 6, 2001. The well was initially pumped at 35 gpm for about 10 minutes, then reduced to 30 gpm for 51 minutes of pumping. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period. Observation wells D4-40 and D4-42 were also monitored during the event. Changes in the water level with time are shown in Figures 5-17 and 5-18.

5.9.2 Analysis

Consistent transmissivity estimates are obtained with Cooper-Jacob analysis of the drawdown data and the Theis recovery analysis. A transmissivity of 640 m^2/d is estimated as shown in Figure 5-19. The derivative of the drawdown with respect to time, $\partial s/\partial \ln(t)$, is shown at the bottom of Figure 5-19. The Cooper-Jacob analysis is applied over the period where the derivative flattens, confirming that the Cooper-Jacob straight line is fit to the portion of the drawdown responses caused only by the aquifer. The unrealistically small storage coefficient (S) is caused by wellbore storage effects lasting for several minutes.

5.10 Analysis of Well Development Data at Well 199-D4-62

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C3292_WD_199-D4-62_2001-06-26.xls*.

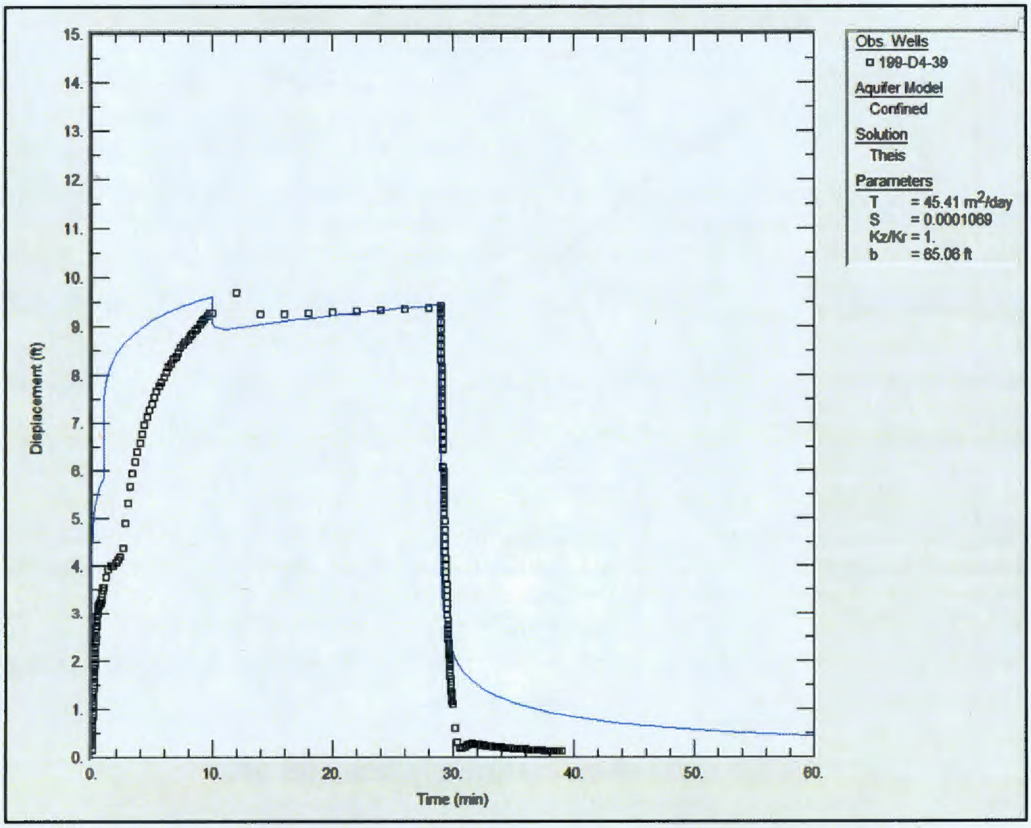


Figure 5-16. Theis Drawdown Analysis at 199-D4-39

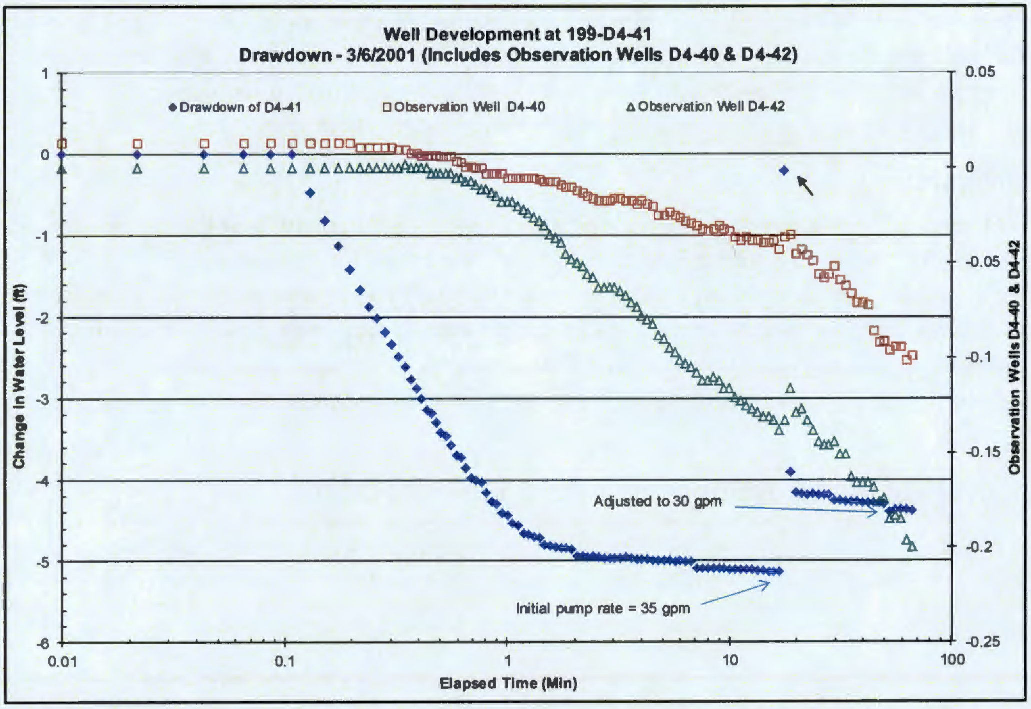


Figure 5-17. Drawdown Data at 199-D4-41 and Two Nearby Observation Wells

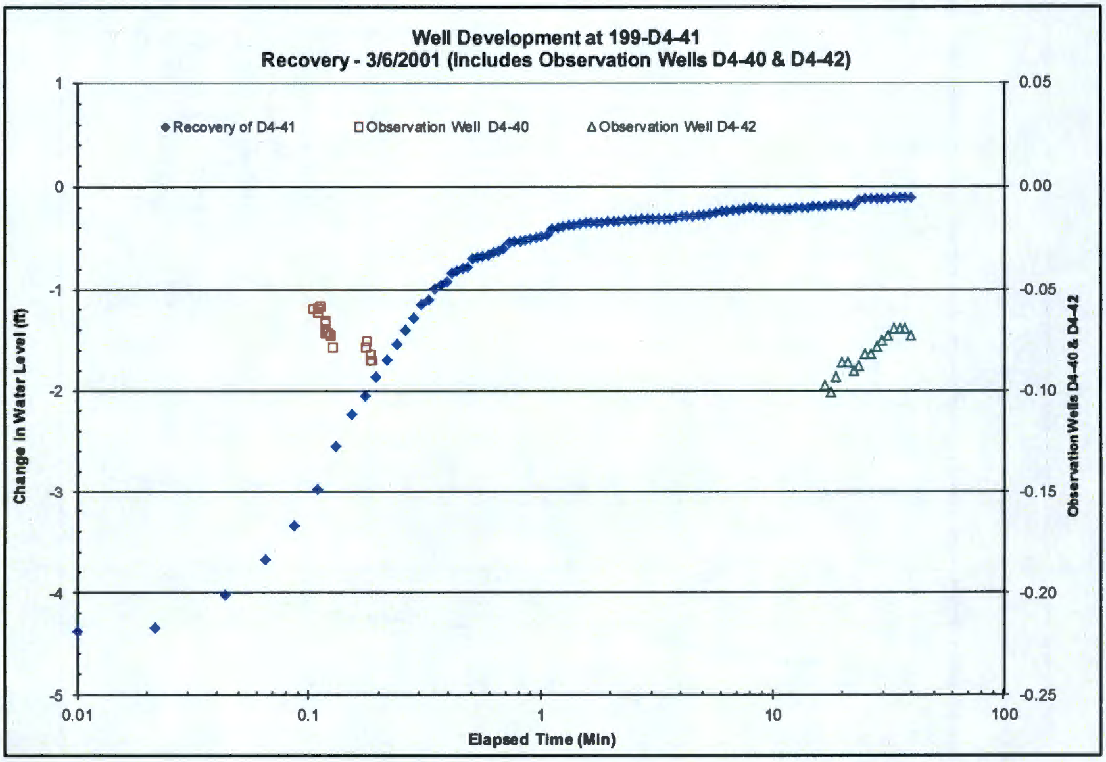


Figure 5-18. Recovery Data at 199-D4-41 and Two Nearby Observation Wells

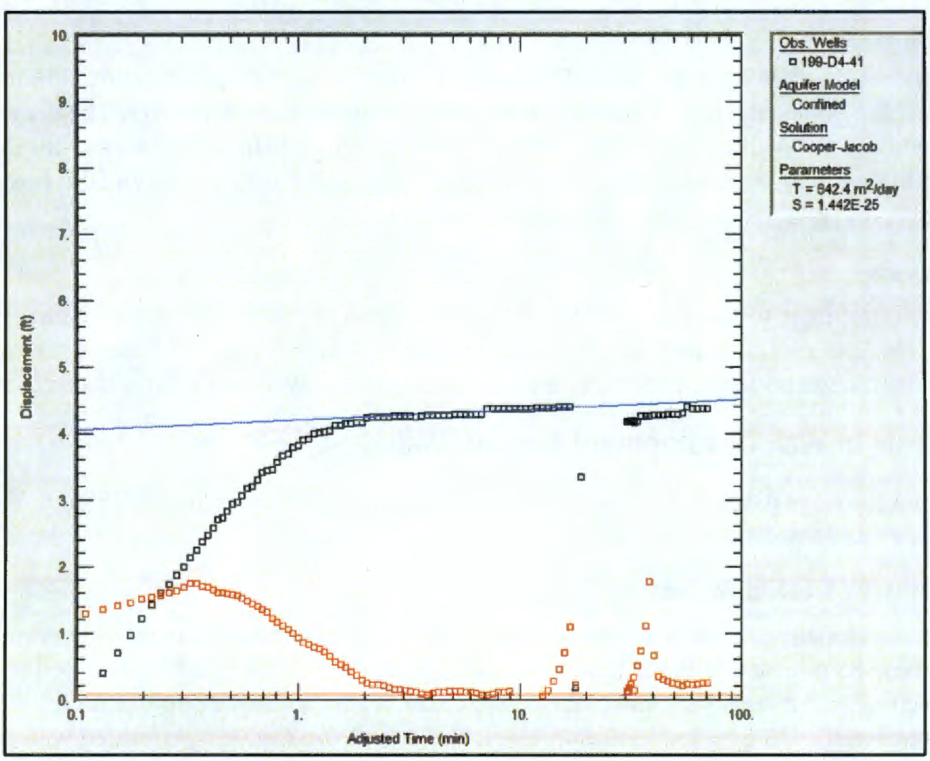


Figure 5-19. Cooper-Jacob Drawdown Analysis at 199-D4-41 (1 of 2)

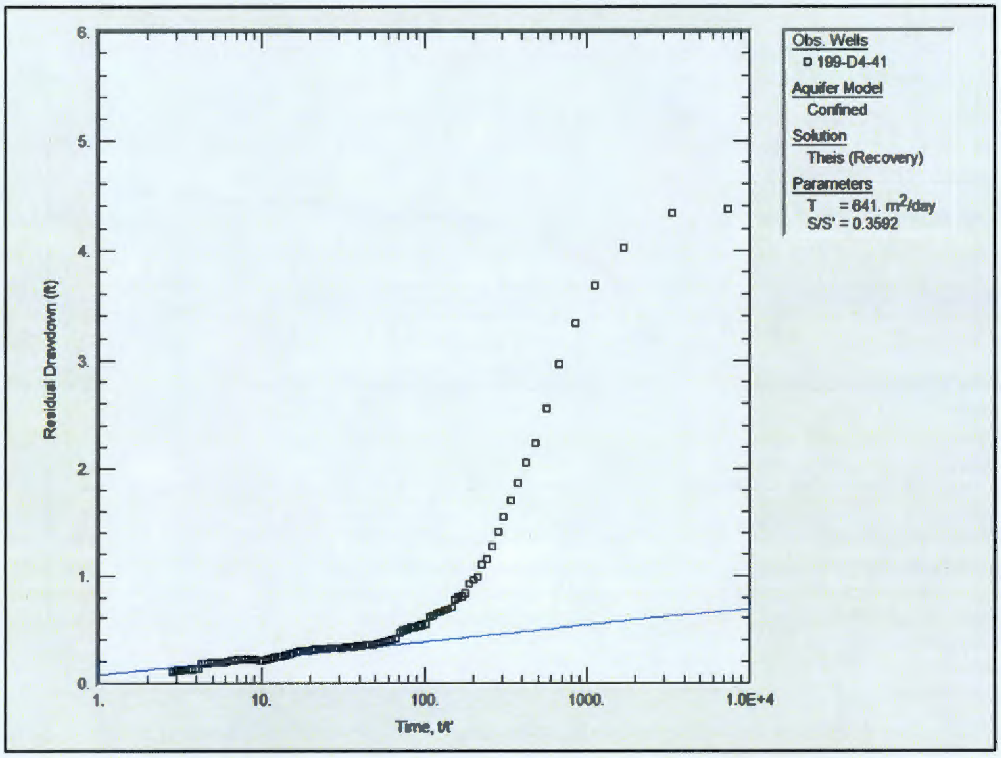


Figure 5-19. Theis Recovery Analysis at 199-D4-41 (2 of 2)

5.10.1 Summary of Available Data

The well was developed on June 26, 2001. The well was pumped at 15.5 gpm for about 116 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-20. A second test was conducted the same day with the pump 10 ft higher, per the field activity report (FAR); however, no data were collected.

5.10.2 Analysis

A transmissivity estimate of 50 m^2/d is obtained from the match of the Theis solution to the observed drawdowns. The Theis solution fit to the drawdown data is shown in Figure 5-21. Since the well recovered faster than expected, the recovery estimated transmissivity of 168 m^2/d was discarded.

5.11 Analysis of Well Development Data at Well 199-D4-68

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C3298_WD_199-D4-68_2002-02-01.xls.*

5.11.1 Summary of Available Data

The well was developed on January 31 and February 1, 2002. On January 31, the well was pumped at 32 gpm for about 88 minutes, with rawhiding beginning after the first 24 minutes. The well was then allowed to recover, but no recovery data were collected. On February 1, the pump was raised 14 ft, and the well was pumped at 32 gpm for 13 minutes. Another drawdown test was performed with pumping at 30 gpm for 126 minutes. The water level in the well was monitored during the three drawdown events and the last recovery; changes in the water level with time are shown in Figures 5-22 and 5-23.

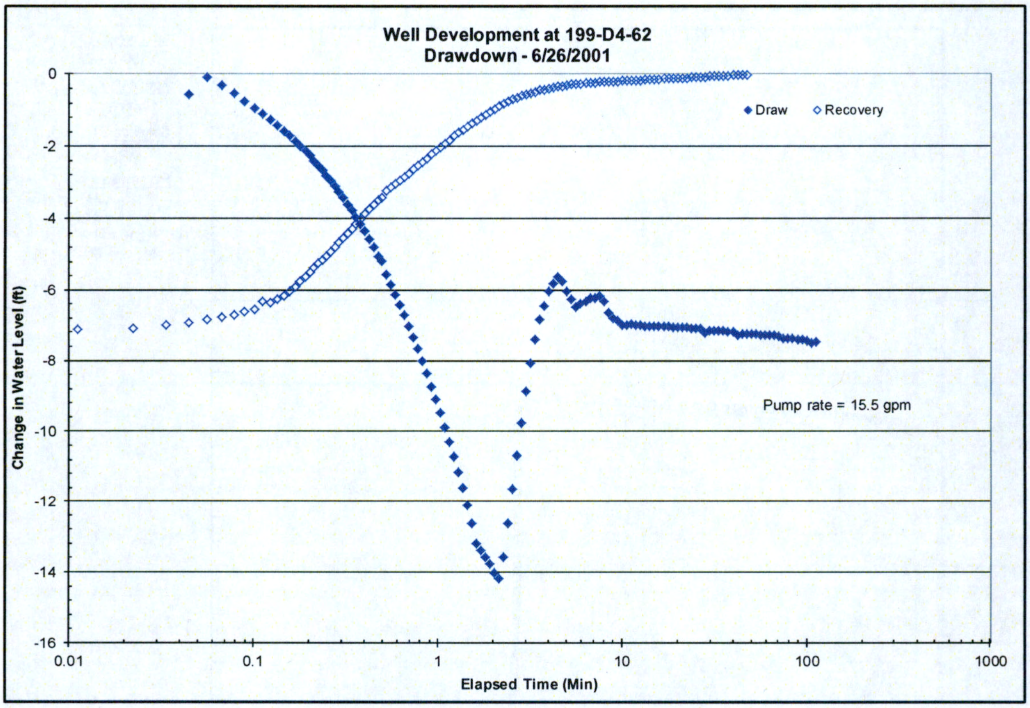


Figure 5-20. Drawdown and Recovery Data at 199-D4-62

5.11.2 Analysis

A transmissivity estimate of 350 m^2/d is obtained from the Cooper-Jacob analysis of the third drawdown interval. A plot of the Cooper-Jacob analysis for the drawdown test is shown in Figure 5-24. The derivative of the drawdown with respect to time, $\partial s/\partial \ln(t)$, is shown at the bottom. The Cooper-Jacob analysis is applied over the period where the derivative flattens, confirming that the Cooper-Jacob straight line is fit to the portion of the drawdown responses caused only by the aquifer. The unrealistically small storage coefficient (S) is caused by wellbore storage effects lasting for several minutes. Since the well recovered faster than expected, the recovery based estimate was not considered.

5.12 Analysis of Well Development Data at Well 199-D4-71

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C3301_WD_199-D4-71_2002-02-26.xls.*

5.12.1 Summary of available data

The well was developed on February 26, 2002. The well was initially pumped at 31 gpm for about 54 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-25.

5.12.2 Analysis

The match of the Theis solution to the drawdown data and a Cooper-Jacob straight-line analysis yields similar transmissivity estimates. A transmissivity estimate of 400 m^2/d is computed from the arithmetic average of the Theis and Cooper-Jacob fits to the drawdown data. The analyses are presented in Figures 5-26 and 5-27. Recovery data are not analyzed because the well recovers to a water level much higher than the initial water level.

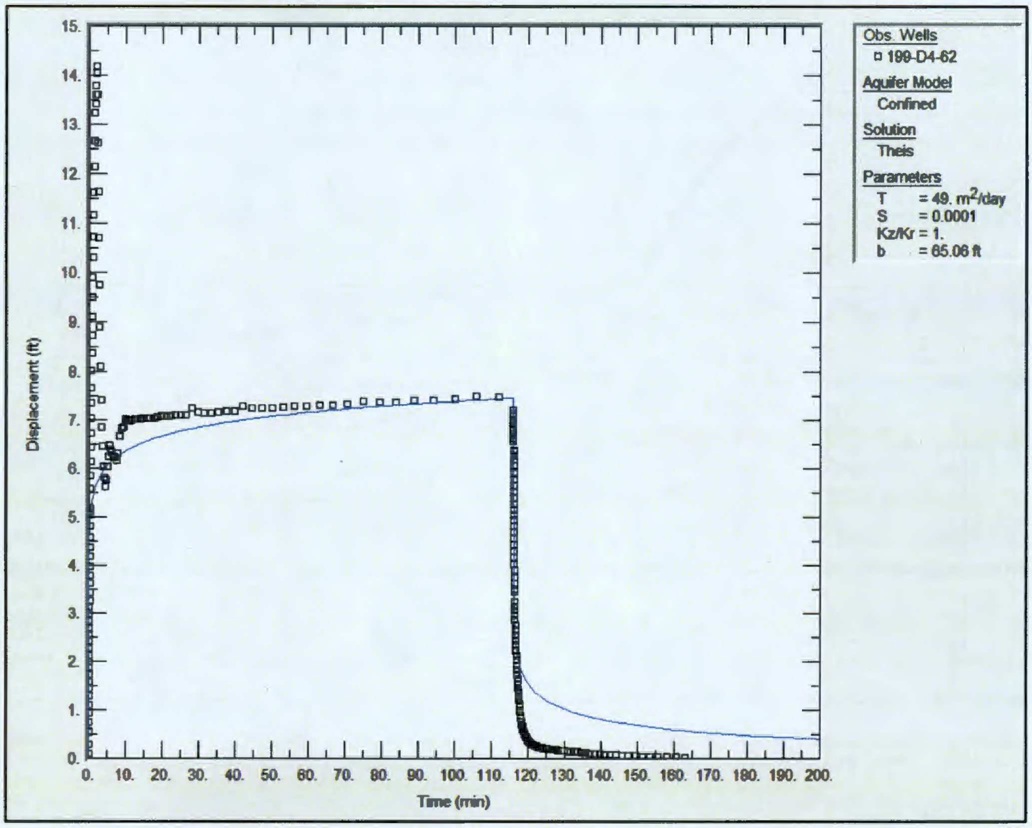


Figure 5-21. Theis Drawdown Analysis at 199-D4-62

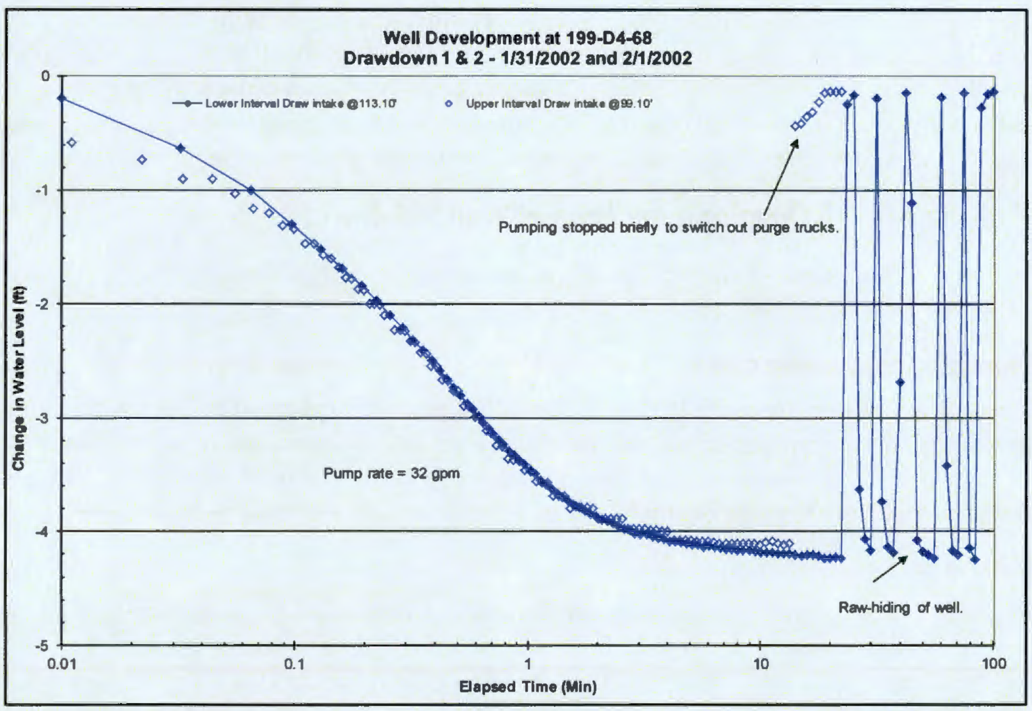


Figure 5-22. Drawdown 1 & 2 Data at 199-D4-68

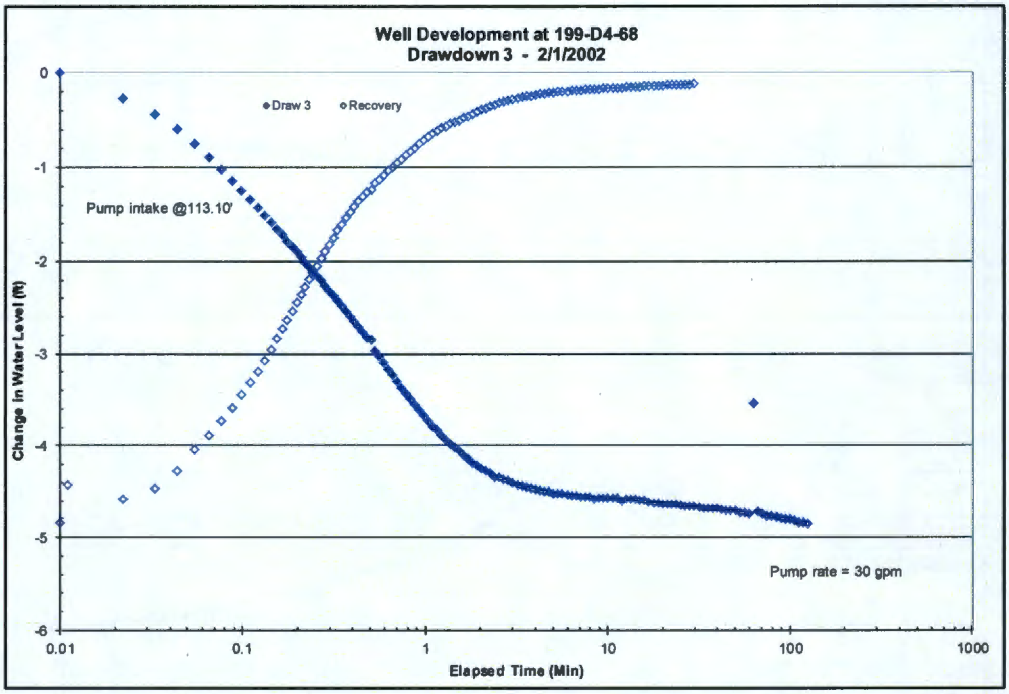


Figure 5-23. Drawdown 3 and Recovery Data at 199-D4-68

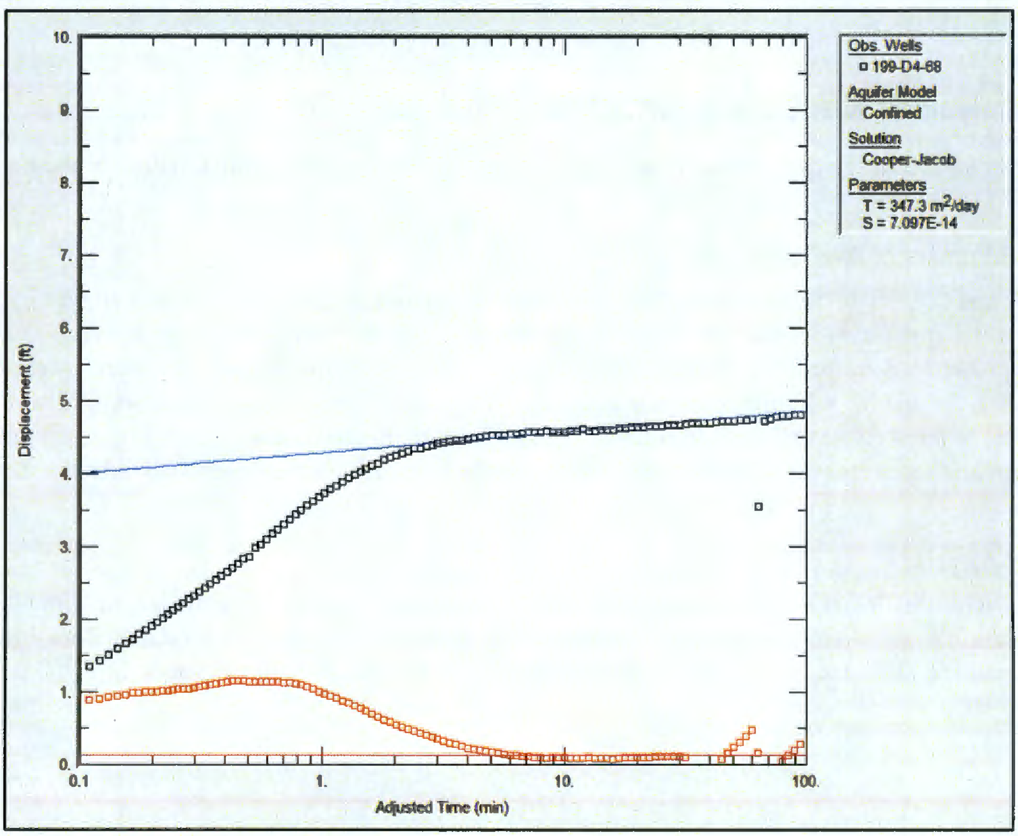


Figure 5-24. Cooper-Jacob Drawdown Analysis at 199-D4-68

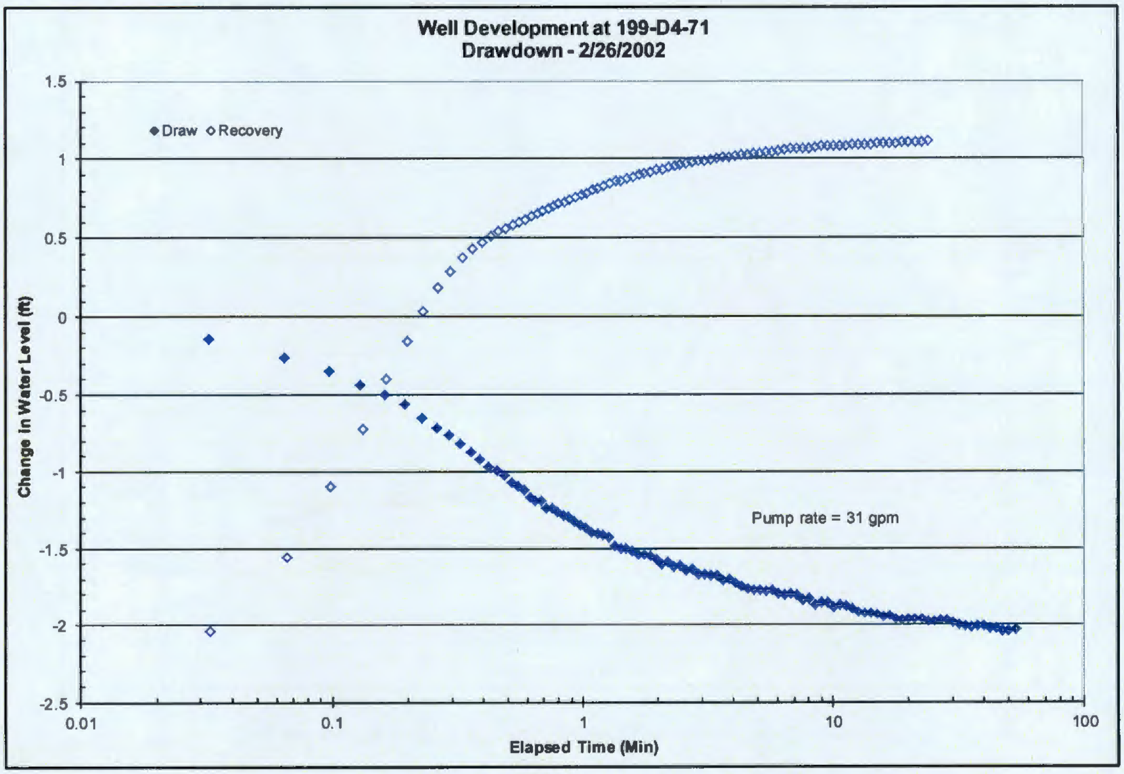


Figure 5-25. Drawdown and Recovery Data at 199-D4-71

5.13 Analysis of Well Development Data at Well 199-D4-81

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C3311_WD_199-D4-81_2002-03-21.xls*.

5.13.1 Summary of Available Data

The well was developed on March 21, 2002 after some pump mechanical issues. The well was initially pumped at 15 gpm for 11 minutes followed by rawhiding. Then the pump intake was lowered to 111.5 ft and pumped at 31 gpm for three 10 minute sessions; each 10 minute interval was followed by rawhiding. Data were collected for a 31 gpm pumping event for 21 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period of the final event, and changes in the water level with time are shown in Figure 5-28.

5.13.2 Analysis

A transmissivity estimate of 2,700 m^2/d is obtained from the match of the drawdown data with the Theis solution as shown in Figure 5-29. Transmissivity estimates from the Cooper-Jacob drawdown analysis and the Theis recovery analysis were much higher. Hence, the lower estimate of 2,700 m^2/d is reported here.

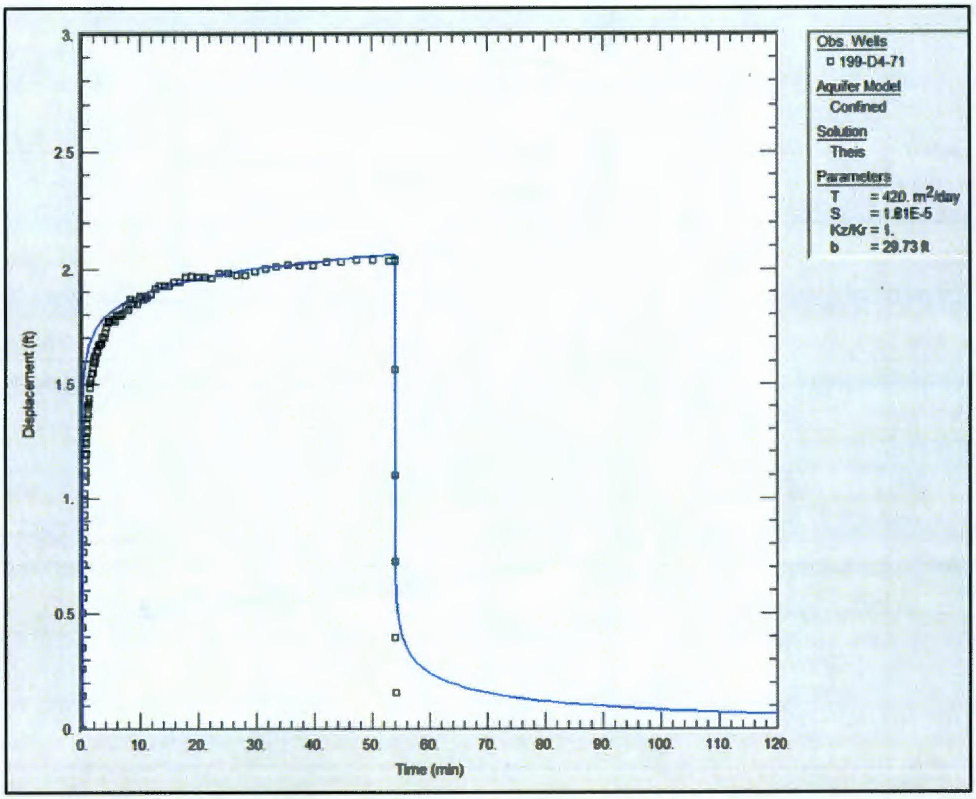


Figure 5-26. Theis Drawdown Analysis at 199-D4-71

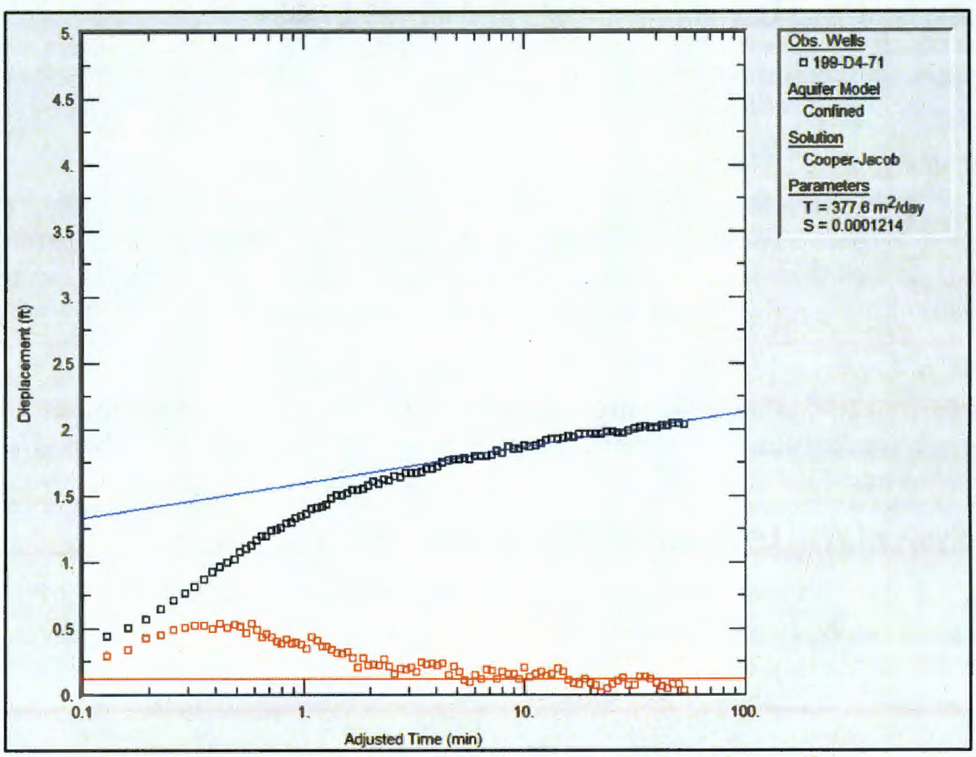


Figure 5-27. Cooper-Jacob Drawdown Analysis at 199-D4-71

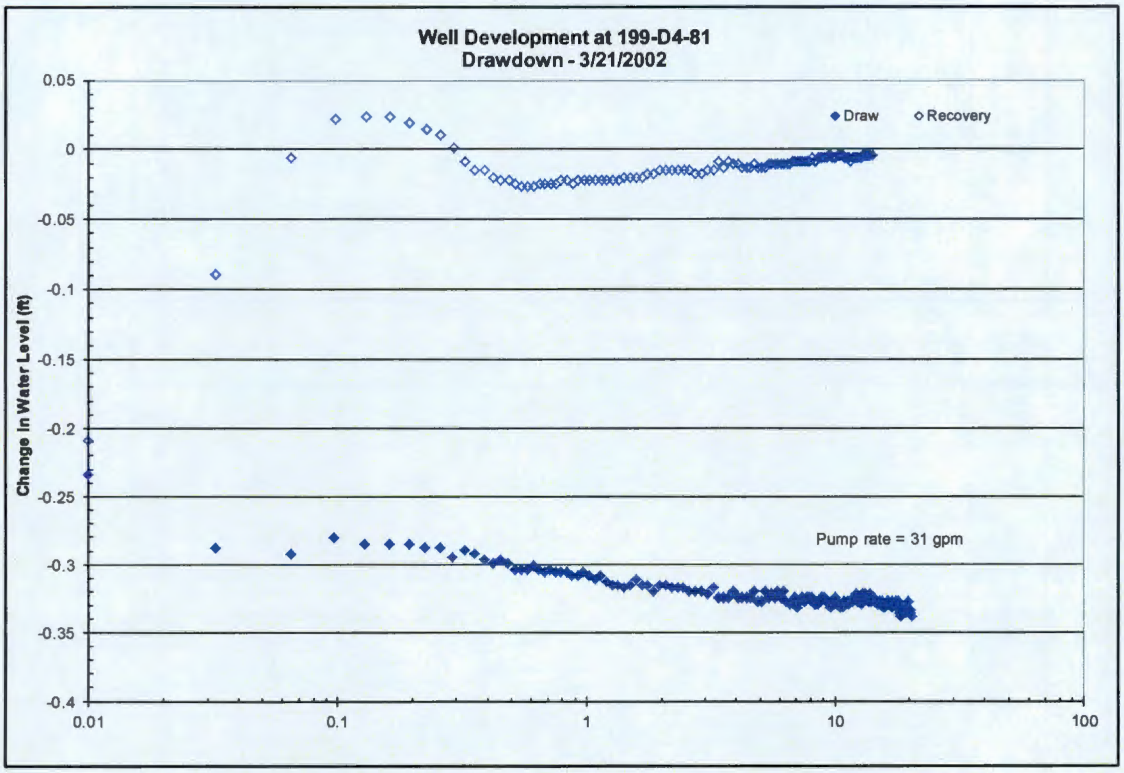


Figure 5-28. Drawdown and Recovery Data at 199-D4-81

5.14 Analysis of Well Development Data at Well 199-D4-83

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C3315_WD_199-D4-83_2001-03-02.xls*.

5.14.1 Summary of available data

The well was developed on March 2, 2001. The well was initially pumped at 30 gpm for about 6 minutes, then reduced to 25 gpm and pumped for an additional 47 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-30.

5.14.2 Analysis

Consistent transmissivity estimates of 410 m^2/d are obtained from the Cooper-Jacob analysis, a match to the drawdowns with the Papadopulos and Cooper solution, and the Theis recovery analysis. The analyses are shown in Figure 5-31.

5.15 Analysis of Well Development Data at Well 199-D4-99

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C7087_WD_199-D4-99_2009-11-23.xls*.

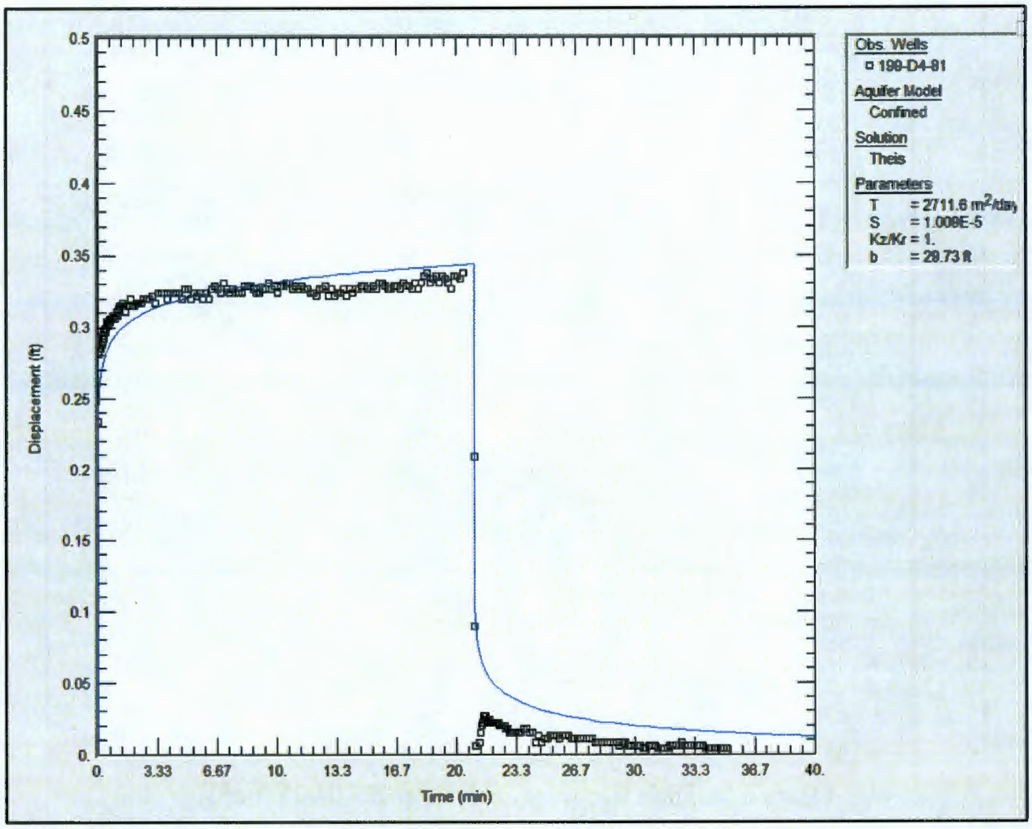


Figure 5-29. Theis Drawdown Analysis at 199-D4-81

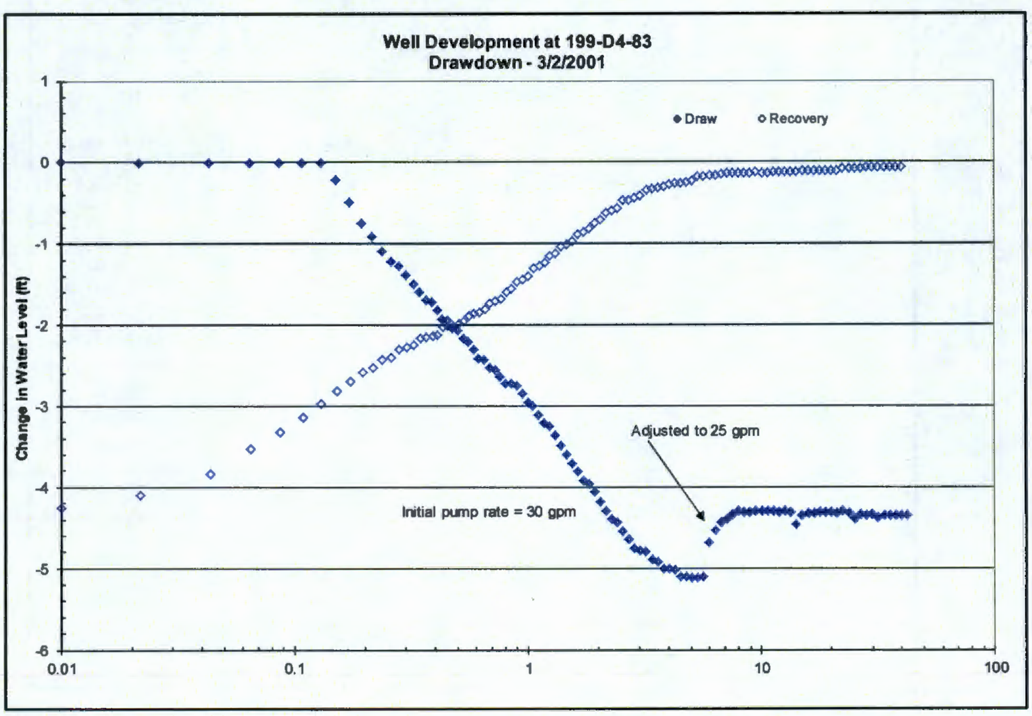


Figure 5-30. Drawdown and Recovery Data at 199-D4-83

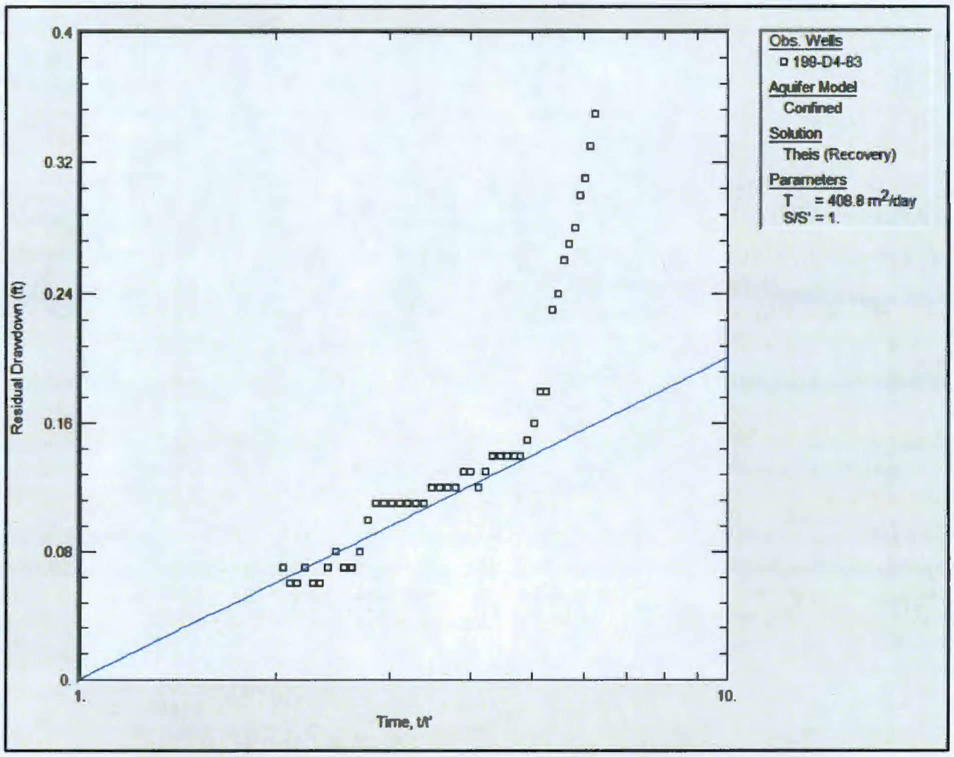


Figure 5-31. Theis Recovery Analysis at 199-D4-83 (1 of 3)

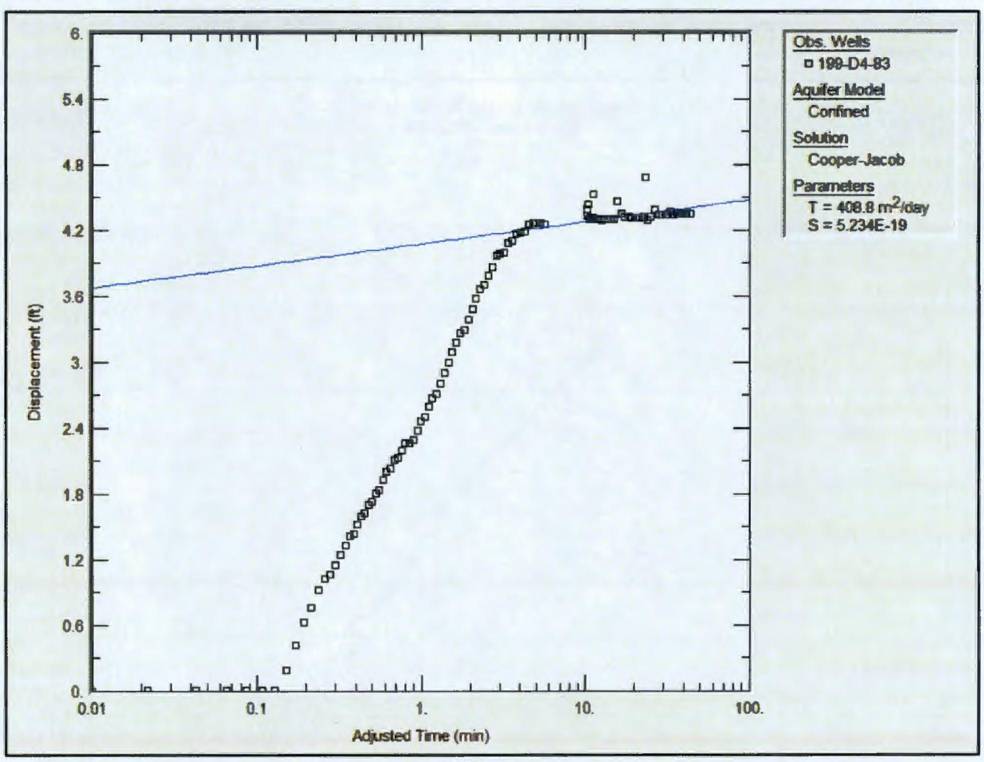


Figure 5-31. Cooper-Jacob Drawdown Analysis at 199-D4-83 (2 of 3)

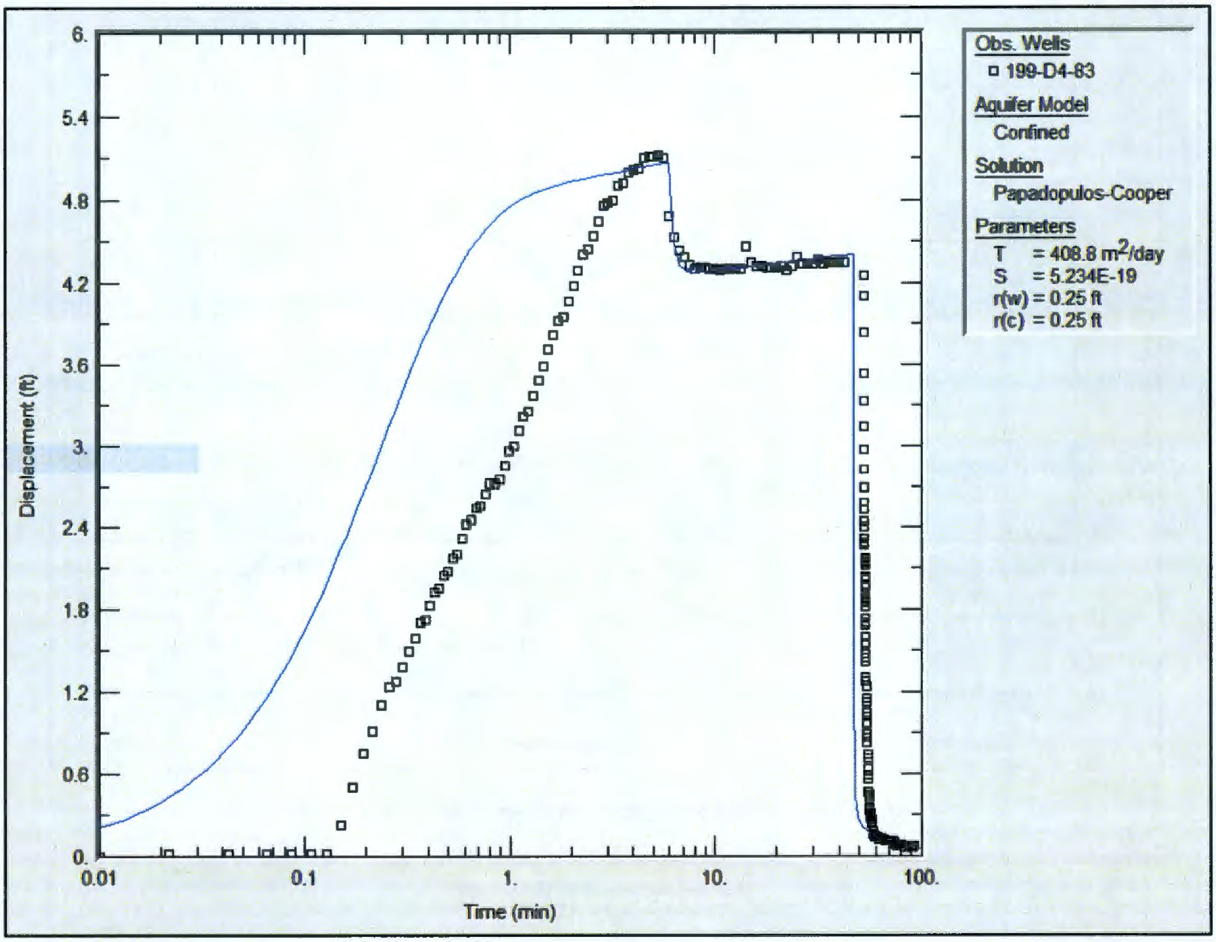


Figure 5-31. Papadopulos-Cooper Drawdown Analysis at 199-D4-83 (3 of 3)

5.15.1 Summary of Available Data

The well was developed on November 23, 2009. The well was initially pumped at 45 gpm for 31 minutes before being reduced to 39 gpm for 20 minutes and then raised to 43.3 gpm. After 13 minutes at that rate, pumping stopped for 2 minutes to switch out the pump truck. Pumping resumed at 43.3 gpm for 13 minutes then was reduced to 41.8 gpm and run for 40 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-32. Another drawdown and recovery test was performed and recorded at 23 gpm for 36 minutes. The drawdown and recovery data for this event are shown in Figure 5-33.

5.15.2 Analysis

Consistent transmissivity estimates are obtained from the Cooper-Jacob analyses of both drawdown intervals. The estimated transmissivity of 100 m^2/d from the Cooper-Jacob analysis of the second drawdown interval is believed to be most representative, and the fit is shown in Figure 5-34. The derivative of the drawdown with respect to time, $\partial s/\partial \ln(t)$, is shown at the bottom. The Cooper-Jacob analysis is conducted over the period where the derivative flattens, confirming that the Cooper-Jacob straight line is fit to the portion of the drawdown responses caused only by the aquifer. Since the well recovered faster than expected, the recovery-based estimate was not considered.

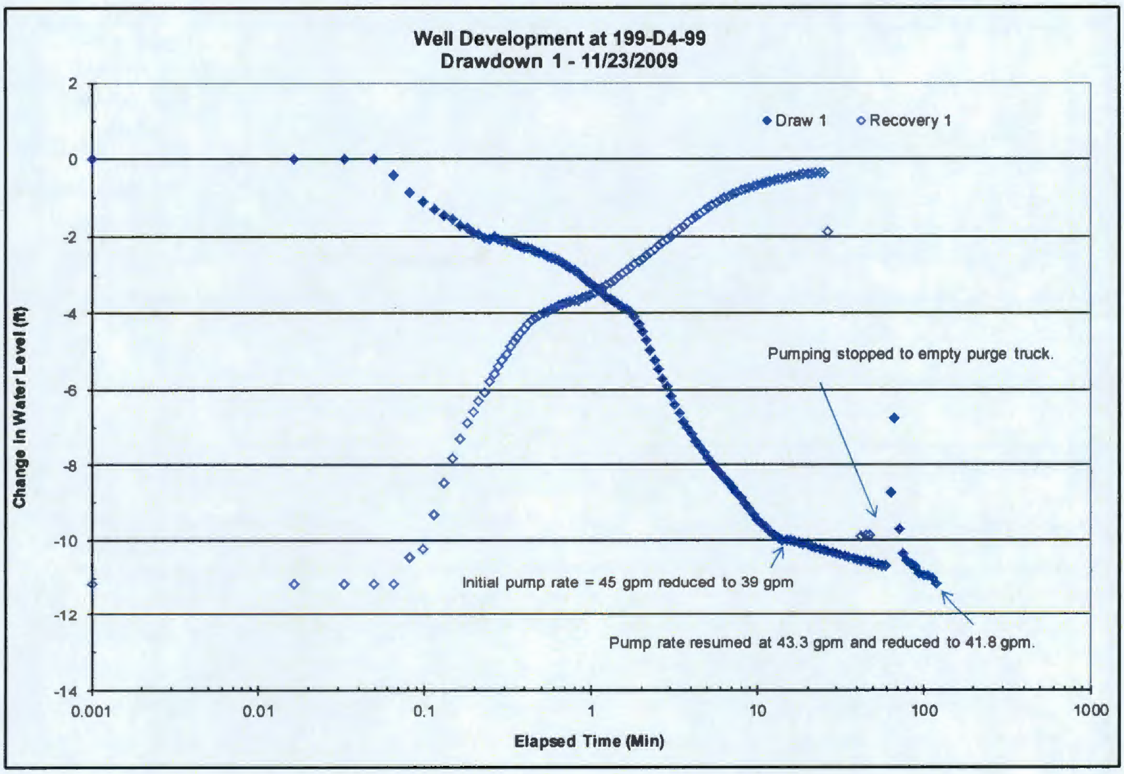


Figure 5-32. Drawdown 1 and Recovery Data at 199-D4-99

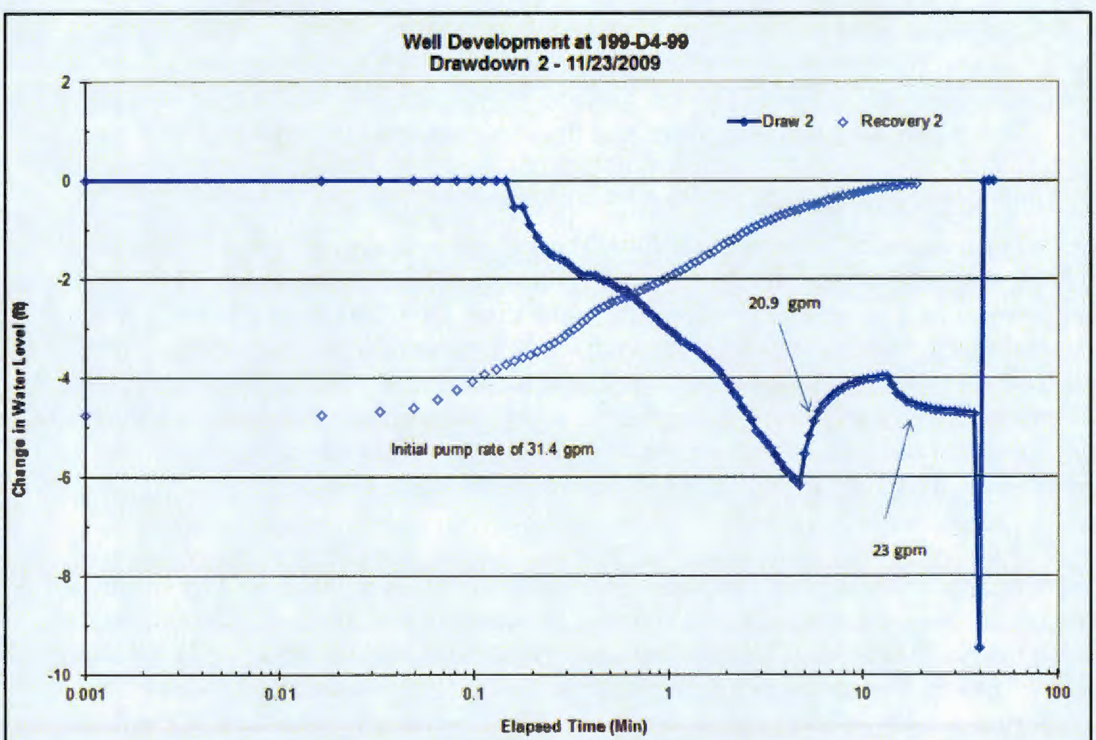


Figure 5-33. Drawdown 2 and Recovery Data at 199-D4-99

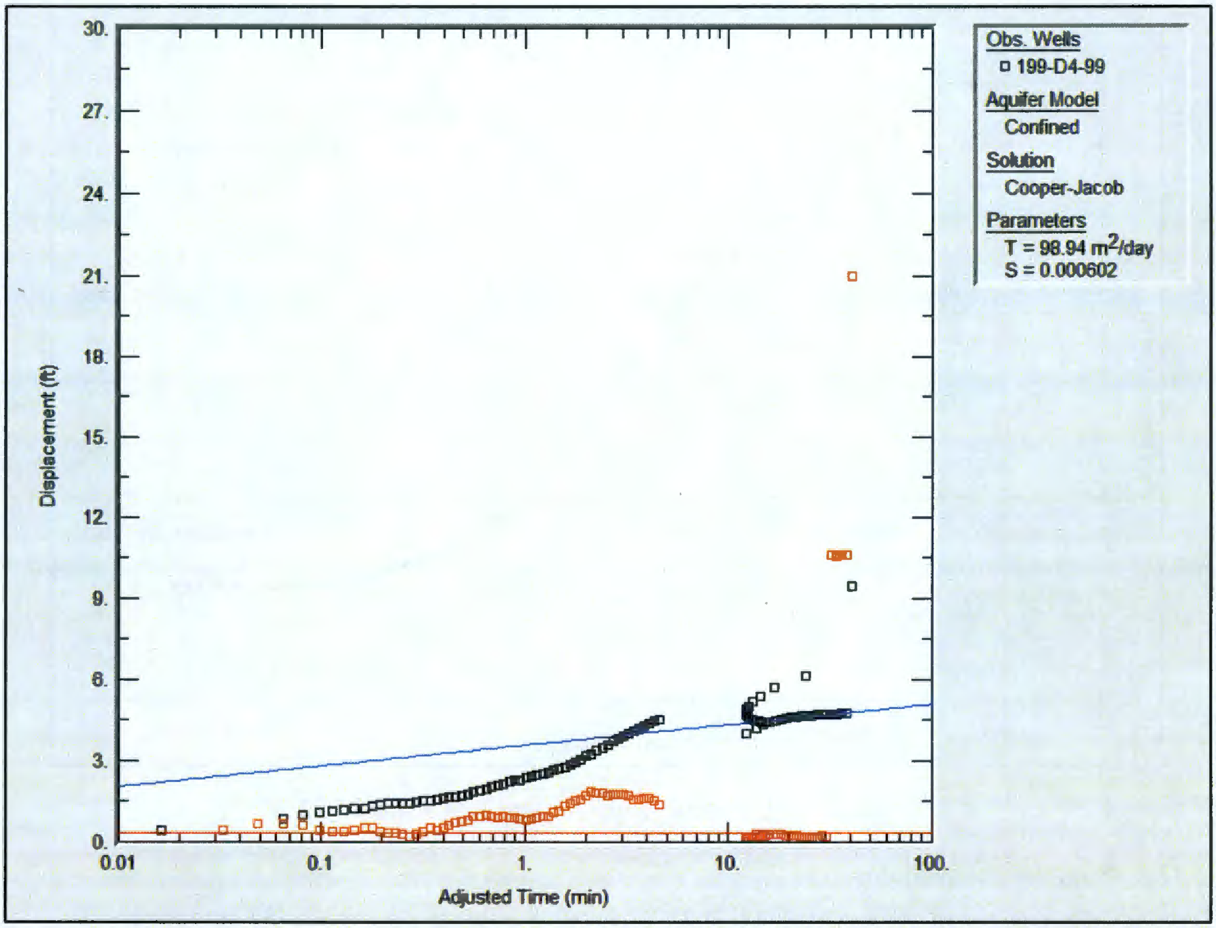


Figure 5-34. Cooper-Jacob Drawdown Analysis at 199-D4-99

5.16 Analysis of Well Development Data at Well 199-D5-32

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C4185_WD_199-D5-32_2003-12-11.xls*.

5.16.1 Summary of available data

The well was developed on December 10 and 11, 2003. The transducer was not working properly, so data were not recorded for the first development conducted on December 10. On December 11, the well was pumped at 36 gpm for about 47 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-35.

5.16.2 Analysis

Consistent transmissivity estimates of 430 m^2/d are obtained from the Cooper-Jacob analysis of the drawdown data and Theis Recovery analysis. The analyses are shown in Figure 5-36.

5.17 Analysis of Well Development Data at Well 199-D5-34

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C4187_WD_199-D5-34_2003-12-11.xls*.

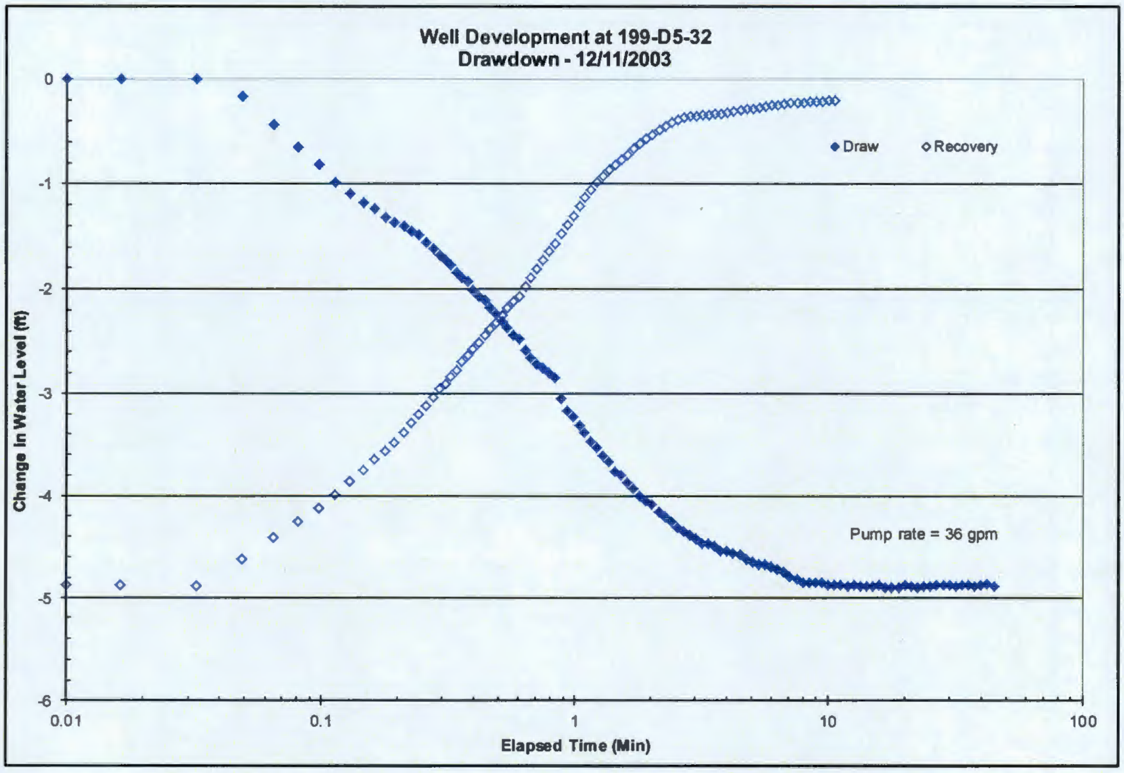


Figure 5-35. Drawdown and Recovery Data at 199-D5-32

5.17.1 Summary of available data

The well was developed on December 11, 2003. The well was initially pumped at 37 gpm for about 19 minutes, then increased to 38 gpm and pumped for 42 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery periods, and changes in the water level with time are shown in Figure 5-37. A second drawdown and recovery test was recorded the same day, pumping at 37 gpm for 58 minutes. Data from this test are shown in Figure 5-38.

5.17.2 Analysis

Consistent transmissivity estimates of 870 m^2/d are obtained from the Cooper-Jacob analysis of the drawdown data and the Theis recovery analysis. The analyses are shown in Figure 5-39.

5.18 Analysis of Well Development Data at Well 199-D5-38

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *B8747_WD_199-D5-38_1999-04-23.xls.*

5.18.1 Summary of available data

The well was developed on April 23, 1999. The well was pumped in four stages: 15 gpm for 10 minutes, 30 gpm for 7 minutes, 60 gpm for 17 minutes, and 50 gpm for 24 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-40. Another drawdown test was performed with two pumping stages: 50 gpm for 50 minutes and 45 gpm for 54 minutes. Data from these drawdown and recovery events are shown in Figures 5-41 and 5-42.

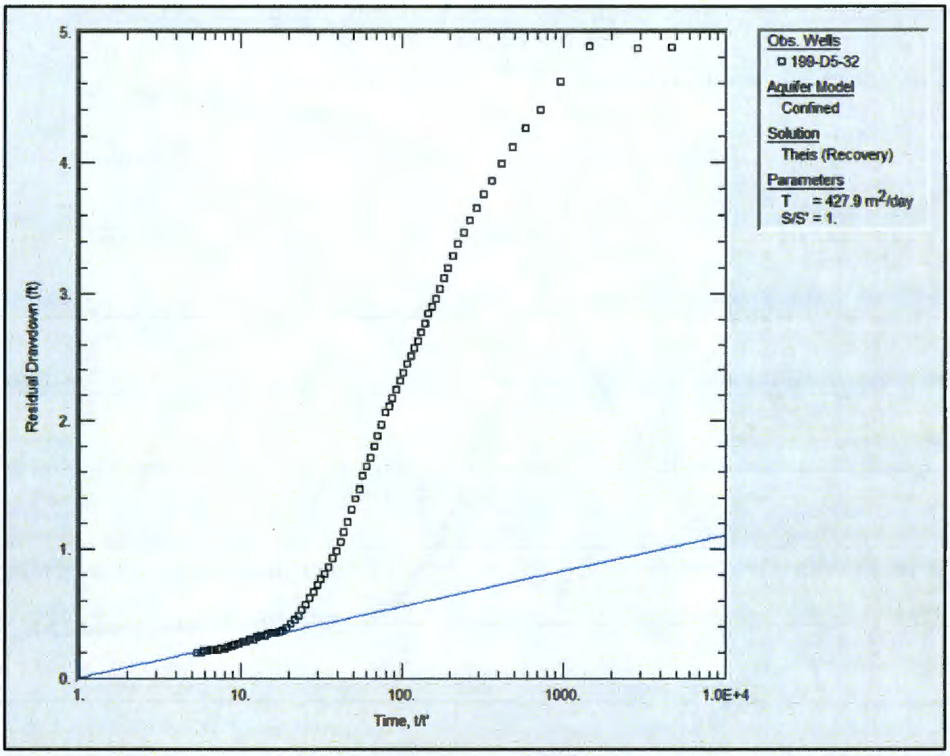


Figure 5-36. Theis Recovery Analysis at 199-D5-32 (1 of 2)

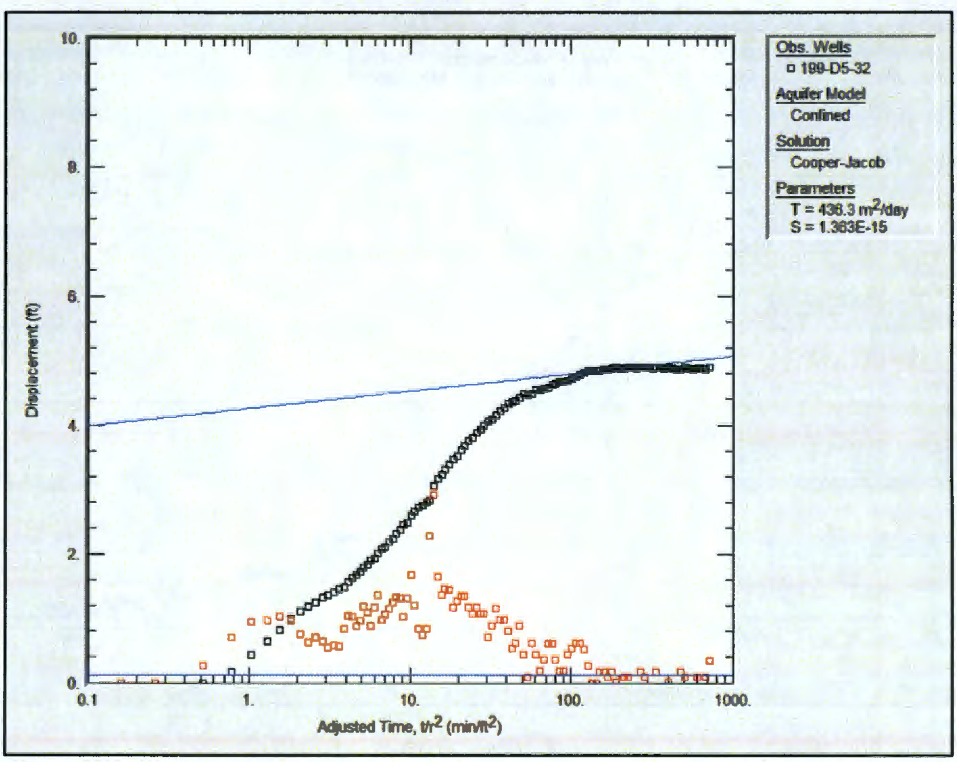


Figure 5-36. Cooper-Jacob Drawdown Analysis at 199-D5-32 (2 of 2)

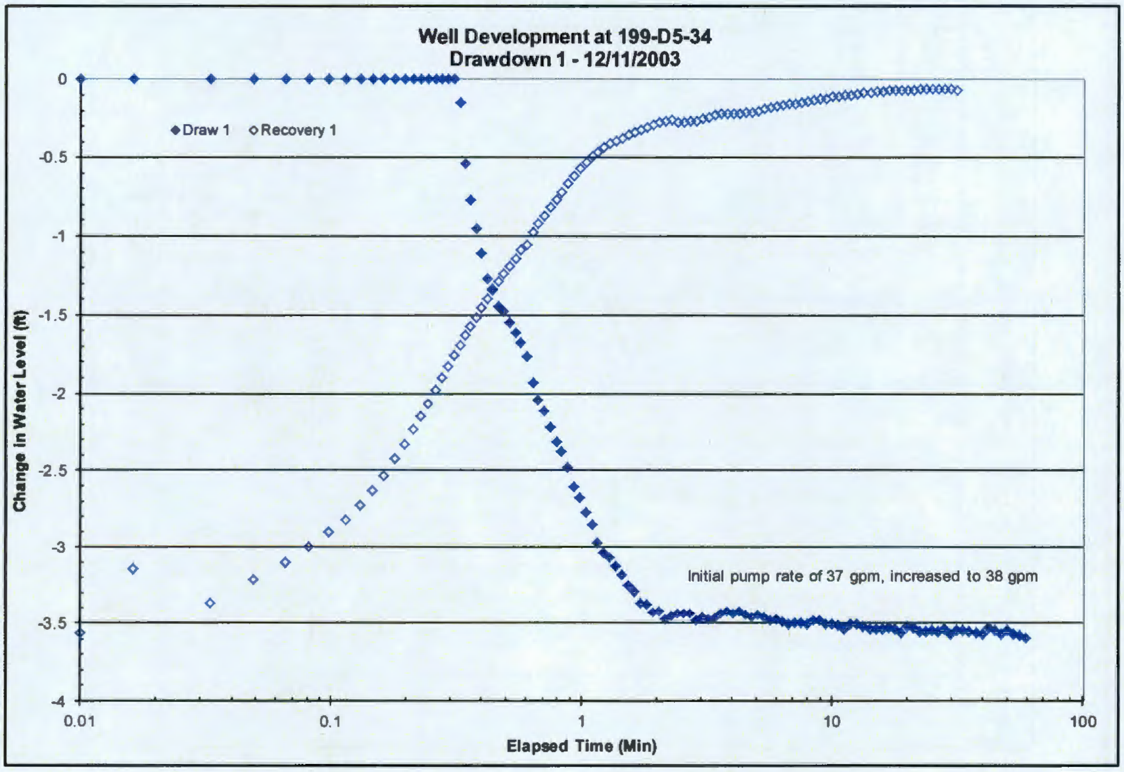


Figure 5-37. Drawdown 1 and Recovery Data at 199-D5-34

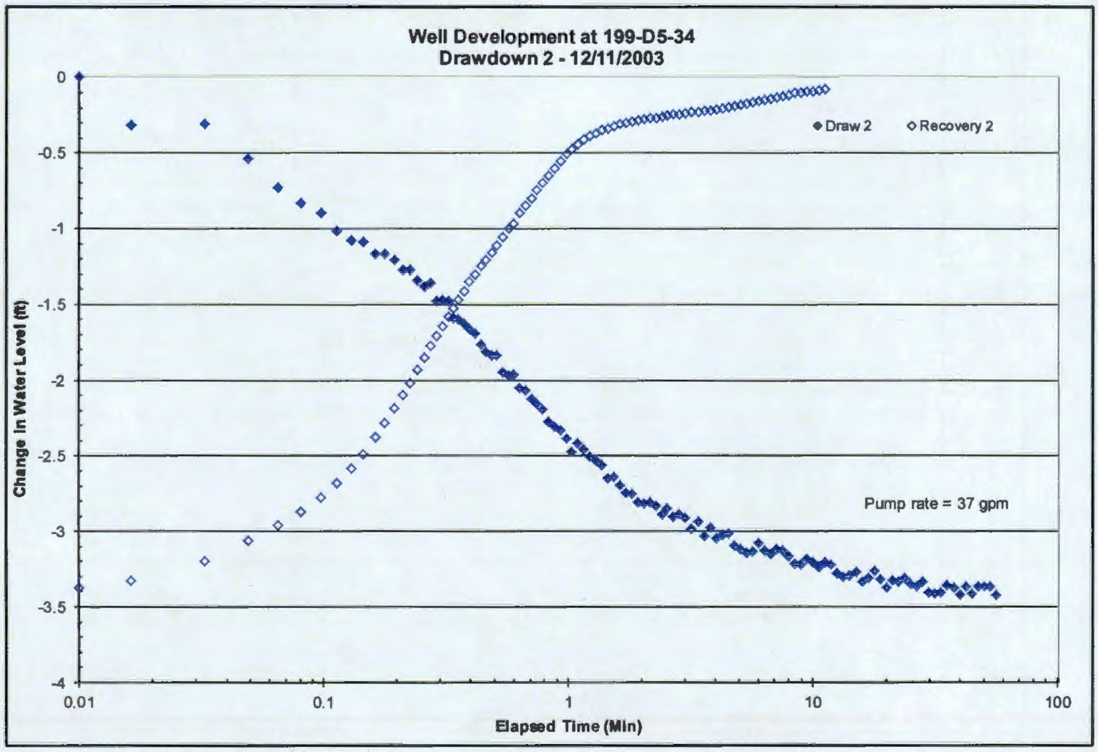


Figure 5-38. Drawdown 2 and Recovery Data at 199-D5-34

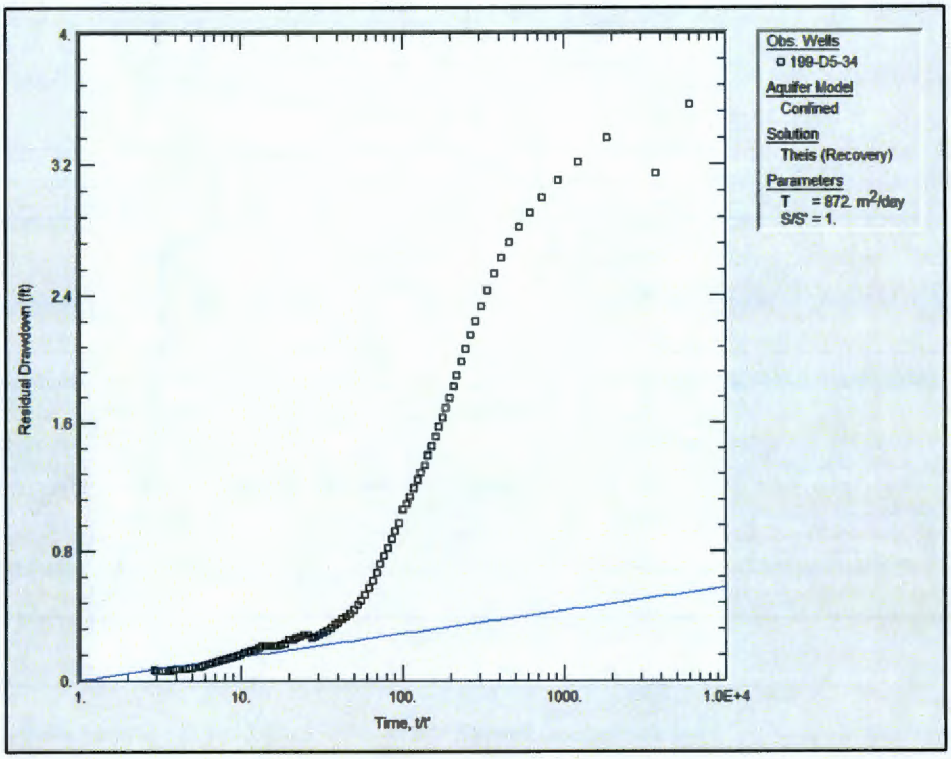


Figure 5-39. Theis Recovery Analysis at 199-D5-34 (1 of 2)

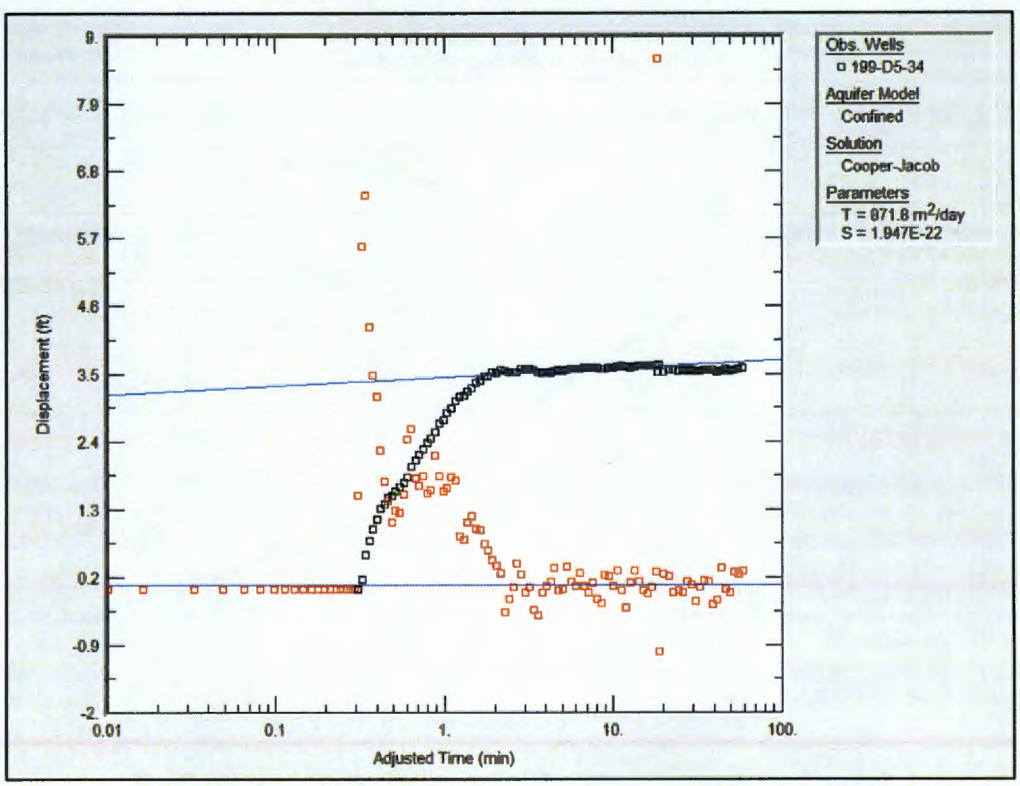


Figure 5-39. Cooper-Jacob Drawdown Analysis at 199-D5-34 (2 of 2)

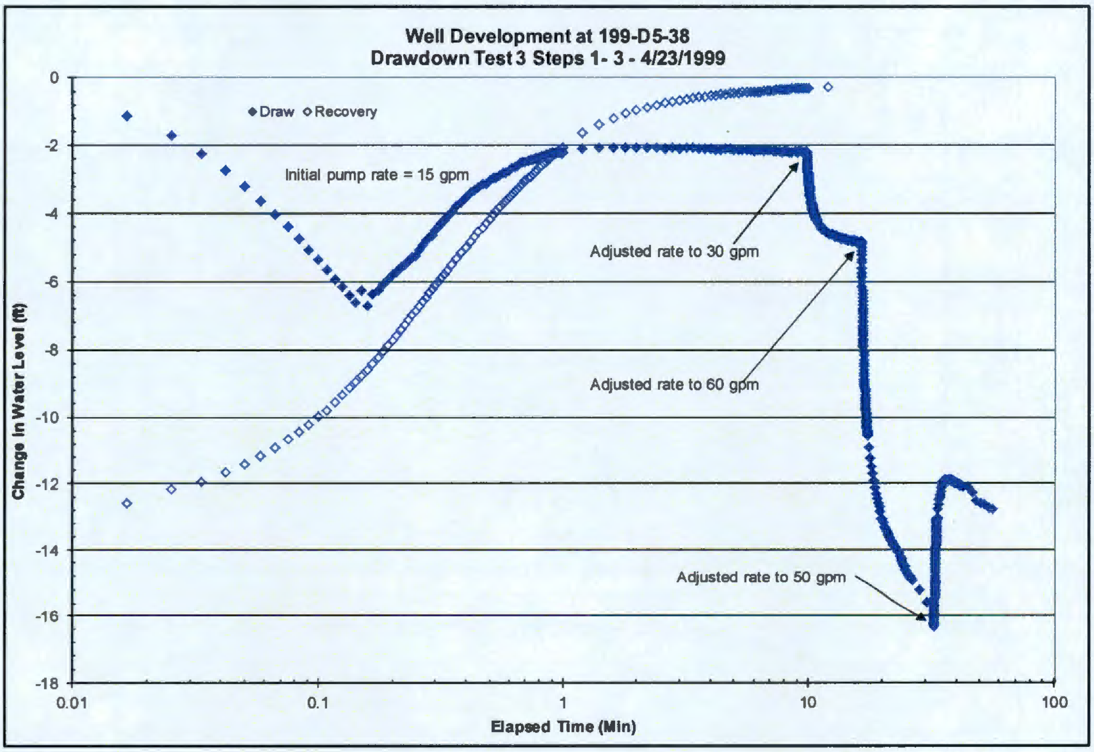


Figure 5-40. Drawdown 3 and Recovery Data at 199-D5-38

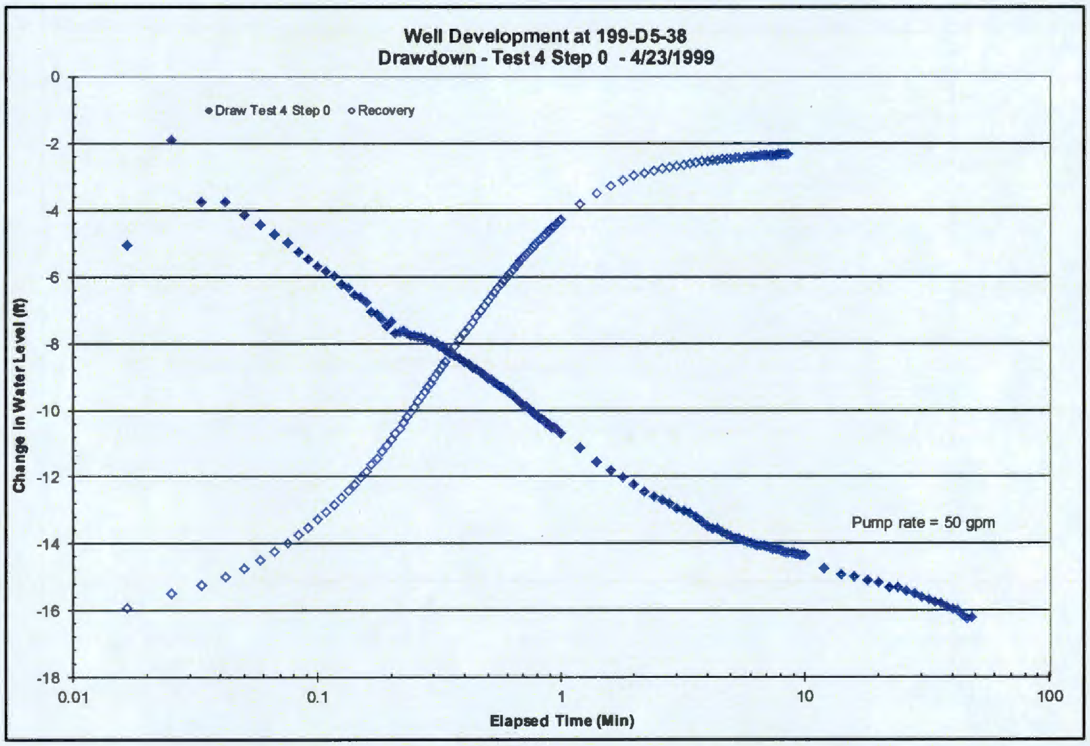


Figure 5-41. Drawdown 4 First Stage and Recovery Data at 199-D5-38

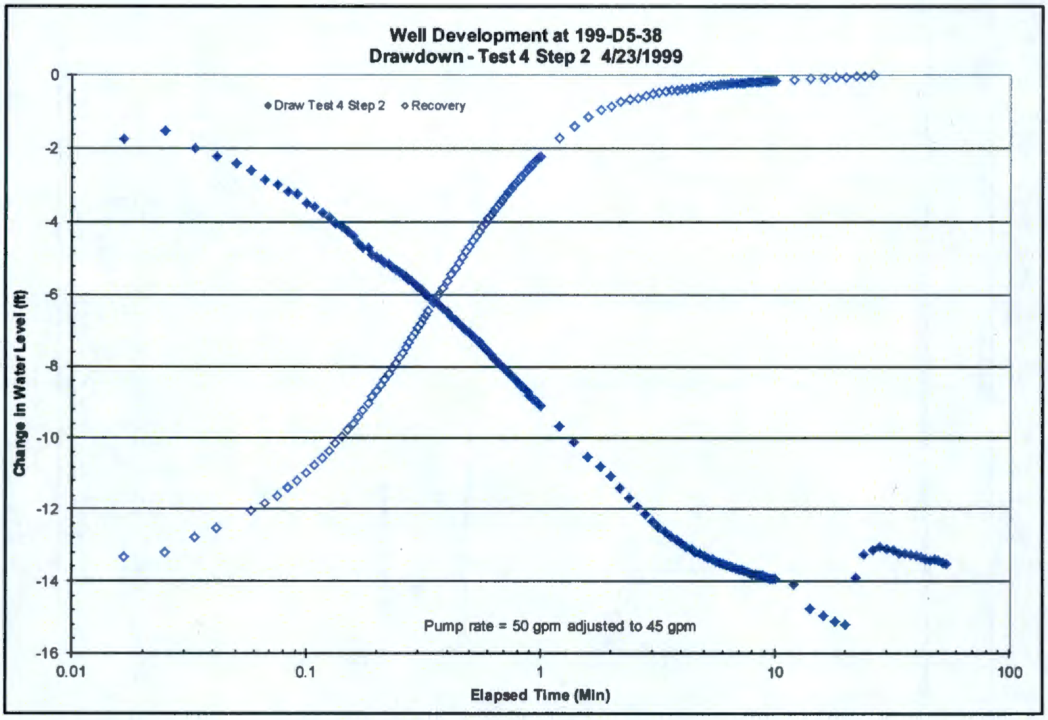


Figure 5-42. Drawdown 4 Second Stage and Recovery Data at 199-D5-38

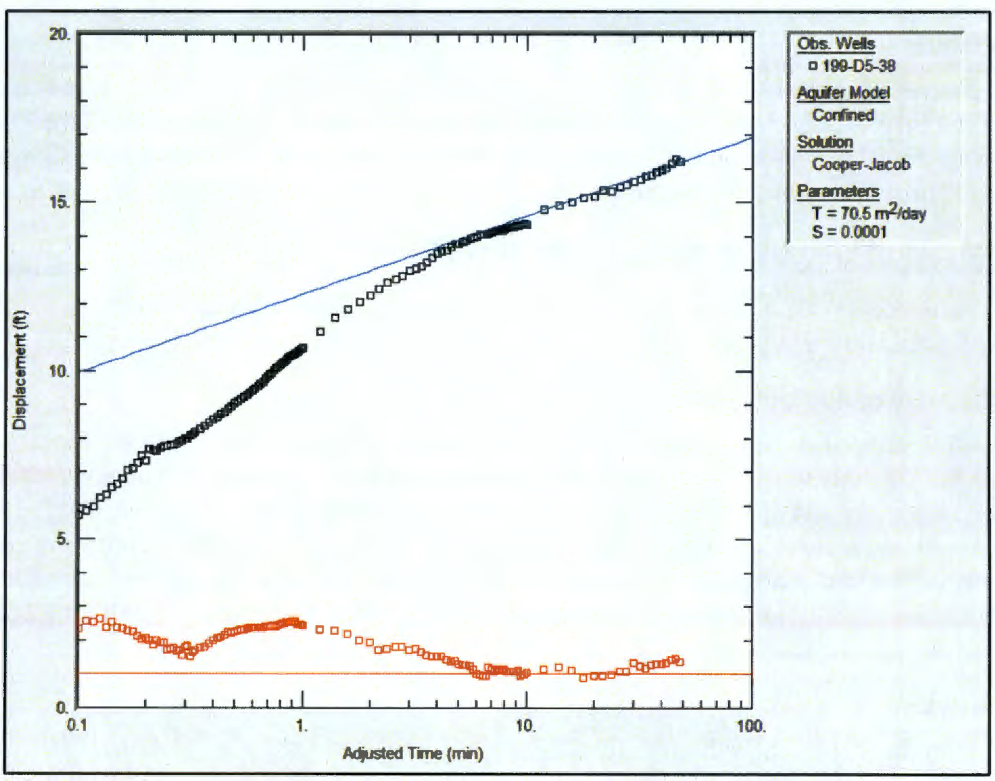


Figure 5-43. Cooper-Jacob Drawdown Analysis at 199-D5-38 (1 of 2)

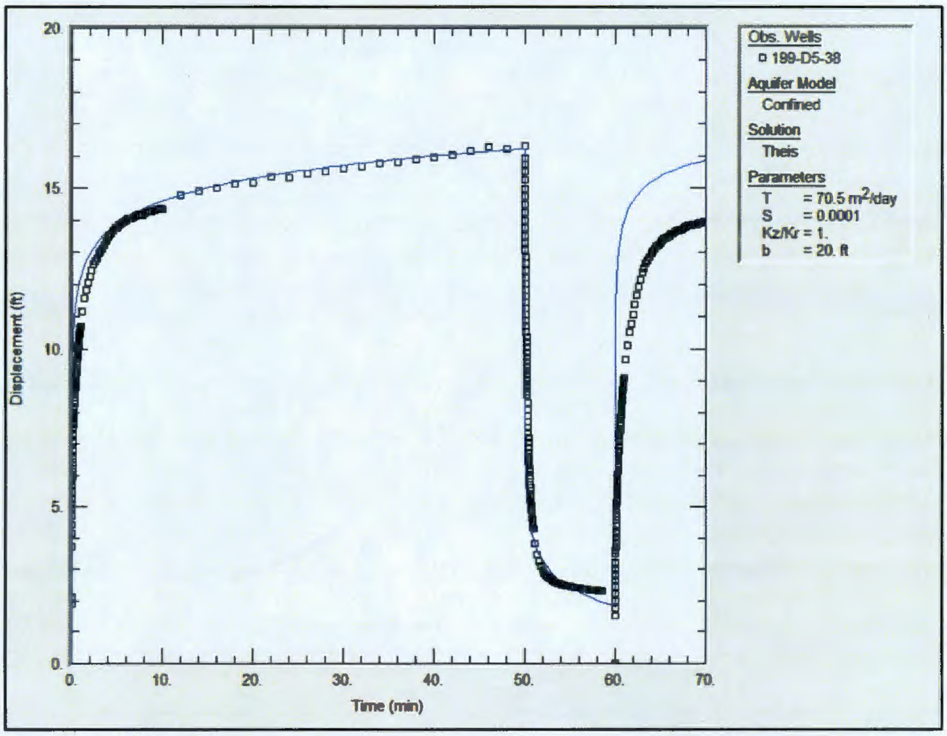


Figure 5-43. Theis Drawdown Analysis at 199-D5-38 (2 of 2)

5.18.2 Analysis

The transmissivity is estimated as 70 m^2/d from the Cooper-Jacob analysis of the drawdowns recorded during "Test 4 Step 0". Consistent transmissivity estimates are obtained with the match of the Theis solution to the drawdown data and the Cooper-Jacob drawdown analysis. The analyses are shown in Figure 5-43. The recovery based estimate was much higher and not considered reliable.

5.19 Analysis of Well Development Data at Well 199-D5-39

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *B8748_WD_199-D5-39_1999-04-27.xls*.

5.19.1 Summary of Available Data

The well was developed on April 27, 1999. The well was initially pumped at 30 gpm for about 10 minutes, then the rate was increased to 40 gpm and pumped for 11 minutes. Pumping was then run at 50 gpm for 14 minutes and then at 60 gpm for 17 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-44. Another drawdown and recovery test was then performed and recorded, with pumping at 50 gpm for 39 minutes. The data for this test are shown in Figure 5-45.

5.19.2 Analysis

Only data from the first test have been analyzed. Pumping was conducted at a sequence of rates, and close matches to the drawdown observations were achieved only for the early steps. Consistent transmissivity estimates of 140 m^2/d are obtained from a match of the Theis solution to the drawdown data and recovery analysis. The analyses are shown in Figure 5-46.

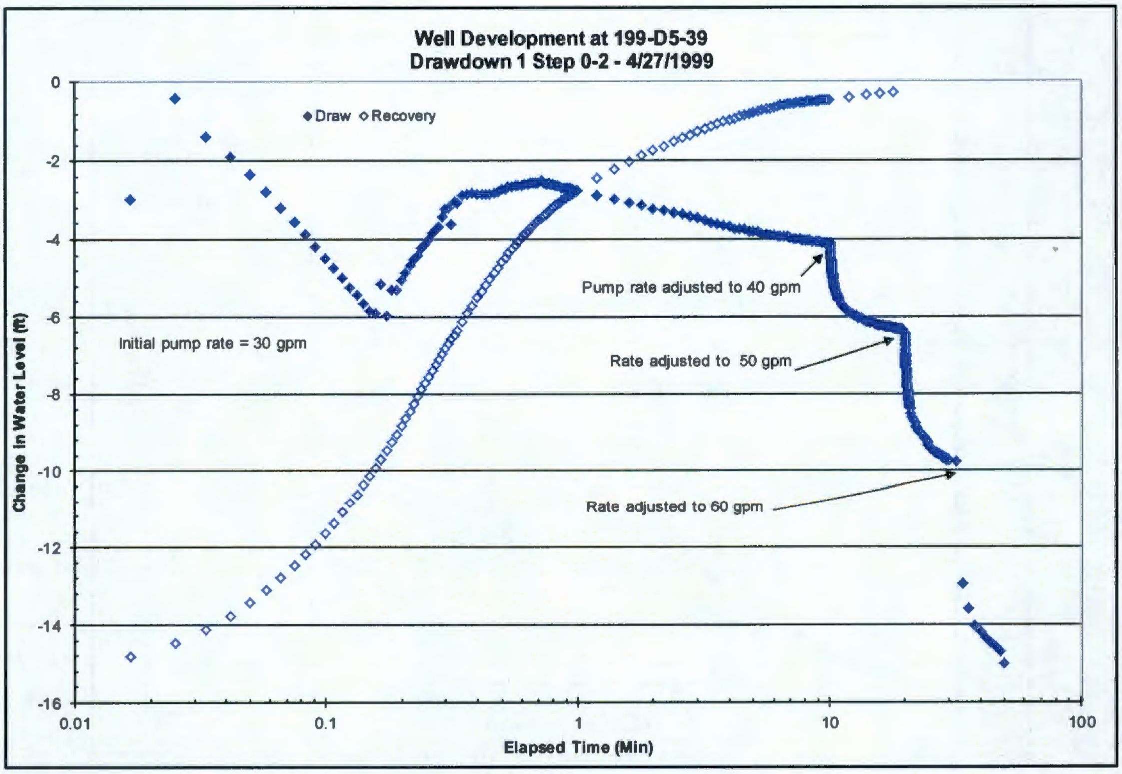


Figure 5-44. Drawdown 1 and Recovery Data at 199-D5-39

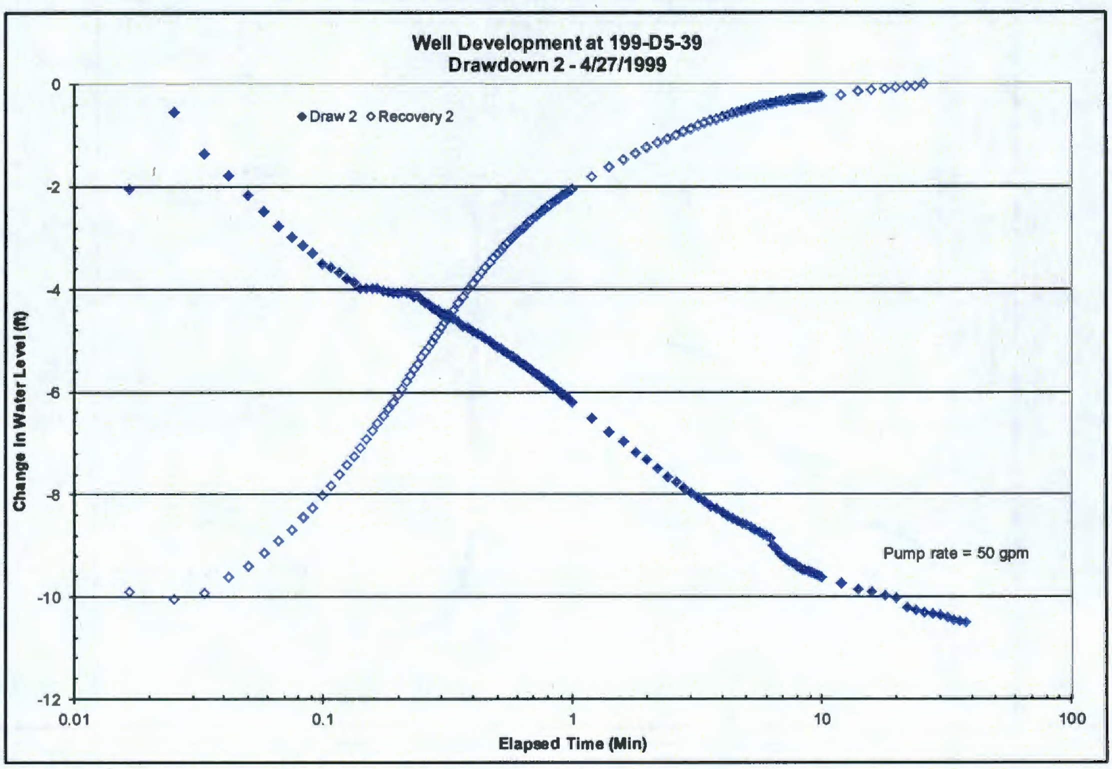


Figure 5-45. Drawdown 2 and Recovery Data at 199-D5-39

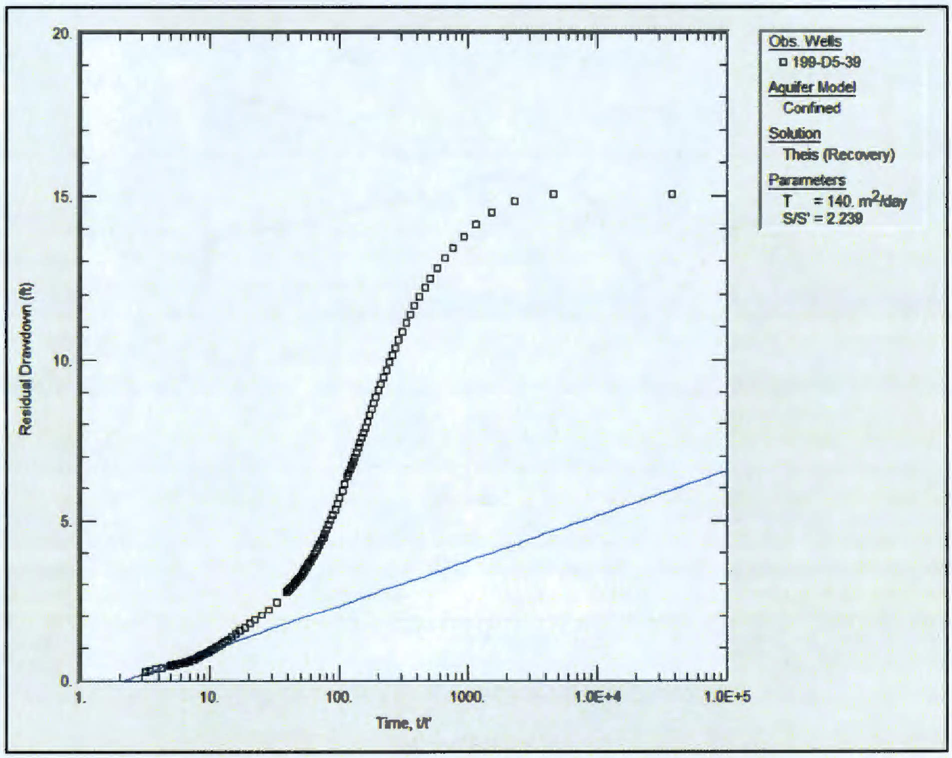


Figure 5-46. Theis Recovery Analysis at 199-D5-39 (1 of 2)

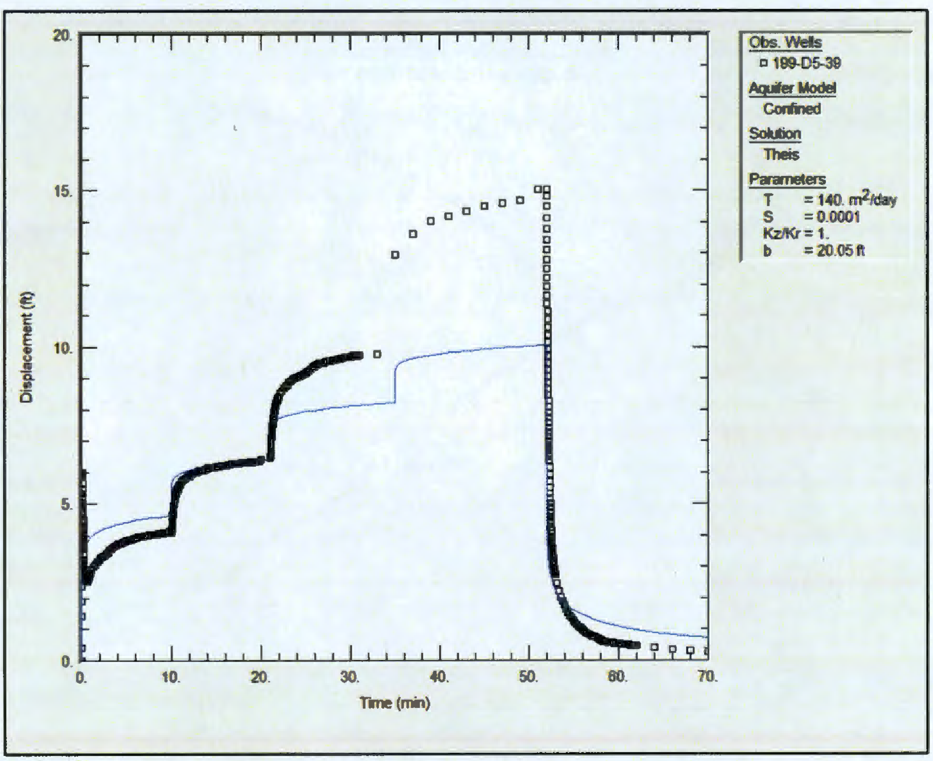


Figure 5-46. Theis Drawdown Analysis at 199-D5-39 (2 of 2)

5.20 Analysis of Well Development Data at Well 199-D5-101

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C7583_WD_199-D5-101_2010-03-12.xls*.

5.20.1 Summary of Available Data

The well was developed on March 12, 2010. The well was initially pumped at 11.9 gpm for about 3 minutes, then increased to 14.9 gpm for 20 minutes. For a second drawdown interval, the pump intake was lowered 10 ft; the well was pumped at 26.4 gpm for 1 minute, then at 44.8 gpm for 13 minutes. A 100 hp pump was then brought in to replace the 50 hp pump to increase the drawdown. The new pump was run at 75 gpm for 40 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery periods, and changes in the water level with time are shown in Figures 5-47 and 5-48.

5.20.2 Analysis

A relatively wide range of transmissivity estimates is obtained from the analyses of the first and second drawdown intervals (380 m^2/d to 2,200 m^2/d). The most representative transmissivity estimate of 1,060 m^2/d is derived from a Cooper-Jacob analysis of the observations from the second drawdown interval, shown in Figure 5-49. The derivative of the drawdown with respect to time, $\partial s/\partial \ln(t)$, is shown at the bottom of the figure. The Cooper-Jacob analysis is conducted for the period where the derivative flattens, confirming that the Cooper-Jacob straight line is fit to the portion of the drawdown responses caused only by the aquifer. The unrealistically small storage coefficient (*S*) is caused by wellbore storage effects lasting for several minutes.

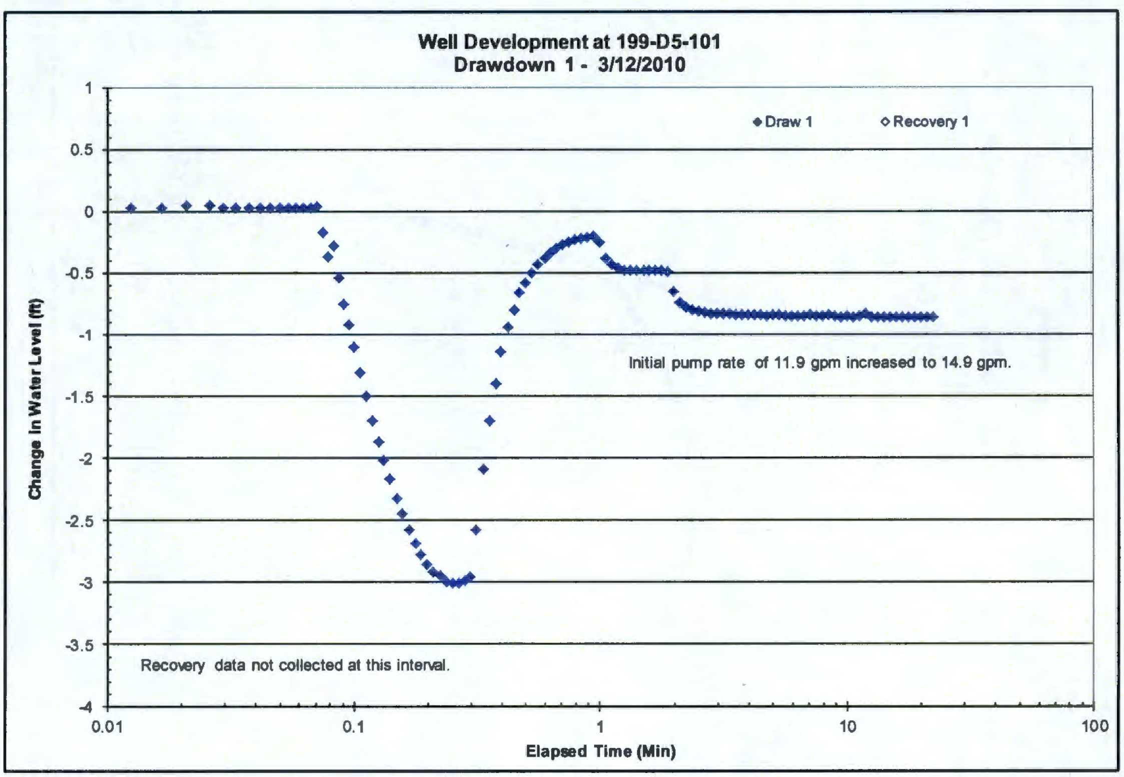


Figure 5-47. Drawdown 1 and Recovery Data at 199-D5-101

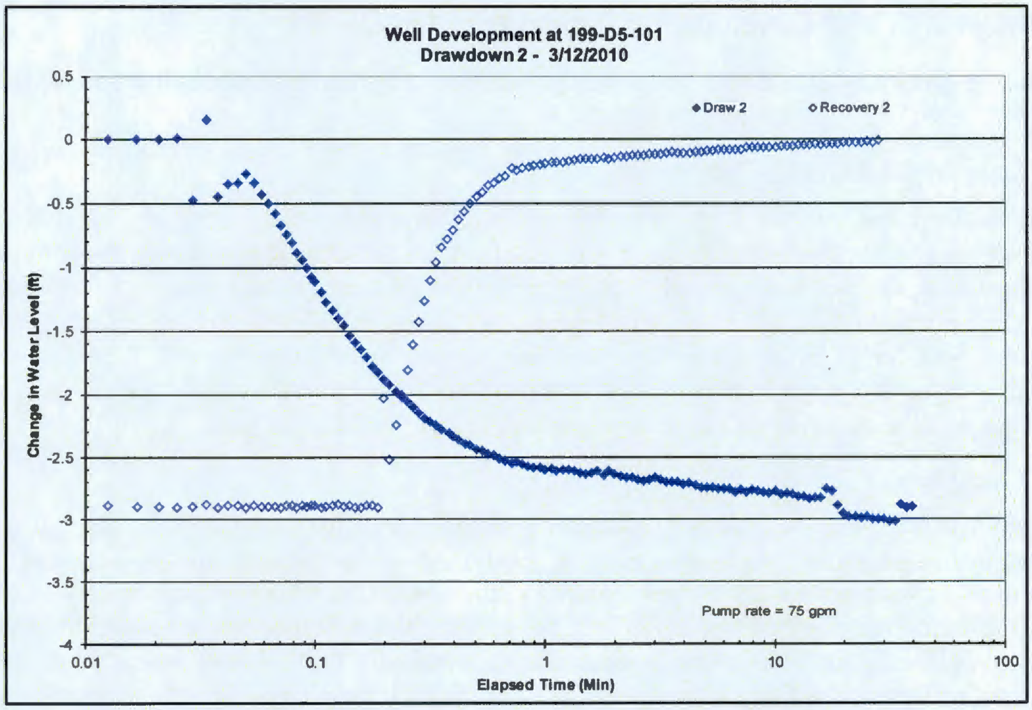


Figure 5-48. Drawdown 2 and Recovery Data at 199-D5-101

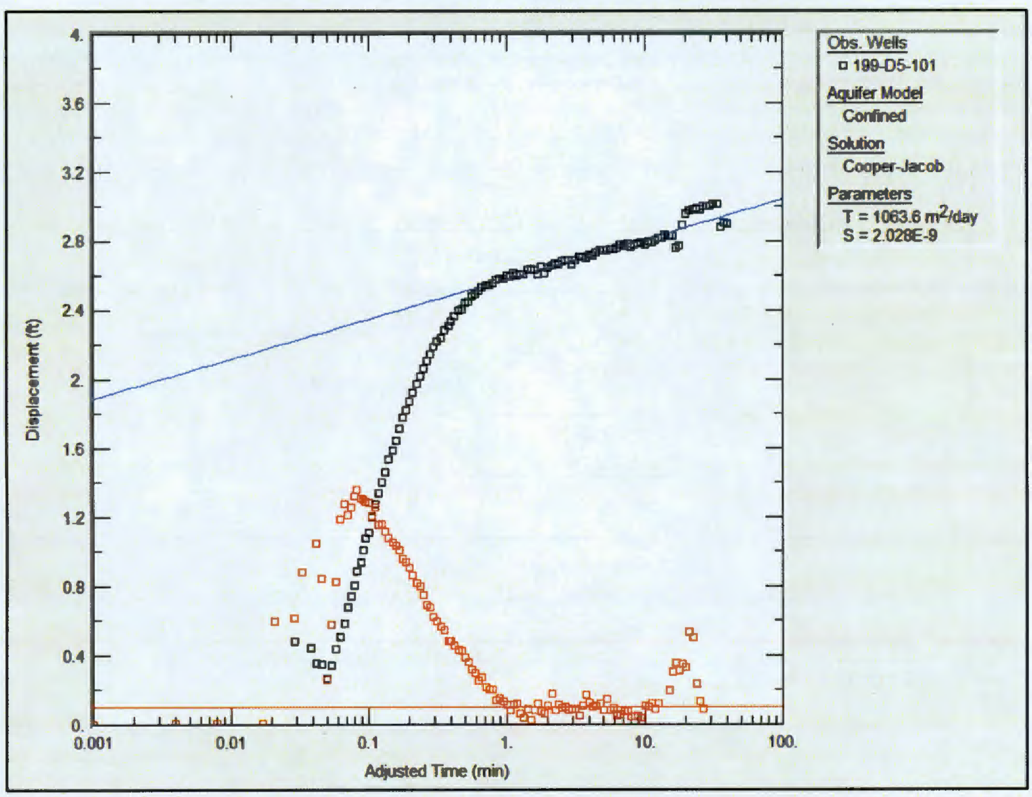


Figure 5-49. Cooper-Jacob Drawdown Analysis at 199-D5-101

5.21 Analysis of Well Development Data at Well 199-D5-126

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C6390_WD_199-D5-126_2008-10-29.xls*.

5.21.1 Summary of available data

The well was developed on October 29, 2008. The well was pumped at 14.28 gpm for about 22 minutes. After 6 minutes of recovery, the pump intake was then raised to 96.7 ft, and a second drawdown test was performed at 14 gpm for 44 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery periods, and changes in the water level with time are shown in Figure 5-50 and 5-51.

5.21.2 Analysis

Consistent transmissivity estimates are obtained from the match of the Theis solution to the observations from both drawdown intervals. Transmissivity of 330 m^2/d is estimated from the Theis fit to the second drawdown interval; the analysis is shown in Figure 5-52.

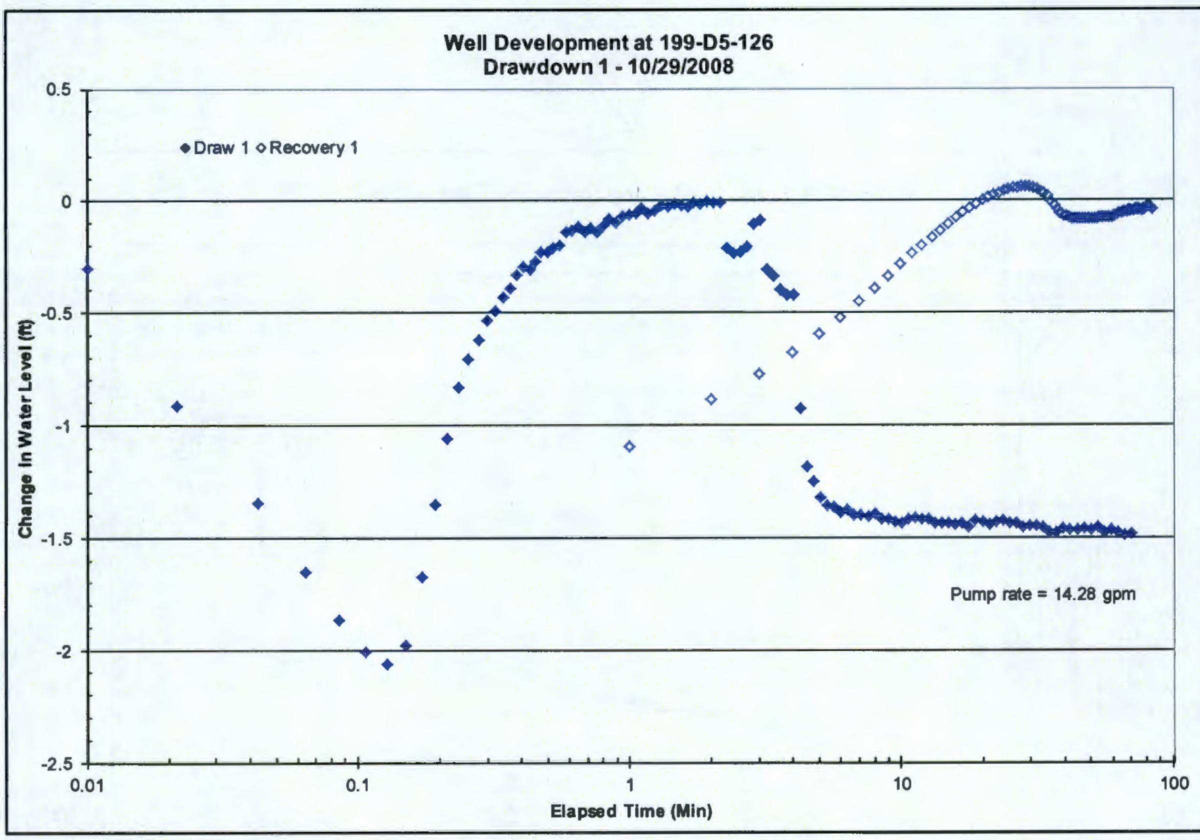


Figure 5-50. Drawdown 1 and Recovery Data at 199-D5-126

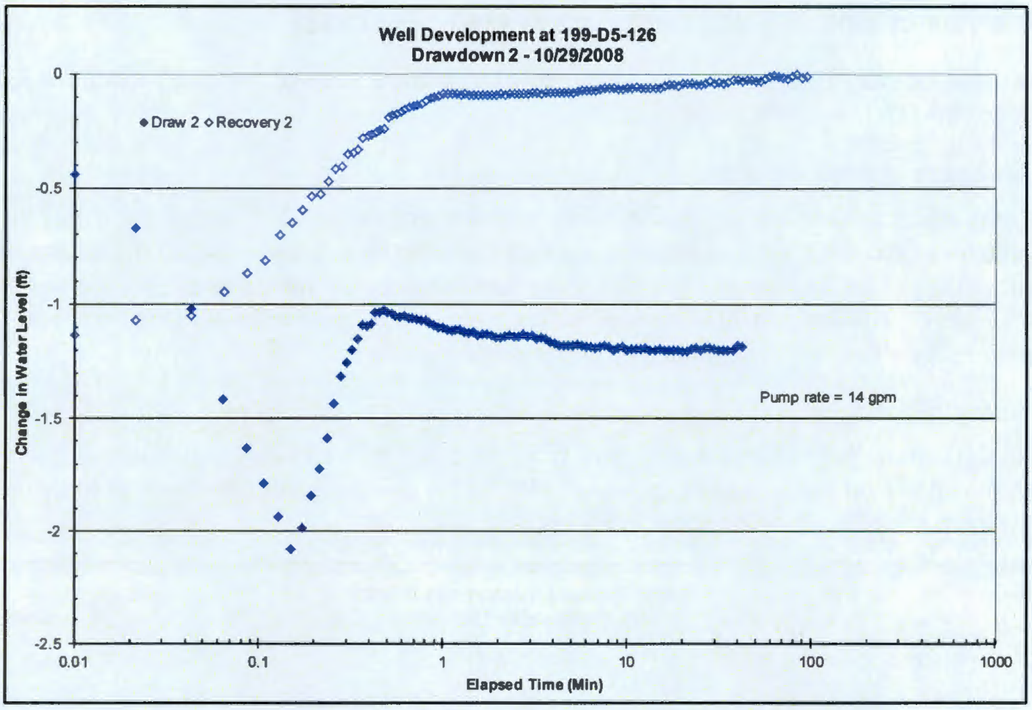


Figure 5-51. Drawdown 2 and Recovery Data at 199-D5-126

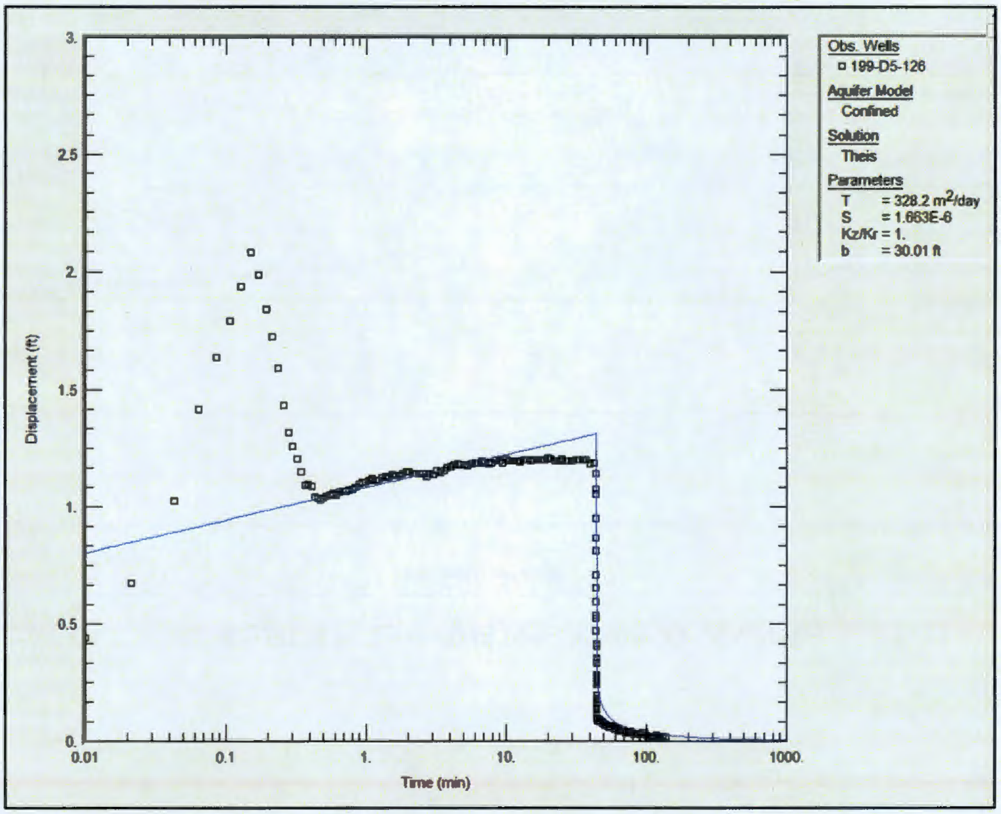


Figure 5-52. Theis Drawdown Analysis at 199-D5-126

5.22 Analysis of Well Development Data at Well 199-D5-128

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C7612_WD_199-D5-128_2010-02-10.xls*.

5.22.1 Summary of Available Data

The well was developed on February 10, 2010. The well was initially pumped at 26.9 gpm for about 3 minutes, then it was reduced to 20 gpm and pumped for 34 minutes. The pumping rate was then increased to 44.8 gpm, and the well was pumped for 22 minutes; then the pump stopped, and the water level in the well was allowed to recover. The datalogger failed to record after 23 minutes of drawdown. Additional drawdown readings were taken from the FARs. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-53.

5.22.2 Analysis

A transmissivity estimate of 890 m^2/d is estimated from Theis analysis of the recovery data as shown in Figure 5-54. The late-time data conform to the expected response for an ideal aquifer. Since the fits to the drawdown data with the Theis and the Cooper-Jacob methods were not good, those estimates are not reported.

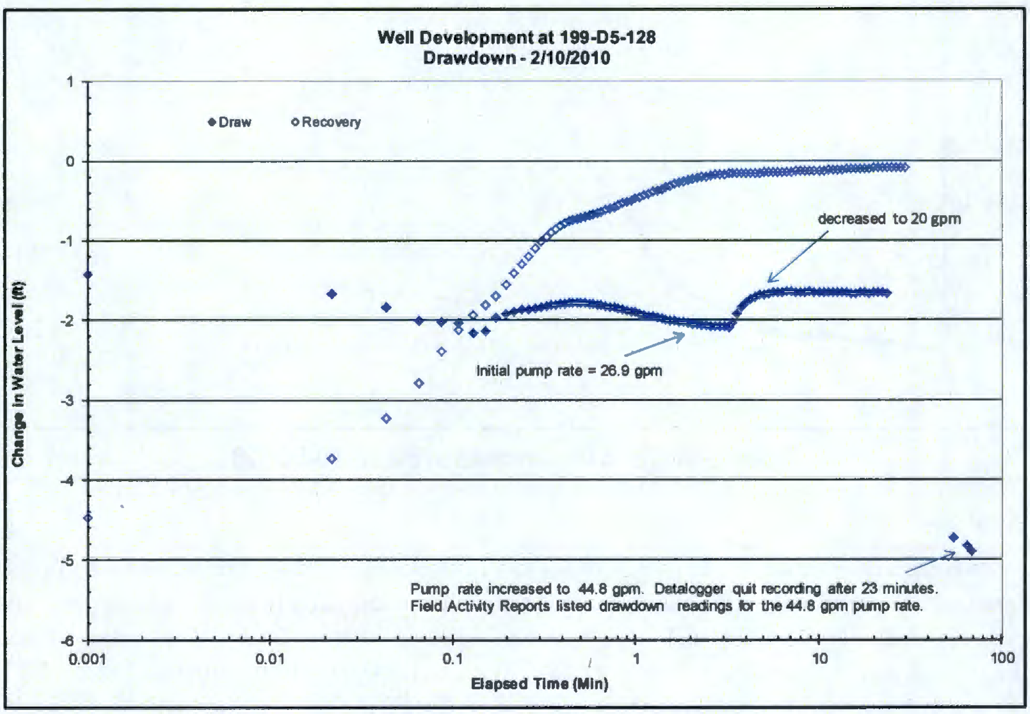


Figure 5-53. Drawdown and Recovery Data at 199-D5-128

5.23 Analysis of Well Development Data at Well 199-D5-141

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C7625_WD_199-D5-141_2011-04-27.xls*.

5.23.1 Summary of available data

The well was developed on April 26 and 27, 2011. The well was initially pumped at 17.1 gpm for about 16 minutes, then the rate was reduced to 1.7 gpm for 286 minutes of pumping. The well was allowed to recover, then a second test was performed on April 27, 2011. The well was pumped at 2 gpm for 185 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery periods, and changes in the water level with time are shown in Figures 5-55 and 5-56.

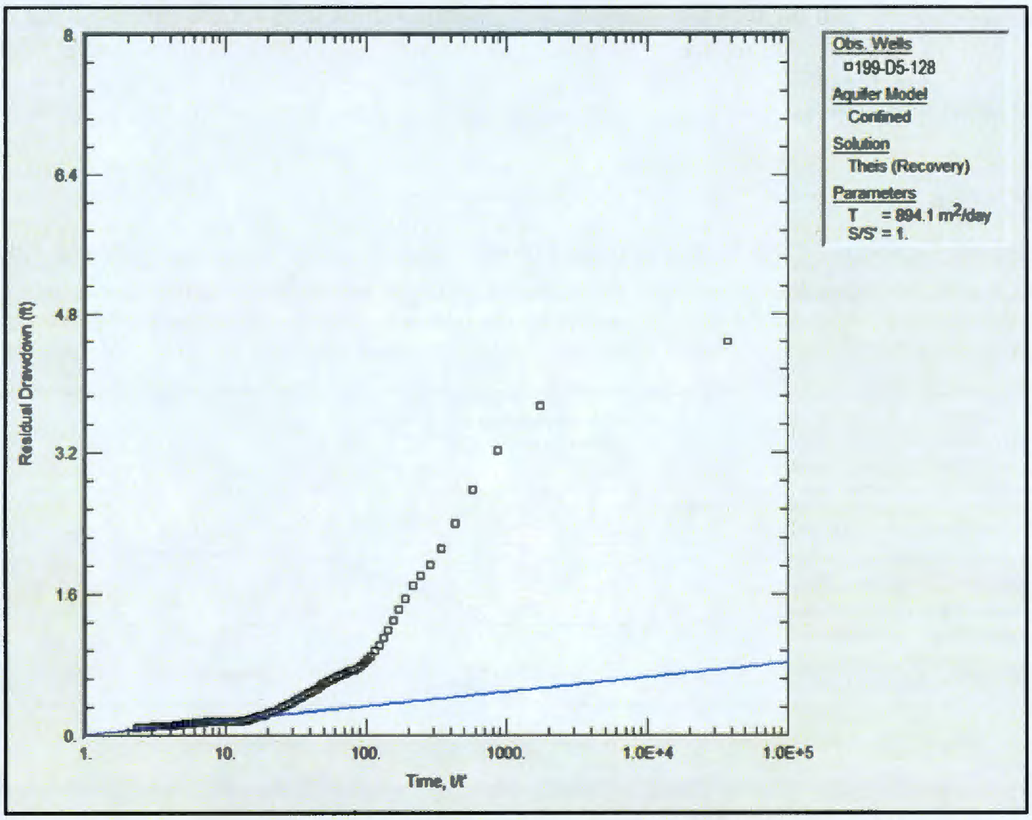


Figure 5-54. Theis Recovery Analysis at 199-D5-128

5.23.2 Analysis

The drawdown responses strongly suggest that this is a low-yield well. These responses are consistent with the well screen elevations, which indicate that the well is completed in the Ringold Upper Mud, a geological unit with very low permeability. A transmissivity estimate of 0.3 m^2/d is obtained from the Cooper-Jacob analysis of the second drawdown test. The Cooper-Jacob fit is shown in Figure 5-57. The derivative of the drawdown with respect to time, $\partial s/\partial \ln(t)$, is shown at the bottom of the figure. The Cooper-Jacob analysis must be applied over the period during which the derivative is constant, indicating that the drawdown responses reflect only the response of the aquifer. Doing so, however, results in a larger transmissivity estimate (5.5 m^2/d) which cannot be reconciled with the high observed drawdowns. It has been interpreted that until about 20 minutes, drawdowns are dominated by the effects of wellbore storage (a prolonged period of wellbore storage is consistent with a well located in an interval of low transmissivity), followed by a brief infinite-acting radial flow period, and then finally the drawdown cone propagates into an outer zone of higher transmissivity which gives the impression of stabilization.

Figure 5-55. Drawdown 1 and Recovery Data at 199-D5-141

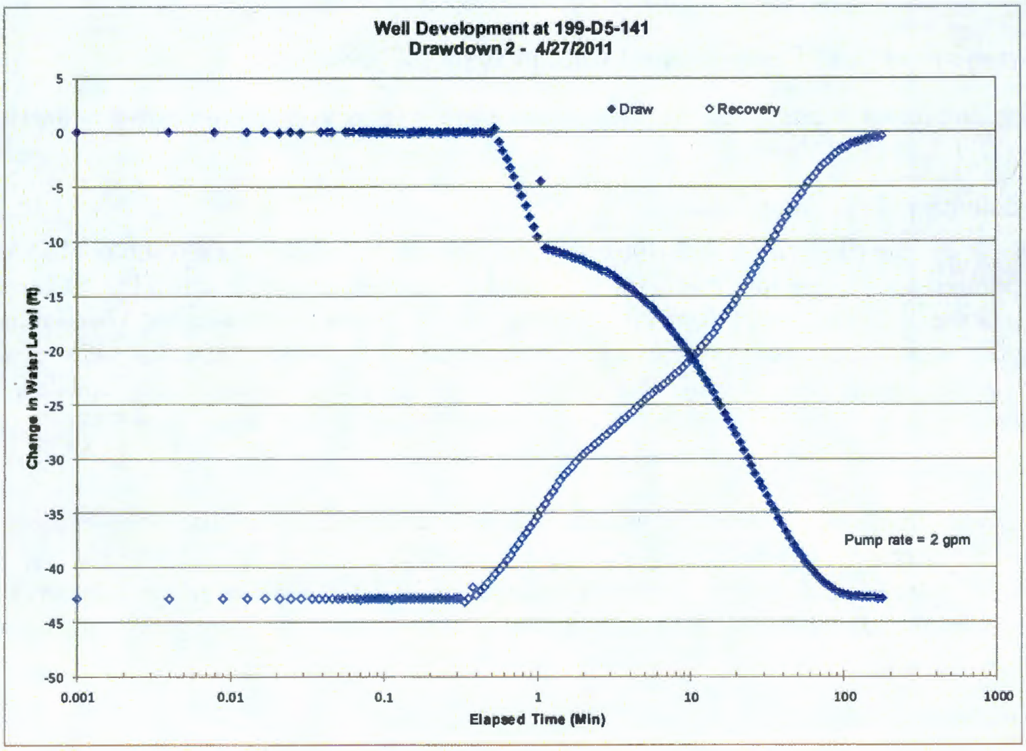


Figure 5-56. Drawdown 2 and Recovery Data at 199-D5-141

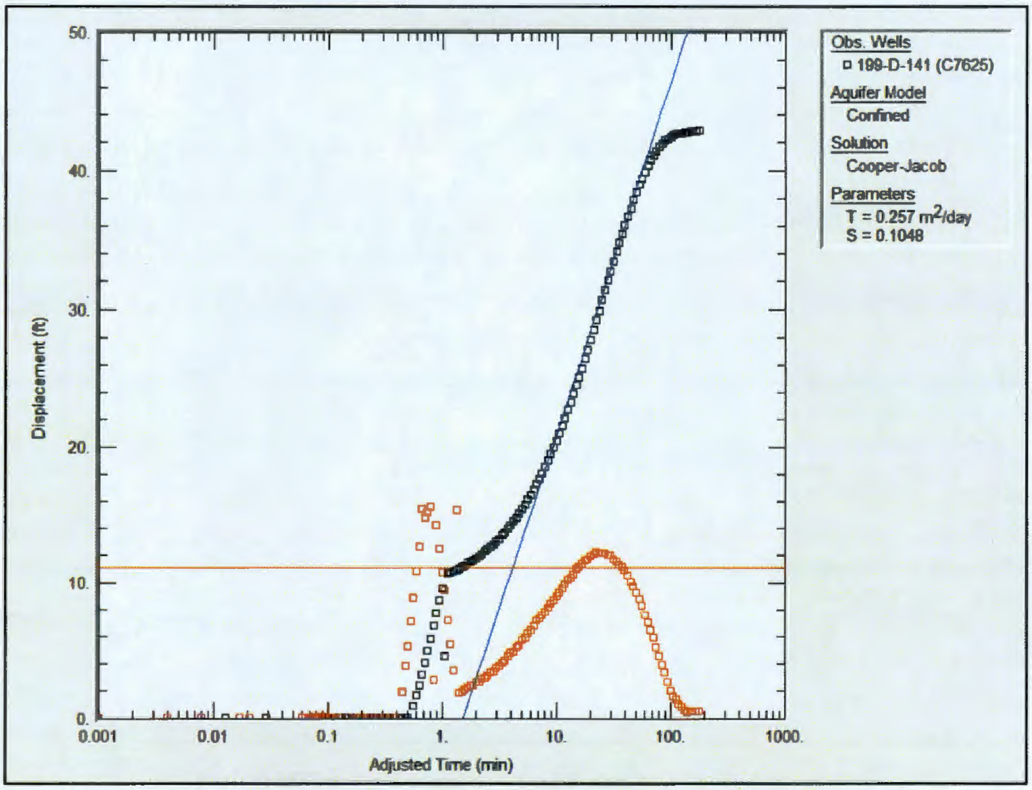


Figure 5-57. Cooper-Jacob Drawdown Analysis at 199-D5-141

5.24 Analysis of Well Development Data at Well 199-D6-2

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C7607_WD_199-D6-2_2010-04-20.xls*.

5.24.1 Summary of Available Data

The well was developed on April 20, 2010. Two sets of data are included in the Excel file. The well was initially pumped at 74.8 gpm for 22 minutes, but only drawdown data were collected. For the second test, the pump intake was lowered by 8 ft, and the well was initially pumped at 29.92 gpm. After 4 minutes, the pumping rate was increased to 44 gpm and increased again to 59.8 gpm. The pump was stopped after an additional 40 minutes, and the water level in the well was allowed to recover. The second data set was chosen for interpretation, and changes in the water level with time are shown in Figure 5-58.

5.24.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-59, aquifer transmissivity is estimated to be 2,600 m^2/d. The late-time recovery data approach the limit of zero drawdown ($t/t' \rightarrow 1$), consistent with the response of an ideal aquifer. Since the fits to the drawdown data with the Theis and the Cooper-Jacob methods were not good, those estimates are not reported.

5.25 Analysis of Well Development Data at Well 199-D7-3

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C7599_WD_199-D7-3_2010-04-21.xlsx*.

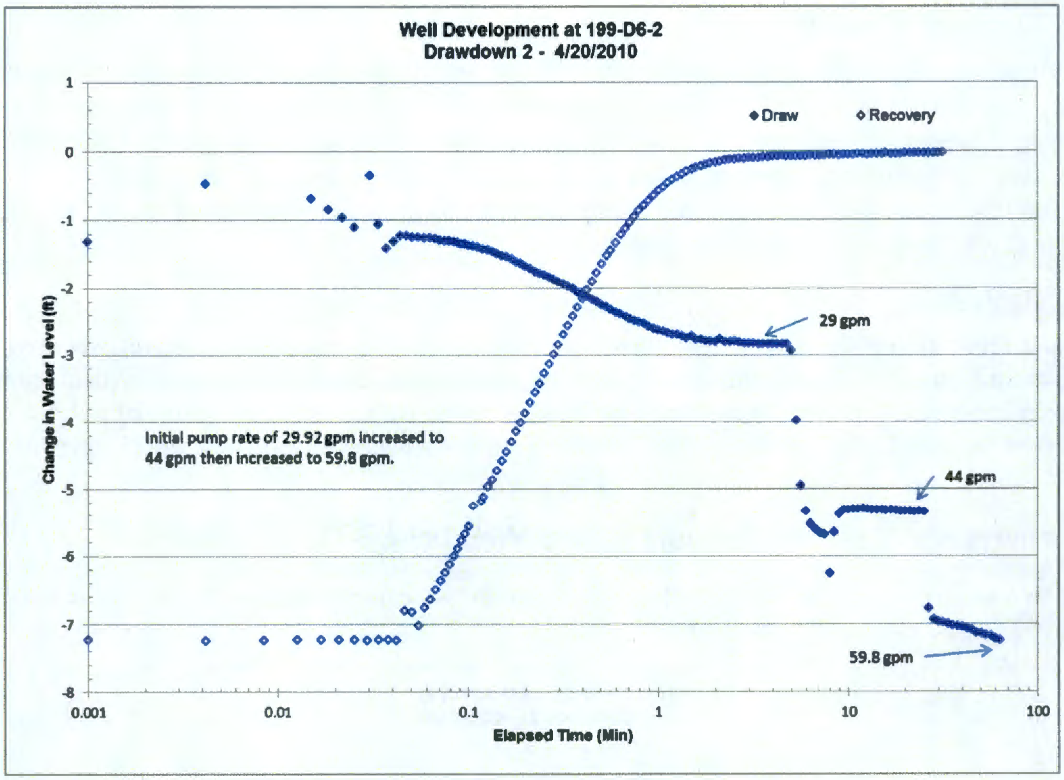


Figure 5-58. Drawdown and Recovery Data at 199-D6-2

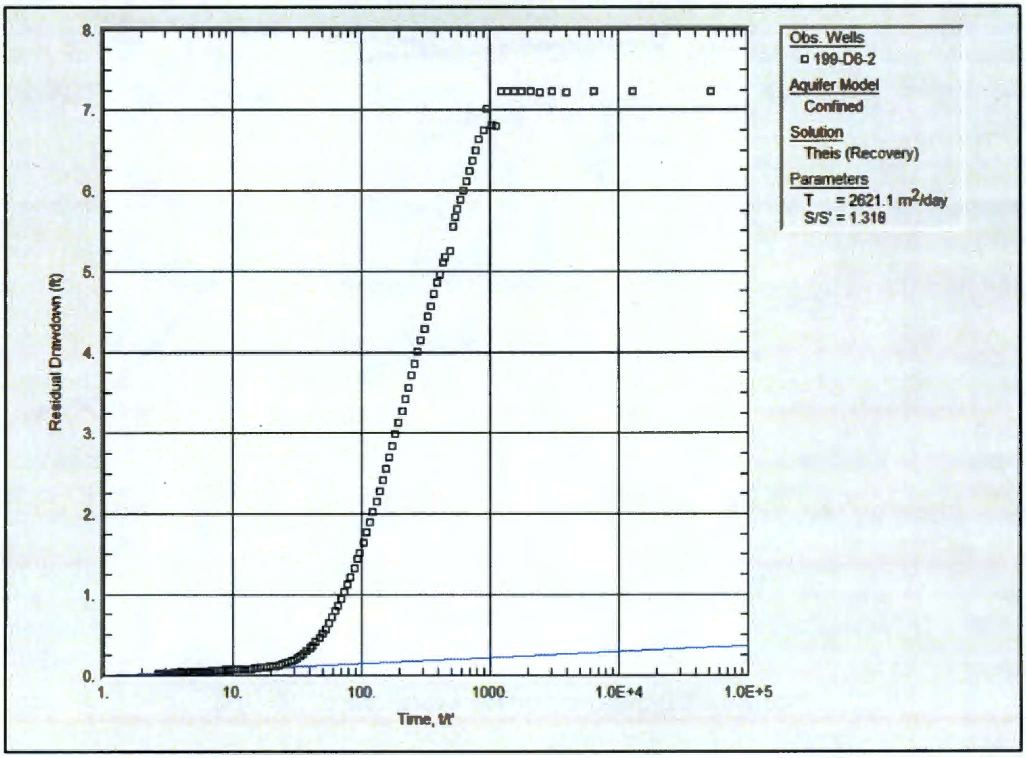


Figure 5-59. Theis Recovery Analysis at 199-D6-2

5.25.1 Summary of available data

The well was developed on April 21, 2010. The well was initially pumped at 53.8 gpm for 55 minutes, but only drawdown data were collected. The pump intake was then lowered, and the well was pumped initially at 41.8 gpm for 4 minutes. The pumping rate was then increased to 50.8 gpm and held steady for 69 minutes. The pump was then stopped, and the water level in the well was allowed to recover.

The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-60.

5.25.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-61, aquifer transmissivity is estimated to be 730 m^2/d. The water level in the well recovered faster than expected for an ideal aquifer, suggesting that an additional source of water replenishes the drawdown cone. Since the fits to the drawdown data with the Theis and Cooper-Jacob methods were not good, those estimates are not reported.

5.26 Analysis of Well Development Data at Well 199-D8-71

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *B2775_WD_199-D8-71_1996-08-22.xls*.

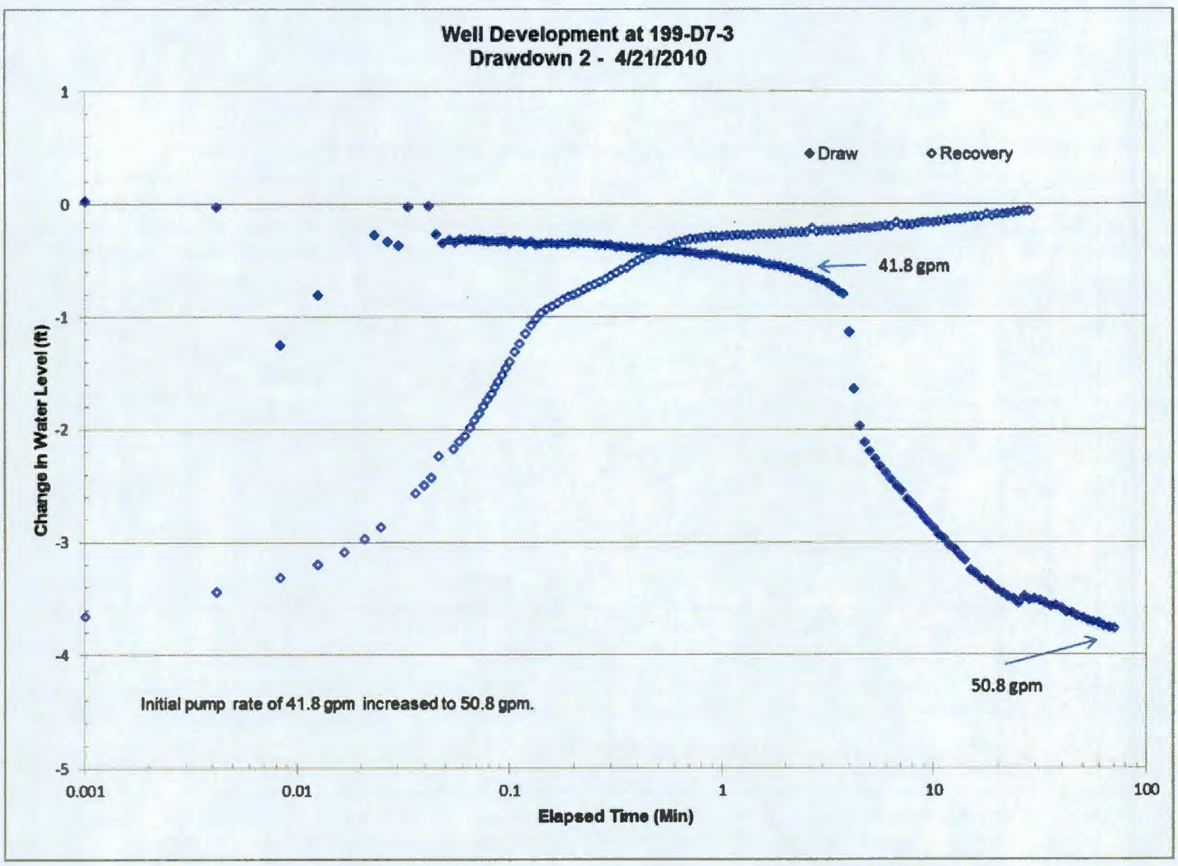


Figure 5-60. Drawdown and Recovery Data at 199-D7-3

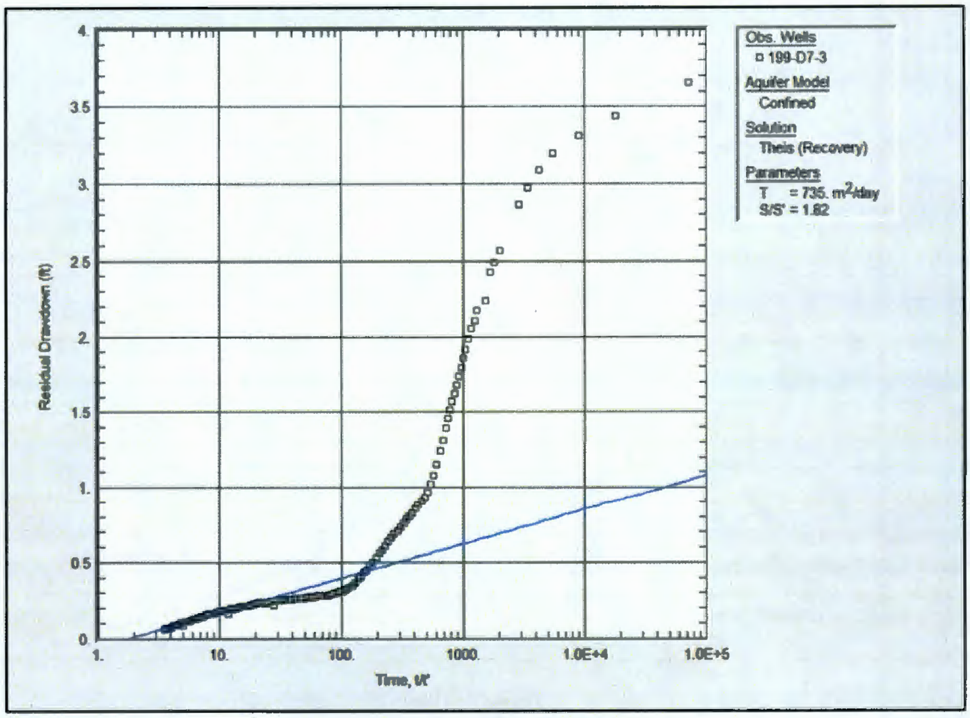


Figure 5-61. Theis Recovery Analysis at 199-D7-3

5.26.1 Summary of available data

The well was developed on August 22, 1996. The well was pumped at 97 gpm for 37 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-62.

5.26.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-63, aquifer transmissivity is estimated to be 150 m^2/d. The recovery plot shows that the recovery process is faster than expected for an ideal aquifer, suggesting that an additional source of water acts to replenish the drawdown cone.

5.27 Analysis of Well Development Data at Well 199-D8-90

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C7092_WD_199-D8-90_2010-01-28.xls*.

5.27.1 Summary of Available Data

The well was developed first on January 26, 2010 and then again on January 28, 2010. The well was initially pumped at 14.9 gpm (later increased to 14.96 gpm) for 40 minutes, but only drawdown data were collected. The pump intake was lowered on January 27, 2010. On January 28, 2010, the well was pumped at 32.9 gpm for 85 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period. Changes in the water level with time for the second test are shown in Figure 5-64. The data plotted in Figure 5-64 suggest that the well does not fully recover, but a permanent drawdown of about 0.3 ft is exhibited.

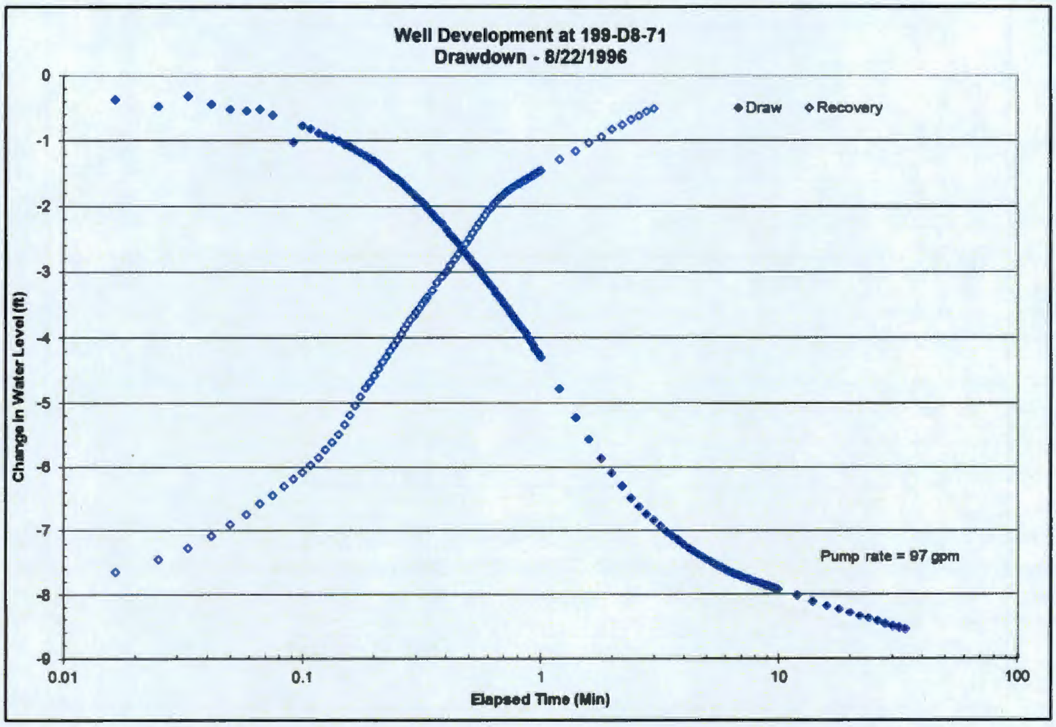


Figure 5-62. Drawdown and Recovery Data at 199-D8-71

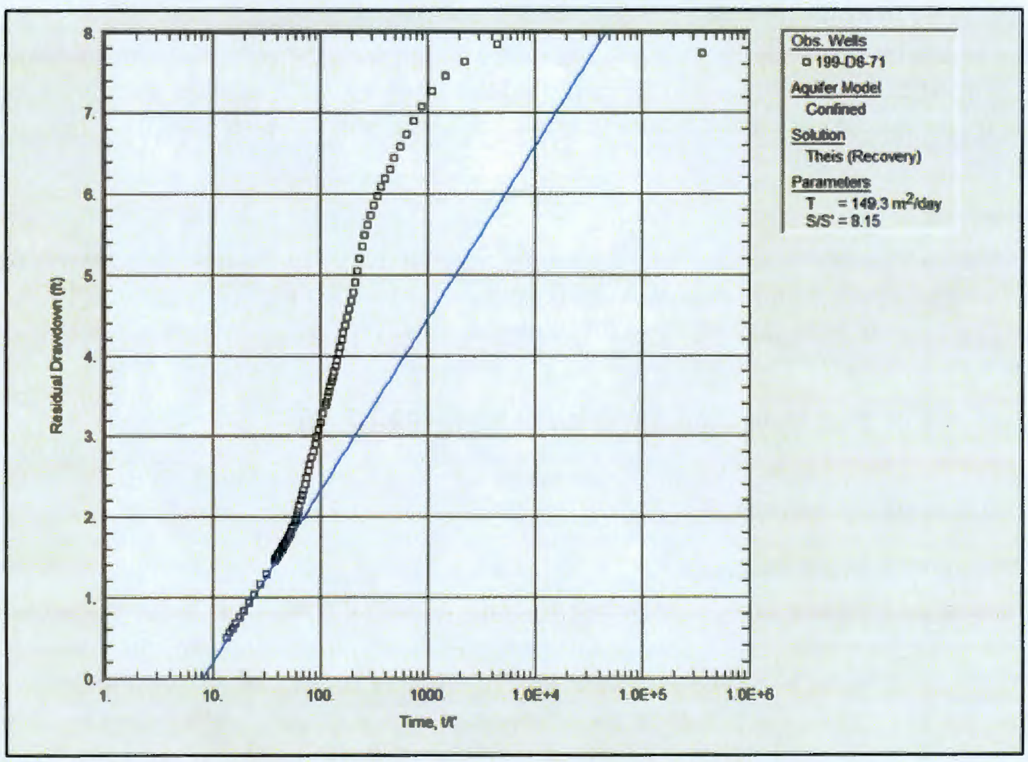


Figure 5-63. Theis Recovery Analysis at 199-D8-71

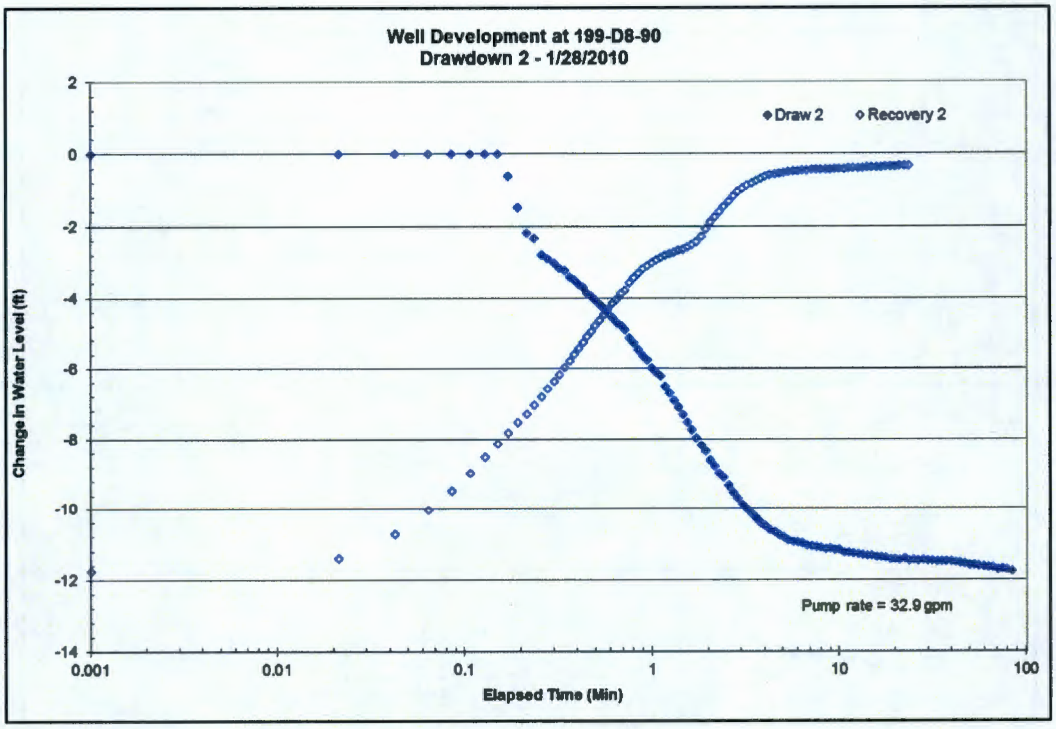


Figure 5-64. Drawdown and Recovery Data at 199-D8-90

5.27.2 Analysis

Consistent estimates of transmissivity are obtained between recovery data analysis with the Theis recovery method and drawdown data analysis with the Cooper-Jacob method. As shown in Figure 5-65, aquifer transmissivity is estimated to be 310 m^2/d.

5.28 Analysis of Well Development Data at Well 199-D8-91

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C7093_WD_199-D8-91_2010-01-26.xls*.

5.28.1 Summary of Available Data

The well was developed on January 26, 2010. The well was initially pumped at 29.9 gpm. Two minutes into the test, the pumping rate was reduced to 25 gpm and then increased to 29.9 gpm after 10 minutes and reduced later to 26.9 gpm. The pump was stopped after 85 minutes, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-66.

5.28.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-67, aquifer transmissivity is estimated to be 270 m^2/d. The late-time recovery data conform to the expected response for an ideal aquifer. Drawdown data were not analyzed because of the complicated pumping history.

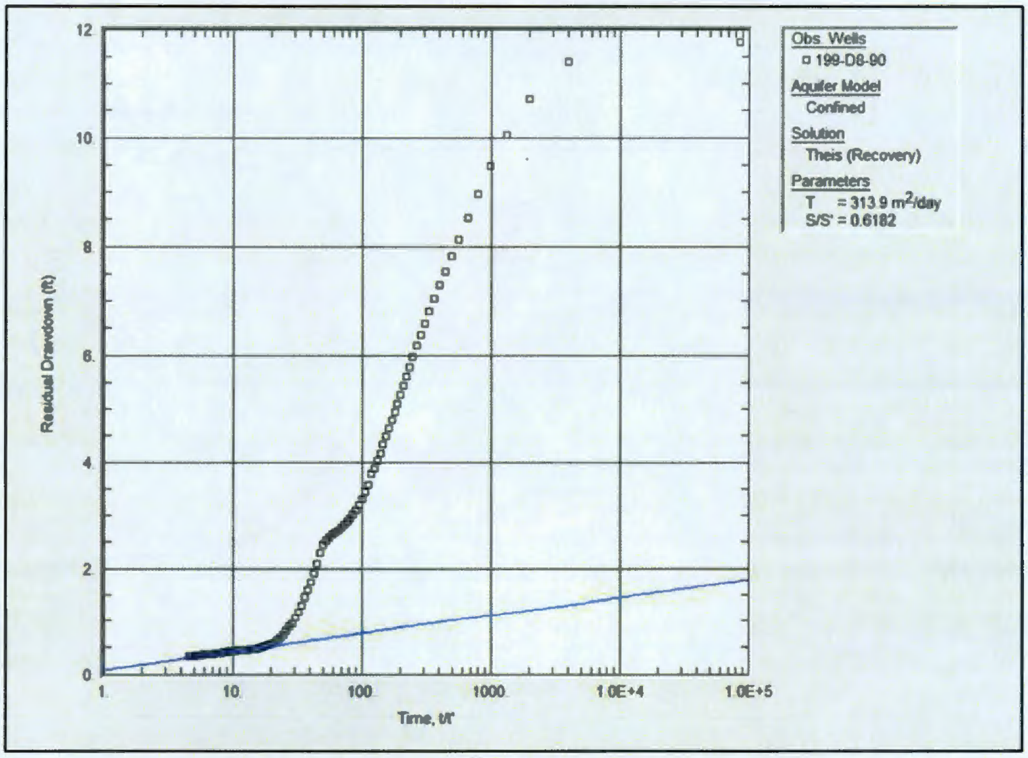


Figure 5-65. Theis Recovery Analysis at 199-D8-90 (1 of 2)

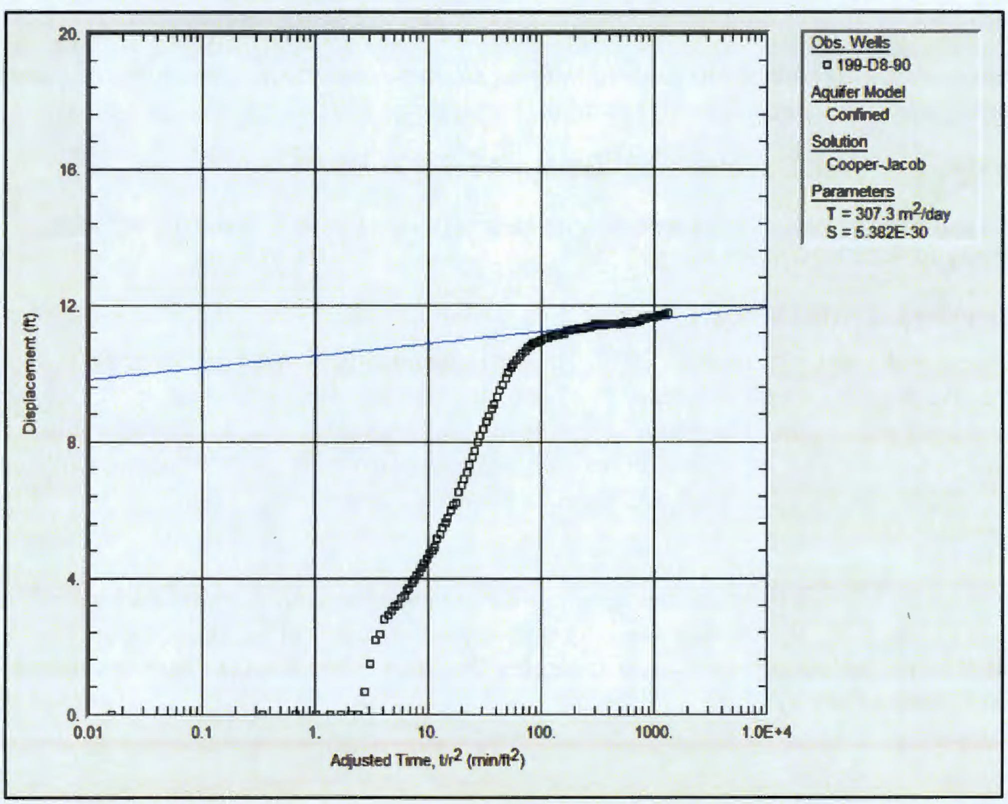


Figure 5-65. Cooper-Jacob Drawdown Analysis at 199-D8-90 (2 of 2)

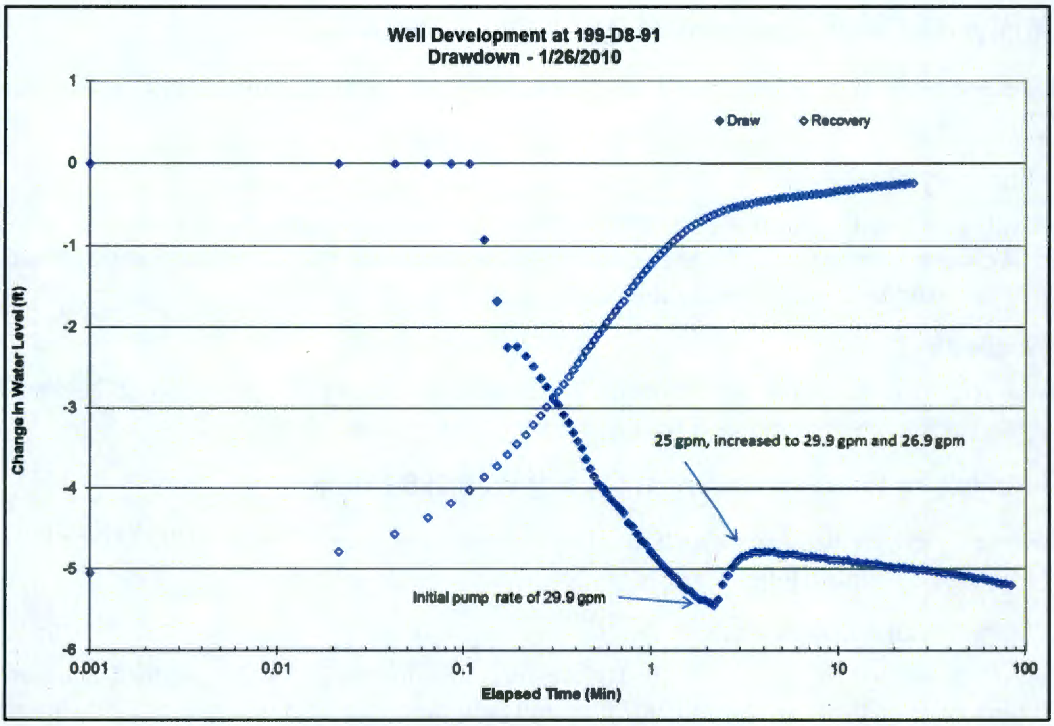


Figure 5-66. Drawdown and Recovery Data at 199-D8-91

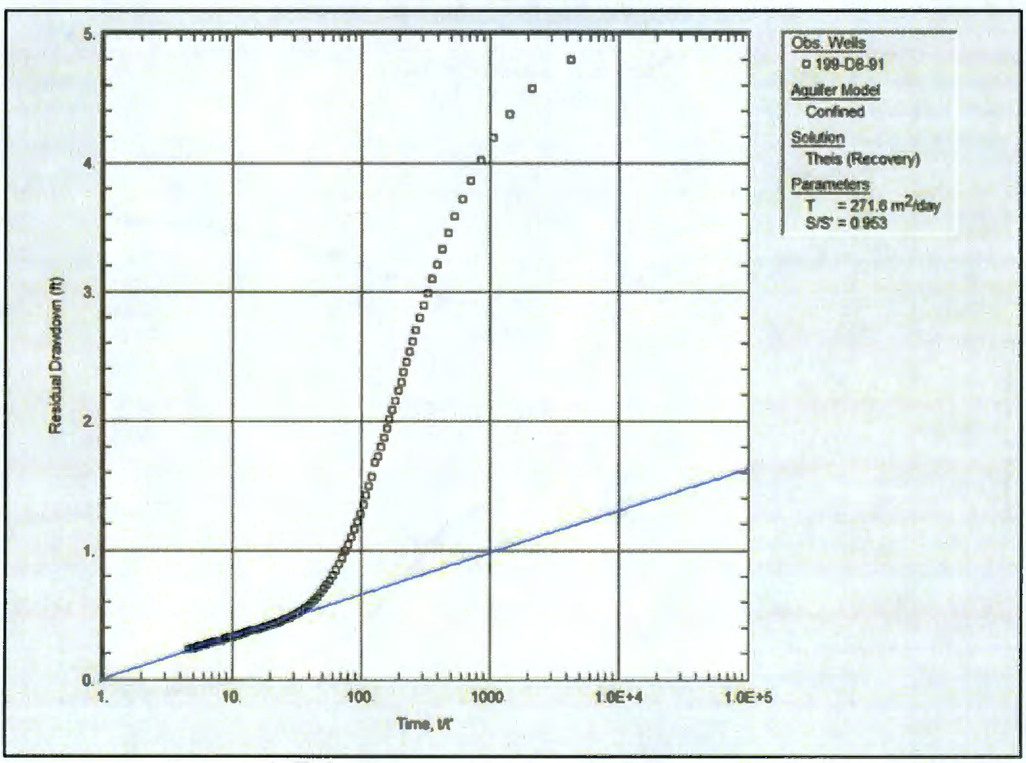


Figure 5-67. Theis Recovery Analysis at 199-D8-91

5.29 Analysis of Well Development Data at Well 199-D8-95

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C7589_WD_199-D8-95_2010-04-29.xlsx*.

5.29.1 Summary of Available Data

The well was developed on April 29, 2010. The well was pumped at 33 gpm for an hour and allowed to recover. The water level in the well was monitored during the drawdown and recovery periods, and changes in the water level with time are shown in Figure 5-68.

5.29.2 Analysis

A transmissivity estimate of 160 m^2/d is obtained from both the Cooper-Jacob analysis of the drawdown data and the Theis recovery analysis. The analyses are shown in Figure 5-69.

5.30 Analysis of Well Development Data at Well 199-D8-96

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C7603_WD_199-D8-96_2010-04-27.xlsx*.

5.30.1 Summary of Available Data

The well was developed on April 27, 2010. The well was initially pumped at 24 gpm for 5 minutes. The pumping rate was then increased to 34.2 gpm and held steady for 10 minutes. Finally, the pumping rate was increased to 38.8 gpm and held steady for 85 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-70.

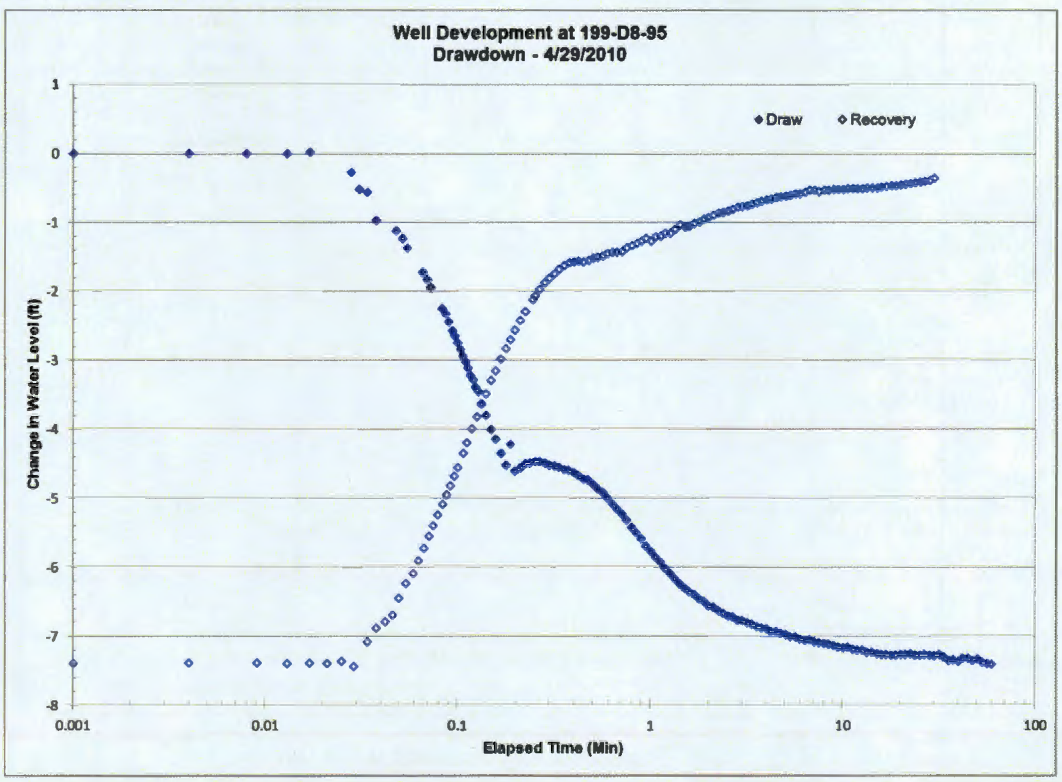


Figure 5-68. Drawdown 1 and Recovery Data at 199-D8-95

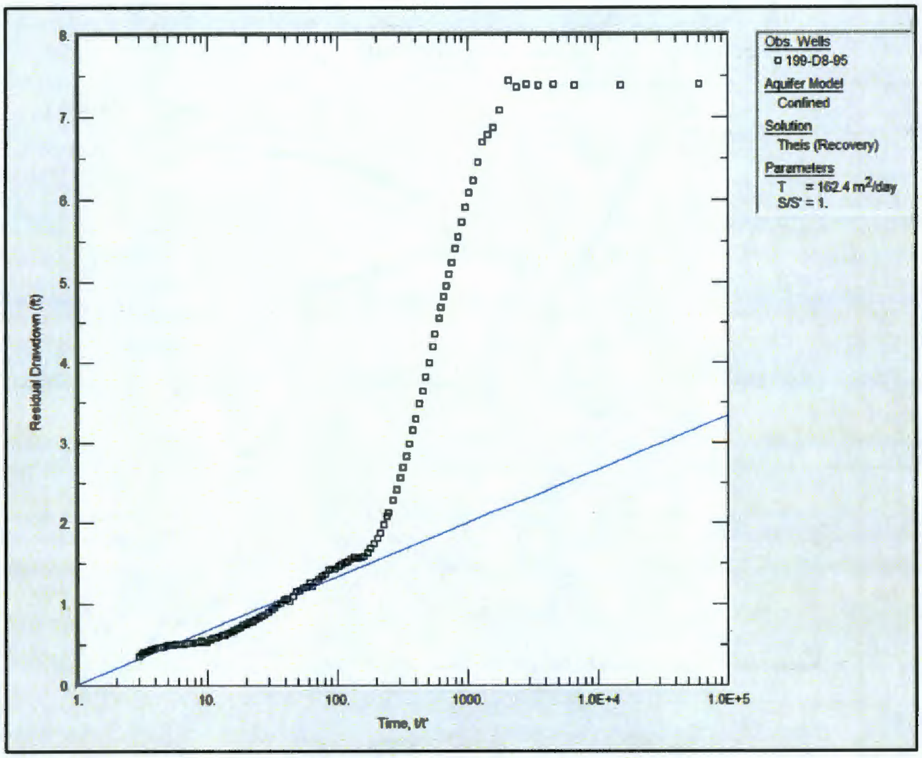


Figure 5-69. Theis Recovery Analysis at 199-D8-95 (1 of 2)

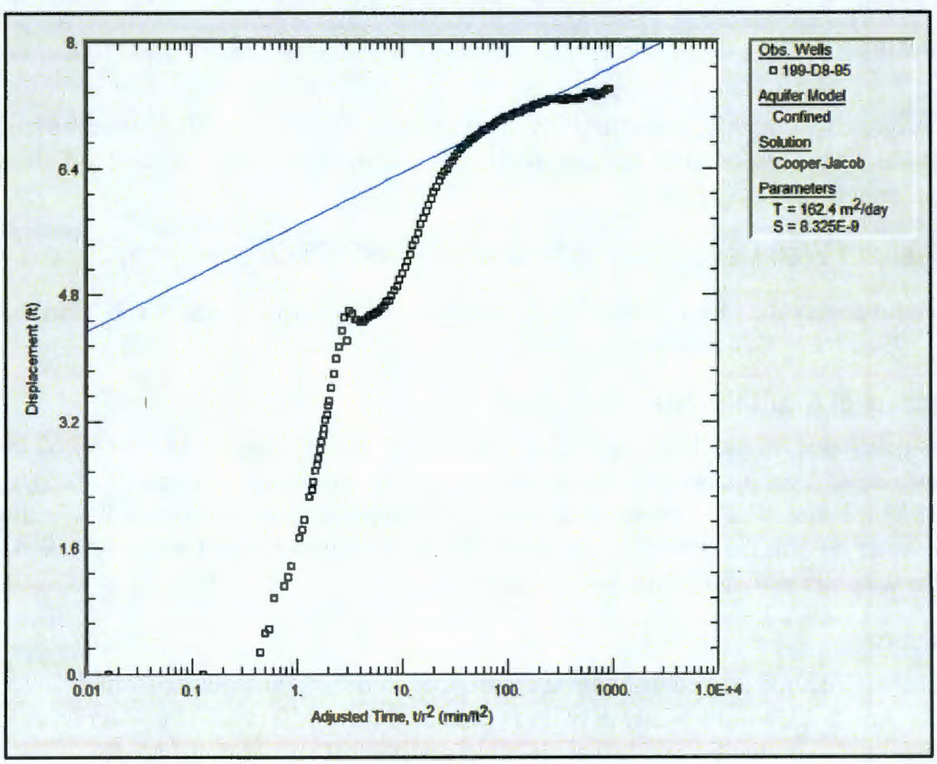


Figure 5-69. Cooper-Jacob Drawdown Analysis at 199-D8-95 (2 of 2)

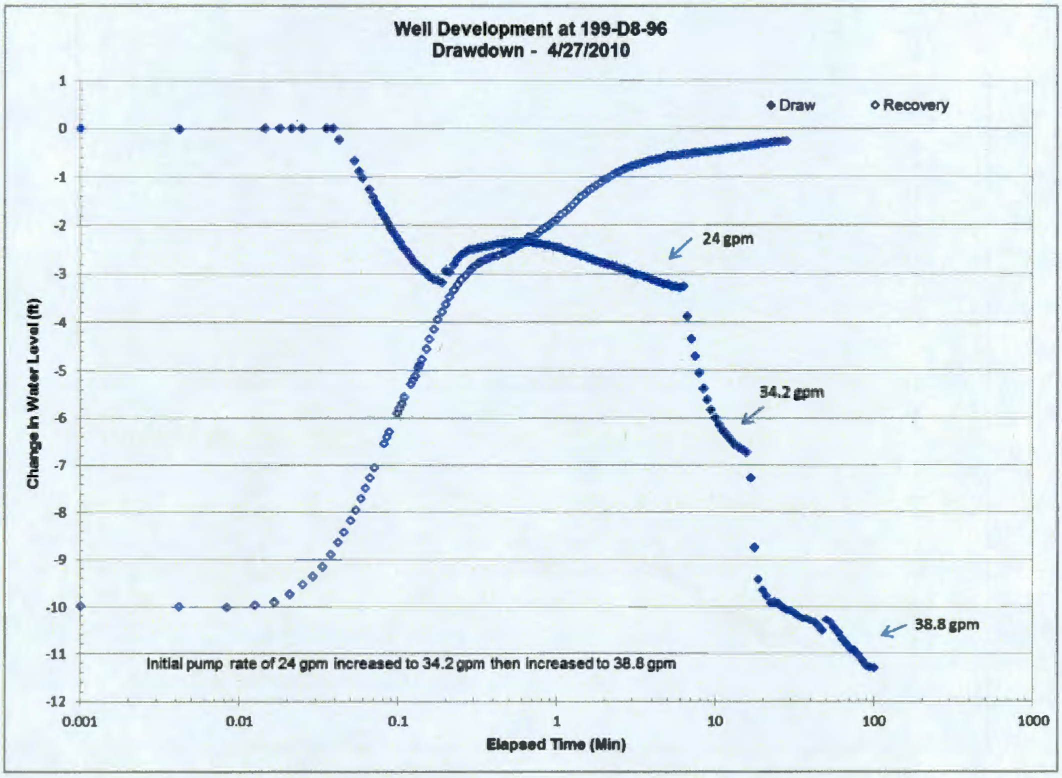


Figure 5-70. Drawdown and Recovery Data at 199-D8-96

5.30.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-71, aquifer transmissivity is estimated to be 300 m^2/d. The late-time recovery data conform to the expected response for an ideal aquifer. The drawdown data were hard to fit because of the complicated pumping history.

5.31 Analysis of Well Development Data at Well 199-D8-97

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C7582_WD_199-D8-97_2010-04-26.xls*.

5.31.1 Summary of Available Data

The well was developed on April 26, 2010. The well was initially pumped at 27 gpm for 60 minutes, but only drawdown data were collected. The pump intake was then raised by 10 ft, and the well was pumped at 18 gpm for 53 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-72.

5.31.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-73, aquifer transmissivity is estimated to be 130 m^2/d. The water level in the well recovers earlier than expected for an ideal aquifer, suggesting that an additional source of water replenishes the drawdown cone. Drawdown data were not analyzed because the water level dropped below the transducer during the test.

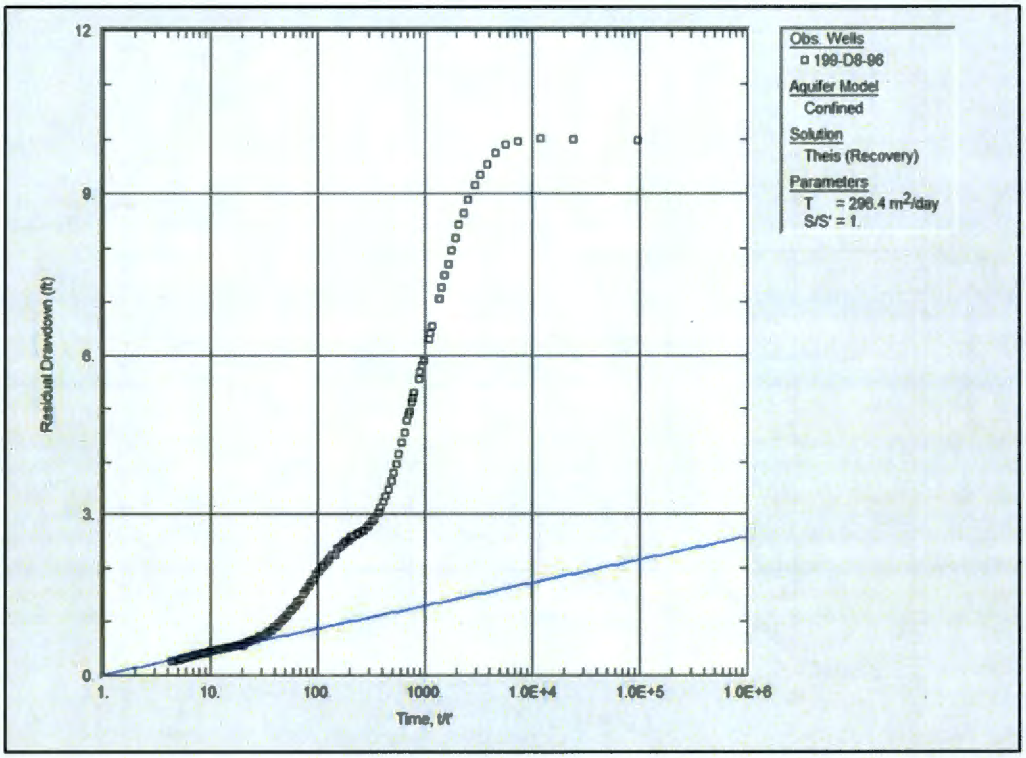


Figure 5-71. Theis Recovery Analysis at 199-D8-96

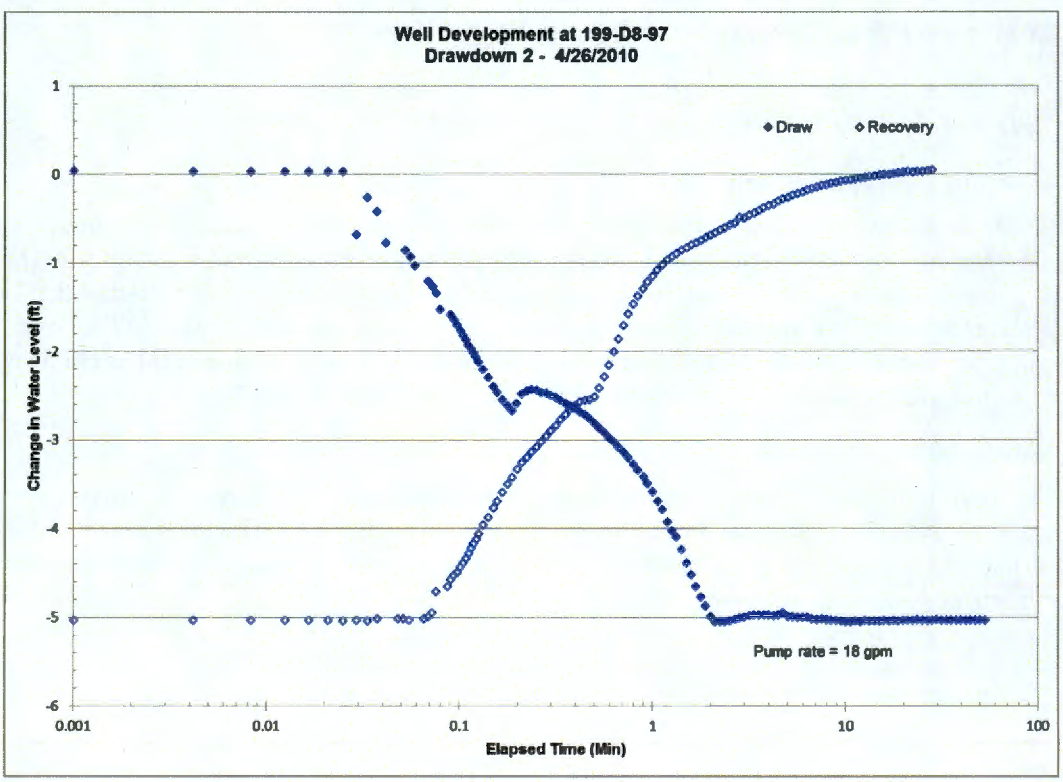


Figure 5-72. Drawdown and Recovery Data at 199-D8-97

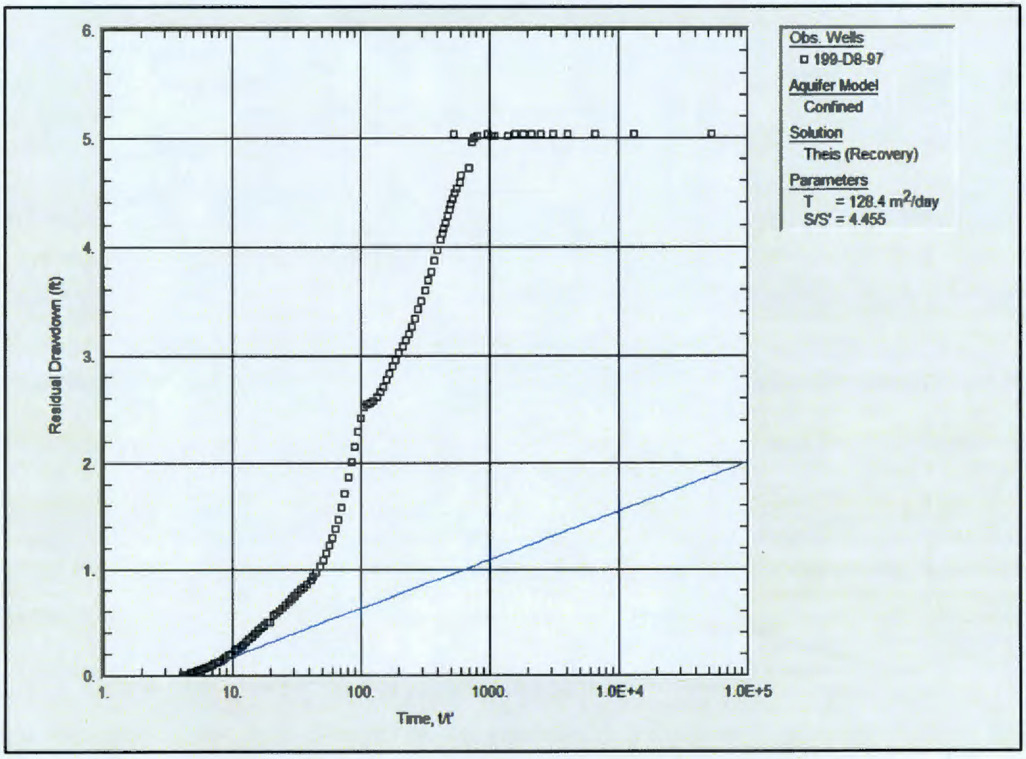


Figure 5-73. Theis Recovery Analysis at 199-D8-97

5.32 Analysis of Well Development Data at Well 199-H1-5

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C7610_WD_199-H1-5_2010-06-21.xls*.

5.32.1 Summary of available data

The well was developed on June 21, 2010. The well was initially pumped at 65.8 gpm for about 35 minutes, but only drawdown data were collected. The pump intake was then lowered by 5 ft. The well was then pumped at 74.8 gpm for about 70 minutes, but no data were collected for this test. After 2 hours, the well was pumped at 71.8 gpm for about 36 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-74.

5.32.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-75, aquifer transmissivity is estimated to be 790 m^2/d. The late-time recovery data are consistent with the response expected for an ideal aquifer. A similar estimate was obtained from a Cooper-Jacob analysis of the drawdown data.

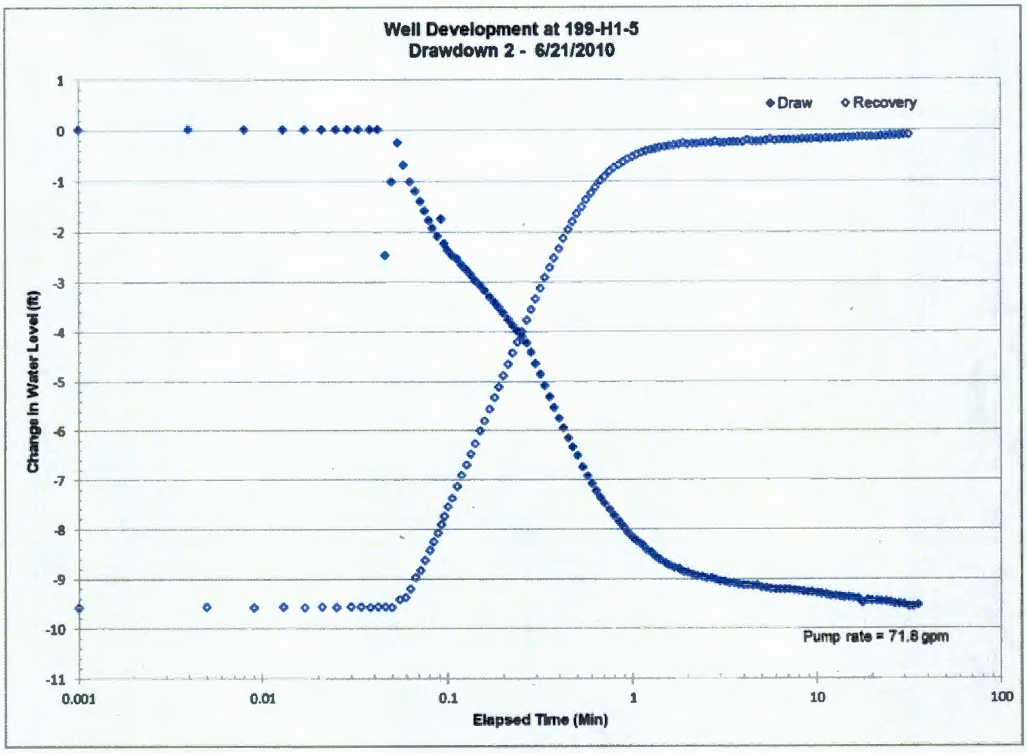


Figure 5-74. Drawdown and Recovery Data at 199-H1-5

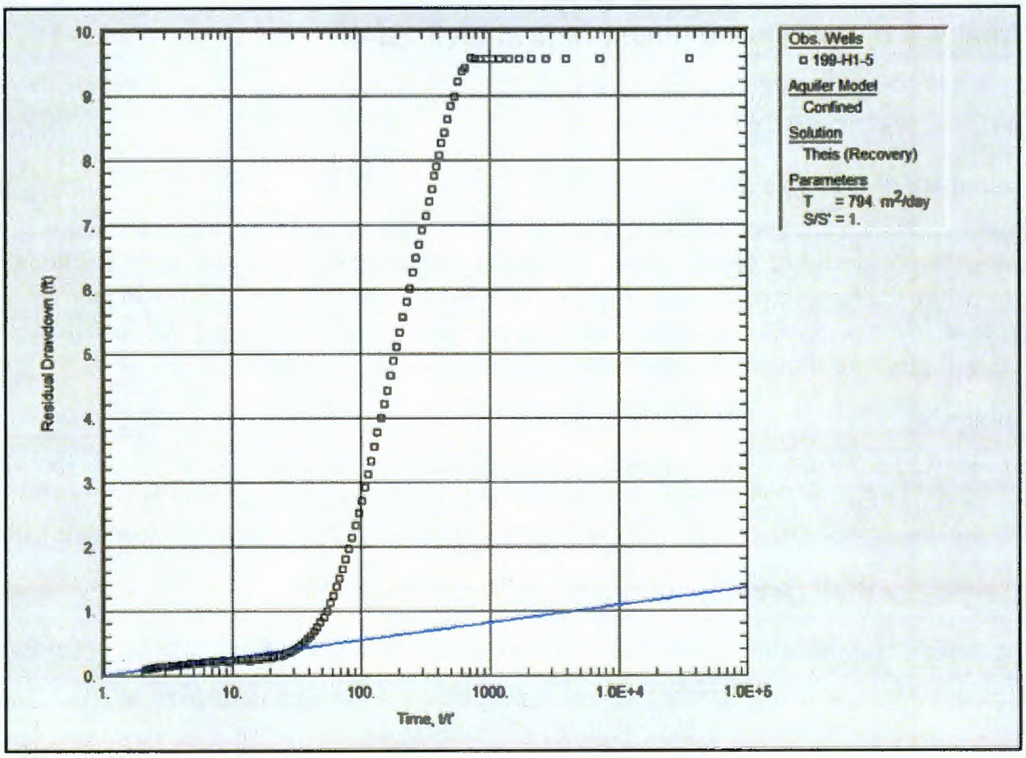


Figure 5-75. Theis Recovery Analysis at 199-H1-5 (1 of 2)

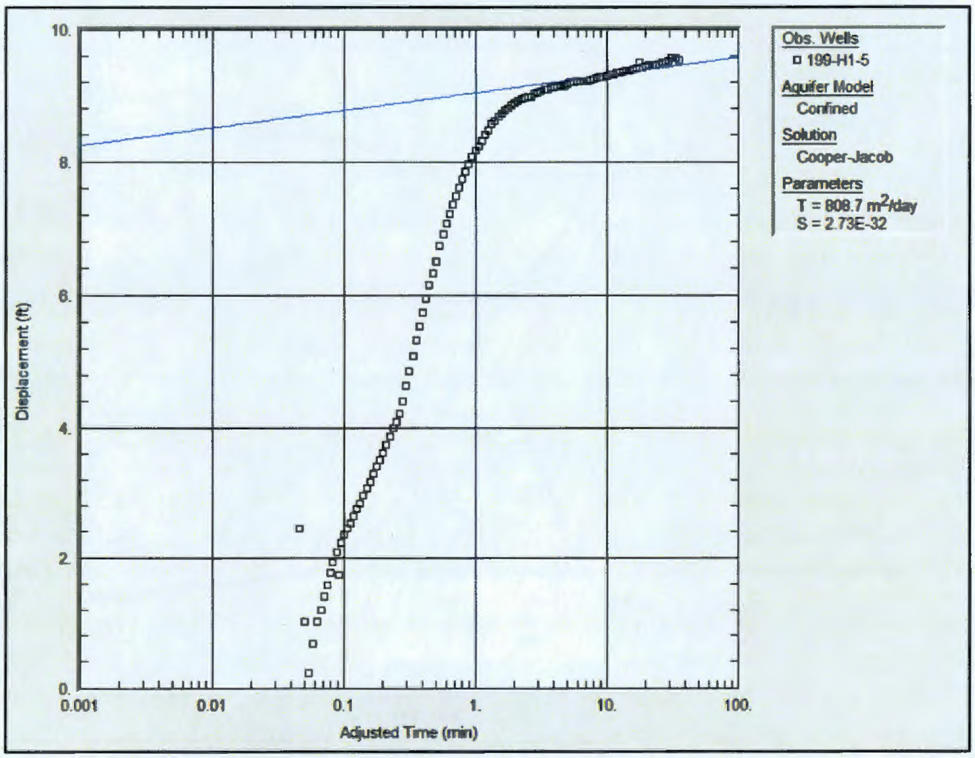


Figure 5-75. Cooper-Jacob Drawdown Analysis at 199-H1-5 (2 of 2)

5.33 Analysis of Well Development Data at Well 199-H3-10

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C7640_WD_199-H3-10_2011-04-28.xls*.

5.33.1 Summary of available data

The well was developed on April 28, 2011. The well was initially pumped at 24 gpm for about 115 minutes, then reduced to 20 gpm to trade out the purge truck. It was pumped for an additional 92 minutes before the pump was stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-76.

5.33.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity of 20 m^2/d. The Theis recovery analysis is shown in Figure 5-77. A similar transmissivity estimate is obtained from the Cooper-Jacob analysis of the drawdown data, which were not analyzed because of uncertainty in the pumping history.

5.34 Analysis of Well Development Data at Well 199-H3-27

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C7114_WD_199-H3-27_2009-09-25.xls*.

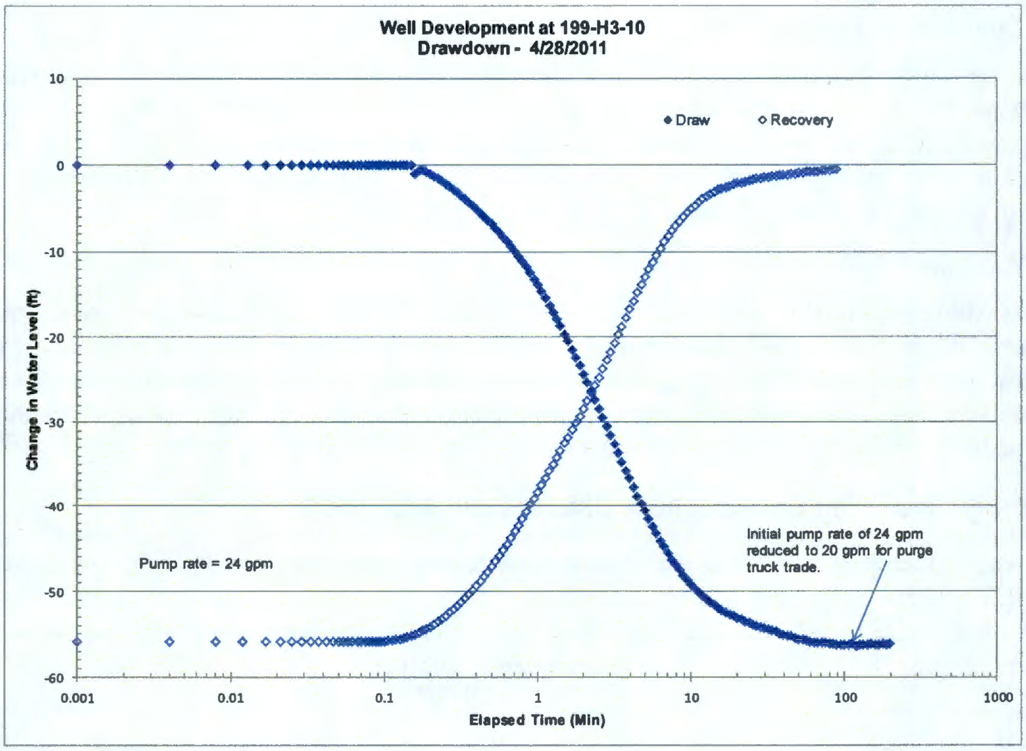


Figure 5-76. Drawdown and Recovery Data at 199-H3-10

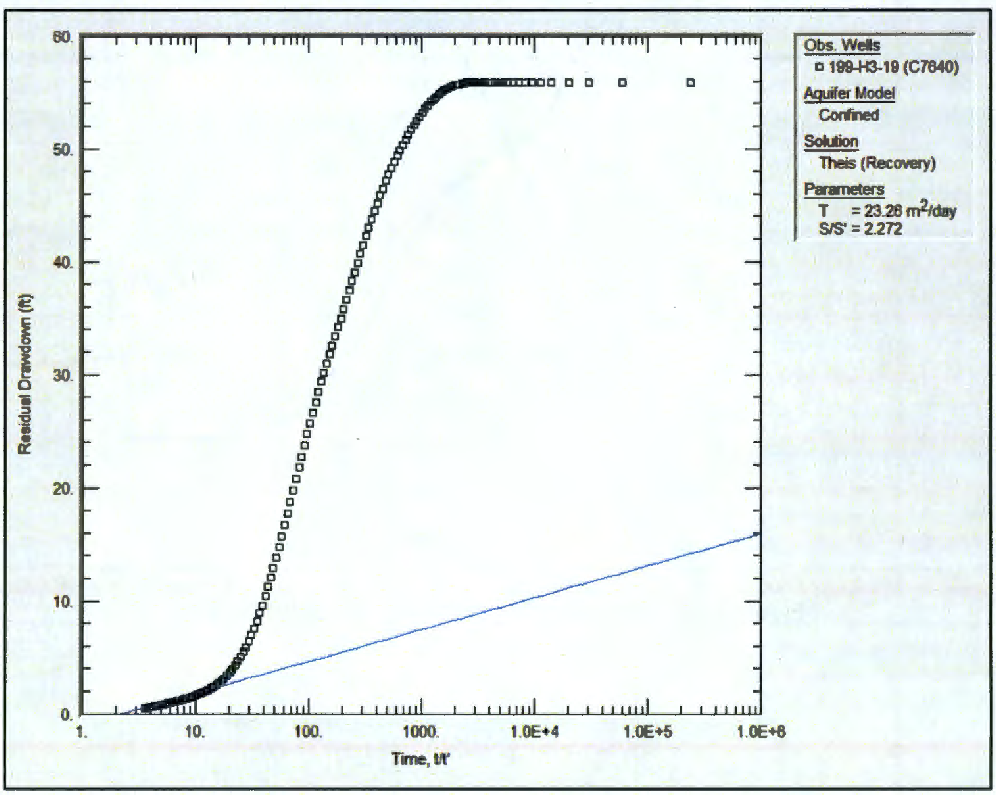


Figure 5-77. Theis Recovery Analysis at 199-H3-10

5.34.1 Summary of Available Data

The well was developed on September 25, 2009. Initially, the pump was operated at 42.5 gallons per minute (gpm) for 18 minutes after which time the pumping rate was reduced to 37 gpm and held steady for about 57 minutes. At this time, the pump was stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-78.

5.34.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-79, aquifer transmissivity is estimated to be 1,200 m^2/d. Water levels in the well recover earlier than expected, suggesting that an external source of water replenishes the drawdown cone. Transmissivity estimates from the drawdown data were two orders of magnitude higher, which are unrealistic for the 100-H Area. Hence, only the recovery based estimate is reported.

5.35 Analysis of Well Development Data at Well 199-H4-81

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C7596_WD_199-H4-81_2010-06-24.xls*.

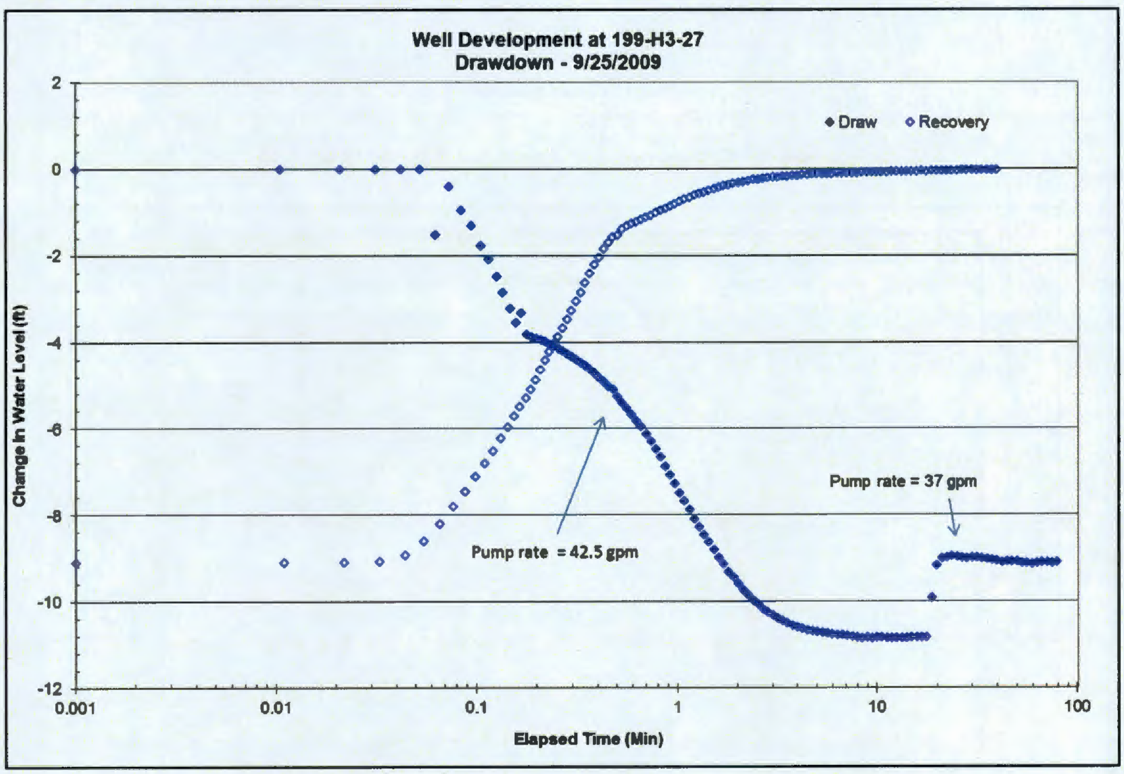


Figure 5-78. Drawdown and Recovery Data at 199-H3-27

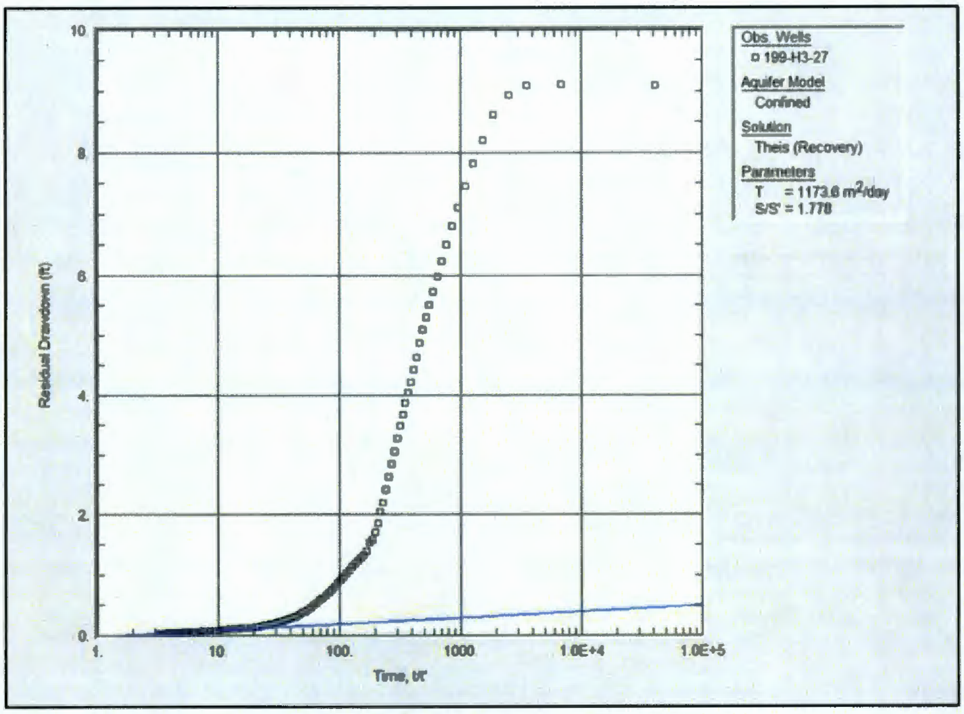


Figure 5-79. Theis Recovery Analysis at 199-H3-27

5.35.1 Summary of Available Data

The well was developed on June 24, 2010. The well was pumped at 60 gpm for about 60 minutes. About 20 minutes into the test, the generator stopped working briefly, but the driller restarted it and pumping resumed. Then the pump was stopped, and the water level in the well was allowed to recover. It was noted that the upper interval of the well could not be developed with the pump that was available, and only the lower interval was developed. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-80.

5.35.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-81, aquifer transmissivity is estimated to be 730 m^2/d. The late-time recovery data are consistent with the response expected for an ideal aquifer. The drawdown data were not analyzed because the water levels may have dropped below the transducer during the test.

5.36 Analysis of Well Development Data at Well 199-H4-82

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C7609_WD_199-H4-82_2010-06-23.xls*.

5.36.1 Summary of Available Data

The well was developed on June 23, 2010. The well was initially pumped at 50 gpm. About 15 minutes into the test, the pumping rate was reduced to 38.8 gpm to reduce drawdown. The well was then pumped at the lower rate for another 55 minutes, before the pump was stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-82.

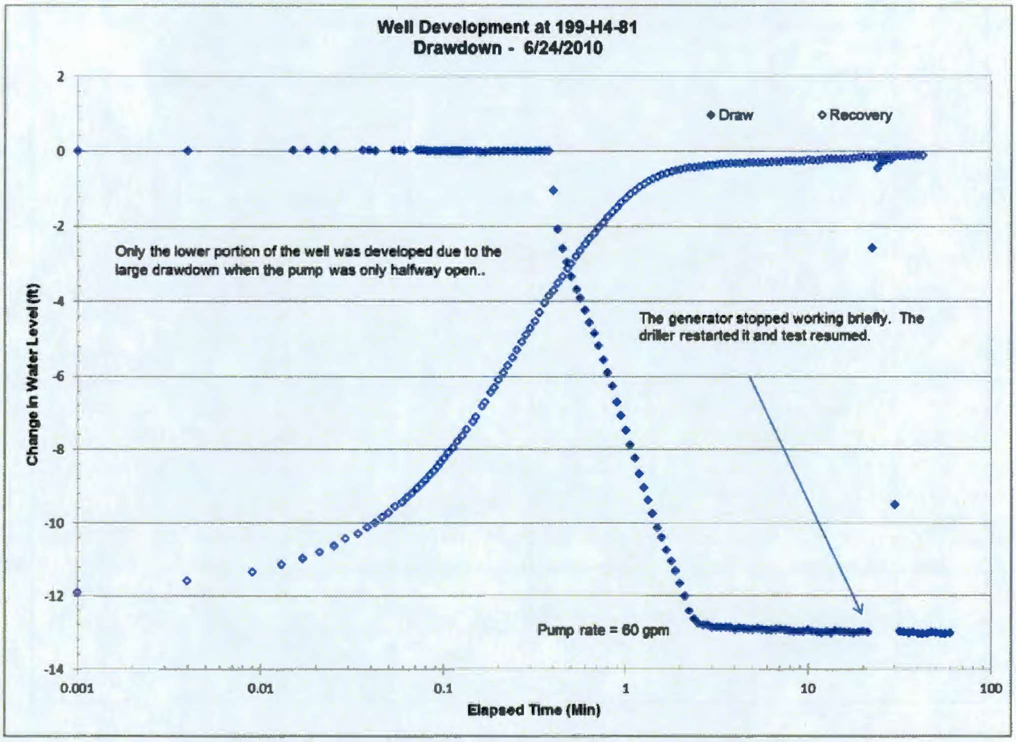


Figure 5-80. Drawdown and Recovery Data at 199-H4-81

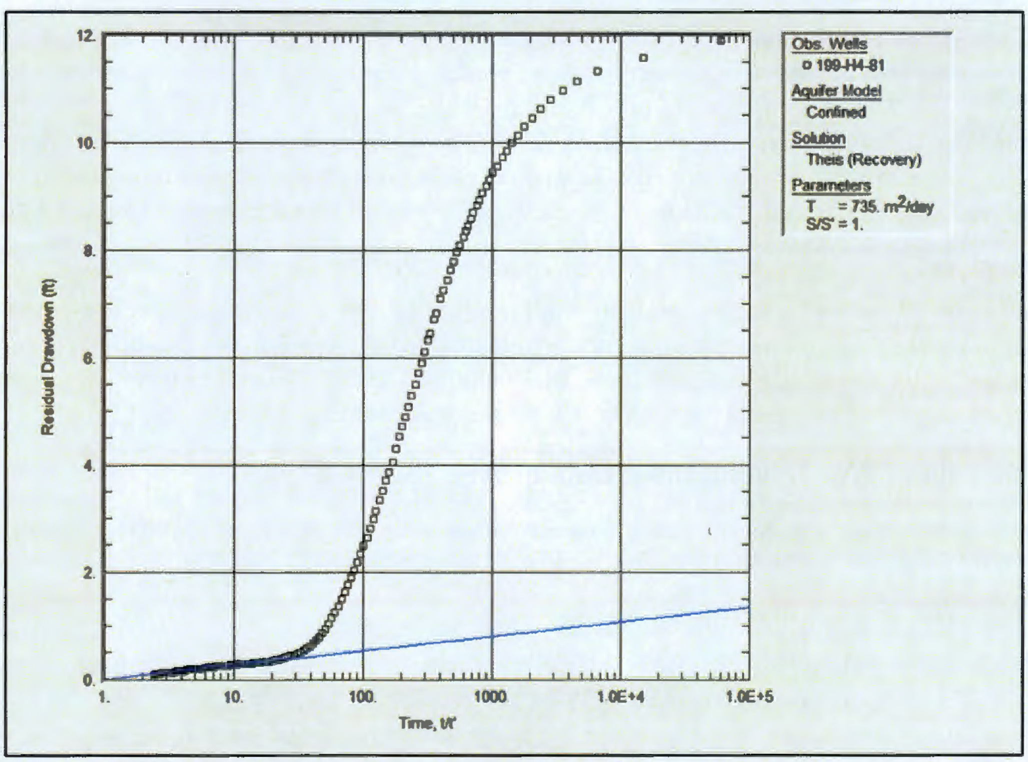


Figure 5-81. Theis Recovery Analysis at 199-H4-81

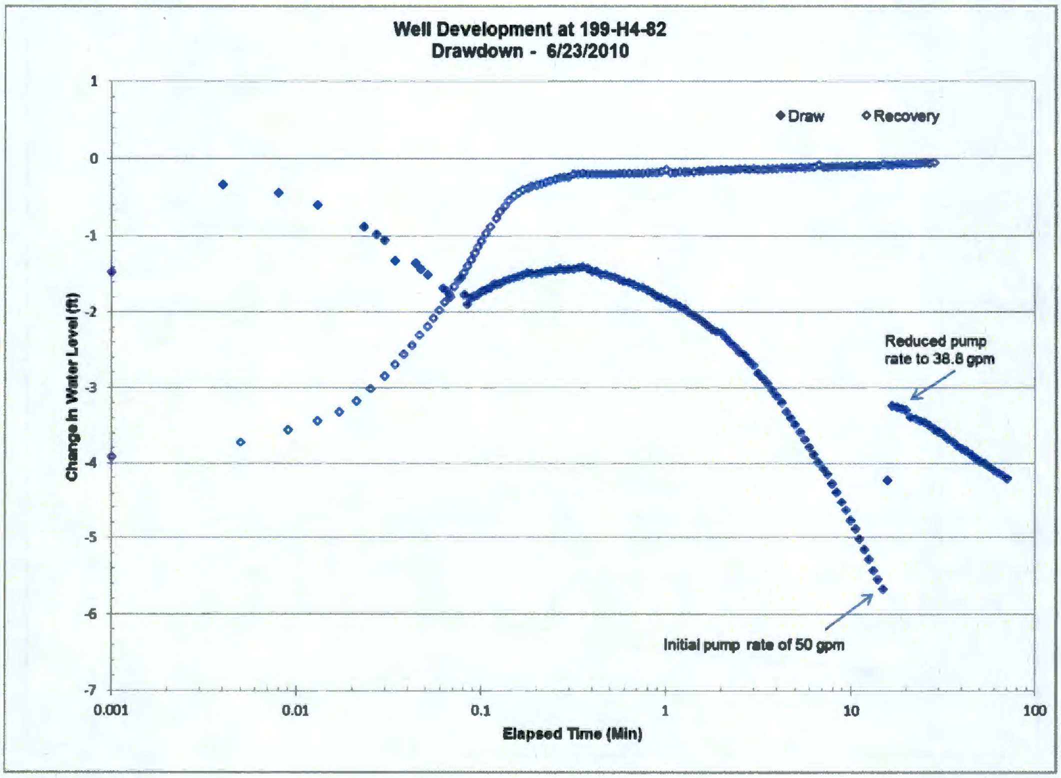


Figure 5-82. Drawdown and Recovery Data at 199-H4-82

5.36.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-83, aquifer transmissivity is estimated to be 1,300 m^2/d. The late-time recovery data are consistent with the response expected for an ideal aquifer. The fits to the drawdown data were not good; hence, only the recovery-based estimate is reported.

5.37 Analysis of Well Development Data at Well 199-H5-1A

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *A4641_WD_199-H5-1A_1992-04-17.xls*.

5.37.1 Summary of Available Data

The well was developed on April 17, 1992. The well was pumped at 13.16 gpm for about 70 minutes. Then the pump was stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-84.

5.37.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-85, aquifer transmissivity is estimated to be 650 m^2/d. The late-time recovery data are consistent with the response expected for an ideal aquifer. The transmissivity estimates from the drawdown data were two orders of magnitude higher, which are unrealistic for the 100-H Area. Hence, only the recovery-based estimate is reported.

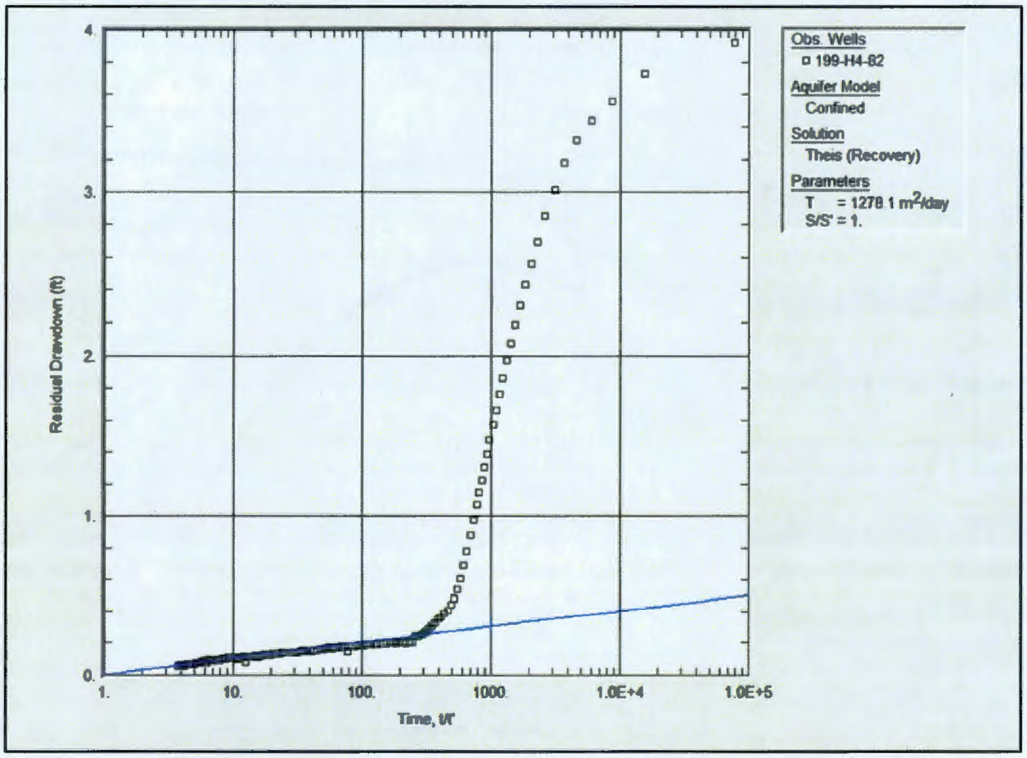


Figure 5-83. Theis Recovery Analysis at 199-H4-82

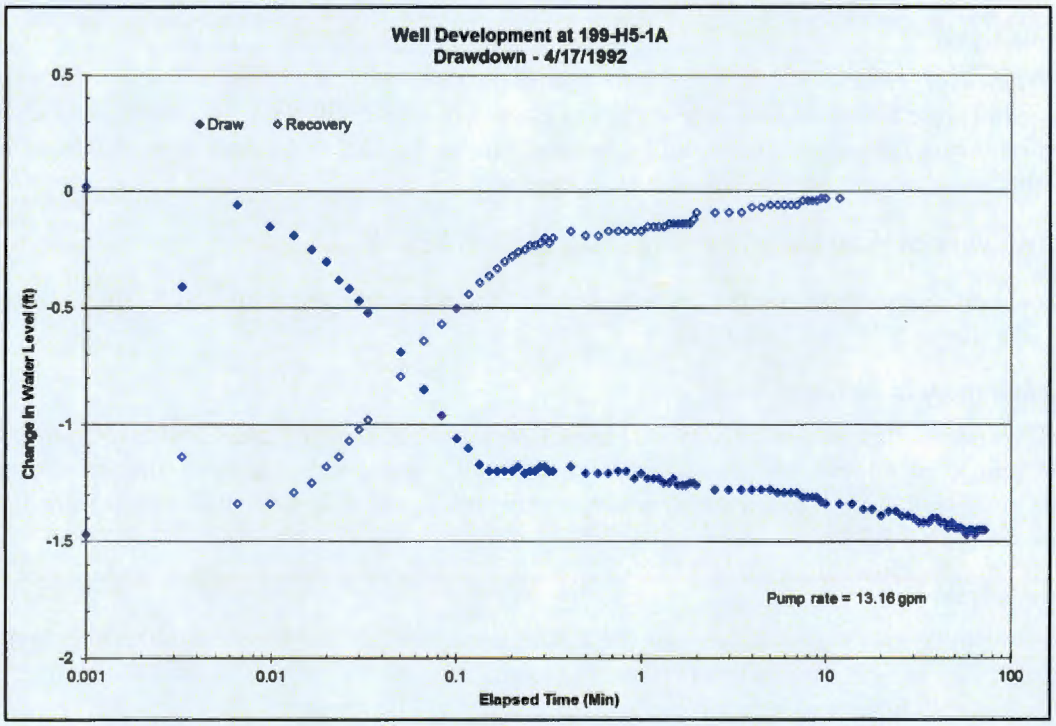


Figure 5-84. Drawdown and Recovery Data at 199-H5-1A

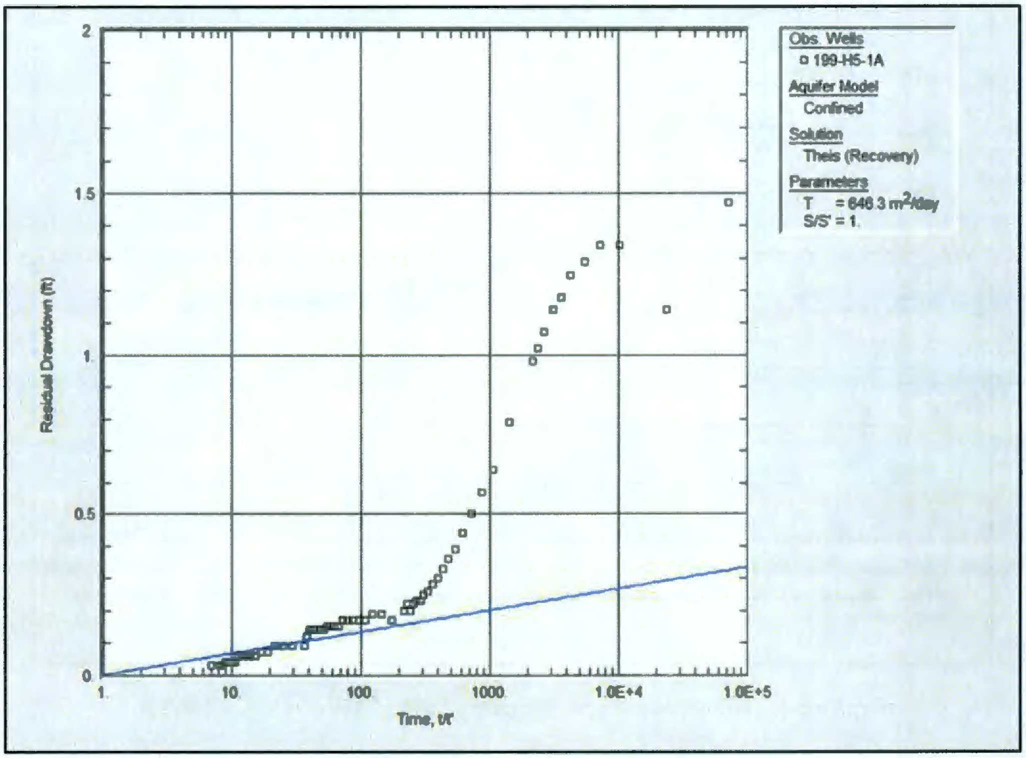


Figure 5-85. Theis Recovery Analysis at 199-H5-1A

5.38 Analysis of Well Development Data at Well 199-K-119A

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *B2806_WD_199-K-119A_1996-10-17.xls*.

5.38.1 Summary of Available Data

The well was developed on October 17, 1996. The well was initially pumped at 22 gpm for about 13 minutes, then increased to 45 gpm for 44 minutes. The well was allowed to recover, and then the pump intake was raised 10 ft. A second drawdown test was performed at 50 gpm for 13 minutes. After recovery, the pump intake was raised 10 ft, and a third drawdown test was performed at 50 gpm for 20 minutes. After pumping the intake was raised another 10 ft. A fourth drawdown test was performed by pumping at 68 gpm for 29 minutes. The pump was then stopped and the water level in the well was allowed to recover. The water level in the well was monitored during the four drawdown and recovery periods and the changes in the water level with time are shown in Figures 5-86, 5-87, 5-88, and 5-89.

Transmissivity estimates have been developed from the drawdown data by matching the data with the Theis solution and with a Cooper-Jacob analysis. The Theis recovery method is used to analyze the recovery data. The transmissivity estimates from the Cooper-Jacob analyses and recovery data are high and not considered reliable. The final transmissivity estimates are obtained from matches of the drawdown with the Theis solution.

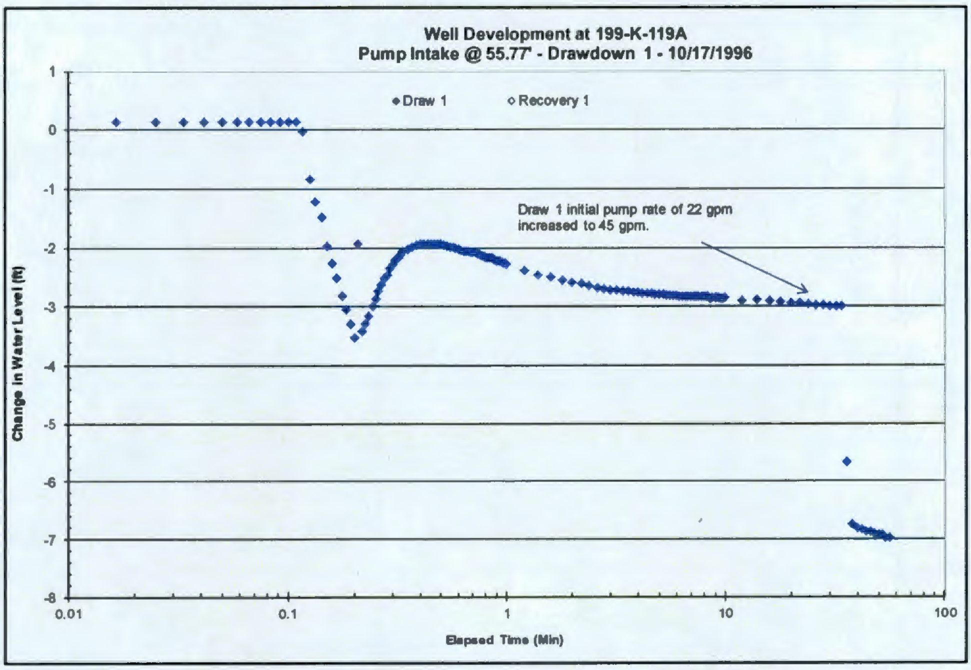


Figure 5-86. Drawdown 1 and Recovery Data at 199-K-119A Analysis

The transmissivity estimates developed from the drawdown intervals vary over a relatively narrow range:

- Draw1: $T = 157.2\ m^2/d$
- Draw2: $T = 143.3\ m^2/d$
- Draw3: $T = 150.1\ m^2/d$
- Draw4: $T = 124.9\ m^2/d$

The "most representative" estimate of transmissivity is estimated as the arithmetical average of the four estimates, 140 m^2/d. The Theis analysis for Draw2 yields a value almost identical to the average, so the results for this analysis are reproduced here in Figure 5-90.

5.39 Analysis of Well Development Data at Well 199-K-125A

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *B8559_WD_199-K-125A_1998-08-08.xls*.

5.39.1 Summary of Available Data

The well was developed on August 8, 1998. During "Drawdown 1" the well was initially pumped at 30 gpm for about 24 minutes. During "Drawdown 2" the well was pumped at 41 gpm for 44 minutes. Pumping stopped due to a full purge truck and the well was allowed to recover. During "Drawdown 3" the well was pumped at 56 gpm for 38 minutes then reduced to 55 gpm for 11 minutes before the pump was shut off and the well was allowed to recover. During "Drawdown 4" the well was initially pumped at 45 gpm for 33 minutes then reduced to 44 gpm for 4 minutes before recovery. For the final drawdown, the pump intake was raised to 51.7 ft. The pump was run at 45 gpm for 22 minutes, then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the five drawdown and recovery periods and the changes in the water level with time are shown in Figures 5-91, 5-92, and 5-93.

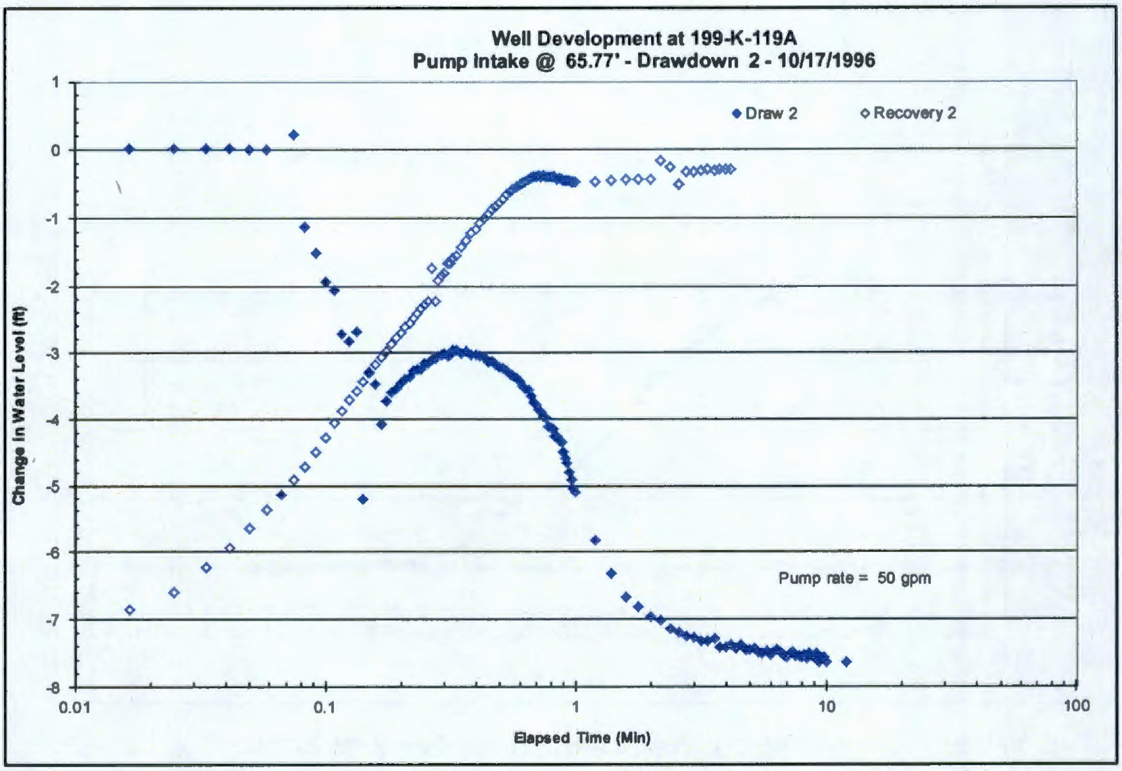


Figure 5-87. Drawdown 2 and Recovery Data at 199-K-119A

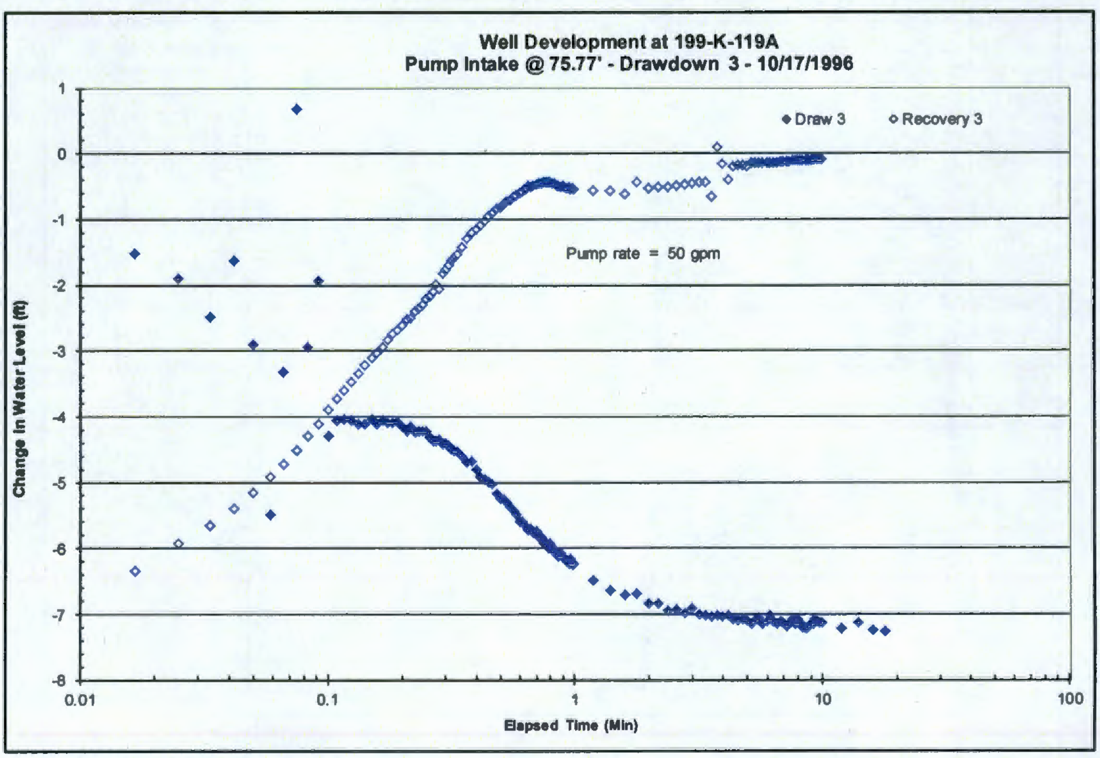


Figure 5-88. Drawdown 3 and Recovery Data at 199-K-119A

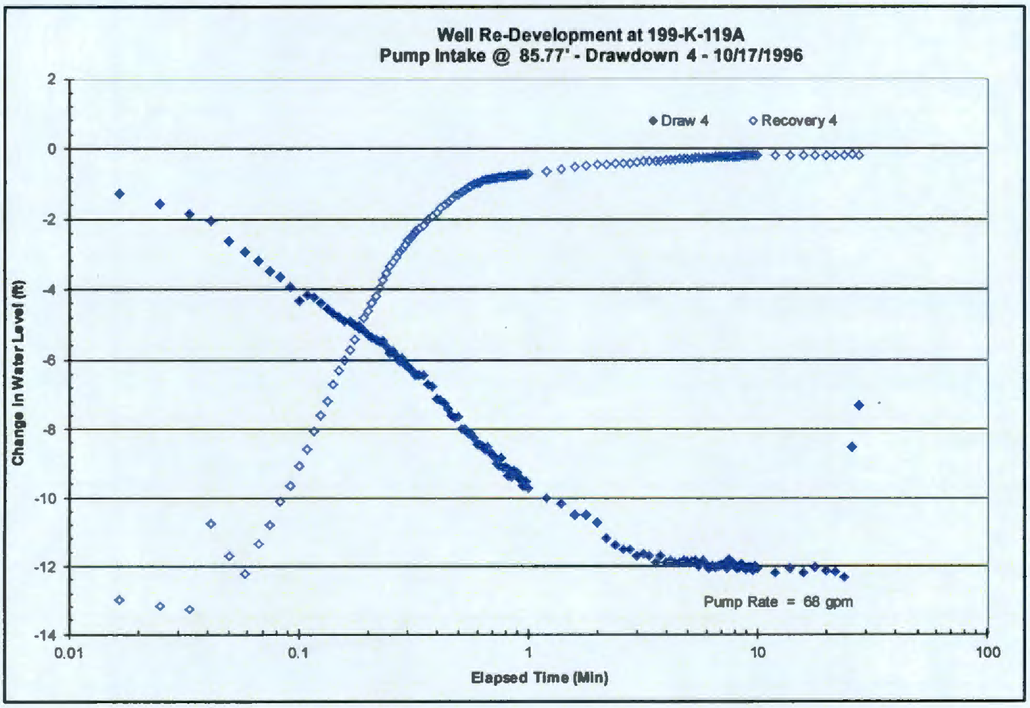


Figure 5-89. Drawdown 4 and Recovery Data at 199-K-119A

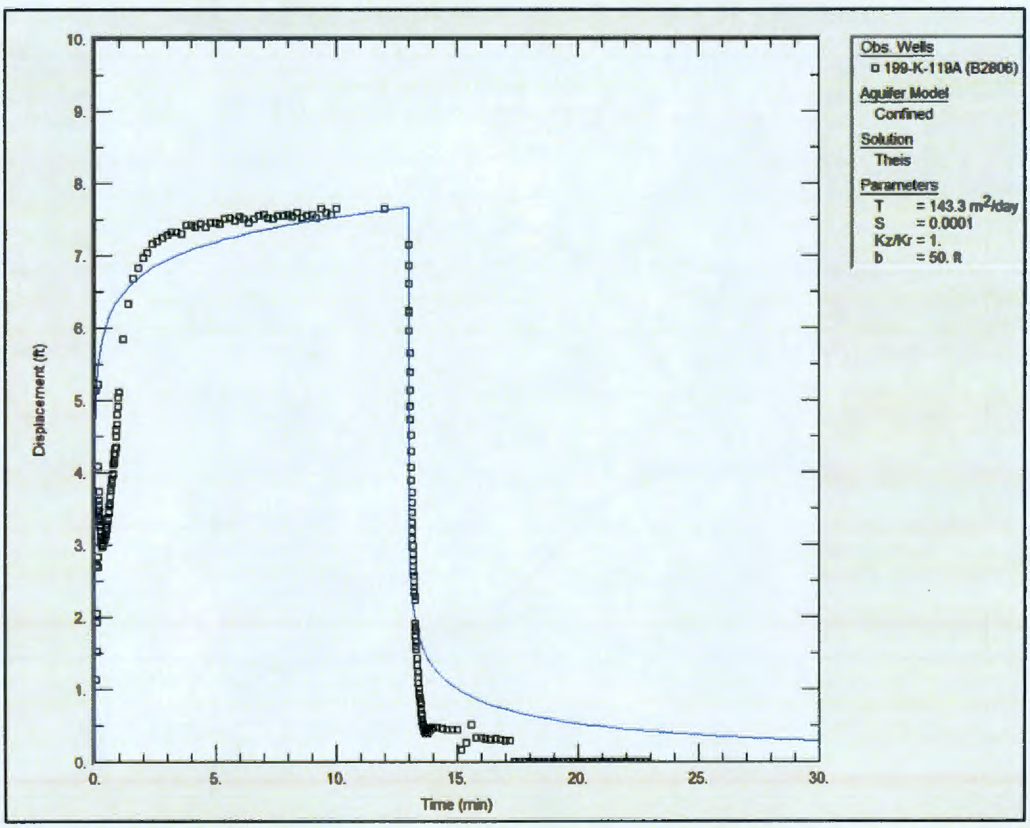


Figure 5-90. Theis Drawdown Analysis at 199-K-119A

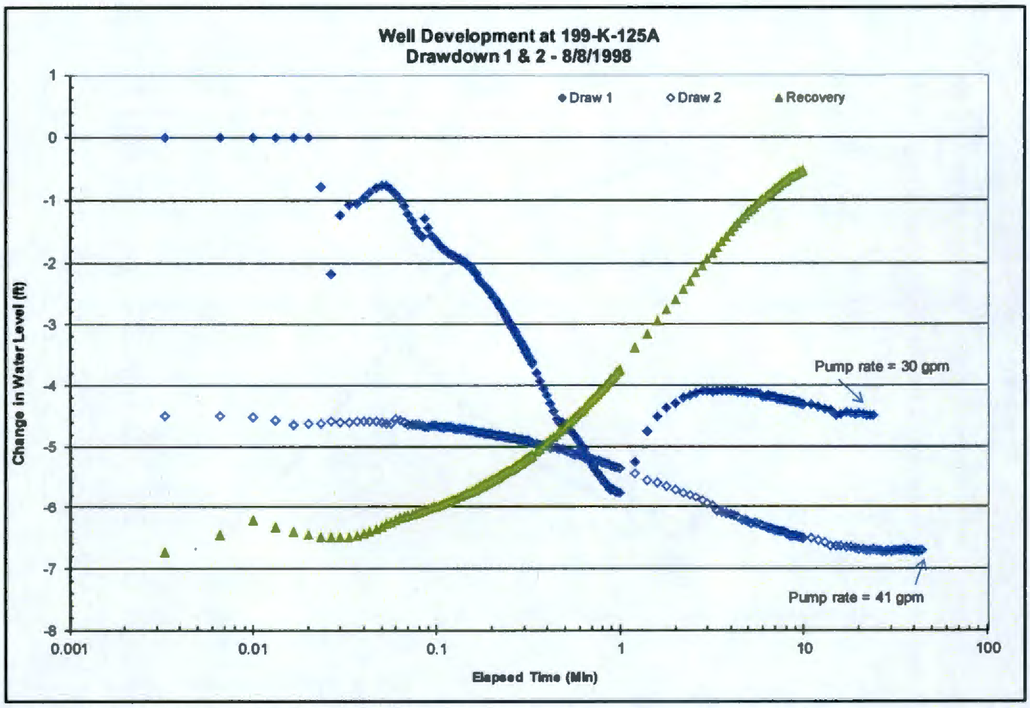


Figure 5-91. Drawdown 1 & 2 and Recovery Data at 199-K-125A

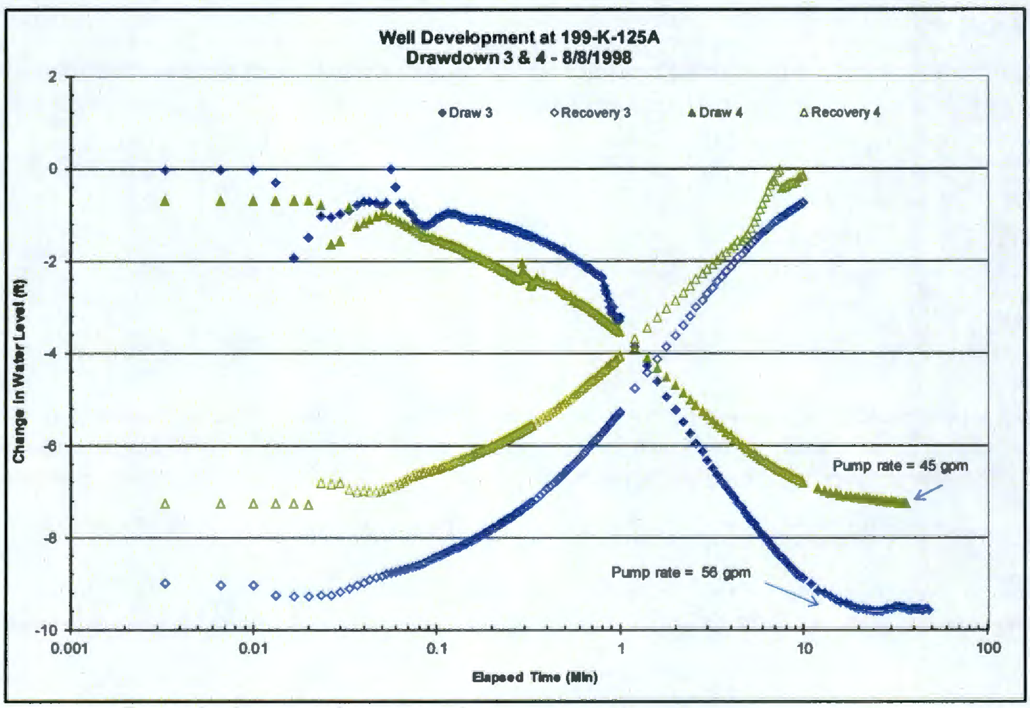


Figure 5-92. Drawdown 3 & 4 and Recovery Data at 199-K-125A

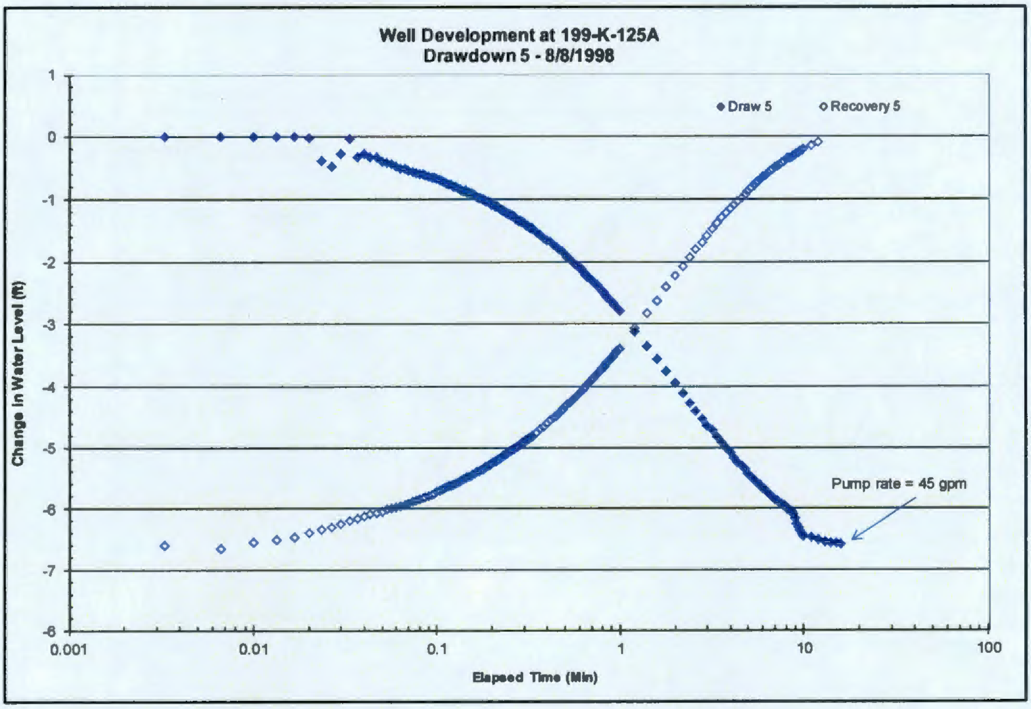


Figure 5-93. Drawdown 5 and Recovery Data at 199-K-125A

5.39.2 Analysis

Transmissivity estimates are developed by matching the drawdown data with the Theis solution. The recovery data do not support a reliable estimation of the transmissivity. The transmissivity estimates that have been developed from the drawdown intervals vary over a relatively narrow range:

- Draw1: $T = 150.1$ m^2/d
- Draw2: $T = 143.3$ m^2/d
- Draw3: $T = 139$ m^2/d
- Draw4: $T = 140$ m^2/d
- Draw5: $T = 153.5$ m^2/d

The "most representative" estimate of transmissivity is calculated as the arithmetical average of the five estimates, 140 m^2/d. The analysis for Draw2 yields a value almost identical to the average, so the results for this analysis are reproduced here in Figure 5-94.

5.40 Analysis of Well Development Data at Well 199-K-126

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *B8760_WD_199-K-126_1999-07-26.xls*.

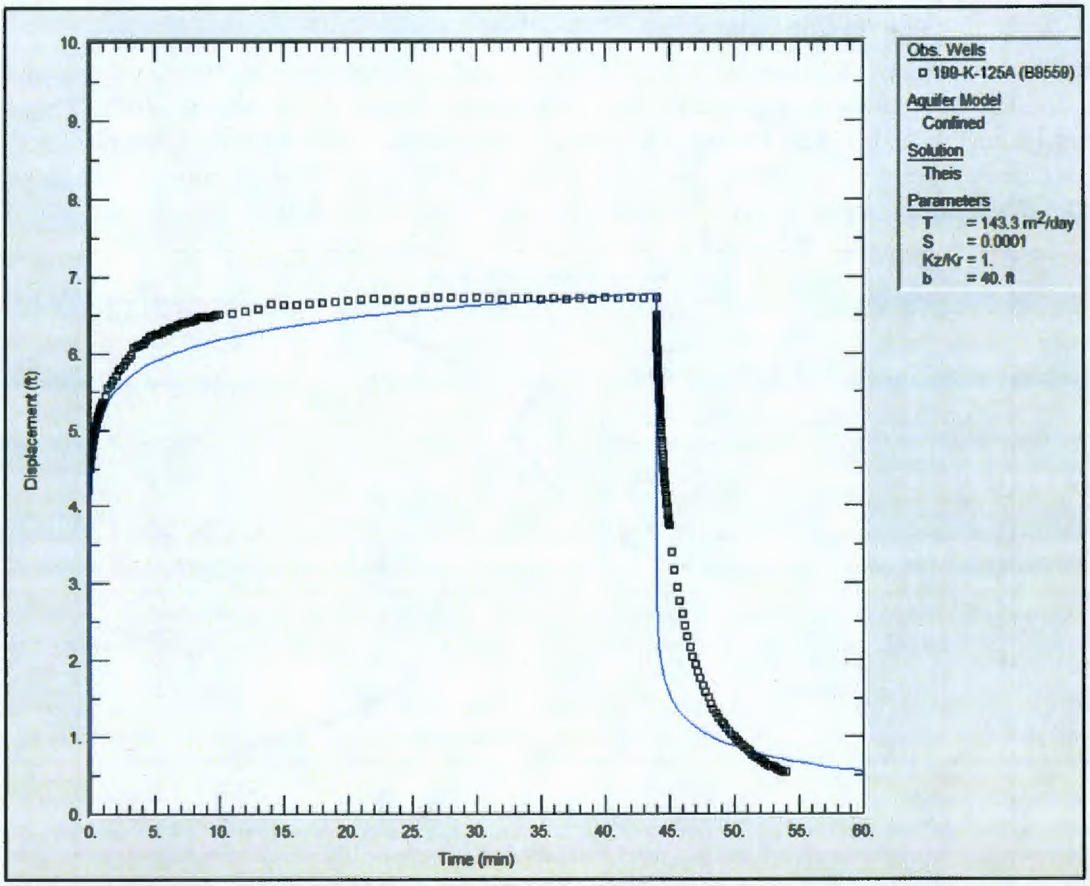


Figure 5-94. Theis Drawdown Analysis at 199-K-125A

5.40.1 Summary of Available Data

Two sets of data were collected during the well development on July 26, 1999. The well was pumped at 14 gpm for about 160 minutes and water level in the well was allowed to recover. Subsequently, the well was pumped at 17 gpm for about 140 minutes. The water level in the well was monitored during the drawdown and recovery period. The changes in the water level for the second test are shown in Figure 5-95. The recovery data of the second test were interpreted.

5.40.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-96, aquifer transmissivity is estimated to be 100 m^2/d. As shown in the recovery plot, the aquifer recovers more quickly than is expected for an ideal aquifer (zero drawdown is attained before *t/t'* declines to 1.0). This response suggests that there is an external source of water that acts to replenish the drawdown cone. A similar estimate was also obtained from Cooper-Jacob analysis of the drawdown data.

5.41 Analysis of Well Development Data at Well 199-K-131

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C4561_WD_199-K-131_2004-09-22.xls*.

5.41.1 Summary of Available Data

The well was developed on September 22, 2004. Two sets of well development data were included in the Excel file. The well was initially pumped at 36 gpm for about 10 minutes and later reduced to 25 gpm and pumped for another 68 minutes. The water level in the well was allowed to recover. Subsequently, the pump intake was raised 15.1 ft, and the well was pumped at 22 gpm for about 50 minutes. Changes in the water level with time during the second well development are shown in Figure 5-97.

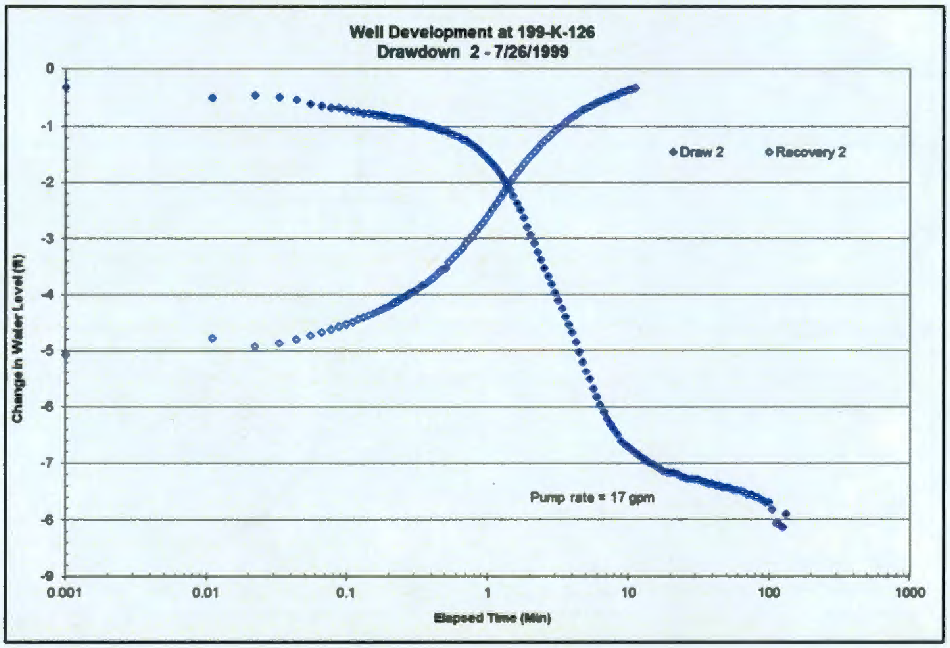


Figure 5-95. Drawdown and Recovery Data at 199-K-126

5.41.2 Analysis

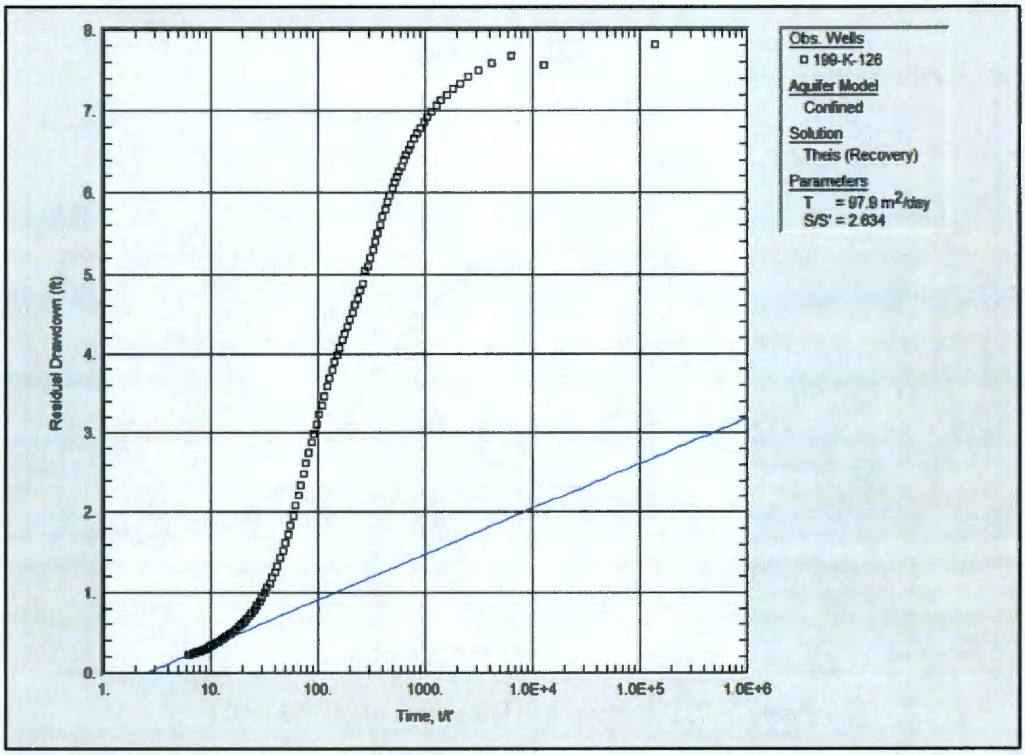
The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-98, aquifer transmissivity is estimated to be 120 m^2/d. During the second well development test, the water level recovers faster than expected, suggesting that an additional source of water replenishes the drawdown cone. The drawdown data were noisy and did not lead to good fits. Hence, only the recovery-based estimate is reported here.

5.42 Analysis of Well Development Data at Well 199-K-132

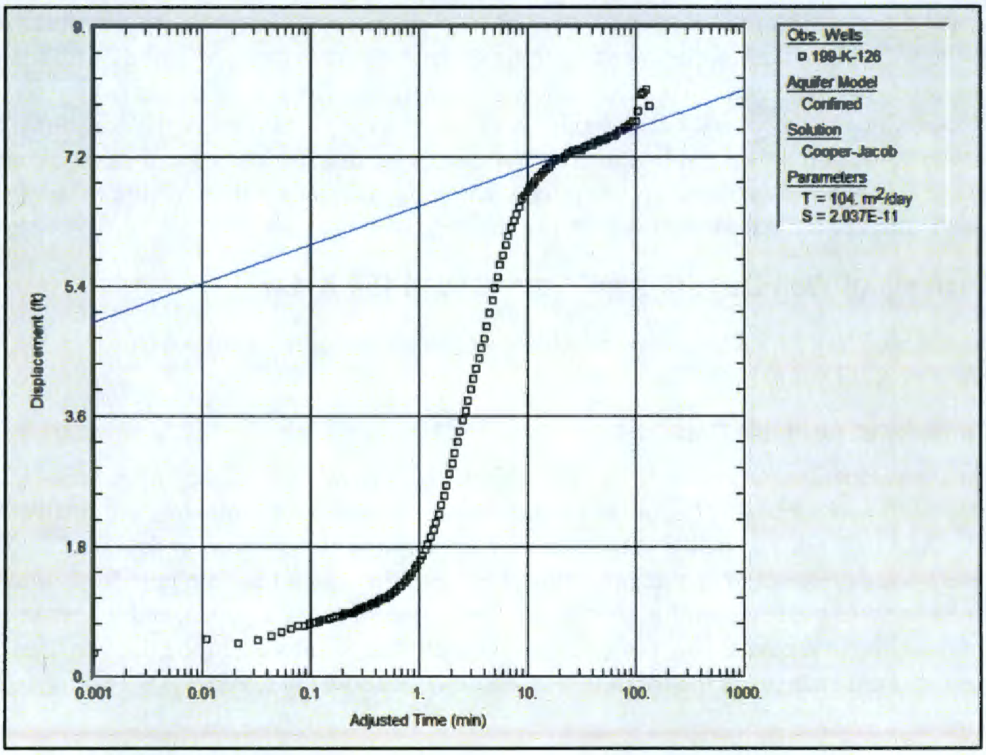
Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C4670_WD_199-K-132_2004-10-06.xls*.

5.42.1 Summary of Available Data

The well was developed on October 6, 2004. The well was pumped at 35 gpm for about 42 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-99.

1 

2 **Figure 5-96. Theis Recovery Analysis at 199-K-126 (1 of 2)**

3 

4 **Figure 5-96. Cooper-Jacob Drawdown Analysis at 199-K-126 (2 of 2)**

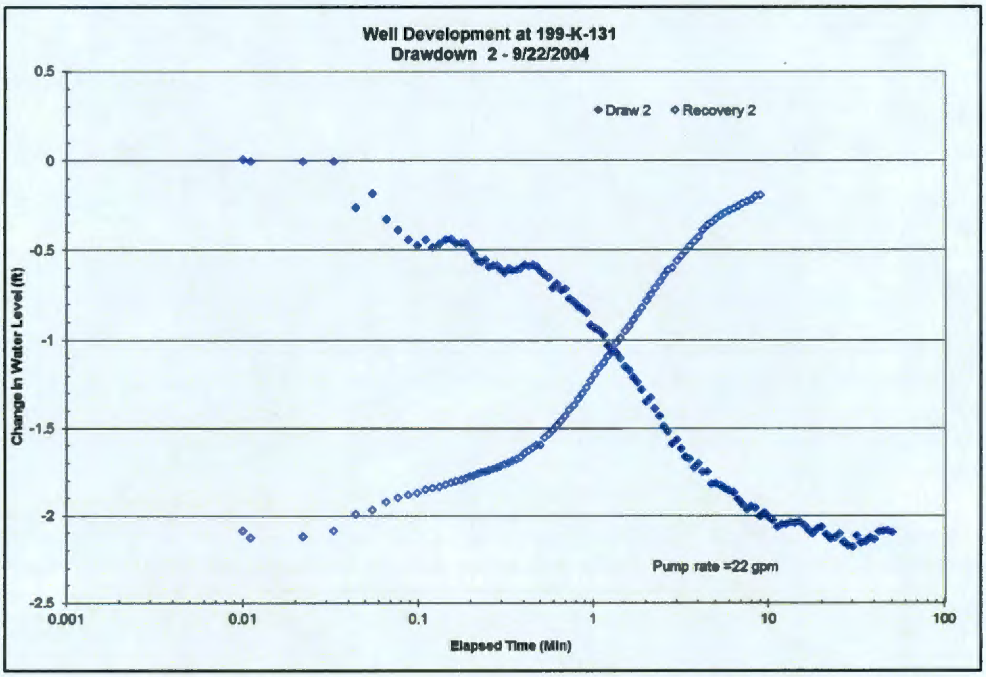


Figure 5-97. Drawdown and Recovery Data at 199-K-131

5.42.2 Analysis

Relatively consistent estimates of transmissivity are obtained from the Cooper-Jacob analyses of the drawdown and the analysis of the recovery data. The most representative estimate of transmissivity is selected as the value from the Cooper-Jacob analysis of the drawdown data (200 m^2/d). The analyses are shown in Figure 5-100. The derivative is also shown in the figure. The plot of the derivative serves to confirm that the Cooper-Jacob analysis is applied over the appropriate portion of the drawdown data, that portion for which the derivative is approximately constant. The unrealistically small storage coefficient (*S*) reflects the influence of wellbore storage effects lasting for several minutes. Wellbore storage does not affect the estimation of the transmissivity with the Cooper-Jacob analysis.

5.43 Analysis of Well Development Data at Well 199-K-137

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C5112_WD_199-K-137_2006-09-22.xls*.

5.43.1 Summary of Available Data

The well was developed on September 21 and 22, 2006. The well was initially pumped at 30 gpm for about 5 minutes then reduced to 27 gpm for 22 minutes, 25.86 gpm for 45 minutes, and finally 26 gpm for 35 minutes. The pump was stopped, and the recovery test ran overnight. The next day (9/22/2006) another drawdown test was performed with the initial rate of 30 gpm for 6 minutes, 28.5 gpm for 2 minutes, 25 gpm for 34 minutes, and 26 gpm for 36 minutes. The pump was then stopped, and the water level in the well was allowed to recover. The water level in the well was monitored during the two drawdown and recovery periods, and changes in the water level with time are shown in Figures 5-101 and 5-102.

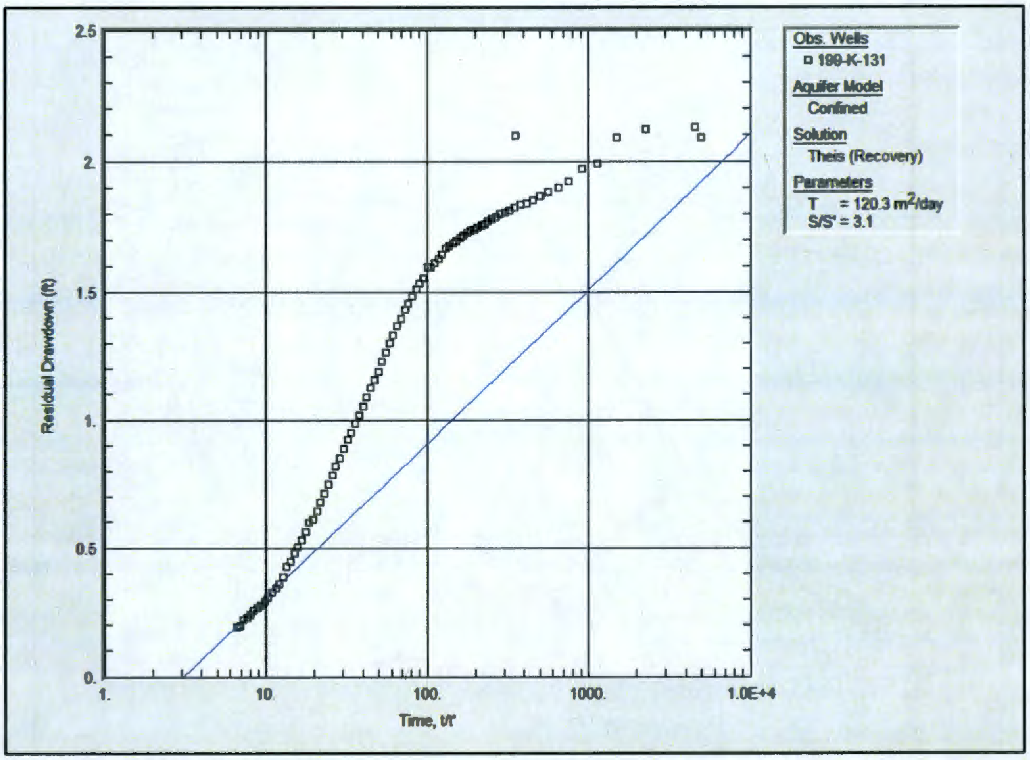


Figure 5-98. Theis Recovery Analysis at 199-K-131

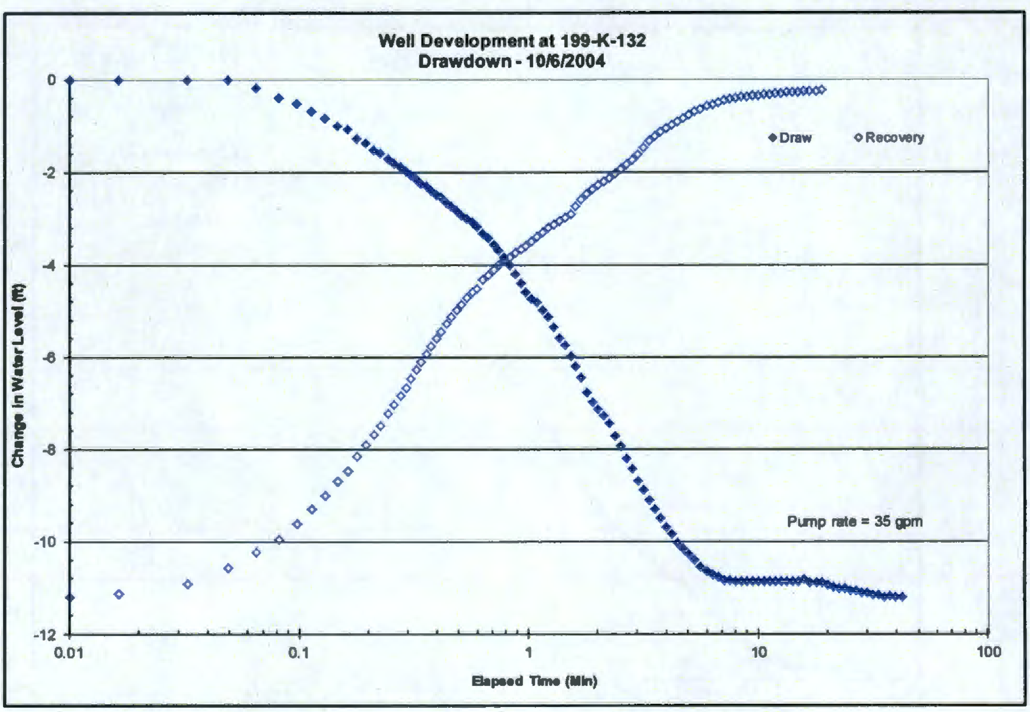


Figure 5-99. Drawdown and Recovery Data at 199-K-132

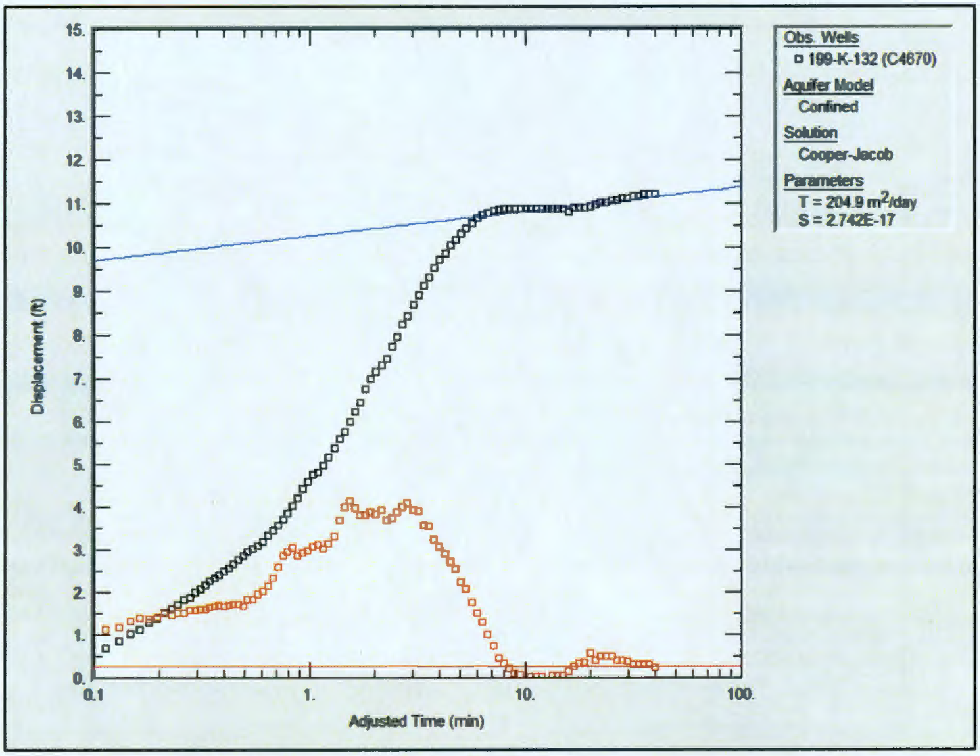


Figure 5-100. Cooper-Jacob Drawdown Analysis at 199-K-132 (1 of 2)

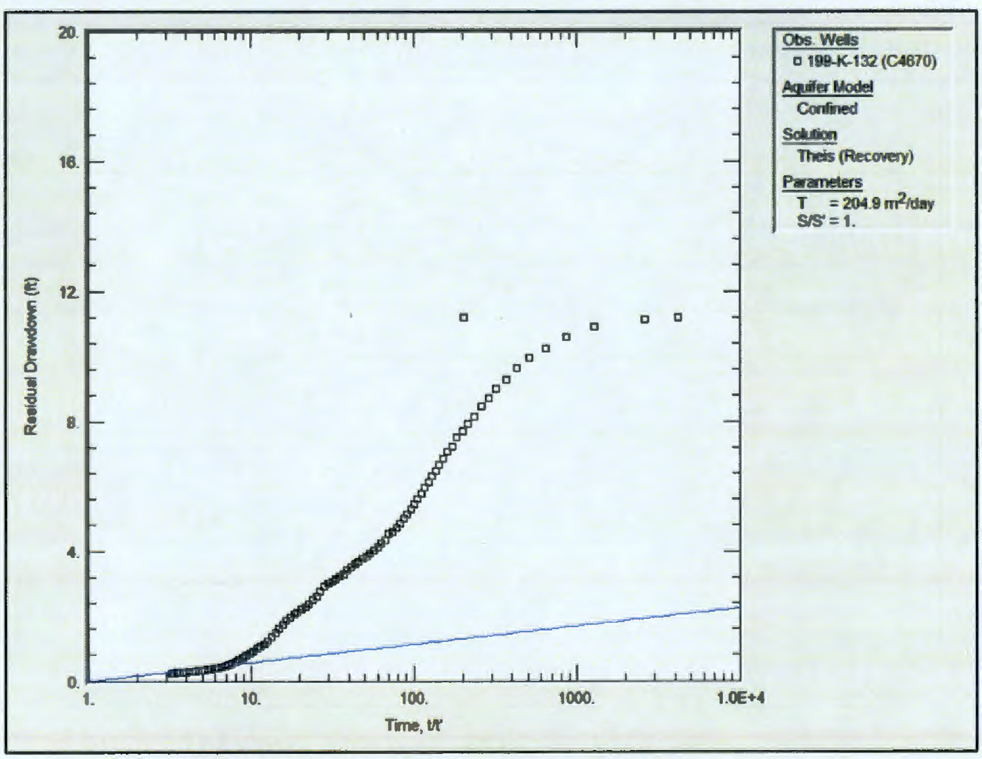


Figure 5-100. Theis Recovery Analysis at 199-K-132 (2 of 2)

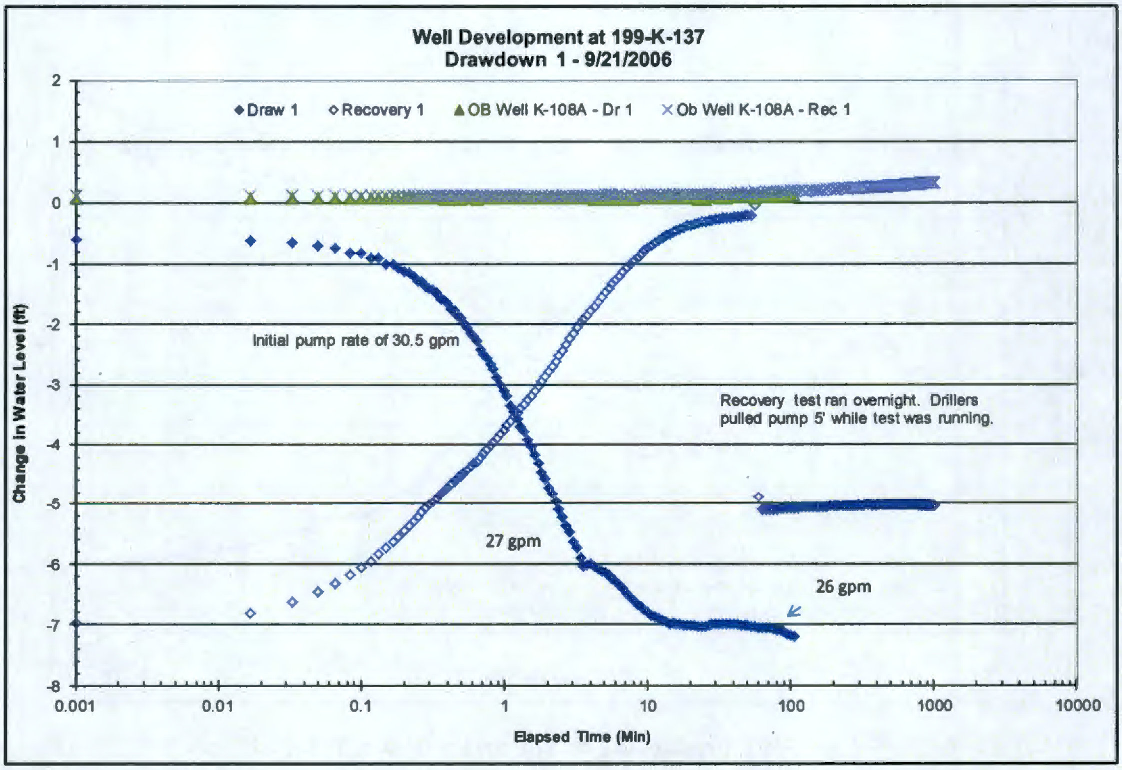


Figure 5-101. Drawdown 1 and Recovery Data at 199-K-137

5.43.2 Analysis

The transmissivity estimates developed from the drawdown intervals vary over a relatively narrow range, from about 90 m^2/d to 200 m^2/d. The most representative estimate of transmissivity is selected as a value consistent with the Cooper-Jacob analysis of the first drawdown interval (160 m^2/d). A consistent estimate was obtained from analysis of the recovery data with the Theis recovery method. The analyses are shown in Figure 5-103. The unrealistically small storage coefficient (*S*) reflects the influence of wellbore storage effects lasting for several minutes. The derivative of the drawdown with respect to time, $\partial s/\partial \ln(t)$, is shown in red to confirm that the Cooper-Jacob straight line is fit to the portion of the drawdown responses caused only by the aquifer.

5.44 Analysis of Well Development Data at Well 199-K-143

Drawdown and recovery data for two well development tests were received from CHPRC in the Excel file *C5305_WD_199-K-143_2007-01-04.xls*.

5.44.1 Summary of Available Data

The well was developed on January 4, 2007, and three data sets were collected. The well was initially pumped at 40 gpm for about 56 minutes and later reduced to 25 gpm and pumped for another 23 minutes. The water level in the well was allowed to recover. Then the well was pumped again at 17.6 gpm for 124 minutes and allowed to recover. Subsequently, the pump intake was raised 23 ft, and the well was pumped at 18.7 gpm for about 47 minutes. Changes in the water level during the second tests are analyzed; they are shown in Figure 5-104.

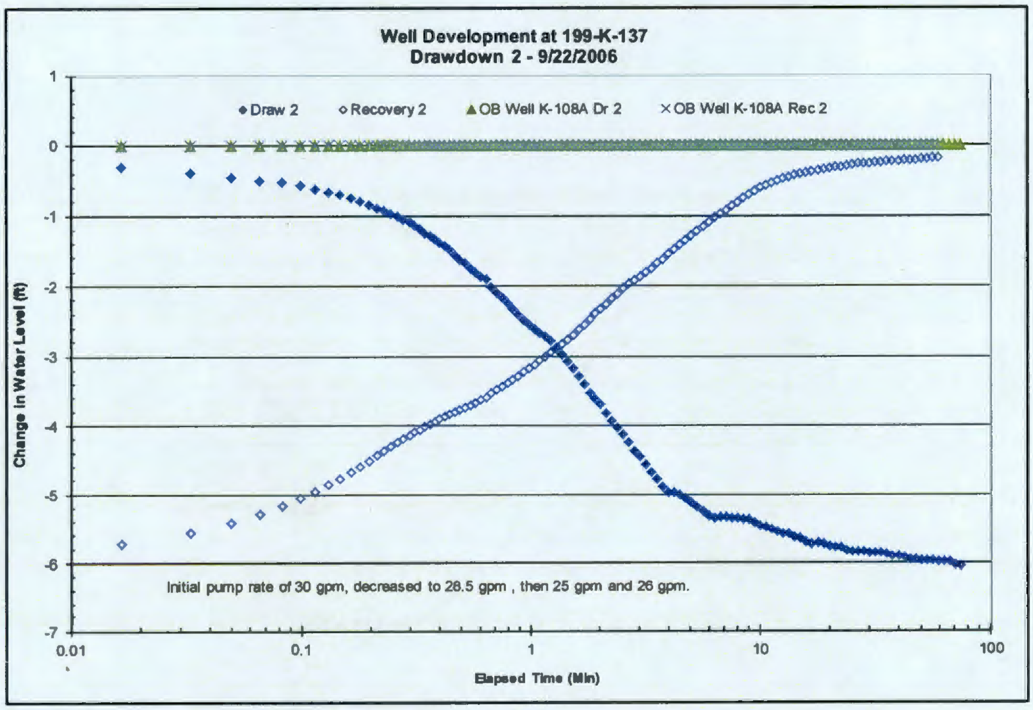


Figure 5-102. Drawdown 2 and Recovery Data at 199-K-137

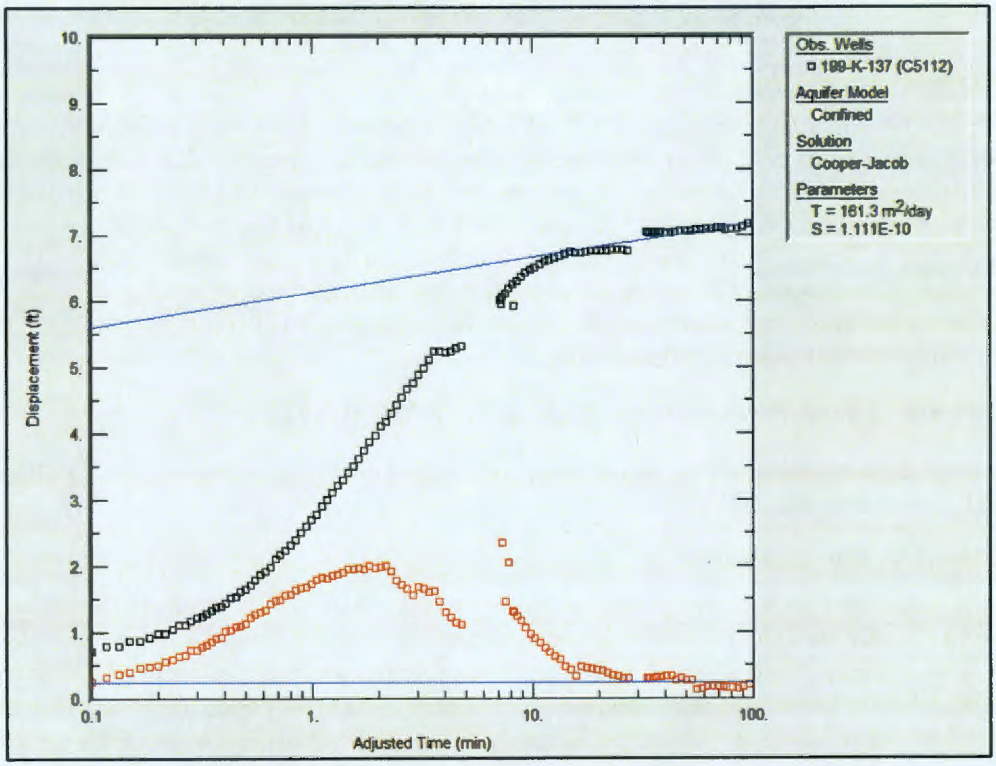


Figure 5-103. Cooper-Jacob Drawdown Analysis at 199-K-137 (1 of 2)

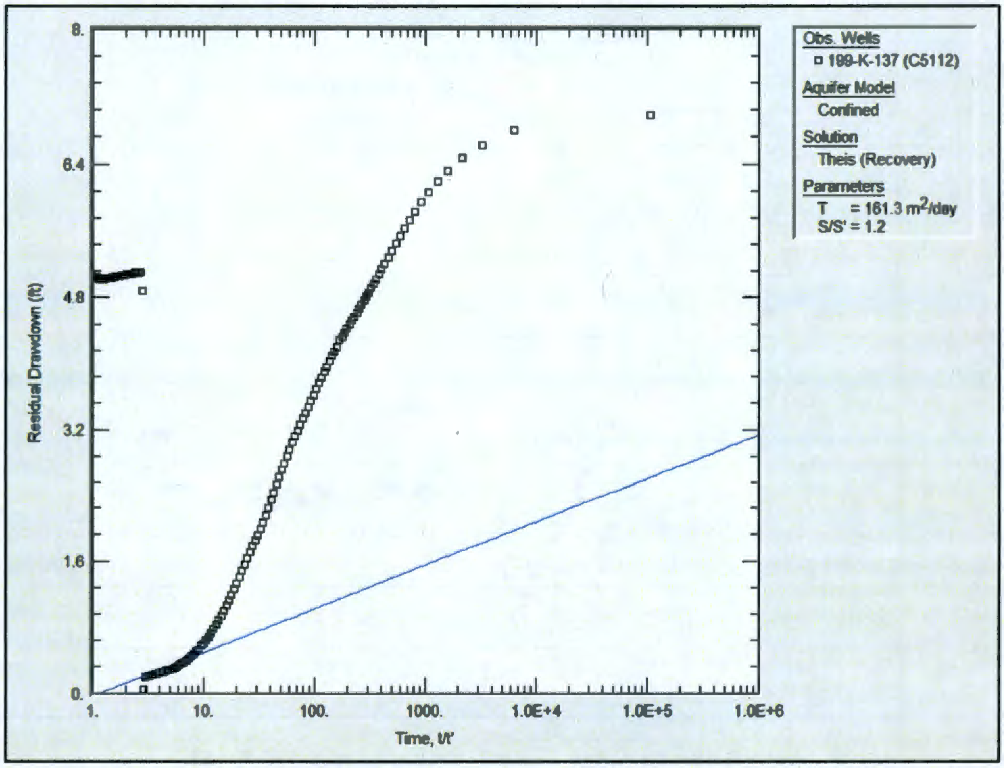


Figure 5-103. Theis Recovery Analysis at 199-K-137 (2 of 2)

5.44.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-105, aquifer transmissivity is estimated to be 3,400 m^2/d. The late-time recovery data are consistent with the response of an ideal aquifer. Drawdown data were noisy and, hence, not analyzed.

5.45 Analysis of Well Development Data at Well 199-K-146

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C5362_WD_199-K-146_2008-01-04.xls*.

5.45.1 Summary of Available Data

The well was developed on January 3 and 4, 2008. For drawdown test 1 on January 3, the well was initially pumped at 15 gpm for about 51 minutes and allowed to recover. Drawdown test 2 was conducted on January 4 during which the well was pumped at 10.5 gpm for 50 minutes and then allowed to recover. The water level in the well was monitored during the two drawdown and recovery periods, and changes in the water level with time are shown in Figures 5-106 and 5-107.

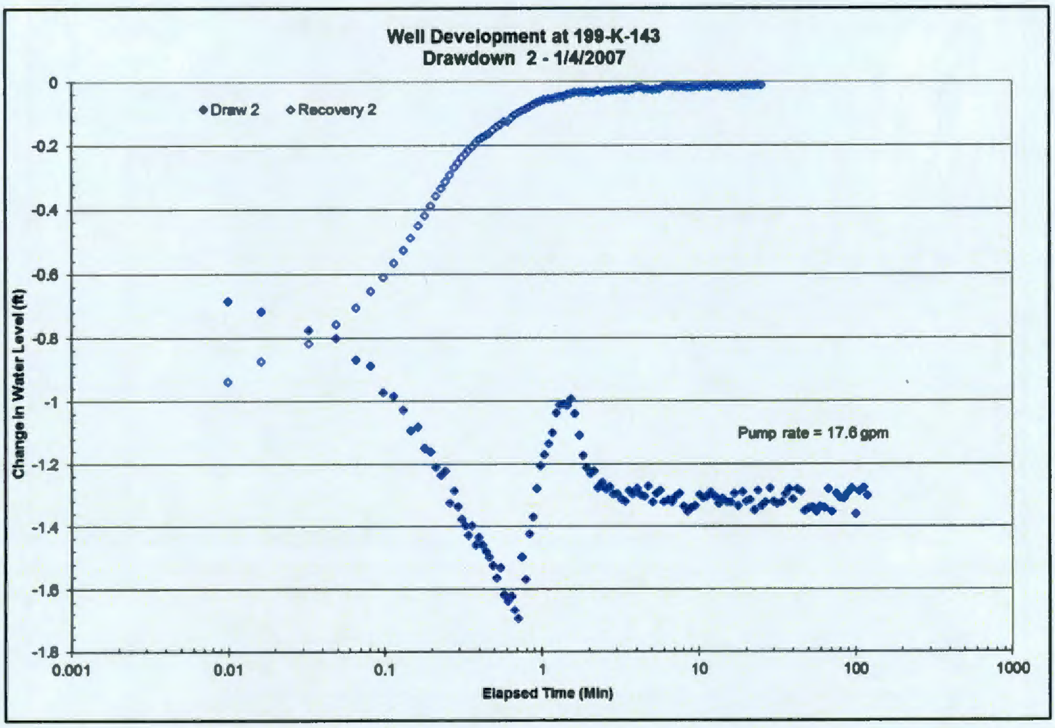


Figure 5-104. Drawdown and Recovery Data at 199-K-143

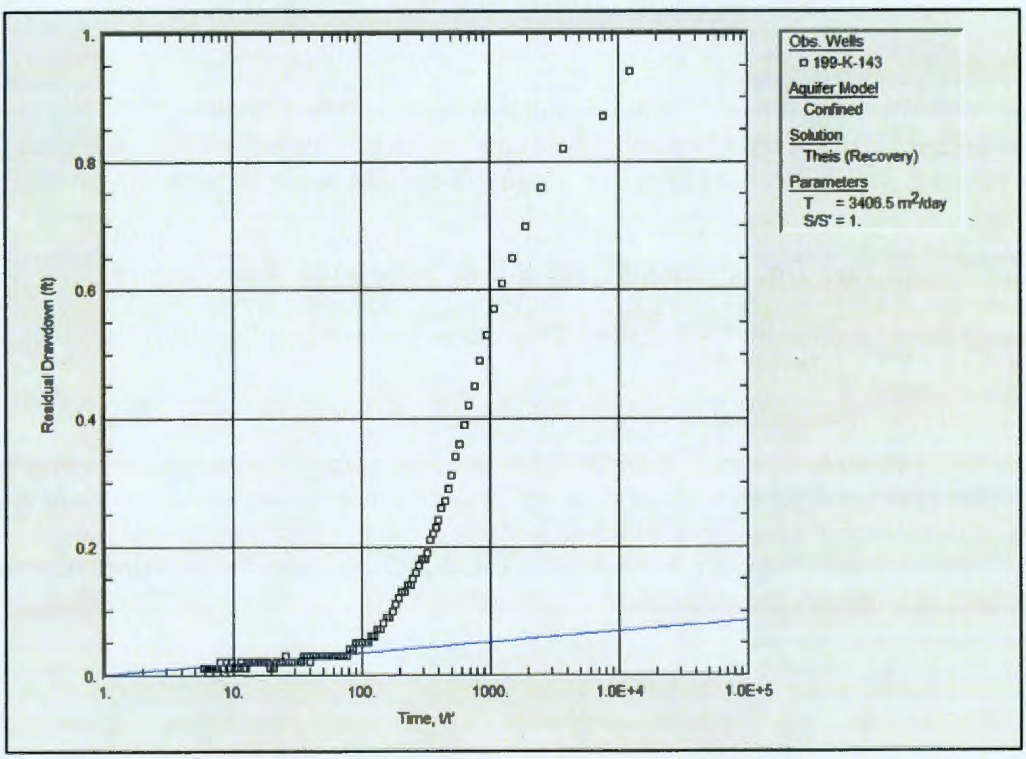


Figure 5-105. Theis Recovery Analysis at 199-K-143

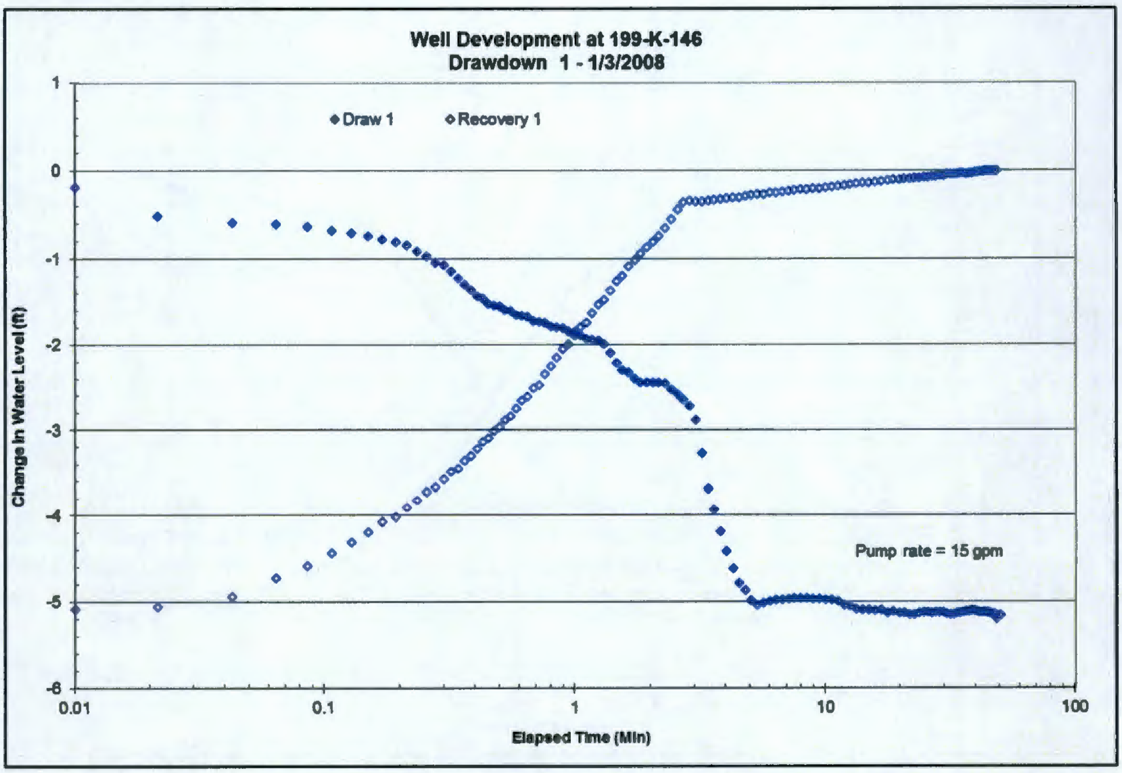


Figure 5-106. Drawdown 1 and Recovery Data at 199-K-146

5.45.2 Analysis

Drawdown and recovery data from the two tests have been analyzed. A transmissivity of 60 m^2/d is estimated from a Cooper-Jacob analysis of the second drawdown test. This estimate is consistent with the transmissivity estimates obtained from matches with the Theis recovery model. The analyses are shown in Figure 5-108. The unrealistically small storage coefficient (*S*) reflects the effects of wellbore storage lasting for several minutes. The derivative of the drawdown with respect to time, $\partial s/\partial \ln(t)$, is shown at the bottom to confirm that the Cooper-Jacob straight line is fit to the portion of the drawdown responses caused only by the aquifer.

5.46 Analysis of Well Development Data at Well 199-K-147

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C5363_WD_199-K-147_2007-11-15.xls*.

5.46.1 Summary of Available Data

The well was developed on November 15, 2007. Two sets of well development data were included in the Excel file. The well was initially pumped at 22.4 gpm for about 10 minutes and later reduced to 25 gpm and pumped for another 31 minutes. The water level in the well was allowed to recover. Subsequently, the pump intake was raised 13 ft, and the well was pumped at 22.5 gpm for about 60 minutes. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level during the second development test are shown in Figure 5-109.

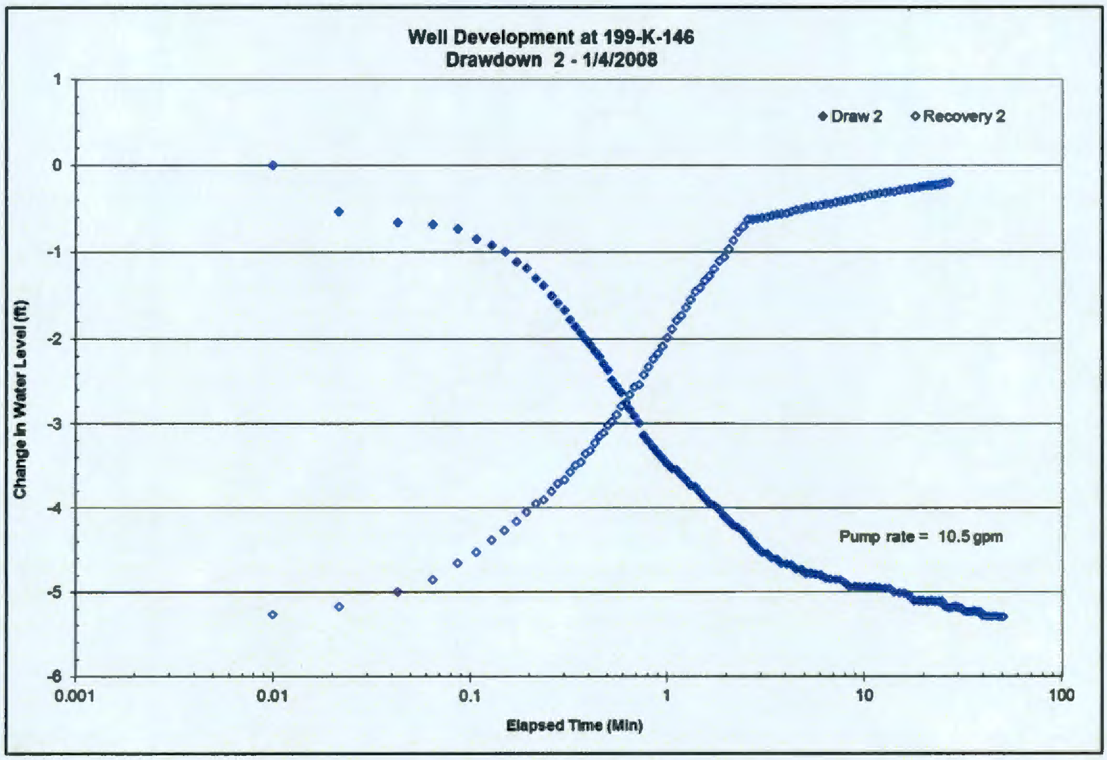


Figure 5-107. Drawdown 2 and Recovery Data at 199-K-146

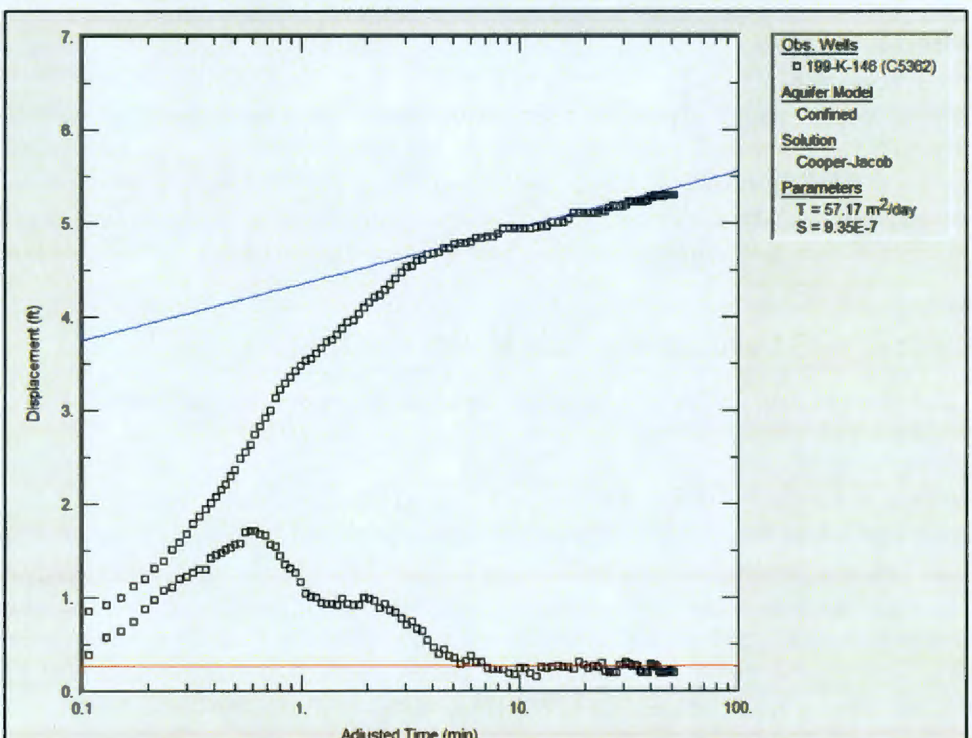


Figure 5-108. Cooper-Jacob Drawdown Analysis at 199-K-146 (1 of 2)

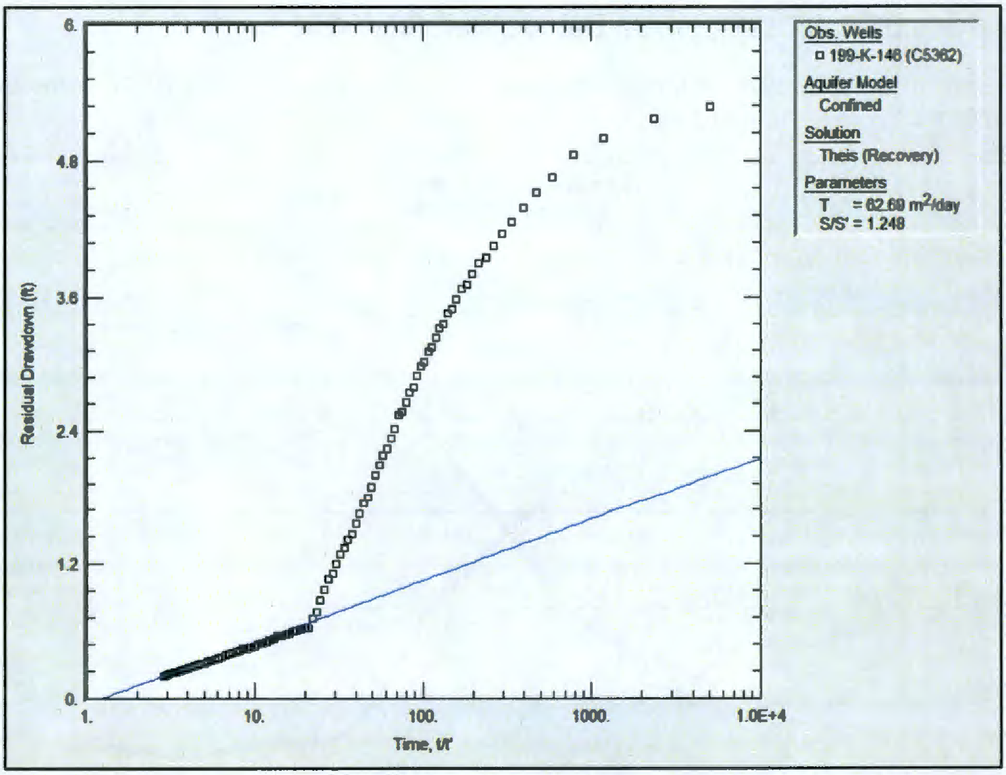


Figure 5-108. Theis Recovery Analysis at 199-K-146 (2 of 2)

5.46.2 Analysis

Consistent estimates of transmissivity were obtained from the Theis Recovery and Cooper-Jacob drawdown methods. As shown in Figure 5-110, aquifer transmissivity is estimated to be 420 m^2/d. The recovery plot reveals that the well recovers more rapidly than expected for an ideal aquifer, suggesting that the replenishment of the drawdown cone is supplemented by an additional source of water.

5.47 Analysis of Well Development Data at Well 199-K-148

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C5364_WD_199-K-148_2007-11-14.xls*.

5.47.1 Summary of Available Data

The well was developed on November 14, 2007. Two sets of well development data are included in the received Excel file. The well was initially pumped at 21.7 gpm for about 23 minutes and later reduced to 15 gpm and pumped for another 23 minutes. The water level in the well was allowed to recover. Subsequently, the pump intake was raised 21 ft, and the well was pumped at 37.5 gpm for about 30 minutes. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level of the second test are shown in Figure 5-111.

5.47.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-112, aquifer transmissivity is estimated to be 4,300 m^2/d. The late-time recovery data are consistent with the response expected for an ideal aquifer.

5.48 Analysis of Well Development Data at Well 199-K-150

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C5366_WD_199-K-150_2008-02-05.xls.*

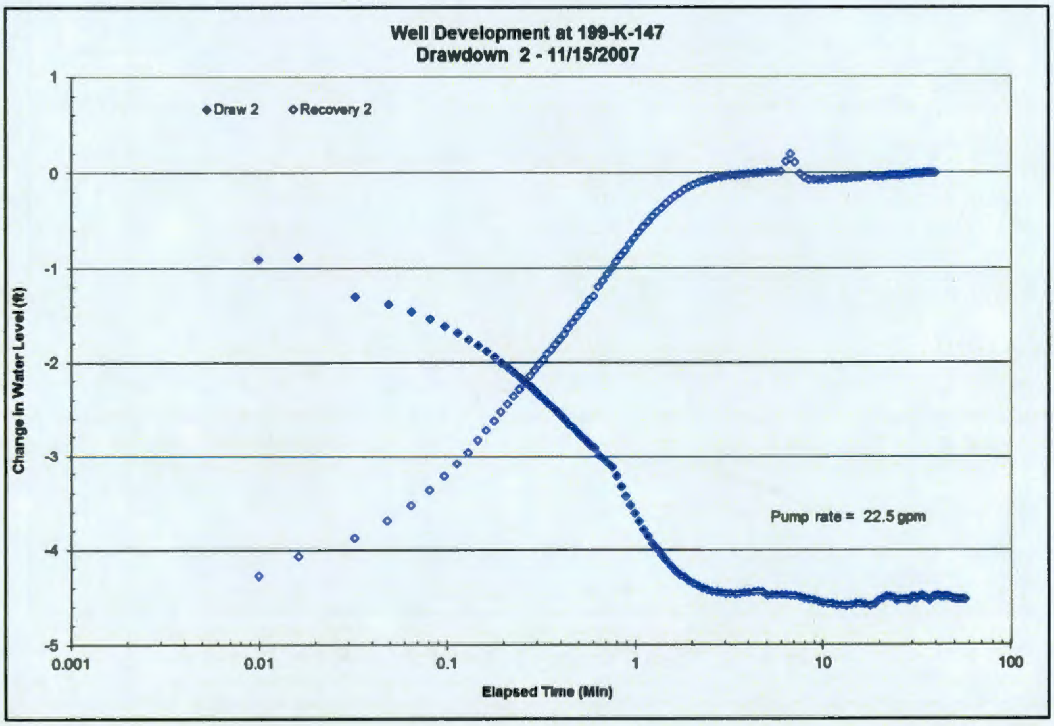


Figure 5-109. Drawdown and Recovery Data at 199-K-147

5.48.1 Summary of Available Data

Two data sets are included in the Excel file. The well was initially developed on February 1, 2008 by pumping at 15.4 gpm for 66 minutes. Subsequently, the pump intake was raised to 87.37 ft. On February 5, 2008, the well was developed again by pumping at 46 gpm for 5 minutes and 12 gpm for 60 minutes. The water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time for the second test are shown in Figure 5-113.

5.48.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-114, aquifer transmissivity is estimated to be 250 m^2/d. The recovery plot shows that recovery is premature relative to the response of an ideal aquifer, suggesting an additional source of water replenishing the drawdown cone. Drawdown data were noisy, and the fits to this data set were not good. Hence, only the recovery-based estimate is reported here.

5.49 Analysis of Well Development Data at Well 199-K-152

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C5368_WD_199-K-152_2008-02-01.xls.*

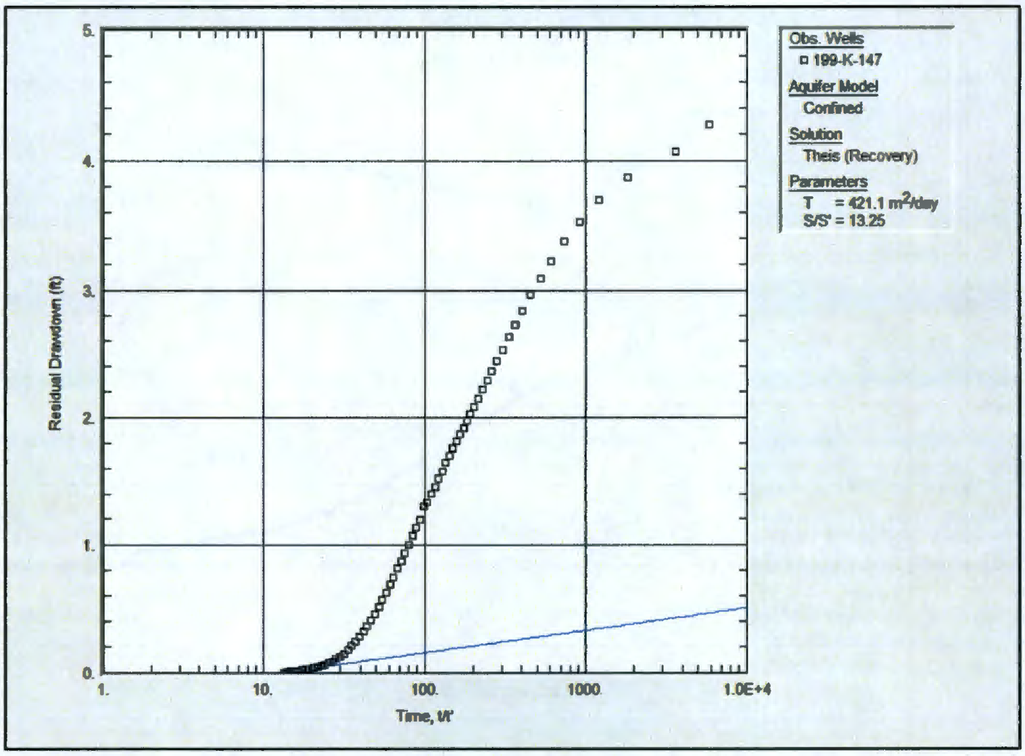


Figure 5-110. Theis Recovery Analysis at 199-K-147 (1 of 2)

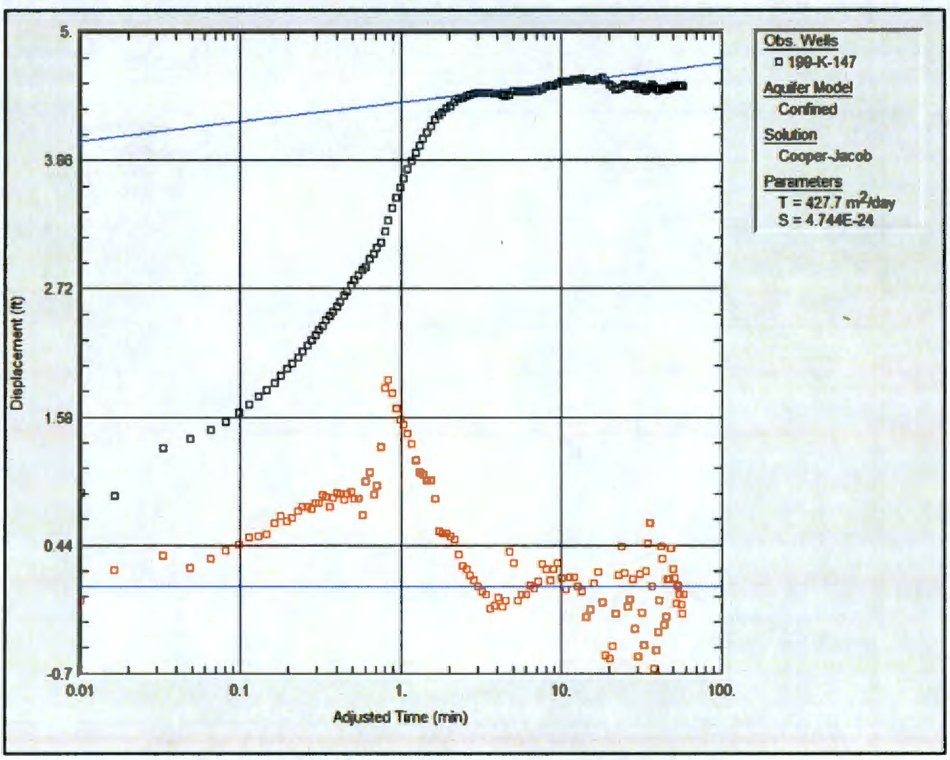


Figure 5-110. Cooper-Jacob Drawdown Analysis at 199-K-147 (2 of 2)

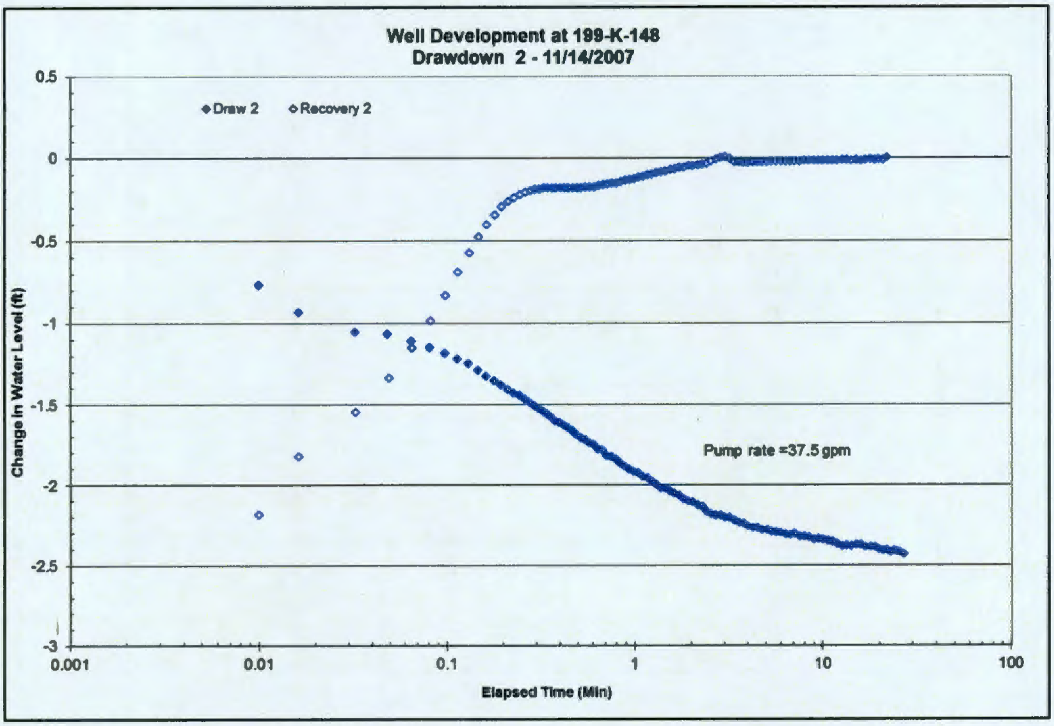


Figure 5-111. Drawdown and Recovery Data at 199-K-148

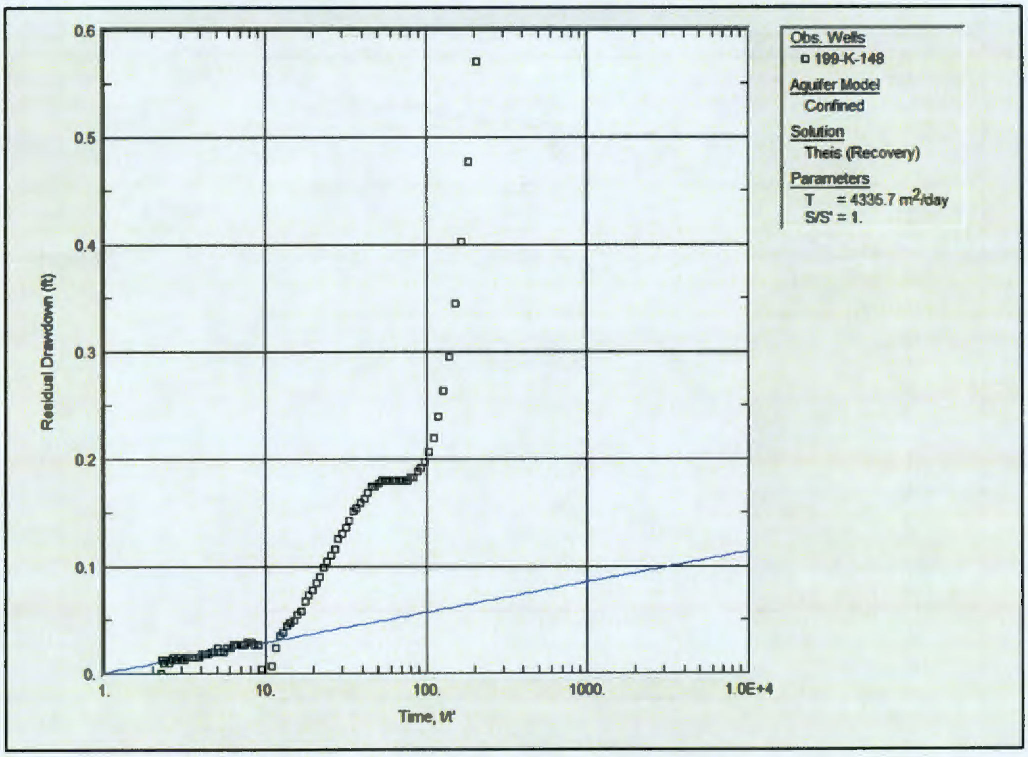


Figure 5-112. Theis Recovery Analysis at 199-K-148

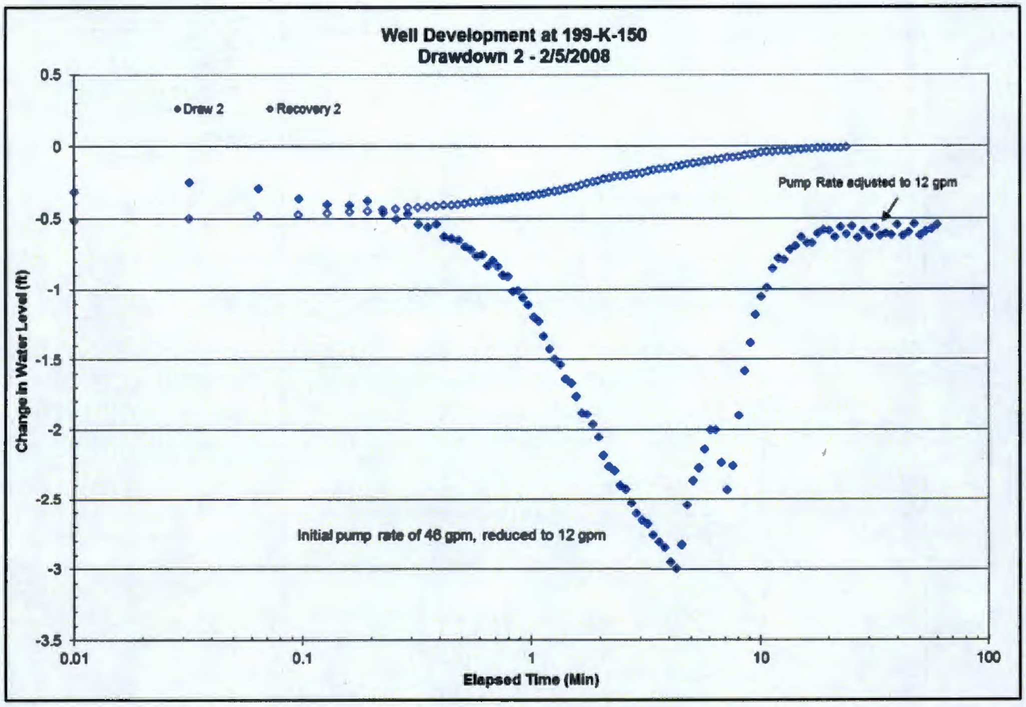


Figure 5-113. Drawdown and Recovery data at 199-K-150

5.49.1 Summary of Available Data

Two data sets are included in the Excel file. The well was initially developed on January 31, 2008 by pumping at 16.2 gpm for 91 minutes. Subsequently, the pump intake was raised by 21 ft. On February 1, 2008, the well was developed again by pumping at a rate of 27.3 gpm for 54 minutes. The water level in the well was allowed to recover and was monitored during the drawdown and recovery period. Changes in the water level with time for the second test are shown in Figure 5-115.

5.49.2 Analysis

Consistent transmissivity estimates were obtained with the Theis recovery and the Cooper-Jacob drawdown methods. As shown in Figure 5-116, aquifer transmissivity is estimated to be 340 m^2/d. The late-time recovery data are consistent with the response expected for an ideal aquifer.

5.50 Analysis of Well Development Data at Well 199-K-153

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C5369_WD_199-K-153_2008-01-03.xls.*

5.50.1 Summary of Available Data

Two data sets are included in the Excel file. The well was developed on January 3, 2008. The well was pumped at 30 gpm for about 80 minutes, and the water level in the well was allowed to recover. Subsequently, the pump intake was raised 21 ft, and the well was pumped at 20 gpm for about 35 minutes. The water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time for the second test are shown in Figure 5-117.

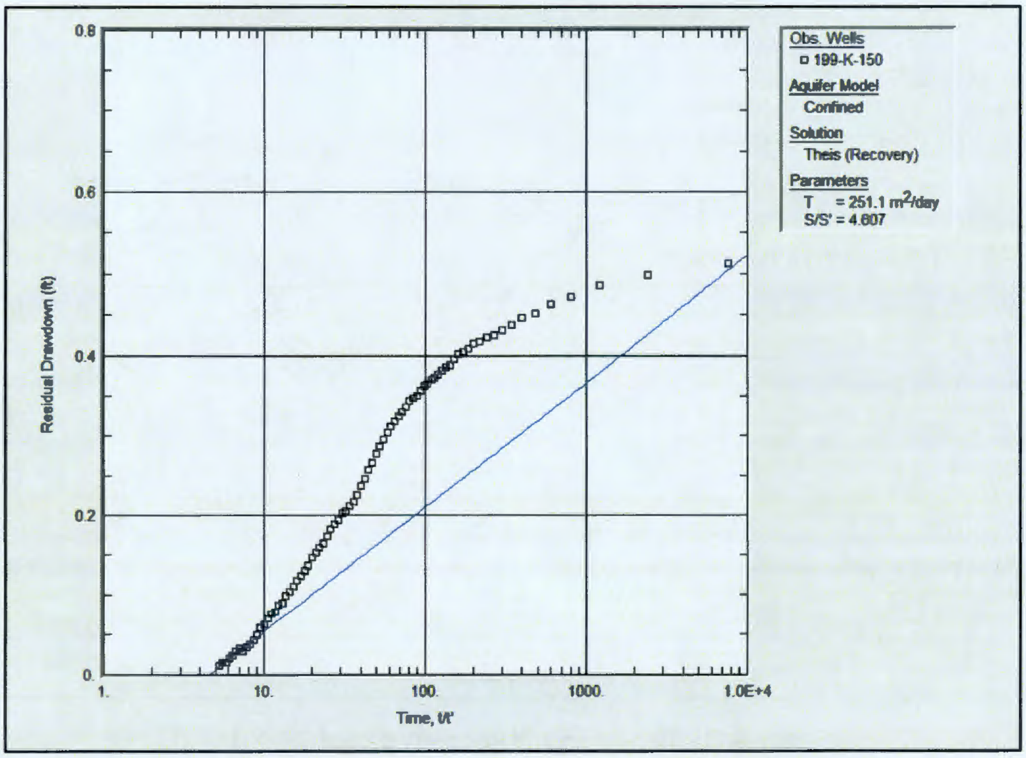


Figure 5-114. Theis Recovery Analysis at 199-K-150

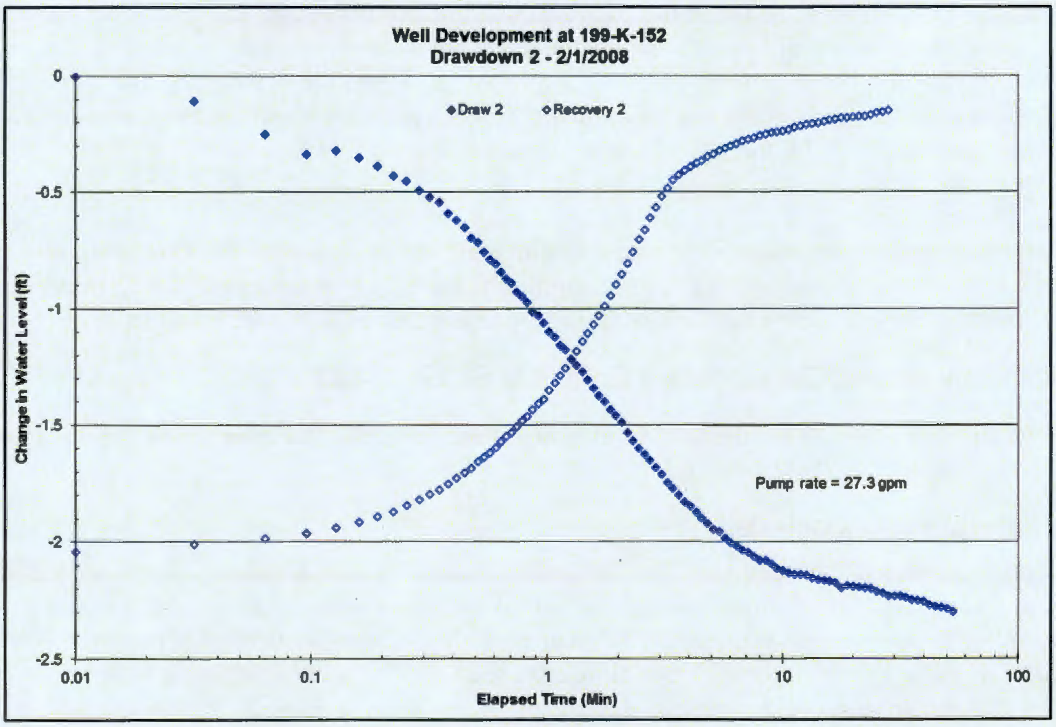


Figure 5-115. Drawdown and Recovery Data at 199-K-152

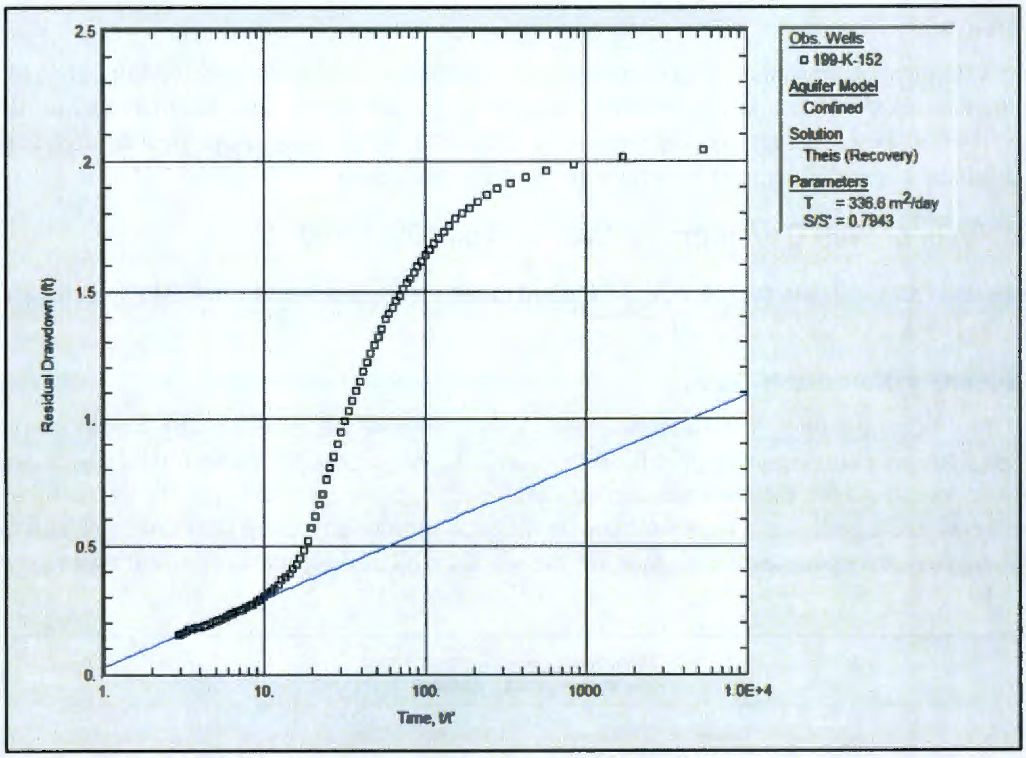


Figure 5-116. Theis Recovery Analysis at 199-K-152 (1 of 2)

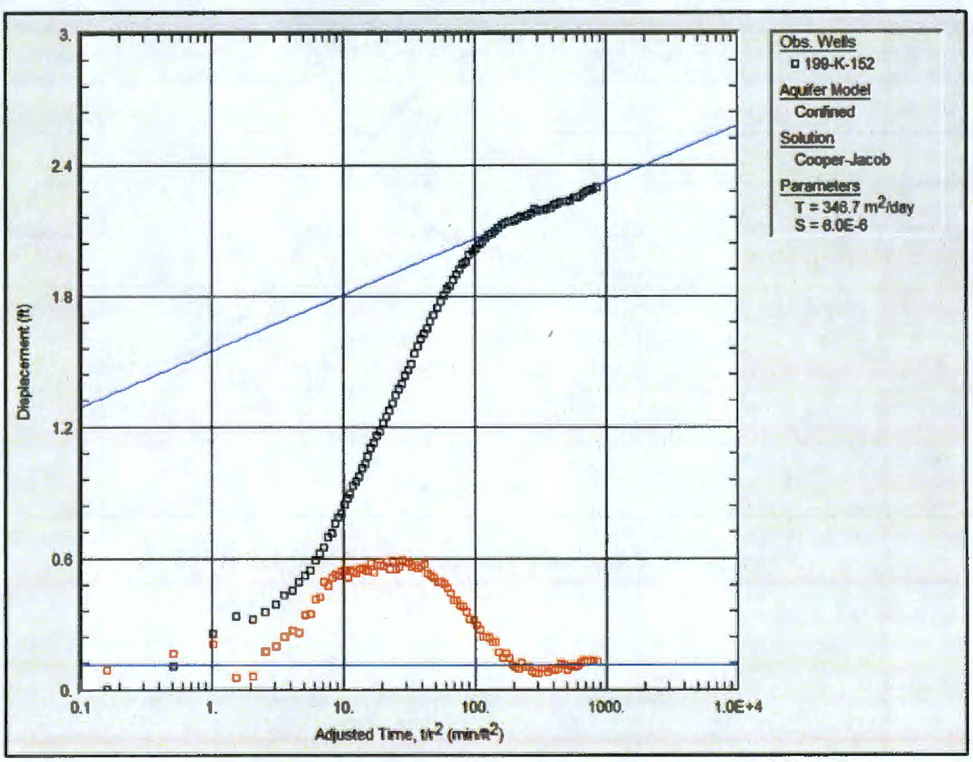


Figure 5-116. Cooper-Jacob Drawdown Analysis at 199-K-152 (2 of 2)

5.50.2 Analysis

Consistent estimates of transmissivity were obtained with the Theis recovery and the Cooper-Jacob drawdown methods. As shown in Figure 5-118, aquifer transmissivity is estimated to be 680 m^2/d. The recovery plot shows that recovery is premature relative to the response of an ideal aquifer, suggesting that an additional source of water is replenishing the drawdown cone.

5.51 Analysis of Well Development Data at Well 199-K-160

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C5938_WD_199-K-160_2007-10-29.xls*.

5.51.1 Summary of Available Data

Two well development data sets are included in the Excel file. The well was initially developed on October 26, 2007 by pumping at 15 gpm for 60 minutes. Subsequently, the pump intake was raised by 21 ft. On October 29, 2007, the well was further developed by pumping at 20 gpm for 64 minutes. The water level in the well was allowed to recover and was monitored during the drawdown and recovery period. Changes in the water level with time for the second well development test are shown in Figure 5-119.

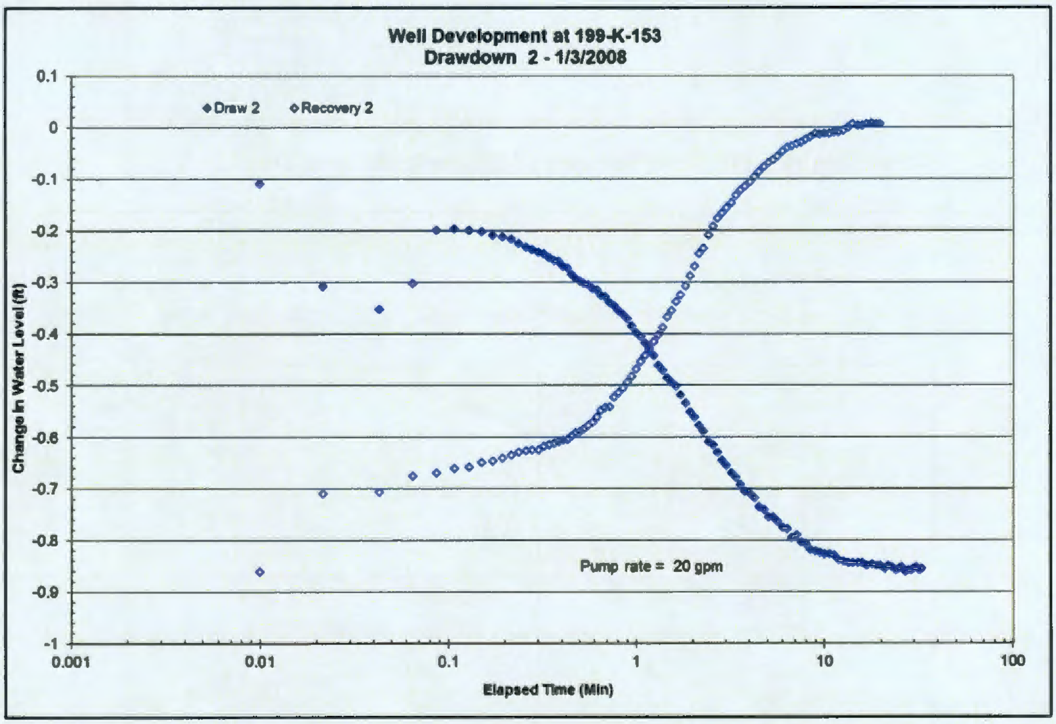


Figure 5-117. Drawdown and Recovery Data at 199-K-153

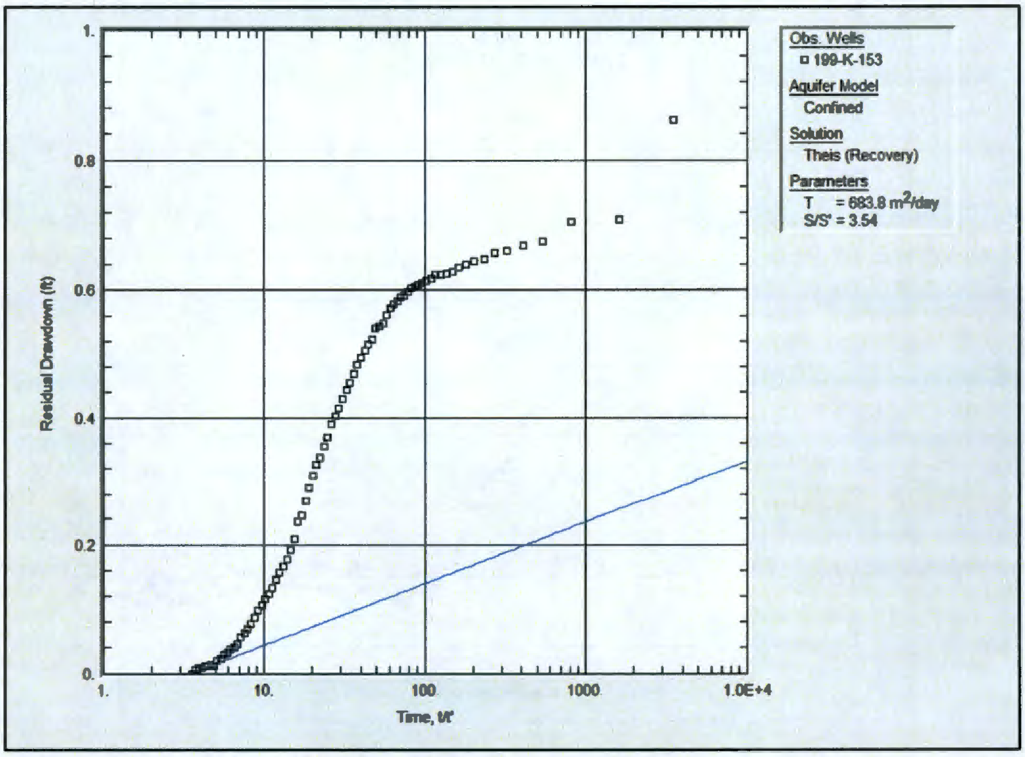


Figure 5-118. Theis Recovery Analysis at 199-K-153 (1 of 2)

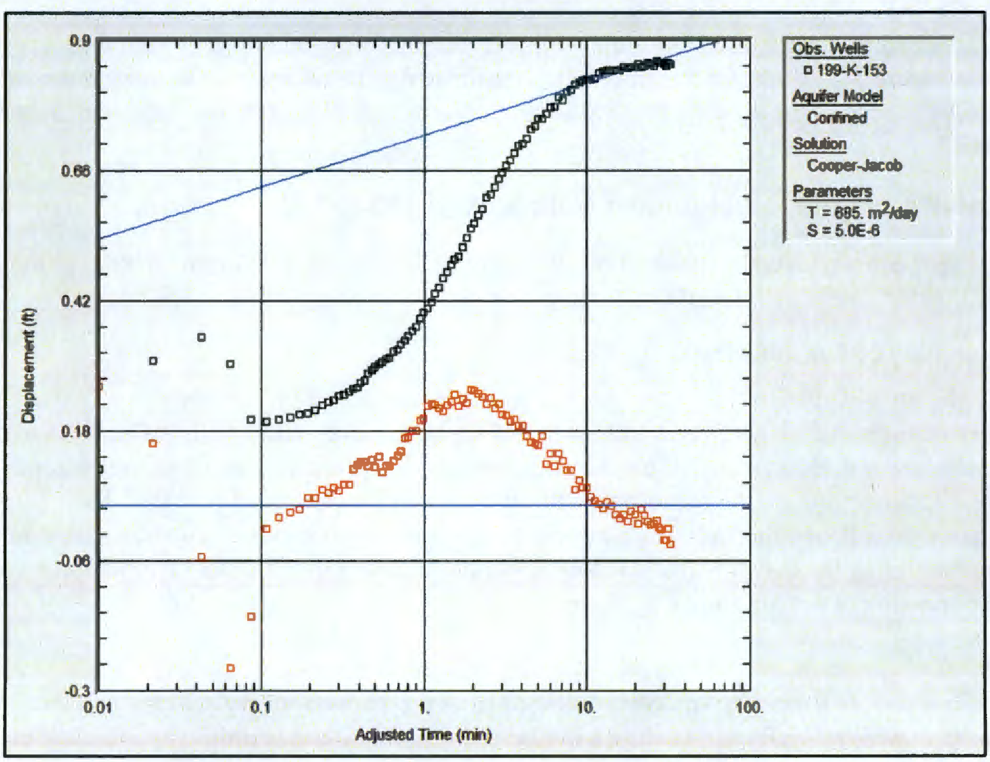


Figure 5-118. Cooper-Jacob Drawdown Analysis at 199-K-153 (2 of 2)

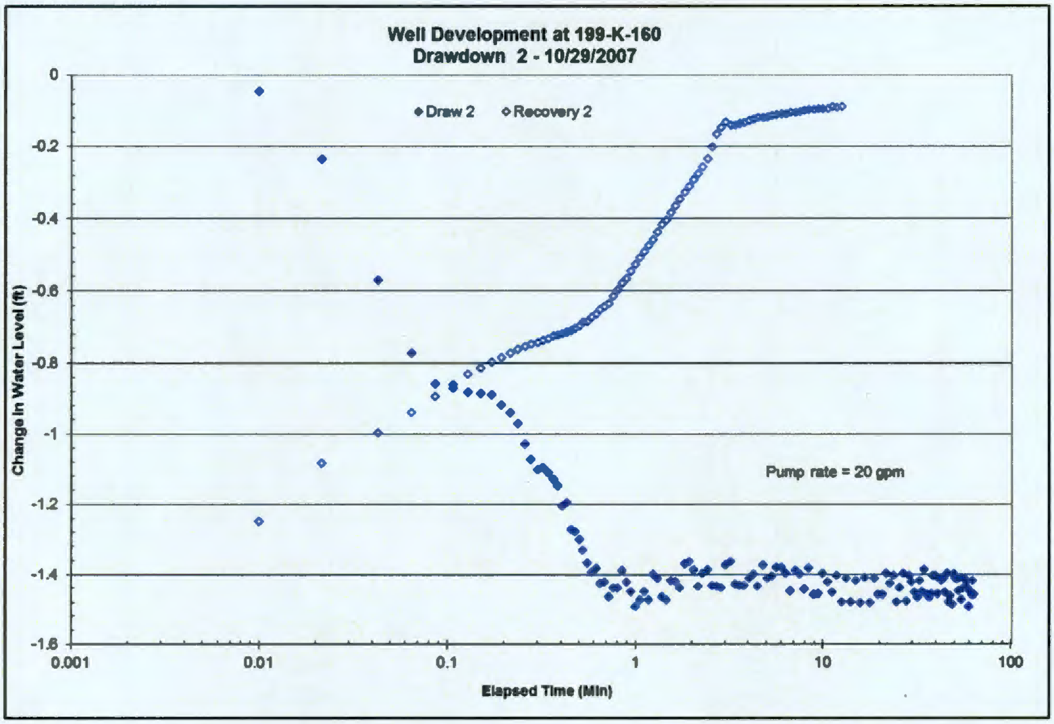


Figure 5-119. Drawdown and Recovery Data at 199-K-160

5.51.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-120, aquifer transmissivity is estimated to be 640 m^2/d. The late-time recovery data conform to the expected response for an ideal aquifer. The drawdown data were noisy and, hence, not analyzed.

5.52 Analysis of Well Development Data at Well 199-K-163

Drawdown and recovery data for two well development tests were received from CHPRC in the Excel file *C6172_WD_199-K-163_2007-11-16.xls*.

5.52.1 Summary of Available Data

Three data sets are included in the Excel file. The well was developed on November 16, 2007. The well was initially pumped at 21.1 gpm for 25 minutes, and the water level in the well was allowed to recover. Subsequently, it was discovered that the pump was not working properly. Next, the well was pumped at 27 gpm for 19 minutes before the pump was shut off because of an electrical problem. The pump intake was then raised 24.2 ft, and the well was pumped at 31.6 gpm for 30 minutes. The water level in the well was monitored during the drawdown and recovery period. Changes in the water level with time for the third well development test are shown in Figure 5-121.

5.52.2 Analysis

Consistent estimates of transmissivity were obtained from the Theis recovery analysis and the Cooper-Jacob drawdown analysis. As shown in Figure 5-122, aquifer transmissivity is estimated to be 1,800 m^2/d. Extrapolation of the late-time recovery data suggests a small residual drawdown. The departure from ideal behavior does not affect the estimation of the transmissivity.

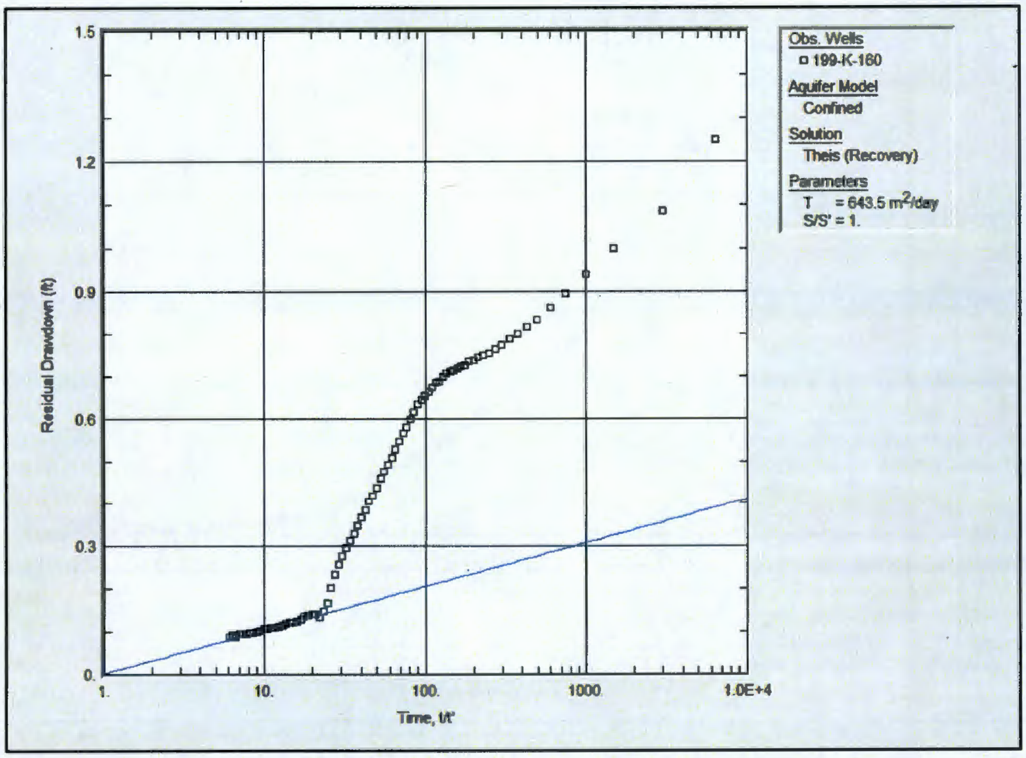


Figure 5-120. Theis Recovery Analysis at 199-K-160

5.53 Analysis of Well Development Data at Well 199-K-164

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C6386_WD_199-K-164_2008-04-11.xls*.

5.53.1 Summary of available data

Three well development data sets are included in the Excel file. The well was initially developed on April 11, 2008 by pumping at 16.7 gpm for 29 minutes. The test was stopped due to generator problems. Next, the well was pumped at 15.8 gpm for 44 minutes. Subsequently, the pump intake was raised by 10 ft. On April 14, 2008, the well was developed again by pumping at 13.6 gpm for 31 minutes. Water level changes with time for the 15.8 gpm event are shown in Figure 5-123.

5.53.2 Analysis

The Theis recovery method was used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-124, aquifer transmissivity is estimated to be 300 m^2/d. As shown in Figure 5-124, the water level in the well did not recover completely by the end of the monitoring period. Extrapolation of the late-time recovery data suggests a small residual drawdown. Drawdown data were noisy and, hence, not analyzed.

5.54 Analysis of Well Development Data at Well 199-K-165

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C6451_WD_199-K-165_2008-09-11.xls*.

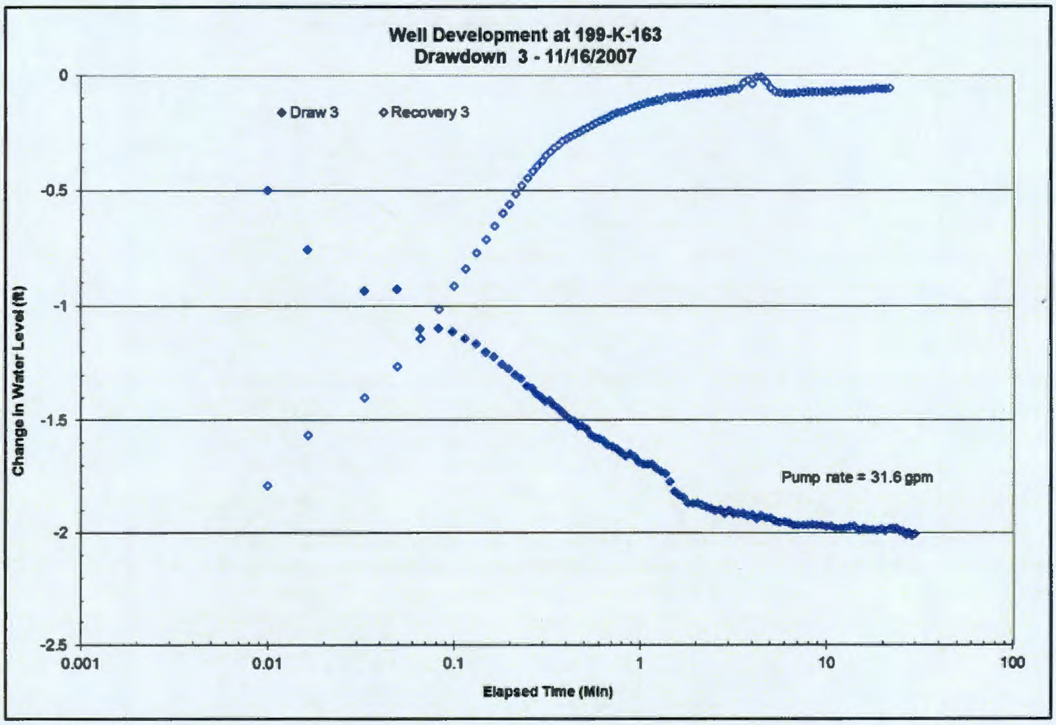


Figure 5-121. Drawdown and Recovery Data at 199-K-163

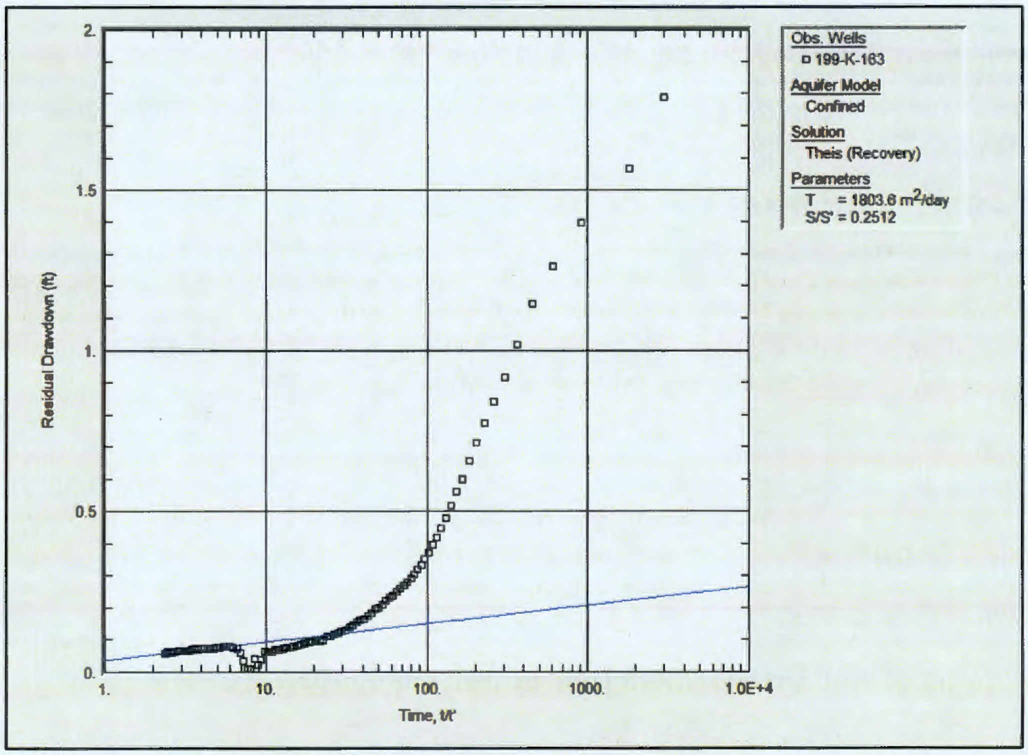


Figure 5-122. Theis Recovery Analysis at 199-K-163 (1 of 2)

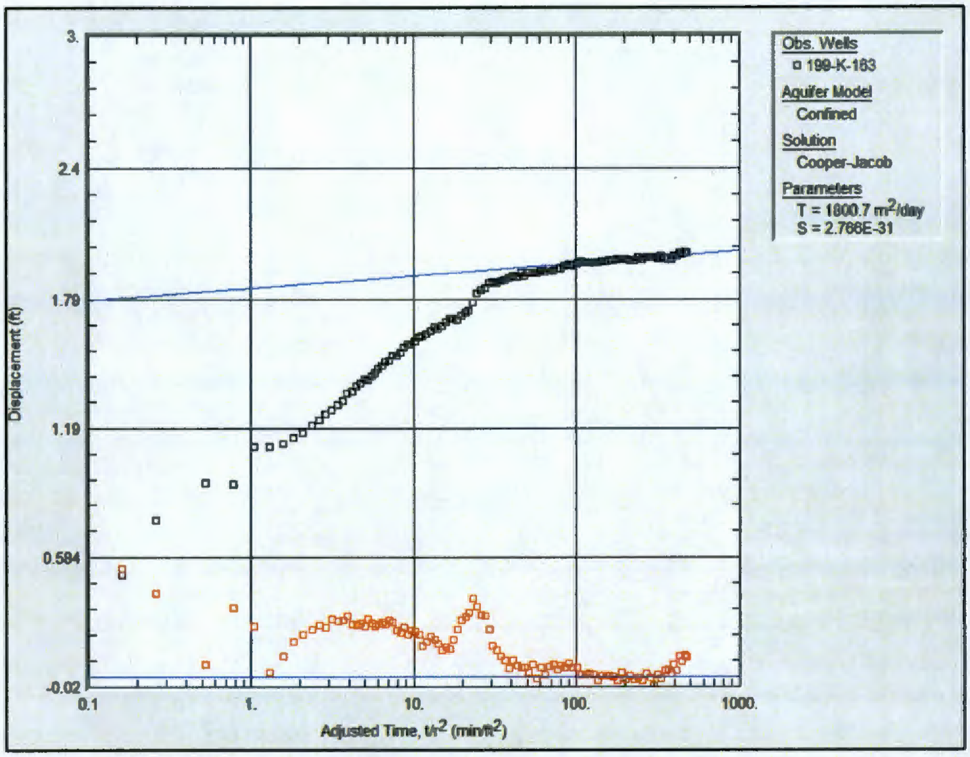


Figure 5-122. Cooper-Jacob Drawdown Analysis at 199-K-163 (2 of 2)

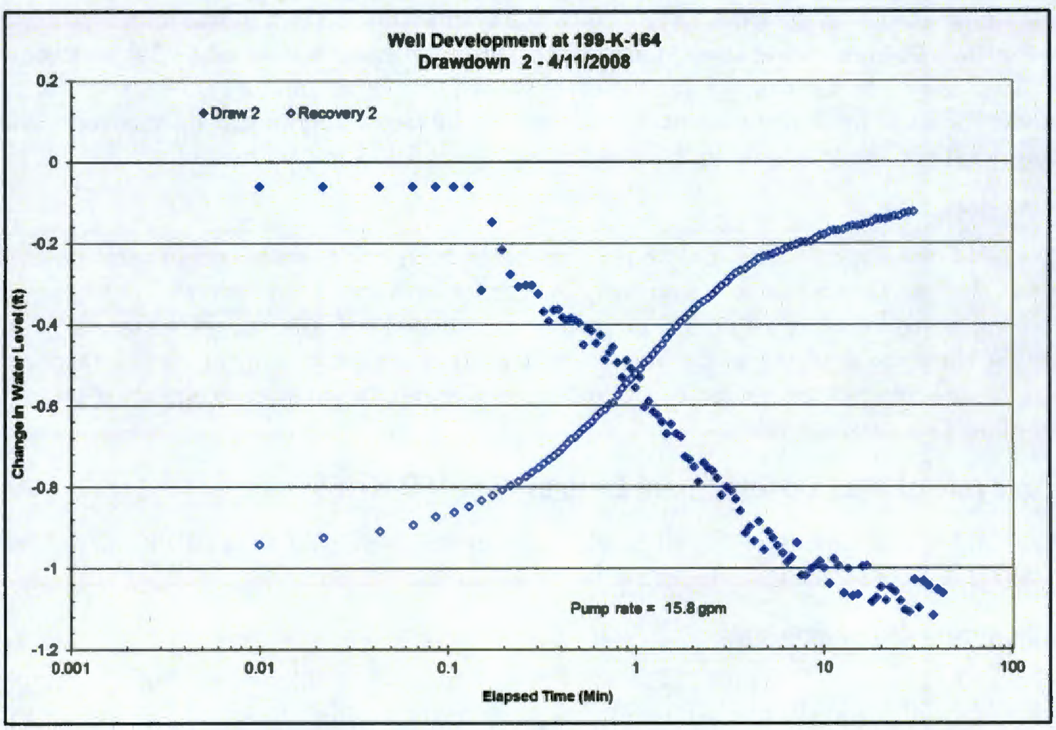


Figure 5-123. Drawdown and Recovery Data at 199-K-164

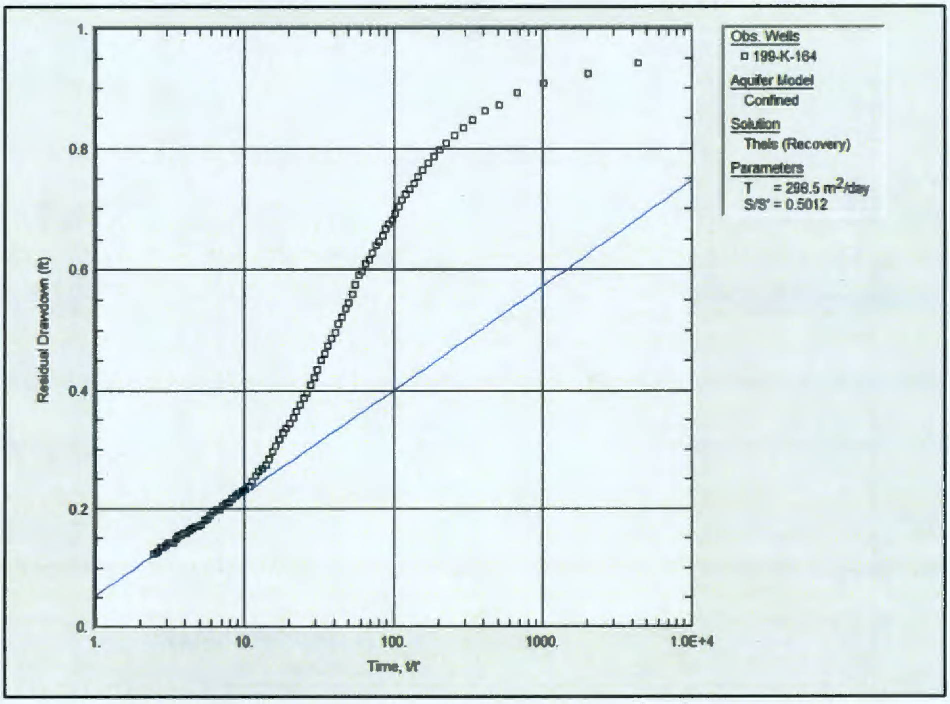


Figure 5-124. Theis Recovery Analysis at 199-K-164

5.54.1 Summary of Available Data

The well was developed on September 11, 2008. For drawdown test 1, the well was initially pumped at 20 gpm for about 90 minutes and allowed to recover. The pump intake was raised 63.3 ft. Drawdown test 2 was conducted by initially pumping at 20 gpm for about 112 minutes and then at 30 gpm for another 20 minutes. The water level in the well was monitored during the two drawdown and recovery periods, and changes in the water level with time are shown in Figures 5-125 and 5-126.

5.54.2 Analysis

Drawdown and recovery data from the two tests have been analyzed. A transmissivity estimate of 640 m^2/d is obtained from a Cooper-Jacob analysis of the second drawdown interval. The Cooper-Jacob analysis is presented in Figure 5-127. The derivative of the drawdown with respect to time, $\partial s/\partial \ln(t)$, is shown at the bottom to confirm that the Cooper-Jacob analysis is applied to the portion of the drawdown responses caused only by the response of the aquifer. Similar transmissivity estimates are obtained from analyses of the first recovery interval.

5.55 Analysis of Well Development Data at Well 199-K-166

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C6452_WD_199-K-166_2008-09-25.xlsx.*

5.55.1 Summary of available data

The well was developed on September 25, 2008. For drawdown test 1, the well was initially pumped at 18.75 gpm for an hour and allowed to recover. The pump intake was then raised 42.4 ft. Drawdown test 2 was conducted by again pumping at 18.75 gpm for an hour. The water level in the well was monitored during the two drawdown and recovery periods, and changes in the water level with time are shown in Figures 5-128 and 5-129.

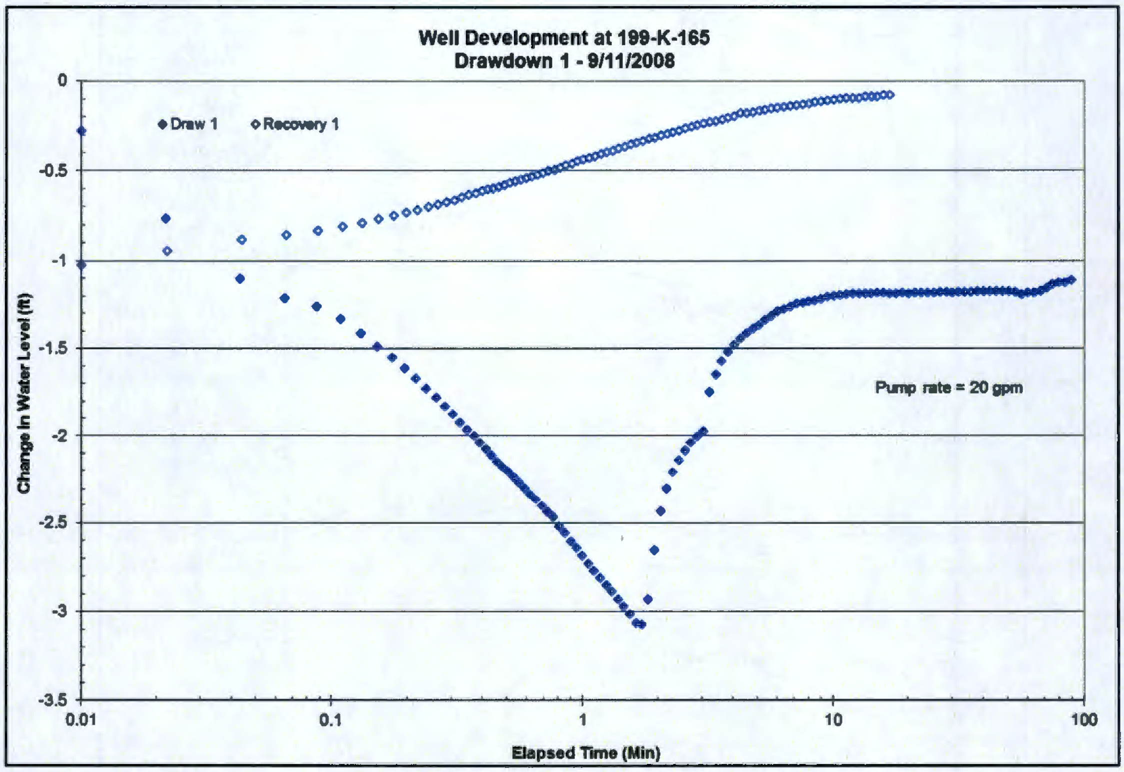


Figure 5-125. Drawdown 1 and Recovery Data at 199-K-165

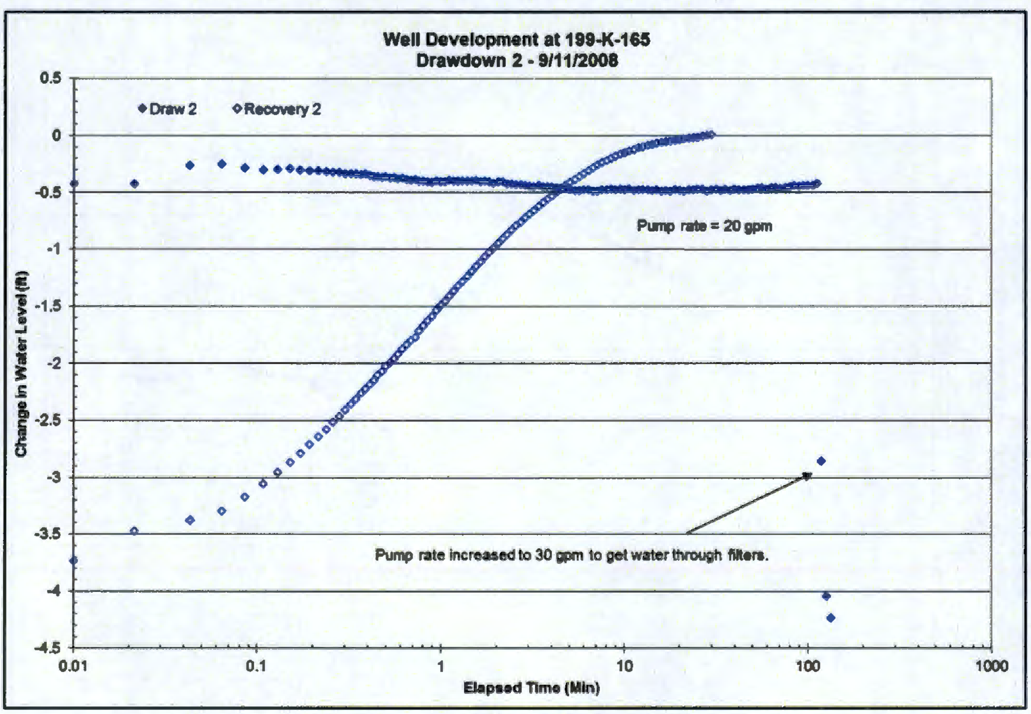


Figure 5-126. Drawdown 2 and Recovery Data at 199-K-165

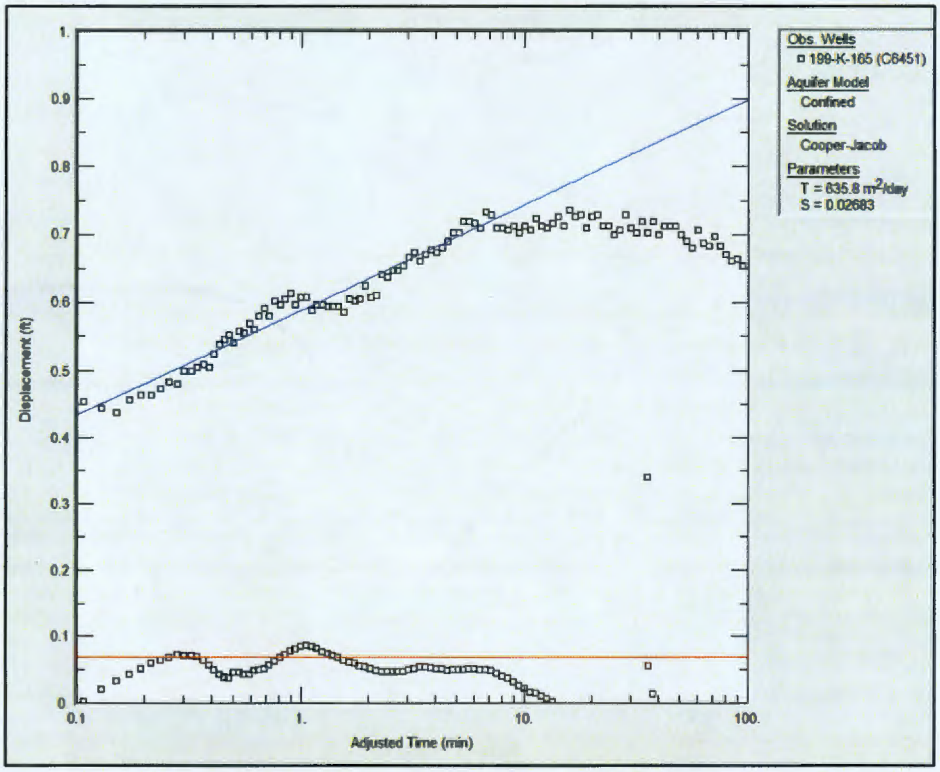


Figure 5-127. Cooper-Jacob Drawdown Analysis at 199-K-165

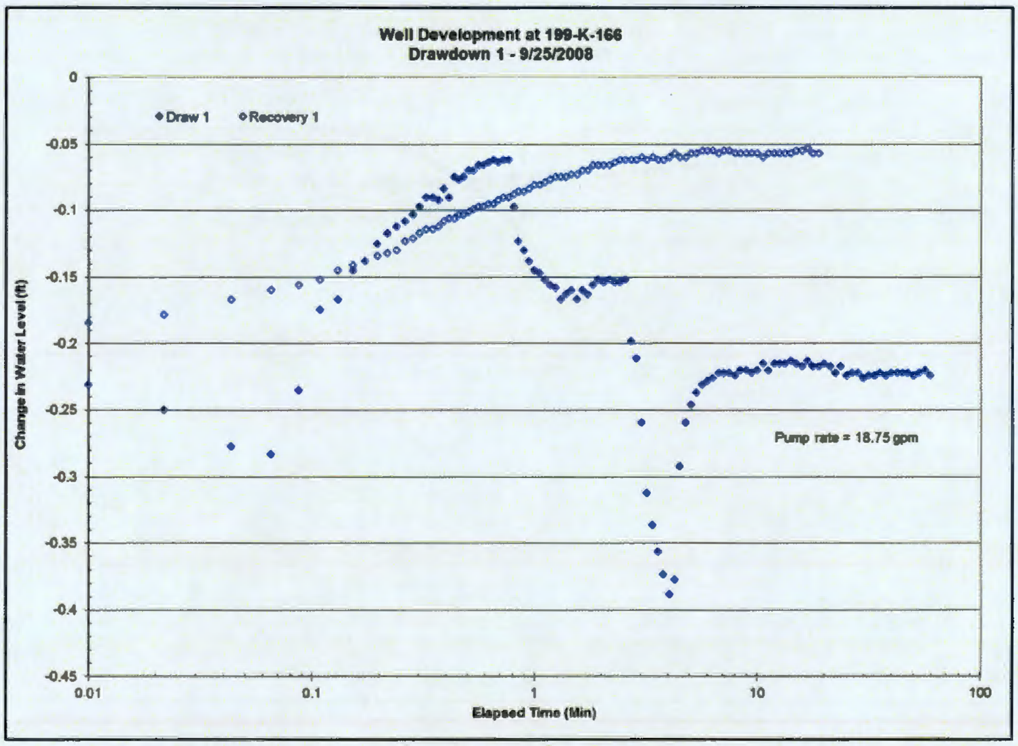


Figure 5-128. Drawdown 1 and Recovery Data at 199-K-166

5.55.2 Analysis

Drawdown and recovery data from the two tests have been analyzed. A transmissivity estimate of 3,300 m^2/d is obtained from matching the Theis solution to the drawdowns observed during the second drawdown test. This estimate is consistent with the analysis of the first recovery test, and the drawdown analyses (Theis, Cooper-Jacob) of the first drawdown test. The plot of the Theis analysis is presented in Figure 5-130.

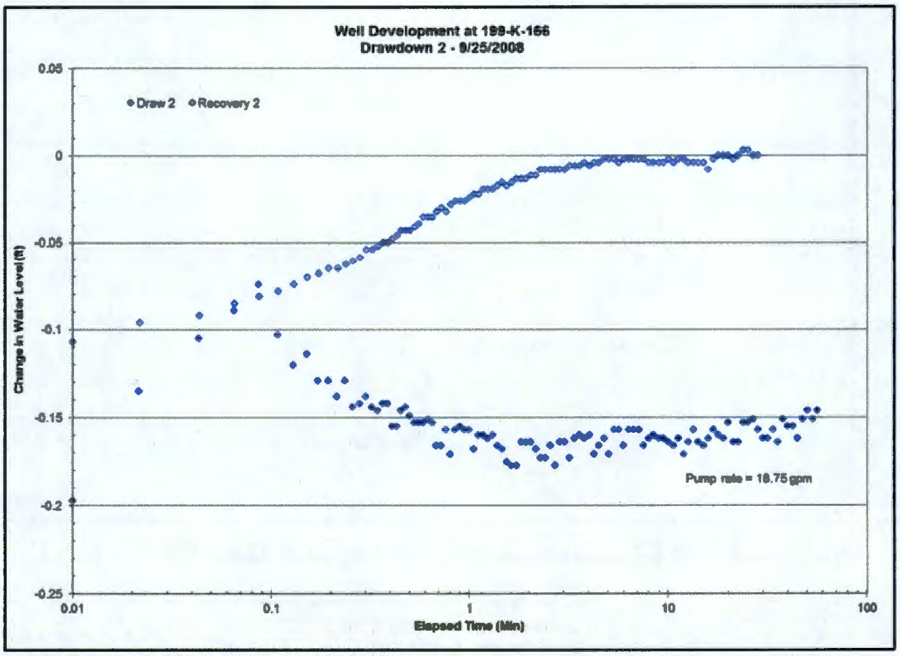


Figure 5-129. Drawdown 2 and Recovery Data at 199-K-166

5.56 Analysis of Well Development Data at Well 199-K-168

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C6454_WD_199-K-168_2008-08-25.xls*.

5.56.1 Summary of Available Data

The well was developed on August 25, 2008. For drawdown test 1, the well was initially pumped at 60 gpm and later reduced to 20.3 gpm for about 90 minutes and allowed to recover. The pump intake was then raised 34.05 ft. Drawdown test 2 was conducted by pumping at 12.5 gpm for an hour. The water level in the well was monitored during the two drawdown and recovery periods, and changes in the water level with time are shown in Figures 5-131 and 5-132.

5.56.2 Analysis

Data from the first test were not analyzed because of the complicated pumping history. Only data from the second test have been analyzed. Consistent estimates of transmissivity were obtained from the Theis recovery analysis and the Cooper-Jacob drawdown analysis. A transmissivity of 660 m^2/d is obtained, as shown in Figure 5-133. The derivative of the drawdown with respect to time, $\partial s/\partial \ln(t)$, is shown at the bottom to confirm that the Cooper-Jacob analysis is applied to the portion of the drawdown responses caused only by the aquifer. The unrealistically small storage coefficient (*S*) reflects the effects of wellbore storage effects lasting for several minutes.

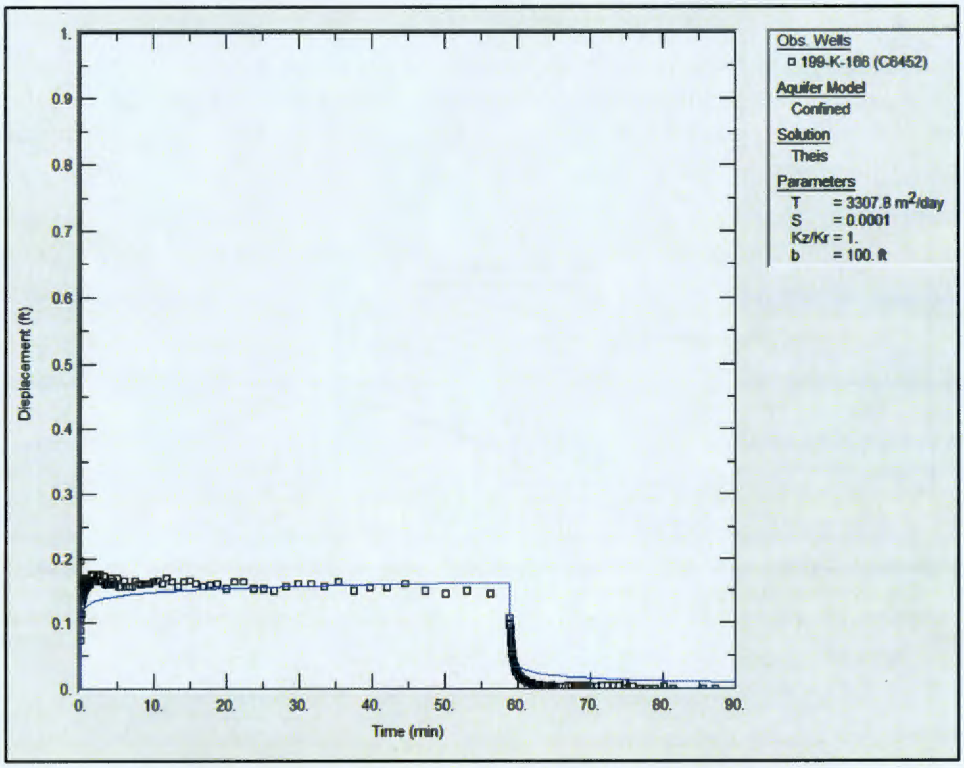


Figure 5-130. Theis Drawdown Analysis at 199-K-166

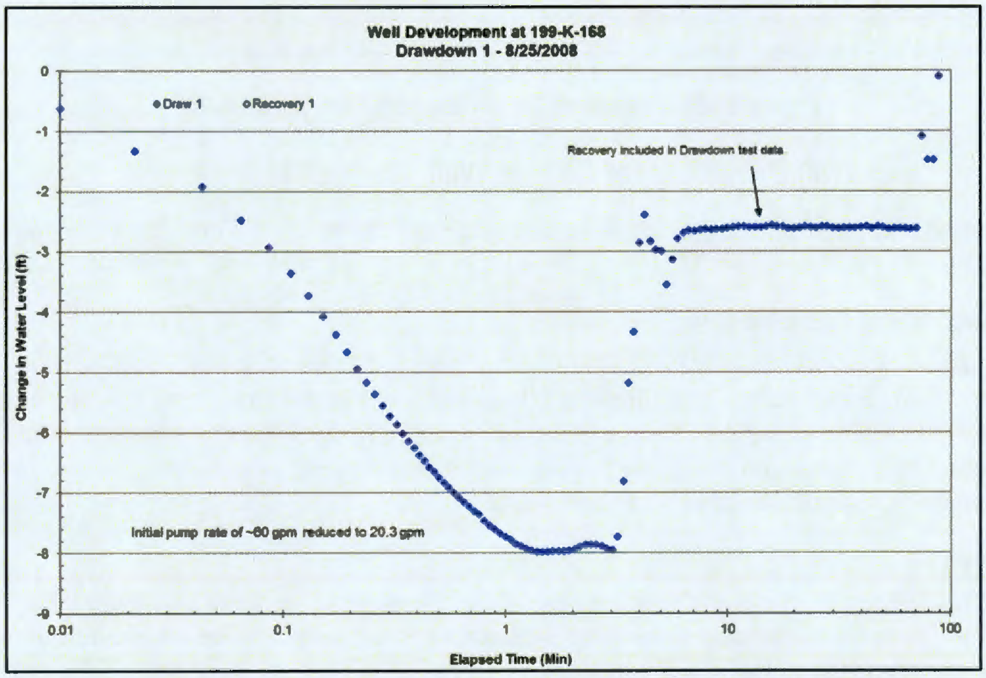


Figure 5-131. Drawdown 1 and Recovery Data at 199-K-168

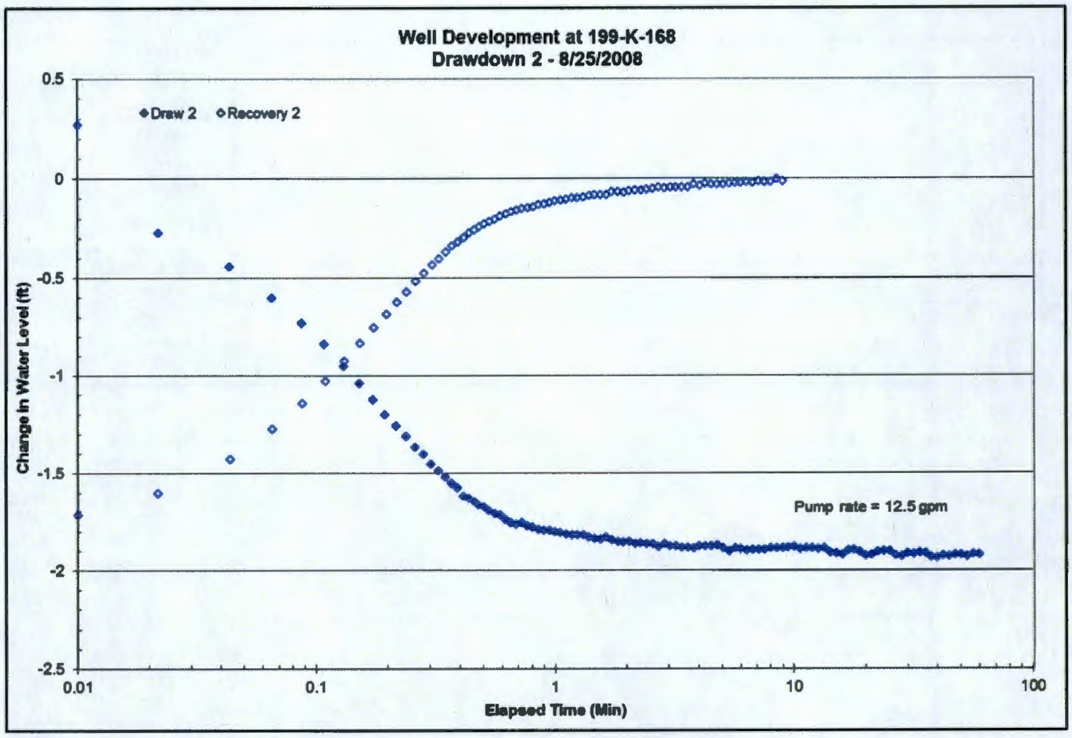


Figure 5-132. Drawdown 2 and Recovery Data at 199-K-168

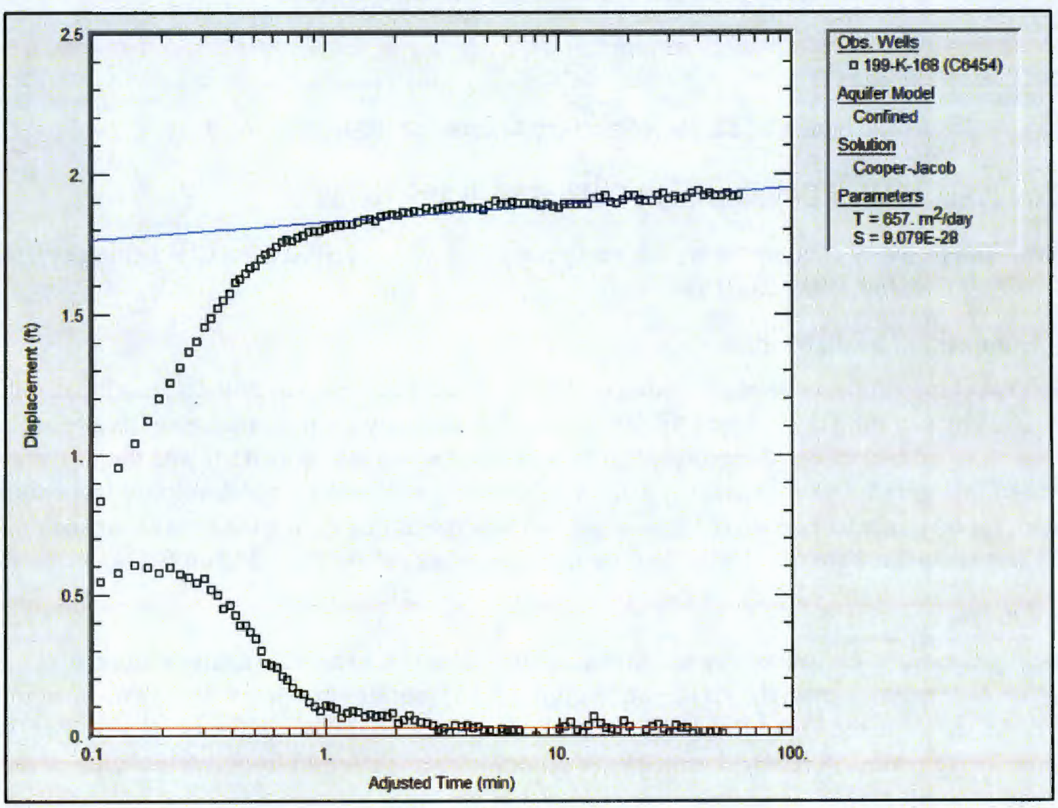


Figure 5-133. Cooper-Jacob Drawdown Analysis at 199-K-168 (1 of 2)

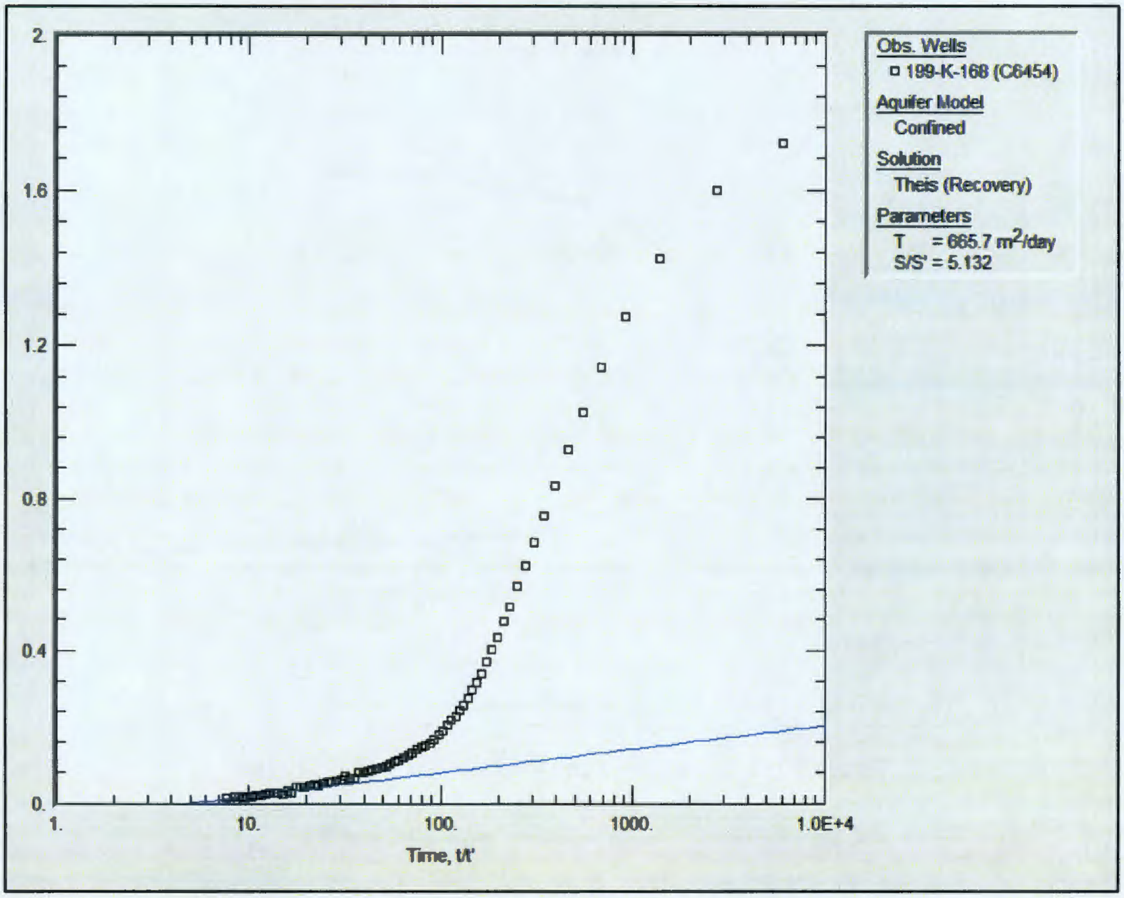


Figure 5-133. Theis Recovery Analysis at 199-K-168 (2 of 2)

5.57 Analysis of Well Development Data at Well 199-K-169

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C6744_WD_199-K-169_2008-08-05.xls*.

5.57.1 Summary of available data

Two well development data sets are included in the Excel file. The well was initially developed on July 31, 2008 by pumping at 16.7 gpm for 60 minutes, but the drawdown data were not usable because of an over-submerged transducer. Subsequently, the pump intake was raised by 42 ft, and the well was pumped at 17.64 gpm for 68 minutes. On August 5, 2008, the well was further developed by pumping at 17.64 gpm for 60 minutes. The water level in the well was monitored during the drawdown and recovery period. Changes in the water level with time for the second test are shown in Figure 5-134.

5.57.2 Analysis

Consistent estimates of transmissivity were obtained from the Theis recovery analysis and the Cooper-Jacob drawdown analysis. As shown in Figure 5-135, aquifer transmissivity is estimated to be 470 m^2/d. As shown in the Figure 5-135, the water level in the well did not recover completely at the end of the monitoring period. A relatively small residual drawdown is inferred from extrapolation of the recovery to $t/t' \rightarrow 1$.

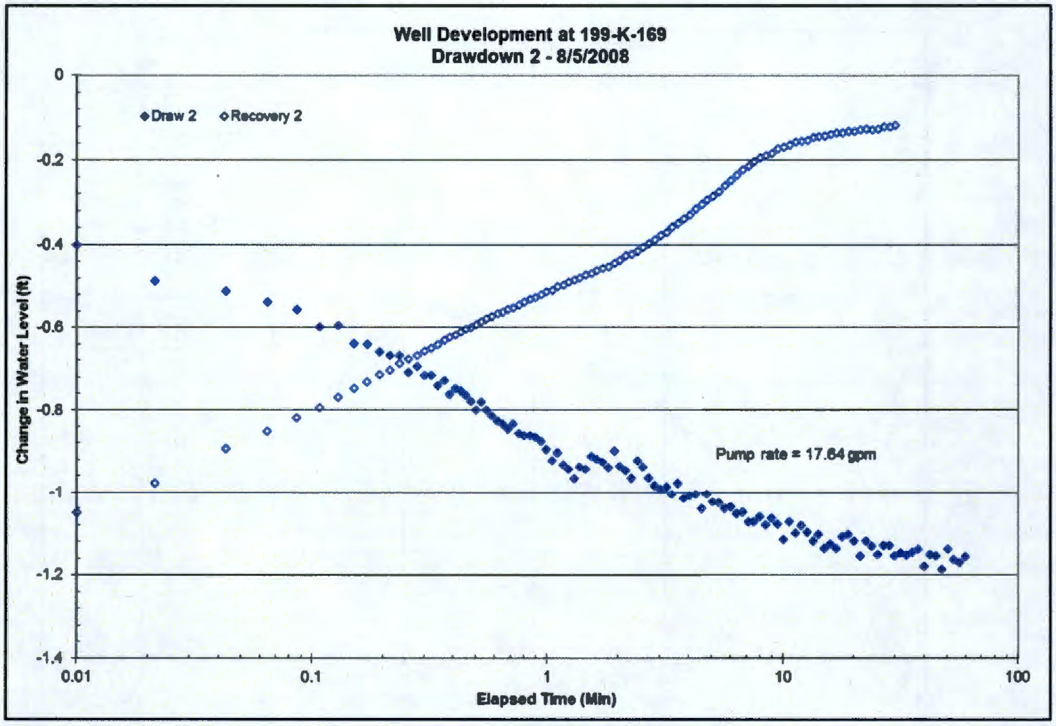


Figure 5-134. Drawdown and Recovery Data at 199-K-169

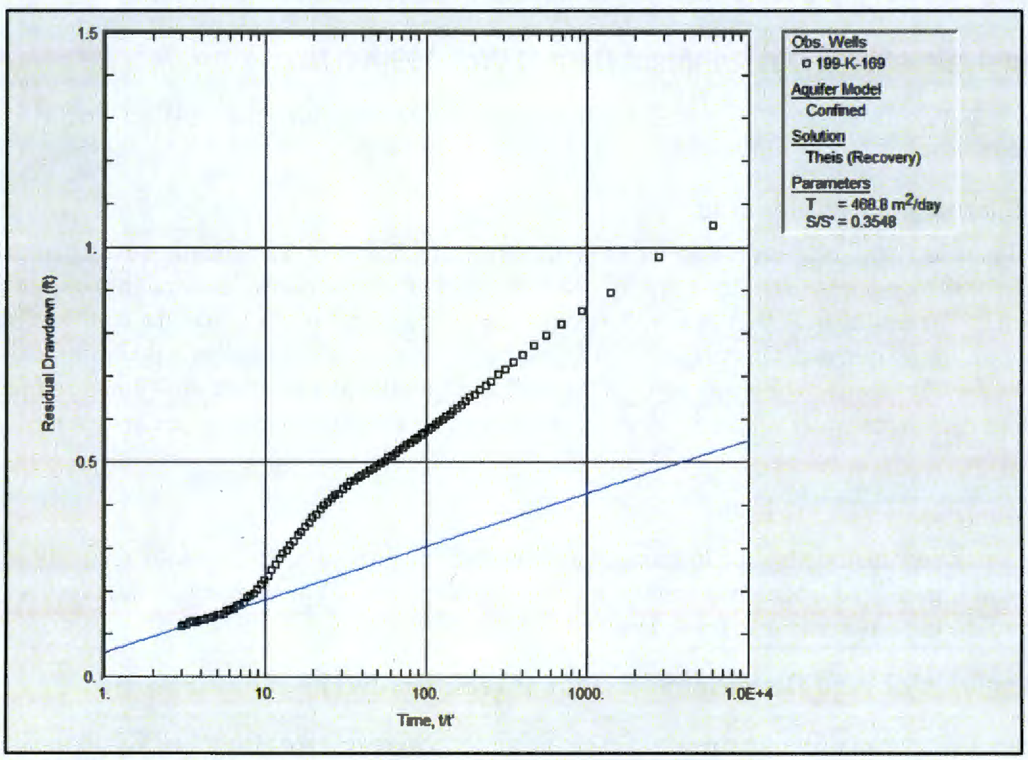


Figure 5-135. Theis Recovery Analysis at 199-K-169 (1 of 2)

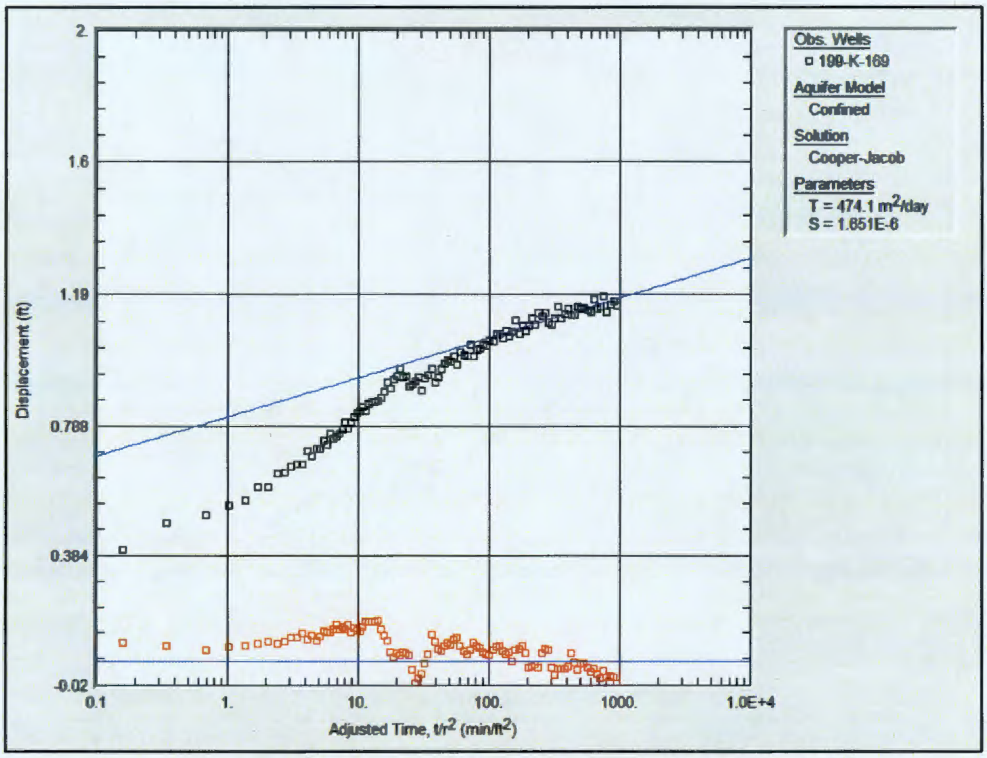


Figure 5-135. Cooper-Jacob Drawdown Analysis at 199-K-169 (2 of 2)

5.58 Analysis of Well Development Data at Well 199-K-170

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C6745_WD_199-K-170_2008-08-05.xls*.

5.58.1 Summary of Available Data

Two well development data sets are included in the Excel file. The well was initially developed on August 1, 2008 by pumping at 17.65 gpm for 85 minutes, but the drawdown data were not usable because of a submerged transducer. Subsequently, the pump intake was raised by 42 ft, and the well was pumped at 17.65 gpm for 60 minutes. On August 5, 2008, the well was further developed by pumping at 17.65 gpm for 75 minutes. The water level in the well was monitored during the drawdown and recovery period. Changes in the water level with time for the second well development test are shown in Figure 5-136.

5.58.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. As shown in Figure 5-137, aquifer transmissivity is estimated to be 80 m^2/d. The late-time recovery data conform to the expected response for an ideal aquifer.

5.59 Analysis of Well Development Data at Well 199-K-171

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C6746_WD_199-K-171_2008-08-18.xls*.

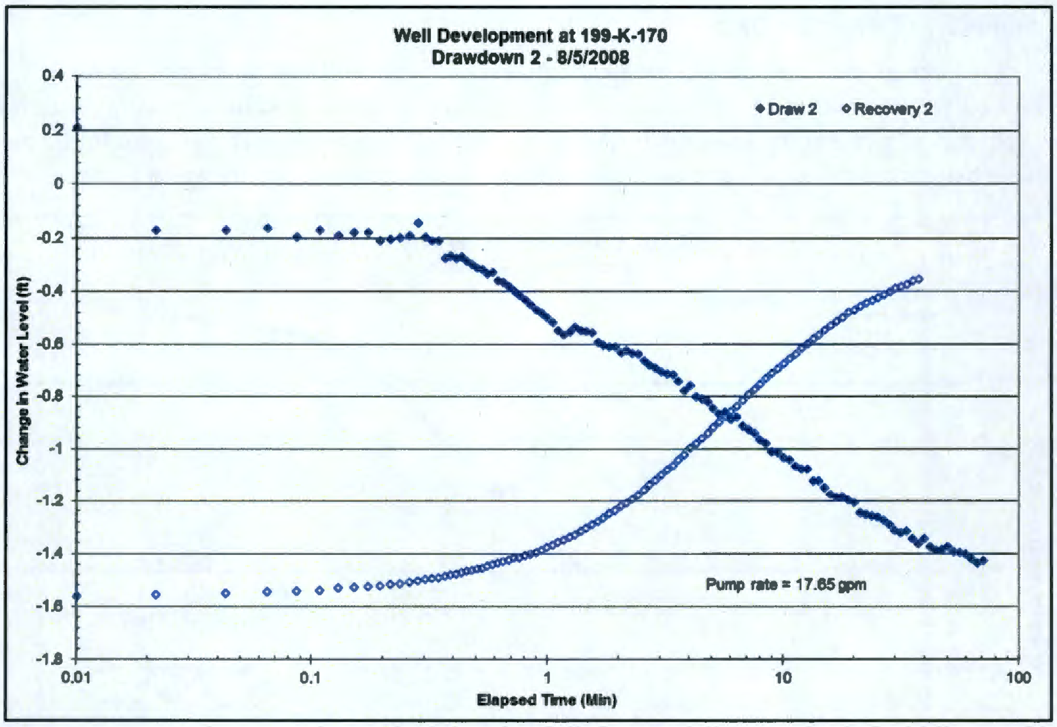


Figure 5-136. Drawdown and Recovery Data at 199-K-170

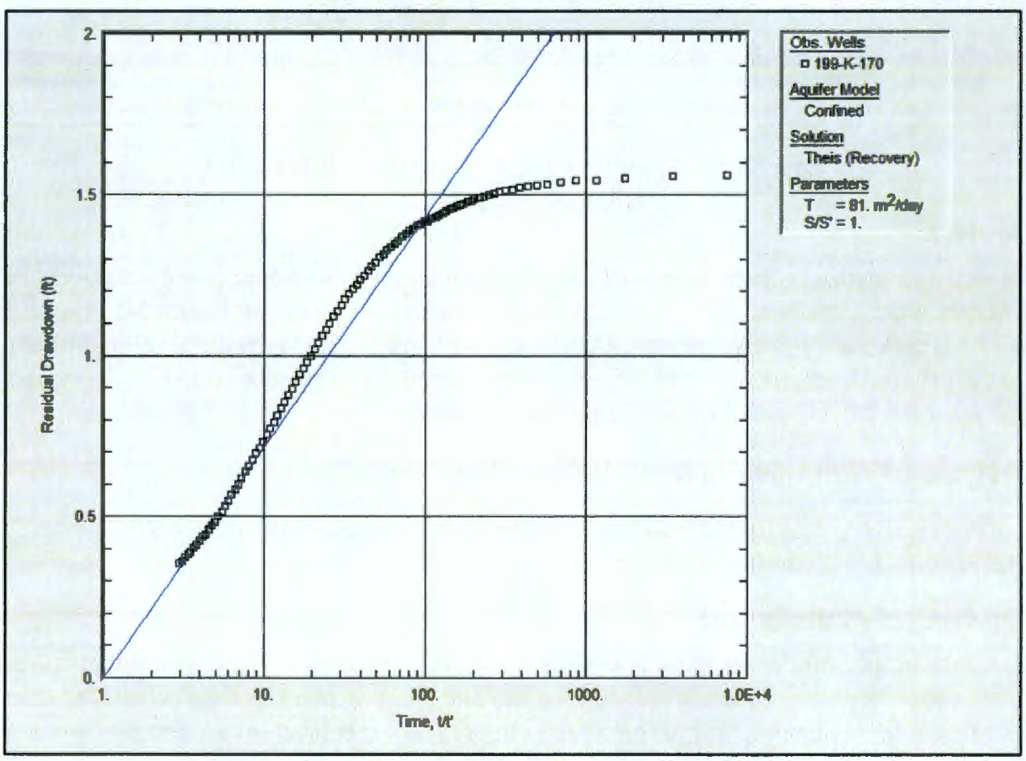


Figure 5-137. Theis Recovery Analysis at 199-K-170

5.59.1 Summary of Available Data

Two well development data sets are included in the Excel file. The well was developed on August 18, 2008. The well was pumped at 17.65 gpm for 72 minutes, and the water level in the well was allowed to recover. Subsequently, the pump intake was raised, and the well was pumped at 16.6 gpm for 85 minutes. Water level changes for the 17.65 gpm event (first well development test) are shown in Figure 5-138.

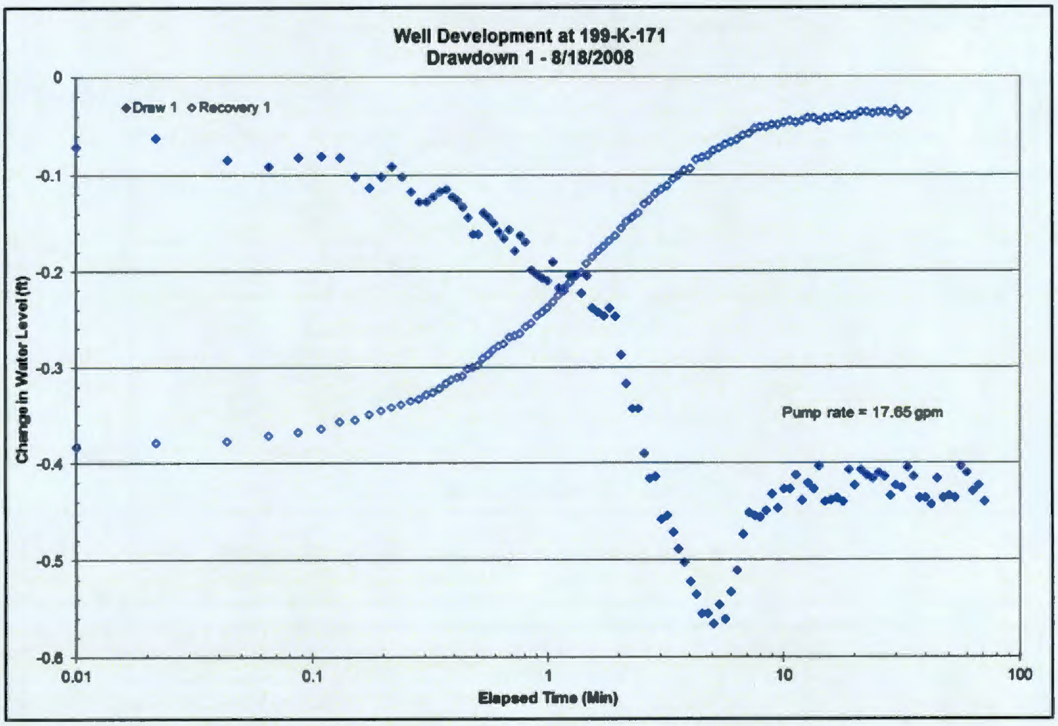


Figure 5-138. Drawdown and Recovery Data at 199-K-171

5.59.2 Analysis

The Theis recovery method is used to estimate aquifer transmissivity and diagnose the recovery response. Drawdown data were noisy, and good fits could not be obtained. As shown in Figure 5-139, aquifer transmissivity is estimated to be 2,000 m^2/d. As shown in Figure 5-139, the water level in the well did not recover to the original level at the end of the monitoring period. Extrapolation of the recovery data to *t/t'* = 1 suggests that a relatively small residual drawdown persists.

5.60 Analysis of Well Development Data at Well 199-K-174

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C7061_WD_199-K-174_2009-02-26.xls*.

5.60.1 Summary of Available Data

The well was developed on February 26, 2009. For drawdown test 1, the well was initially pumped at 17.5 gpm for about 70 minutes and allowed to recover. The pump intake was then raised, and drawdown test 2 was conducted by pumping at 17.6 gpm for an hour. The water level in the well was monitored during the two drawdown and recovery periods, and changes in the water level with time are shown in Figures 5-140 and 5-141.

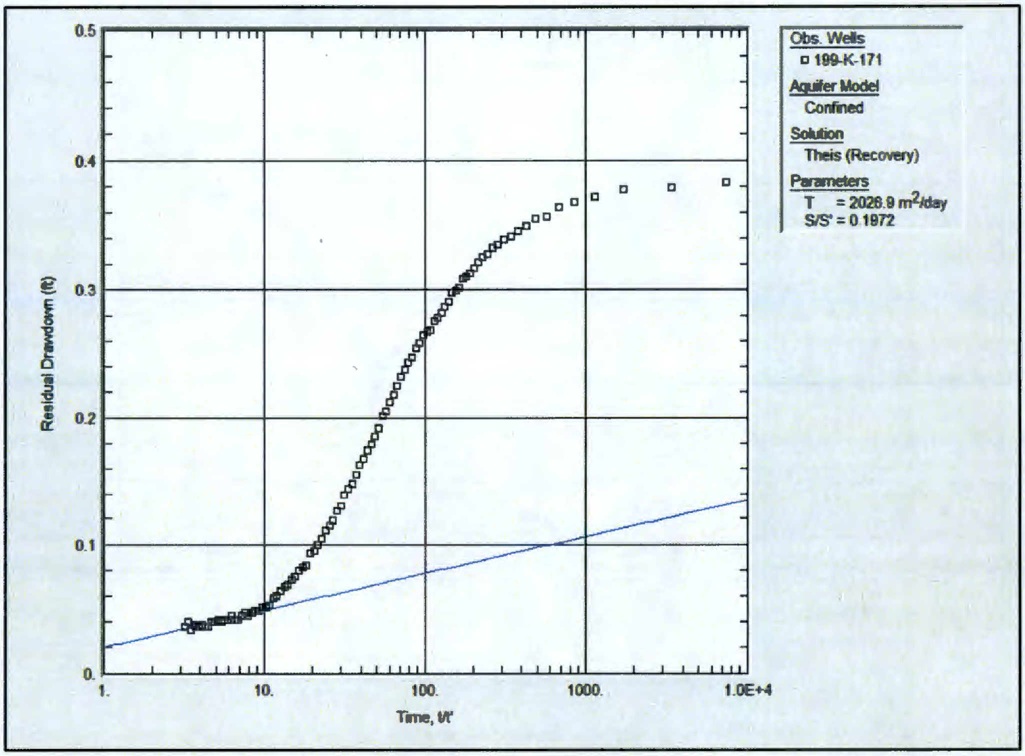


Figure 5-139. Theis Recovery Analysis at 199-K-171

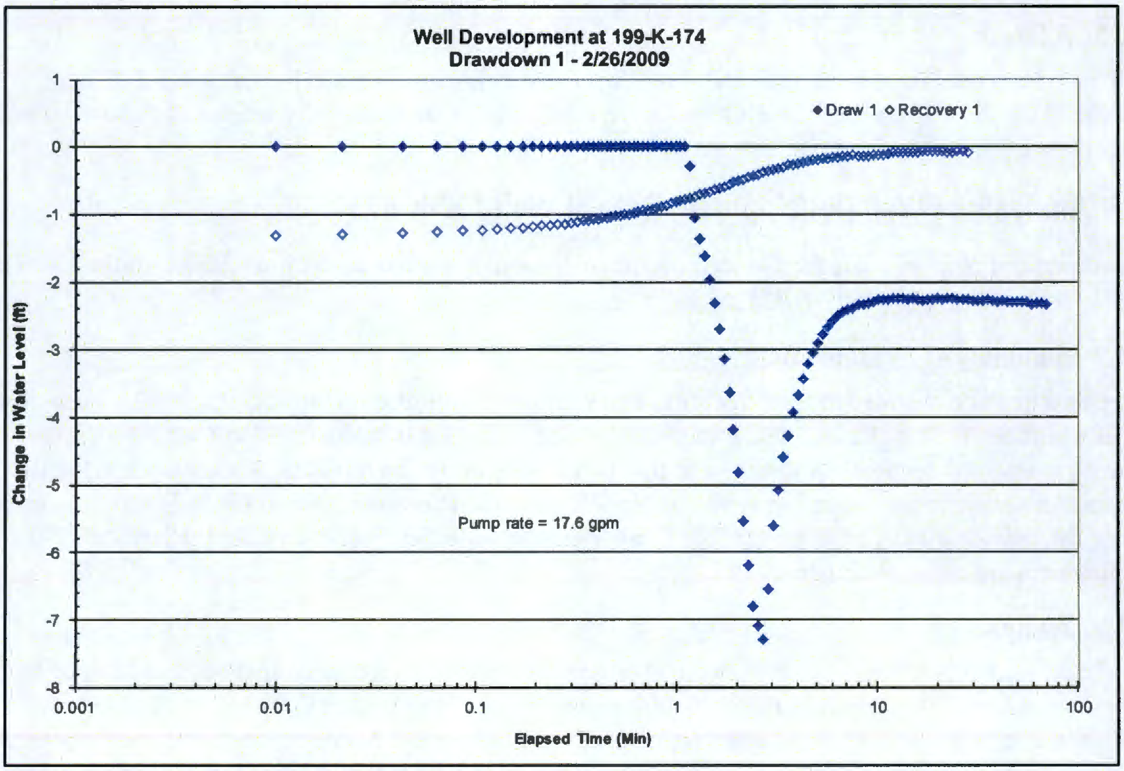


Figure 5-140. Drawdown 1 and Recovery Data at 199-K-174

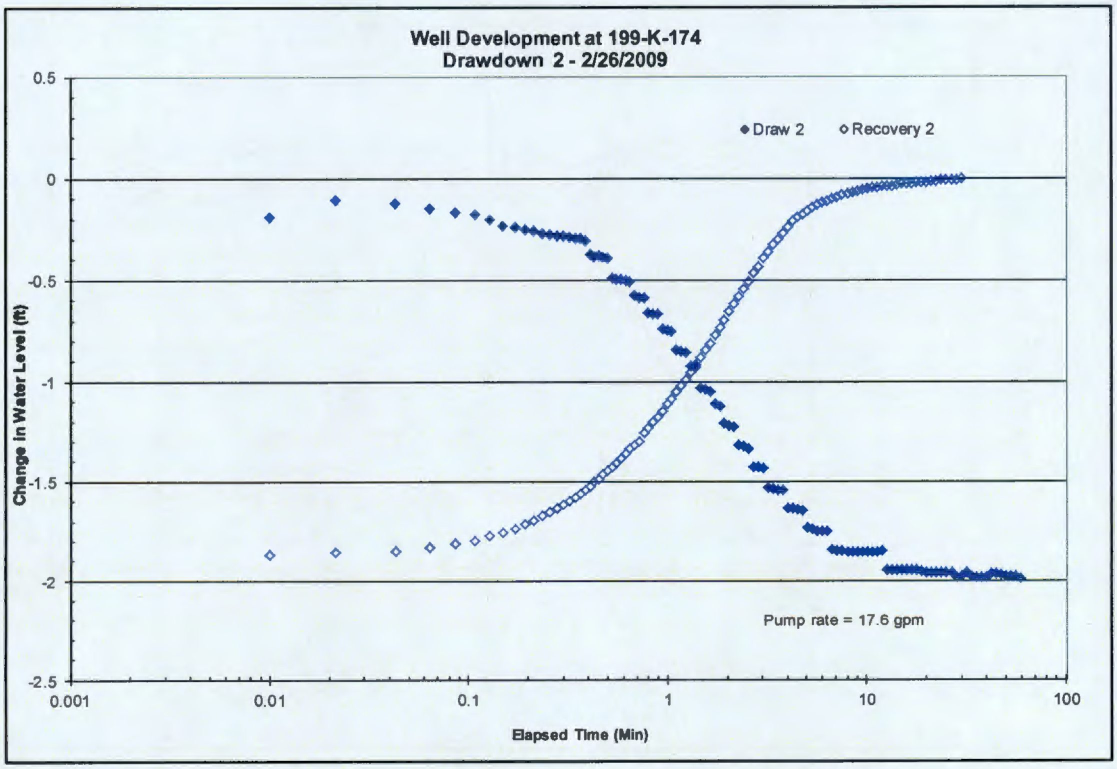


Figure 5-141. Drawdown 2 and Recovery Data at 199-K-174

5.60.2 Analysis

Data from both tests have been analyzed. Transmissivity estimates obtained by matching the Theis solution to the drawdown data from both tests are consistent. A transmissivity estimate of 180 m^2/d is obtained from the analysis of the first test as shown in Figure 5-142.

5.61 Analysis of Well Development Data at Well 199-K-179

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C7150_WD_199-K-179_2009-10-23.xls.*

5.61.1 Summary of Available Data

Three data sets are included in the Excel file. The well was developed on October 23, 2009. The well was initially pumped at 30 gpm, and then increased to 40 gpm, but the transducer did not work properly during this test. Subsequently, the well was pumped at 40 gpm for 56 minutes. After recovery, the well was further developed by pumping at 40 gpm for 29 minutes. The water level in the well was monitored during the drawdown and recovery period. Changes in the water level with time for the last well development are shown in Figure 5-143.

5.61.2 Analysis

Consistent estimates of transmissivity were obtained from the Theis recovery analysis and Cooper-Jacob drawdown analysis. As shown in Figure 5-144, transmissivity is estimated to be 160 m^2/d. As shown in the figure, complete recovery is attained for a value of *t/t'* of about 2.5, corresponding to recovery earlier than expected for an ideal aquifer. This premature recovery suggests that an additional source of water replenishes the drawdown cone.

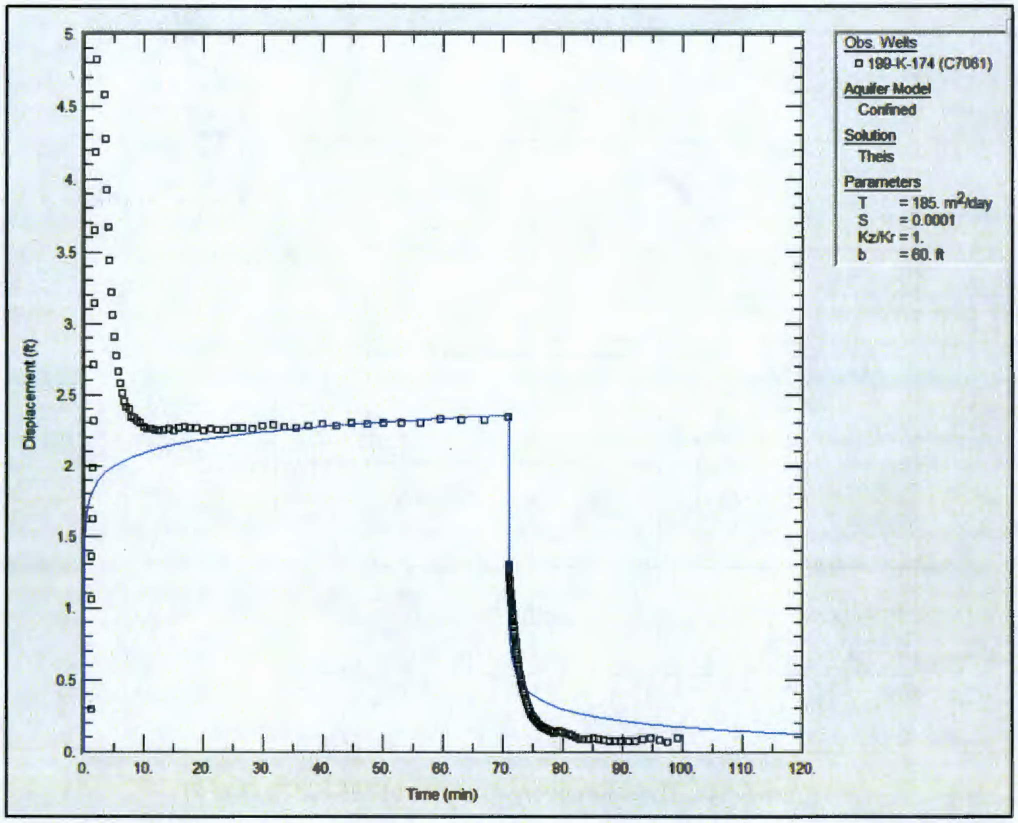


Figure 5-142. Theis Drawdown Analysis at 199-K-174

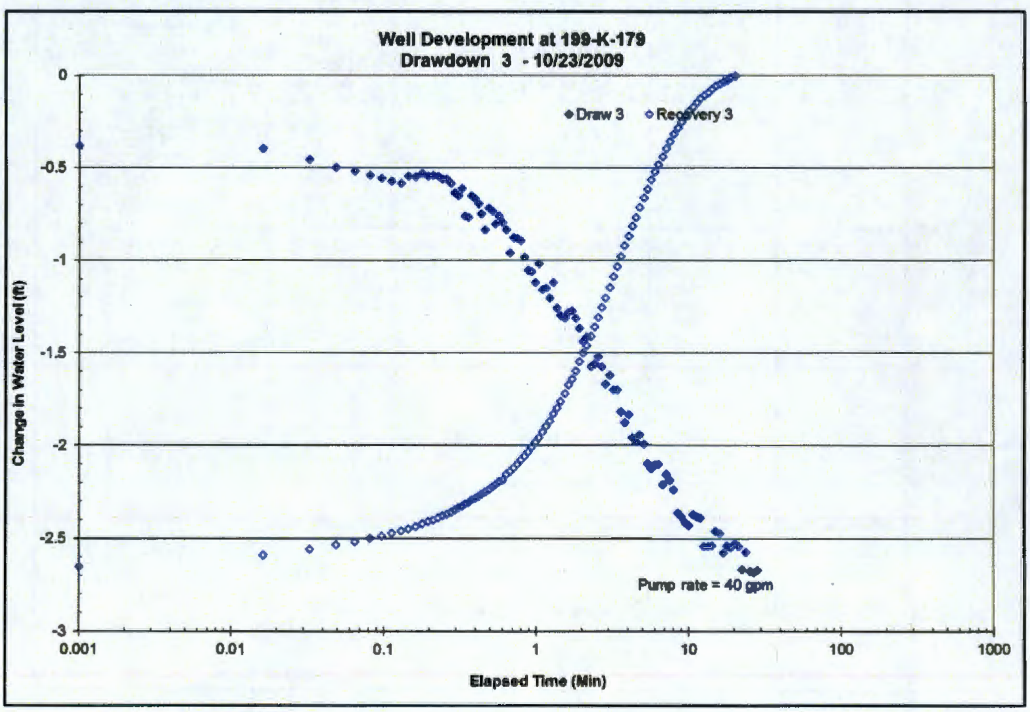


Figure 5-143. Drawdown and Recovery Data at 199-K-179

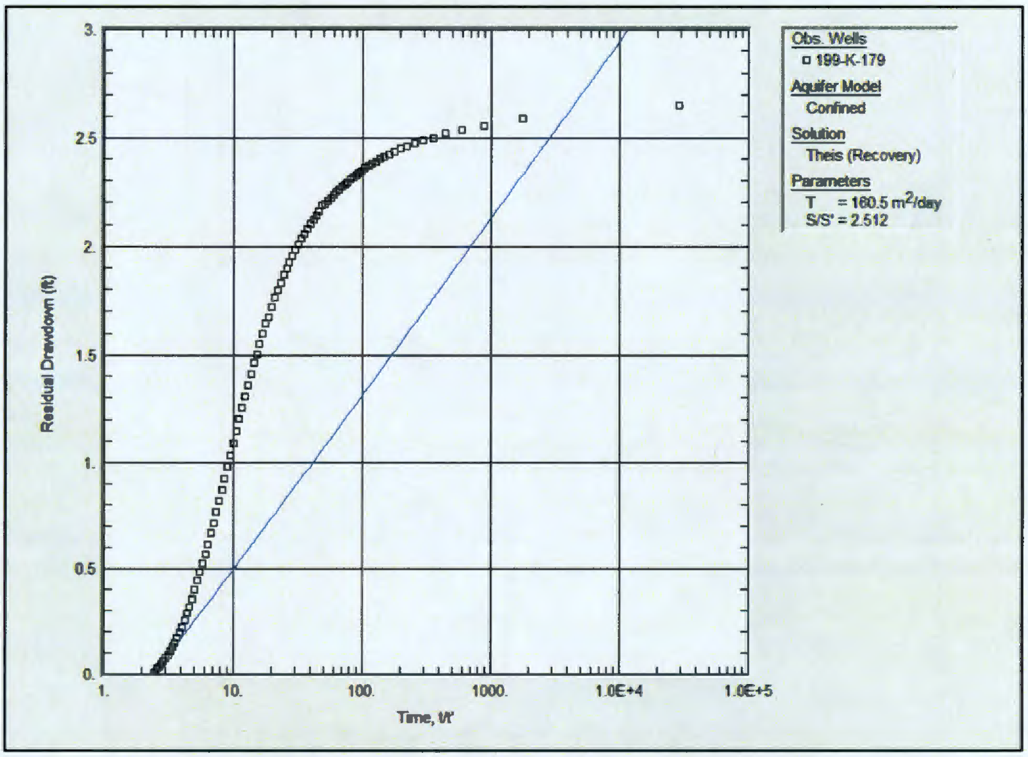


Figure 5-144. Theis Recovery Analysis at 199-K-179 (1 of 2)

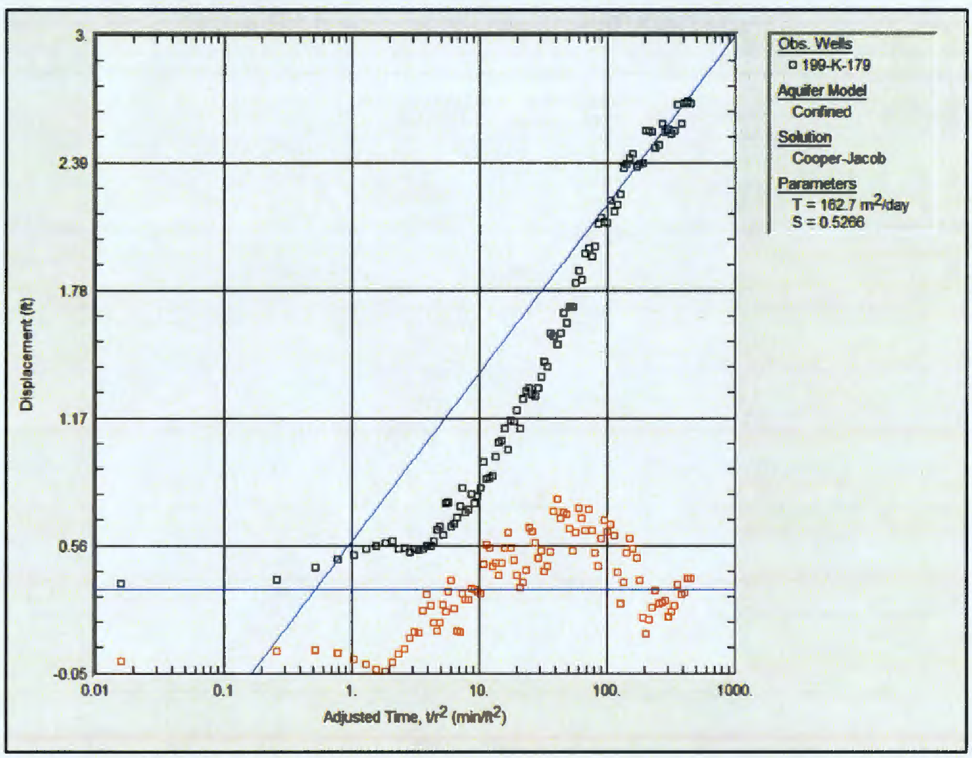


Figure 5-144. Cooper-Jacob Drawdown Analysis at 199-K-179 (2 of 2)

5.62 Analysis of Well Development Data at Well 199-K-180

Drawdown and recovery data for two well development tests were received from CHPRC in the Excel file *C7151_WD_199-K-180_2010-01-18.xls*.

5.62.1 Summary of Available Data

The well was developed on January 18, 2010. Two data sets are included in the Excel file. The well was initially pumped at 20.3 gpm for 77 minutes, and the water level in the well was allowed to recover. Subsequently, the pump intake was raised 21 ft, and the well was pumped at 19.4 gpm for 60 minutes. The water level in the well was monitored during the drawdown and recovery period. Changes in the water level with time for the second well development are shown in Figure 5-145.

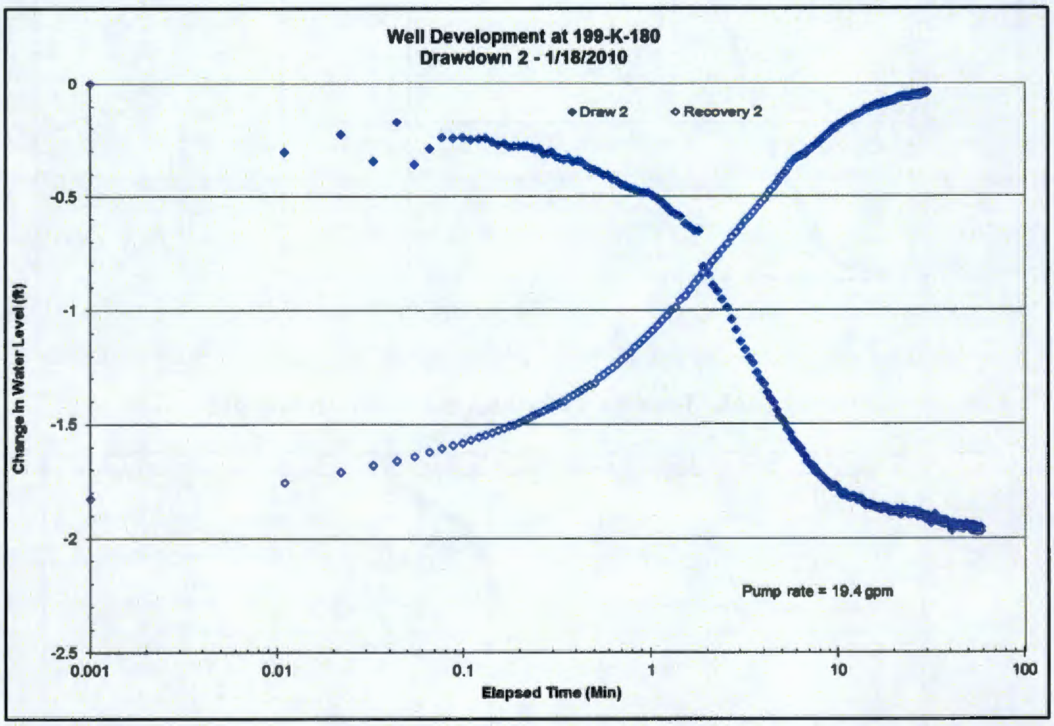


Figure 5-145. Drawdown and Recovery Data at 199-K-180

5.62.2 Analysis

Consistent estimates of transmissivity were obtained from the Theis recovery analysis and the Cooper-Jacob drawdown analysis. Since complete recovery is not attained by the end of the monitoring period, the Theis recovery line is fit only to the last few data points. As shown in Figure 5-146, aquifer transmissivity is estimated to be 620 m^2/d and the late-time aquifer recovery response is consistent with that expected from an ideal aquifer.

5.63 Analysis of Well Development Data at Well 199-K-182

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C7476_WD_199-K-182_2009-12-28.xls*.

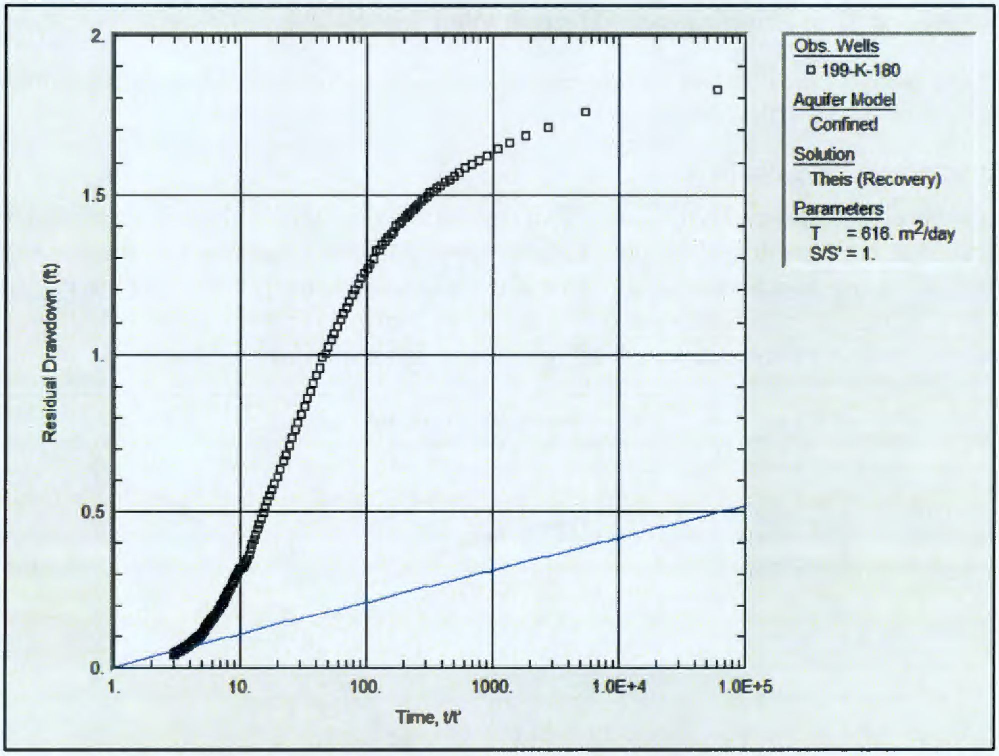


Figure 5-146. Theis Recovery Analysis at 199-K-180 (1 of 2)

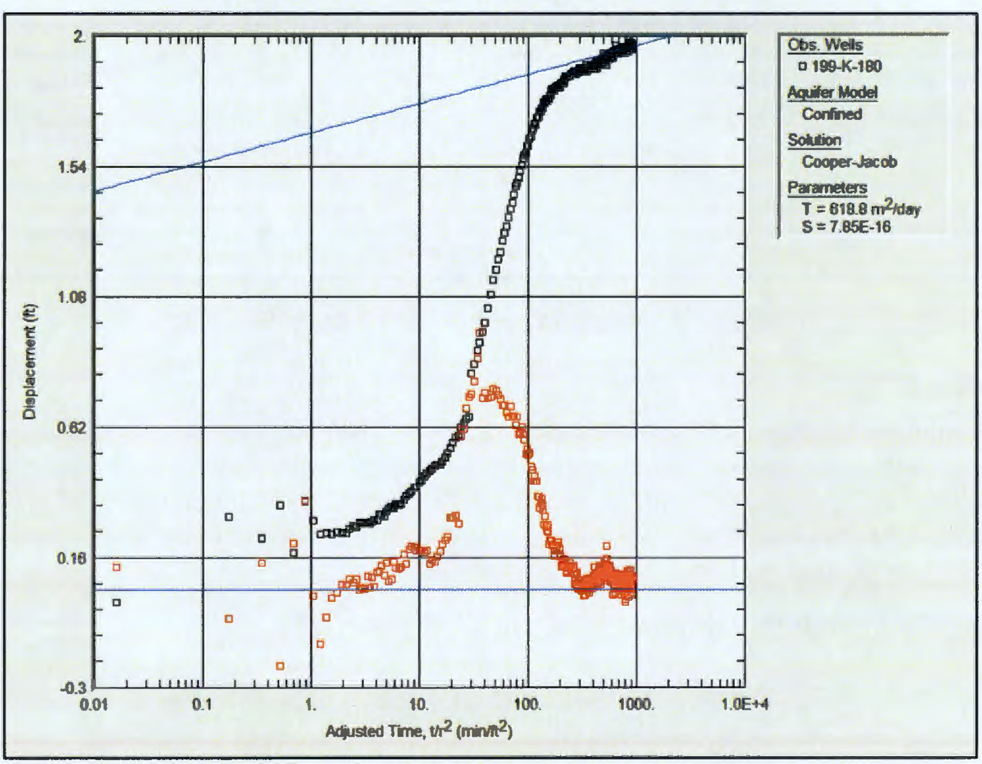


Figure 5-146. Cooper-Jacob Drawdown Analysis at 199-K-180 (2 of 2)

5.63.1 Summary of Available Data

The well was developed on December 28, 2009. For drawdown test 1, the well was initially pumped at 21.4 gpm, then pumping was reduced to 9.4 gpm after which the well was allowed to recover. The pump intake was then raised 23.1 ft, and drawdown test 2 was conducted by pumping at 23.1 gpm followed by reduced pumping at 10.7 gpm. The water level in the well was monitored during the two drawdown and recovery periods, and changes in the water level with time are shown in Figures 5-147 and 5-148.

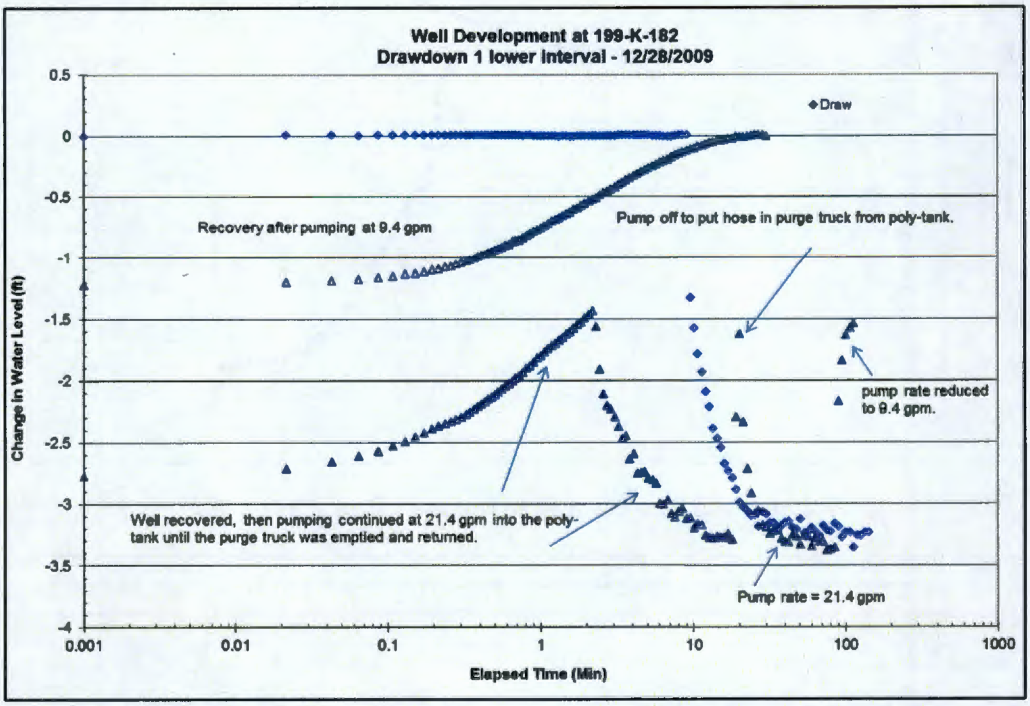


Figure 5-147. Drawdown 1 and Recovery Data at 199-K-182

5.63.2 Analysis

Drawdown data from both the tests have been analyzed. Transmissivity estimates obtained from matching the Theis solution to the drawdowns and from the Cooper-Jacob analyses for both tests are consistent. The most representative estimate of transmissivity (160 m^2/d) is selected from the Cooper-Jacob analysis of the first test and is shown in Figure 5-149. The derivative of the drawdown with respect to time, $\partial s/\partial \ln(t)$, is shown at the bottom to confirm that the Cooper-Jacob analysis is applied to the portion of the drawdown response caused only by the aquifer.

5.64 Analysis of Well Development Data at Well 199-K-198

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C7698_WD_199-K-198_2011-05-24.xlsx*.

5.64.1 Summary of Available Data

The well was developed on May 24, 2011. For drawdown test 1, the well was initially pumped at 120 gpm, then pumping was reduced to 100 gpm and later to 40 gpm after which the well was allowed to recover. The pump intake was then raised, and drawdown test 2 was conducted by pumping at 24 gpm for about 40 minutes. The water level in the well was monitored during the two drawdown and recovery periods, and changes in the water level with time are shown in Figures 5-150 and 5-151.

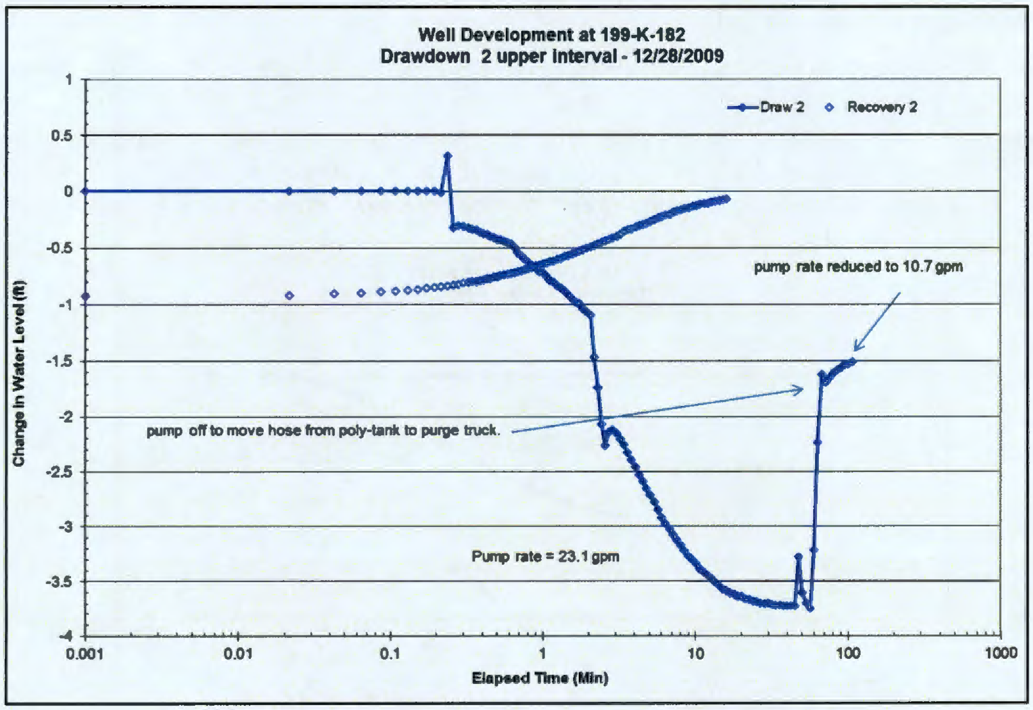


Figure 5-148. Drawdown 2 and Recovery Data at 199-K-182

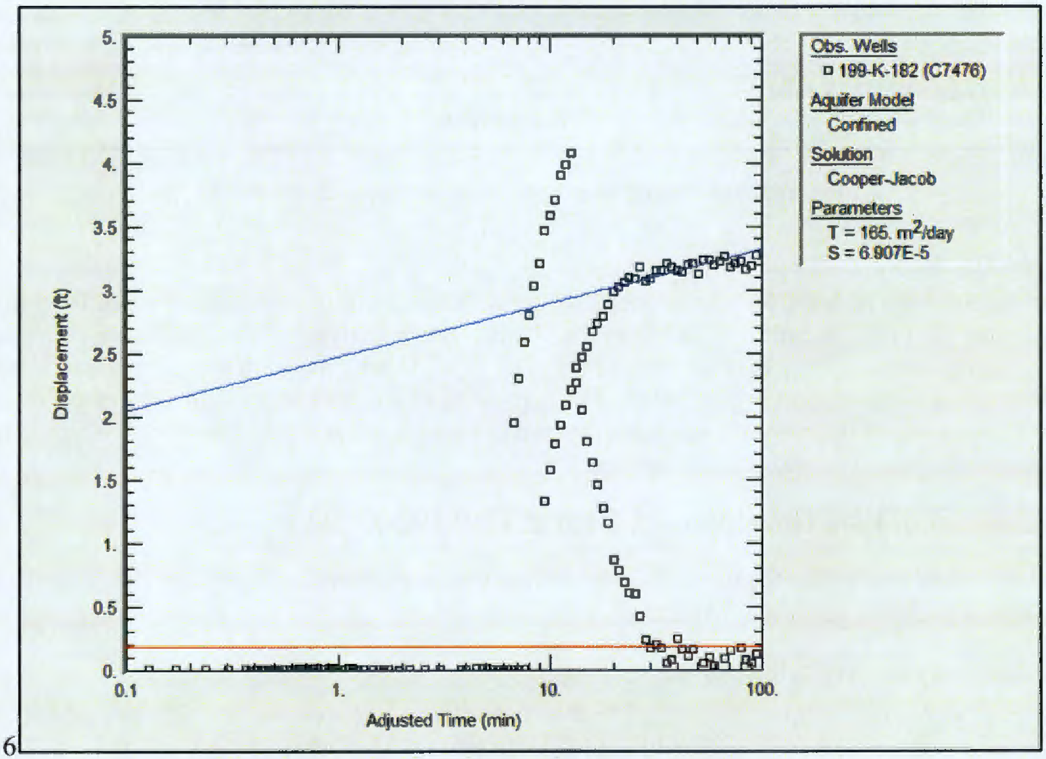


Figure 5-149. Cooper-Jacob Drawdown Analysis at 199-K-182

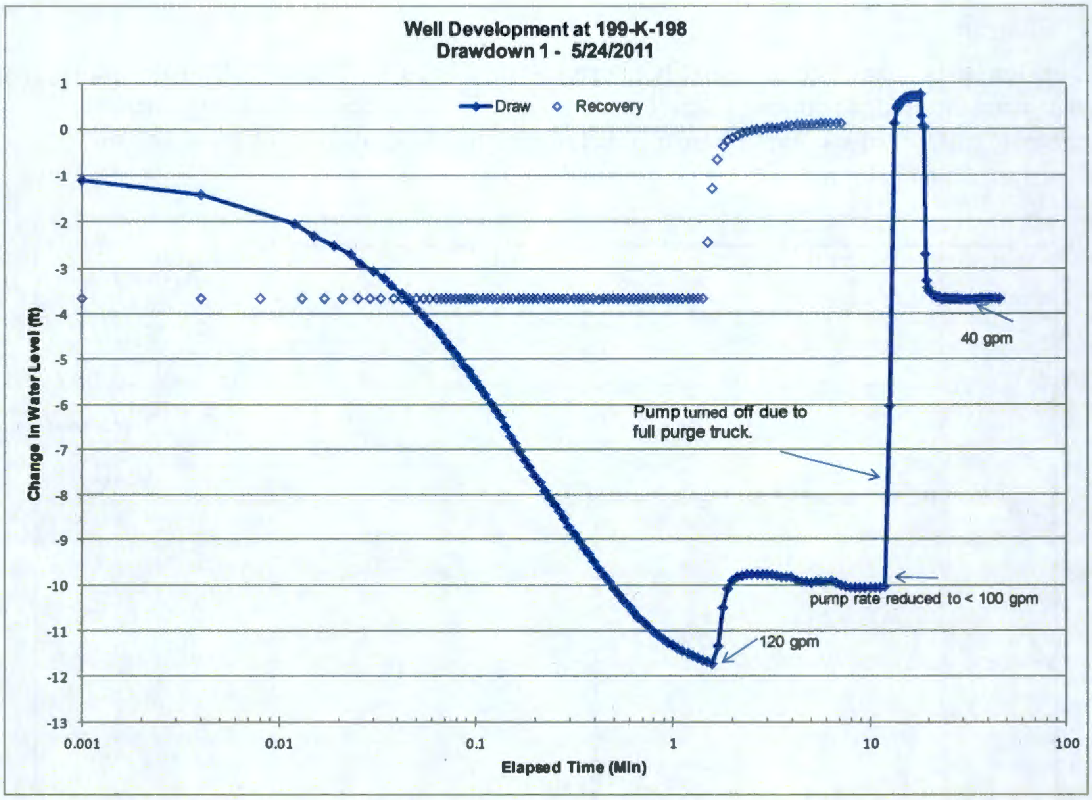


Figure 5-150. Drawdown 1 and Recovery Data at 199-K-198

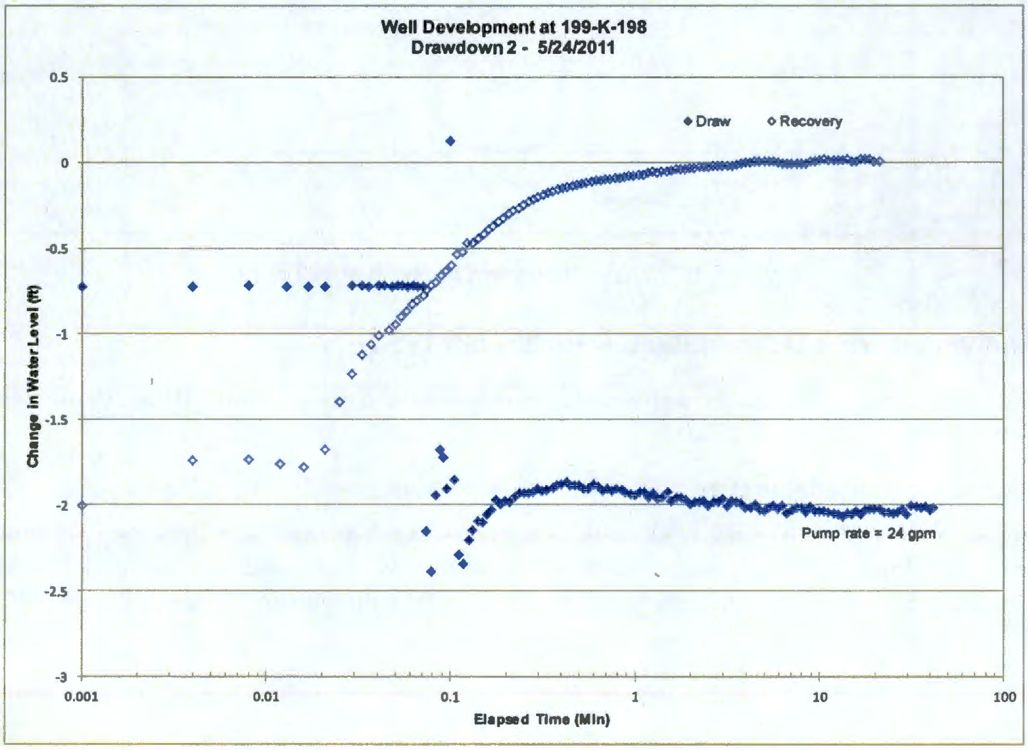


Figure 5-151. Drawdown 2 and Recovery Data at 199-K-198

5.64.2 Analysis

Data from the first pumping interval have not been analyzed because of the complicated pumping history. Only data from the second pumping interval are analyzed. The most representative estimate of transmissivity (290 m^2/d) is inferred from a match of the Theis solution to drawdown data from the second test as shown in Figure 5-152.

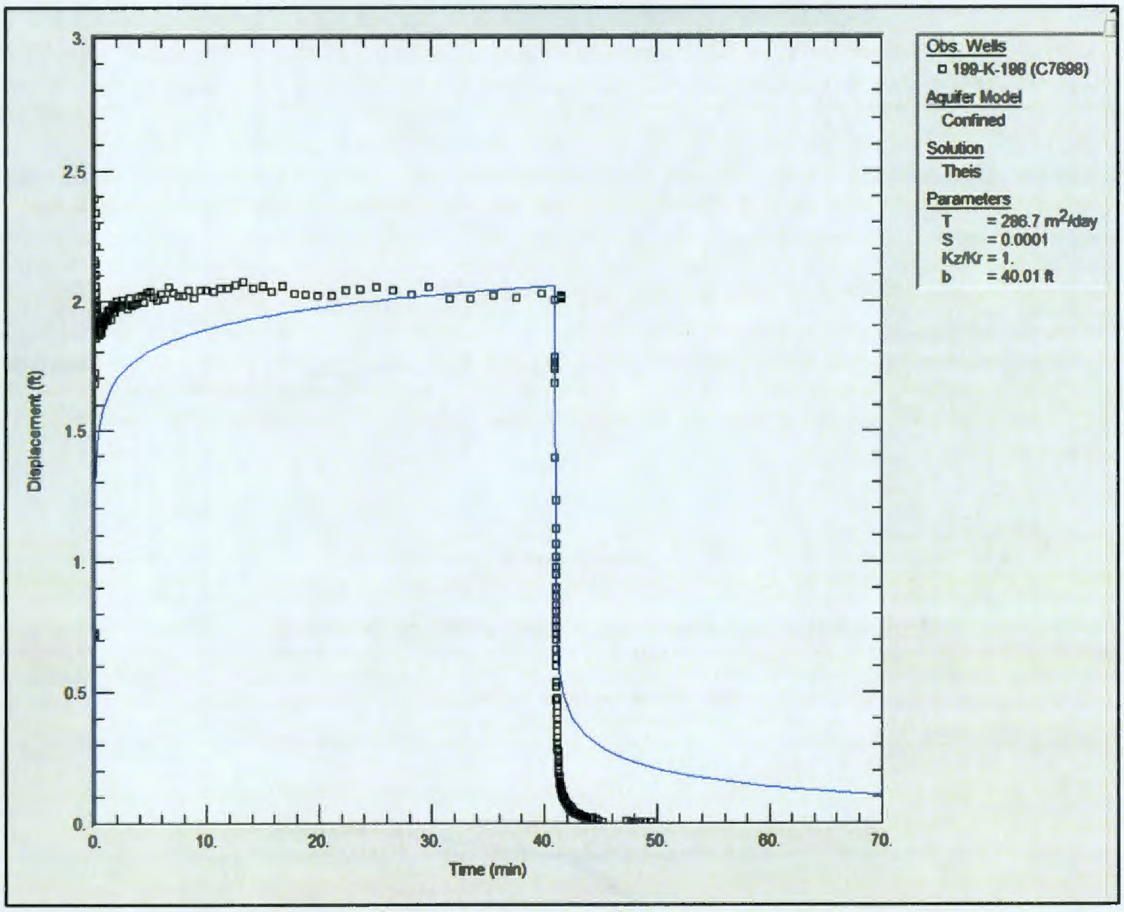


Figure 5-152. Theis Drawdown Analysis at 199-K-198

5.65 Analysis of Well Development Data at Well 199-N-77

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *A5442_WD_199-N-77_1992-11-18.xls*.

5.65.1 Summary of Available Data

The well was developed on November 18, 1992. The well was pumped at 14.26 gpm for 77 minutes, and the water level in the well was allowed to recover. The water level in the well was monitored during the drawdown and recovery period, and changes in the water level with time are shown in Figure 5-153.

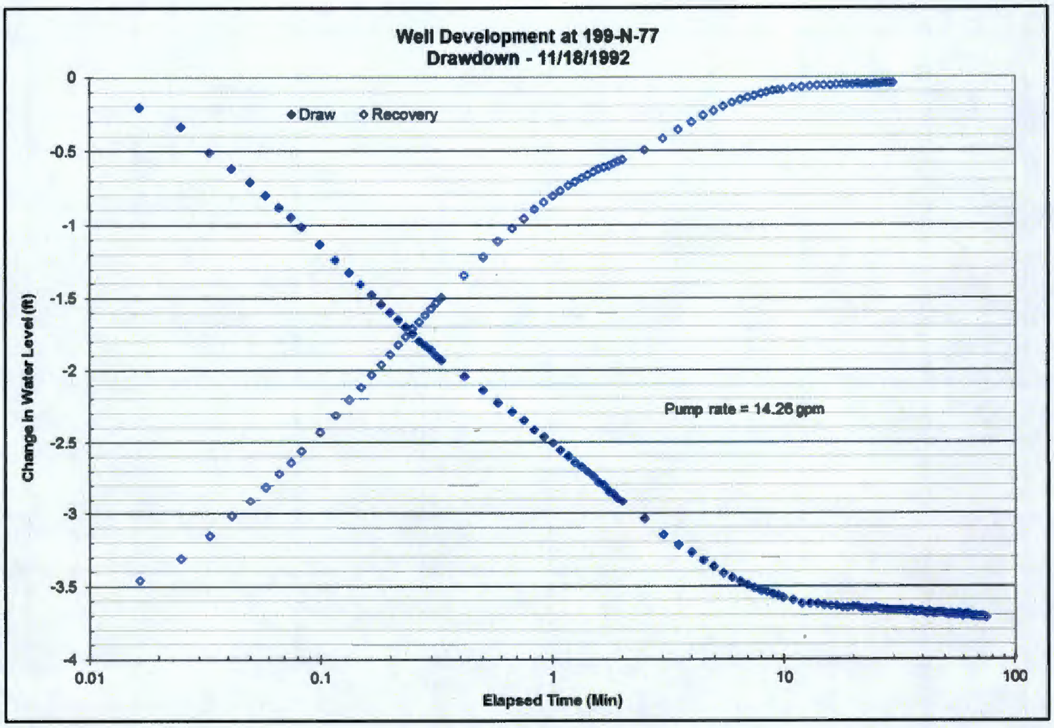


Figure 5-153. Drawdown and Recovery Data at 199-N-77

5.65.2 Analysis

Consistent estimates of transmissivity were obtained from the Theis recovery analysis and Cooper-Jacob drawdown analysis. As shown in Figure 5-154, aquifer transmissivity is estimated to be 630 m^2/d. The late-time recovery data appear to be consistent with the expected response for an ideal aquifer.

5.66 Analysis of Well Development Data at Well 199-N-141

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C5047_WD_199-N-141_2006-04-27.xls*.

5.66.1 Summary of available data

The well was developed on April 19, 2006 and again on April 27, 2006. On April 19, the well was pumped for 1 hour at rates ranging between 7 gpm and 3.1 gpm, and allowed to recover. Water levels in the pumping well and three monitoring wells were monitored during the drawdown and recovery period, and changes in the water levels with time are shown in Figure 5-155 and Figure 5-156. On April 27, the well was pumped for nearly 40 minutes at 9 gpm, followed by a reduction to 8 gpm. Again, water levels in the pumping well and three monitoring wells were monitored during the drawdown and recovery period, and changes in the water levels with time are shown in Figure 5-157 and Figure 5-158.

5.66.2 Analysis

Transmissivity of 20 m^2/d is estimated from Cooper-Jacob analysis of the drawdowns observed in the pumping well during the second drawdown test. The analysis is shown in Figure 5-159. The derivative of the drawdown with respect to time, $\partial s/\partial \ln(t)$, is shown at the bottom to confirm that the Cooper-Jacob analysis is applied to the portion of the drawdown responses caused only by the aquifer.

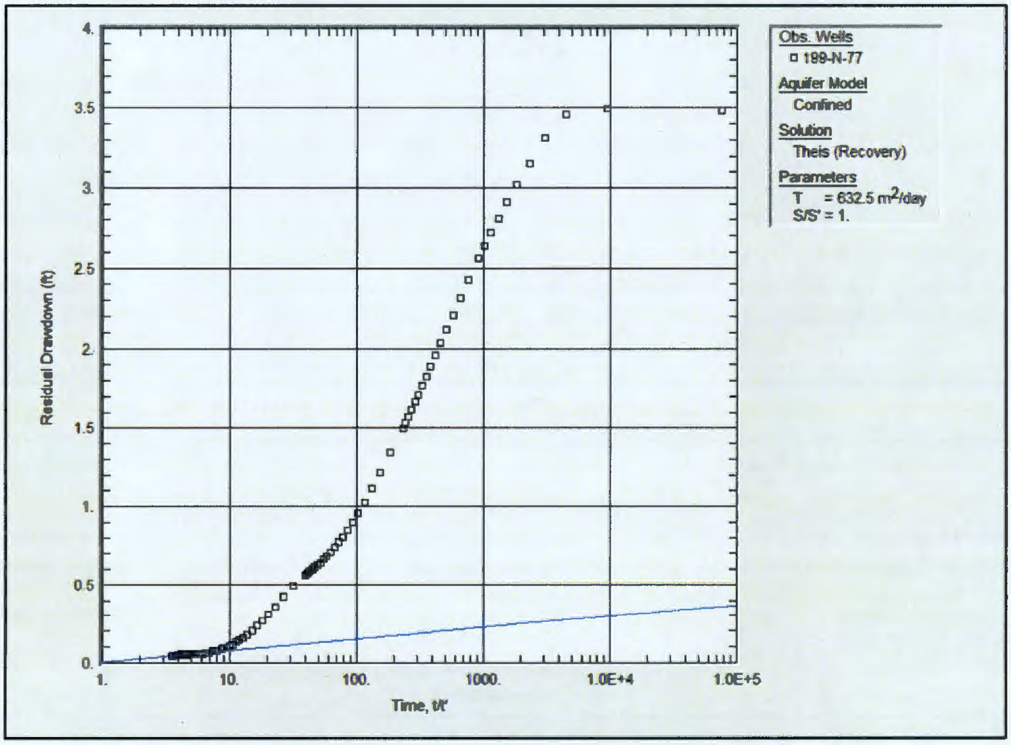


Figure 5-154. Theis Recovery Analysis at 199-N-77 (1 of 2)

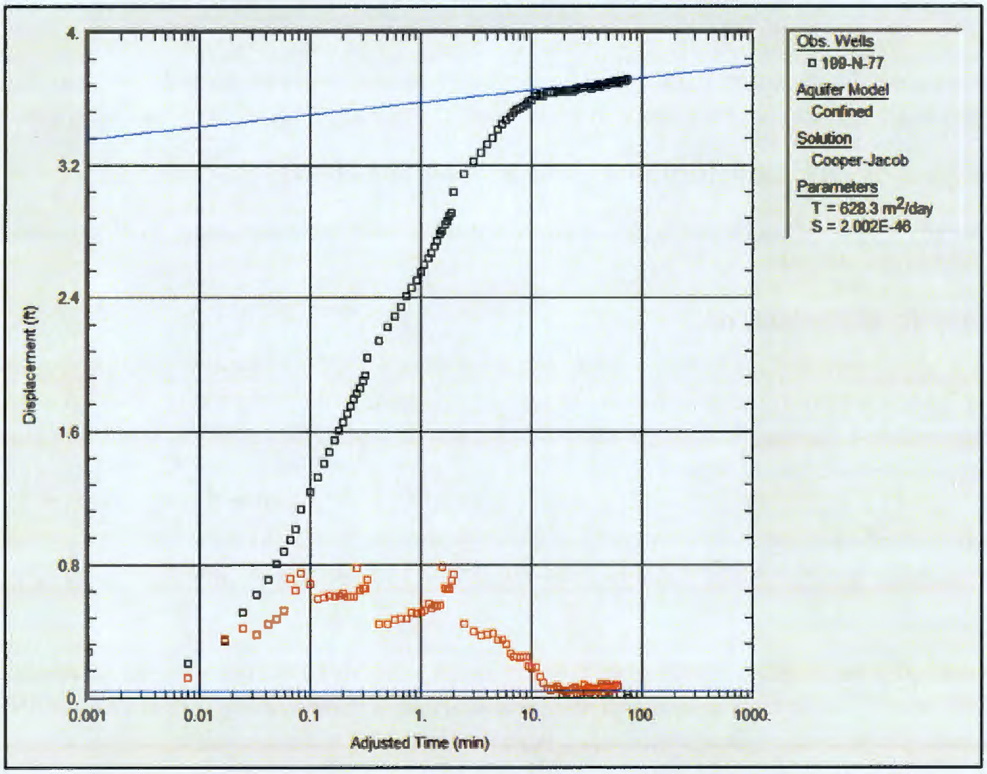


Figure 5-154. Cooper-Jacob Drawdown Analysis at 199-N-77 (2 of 2)

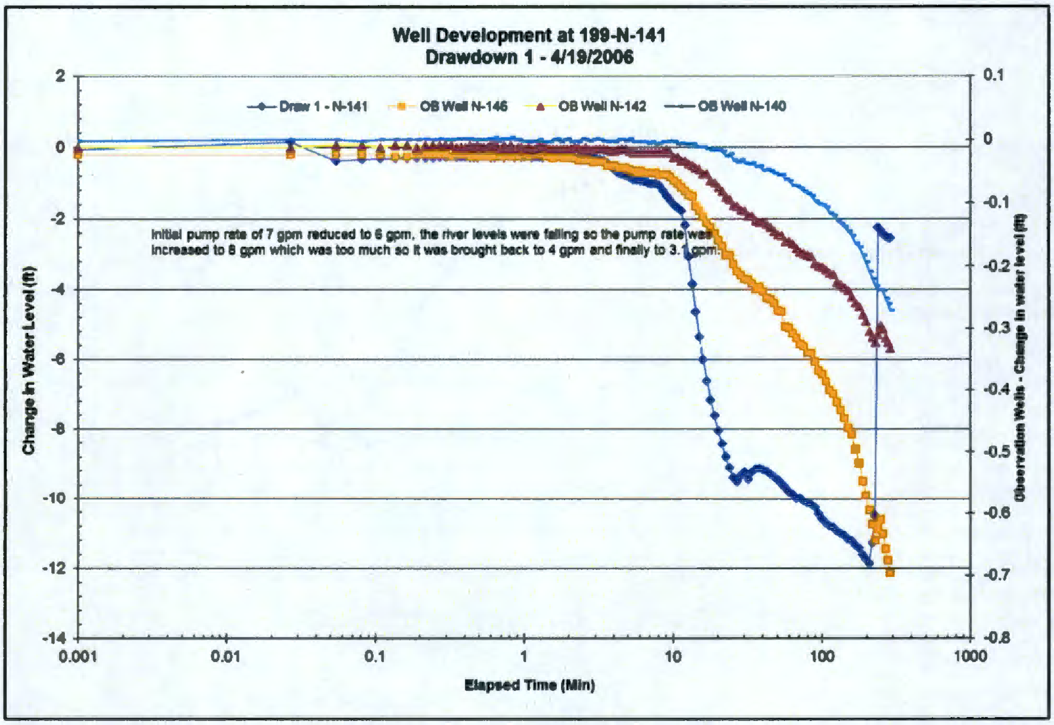


Figure 5-155. Drawdown 1 Data at 199-N-141

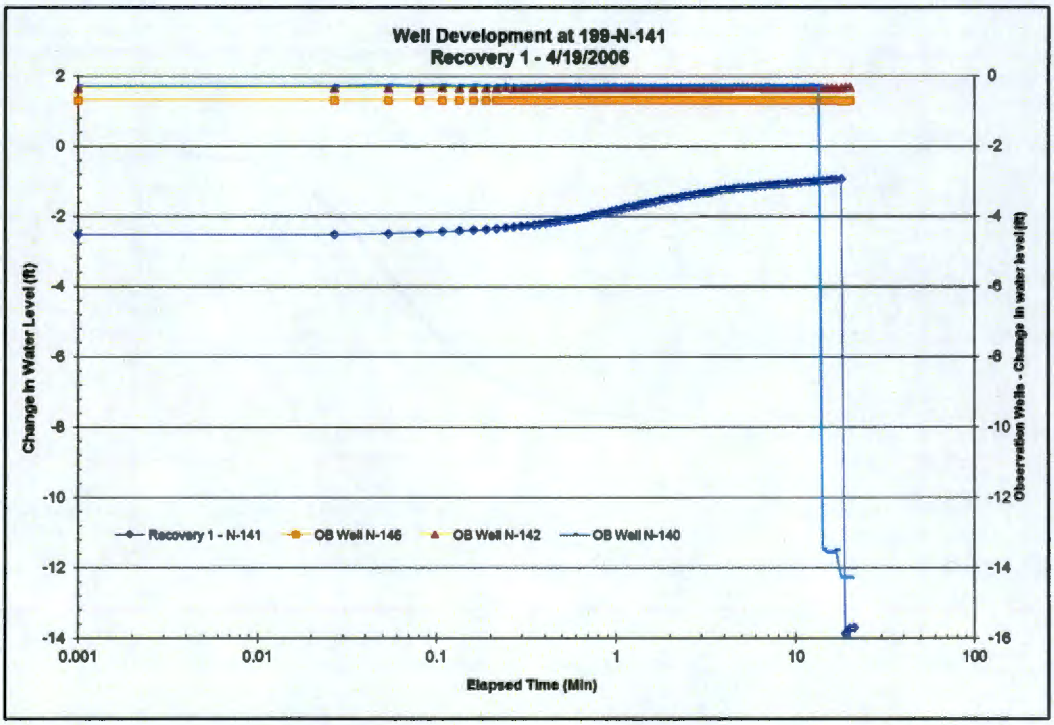


Figure 5-156. Recovery 1 Data at 199-N-141

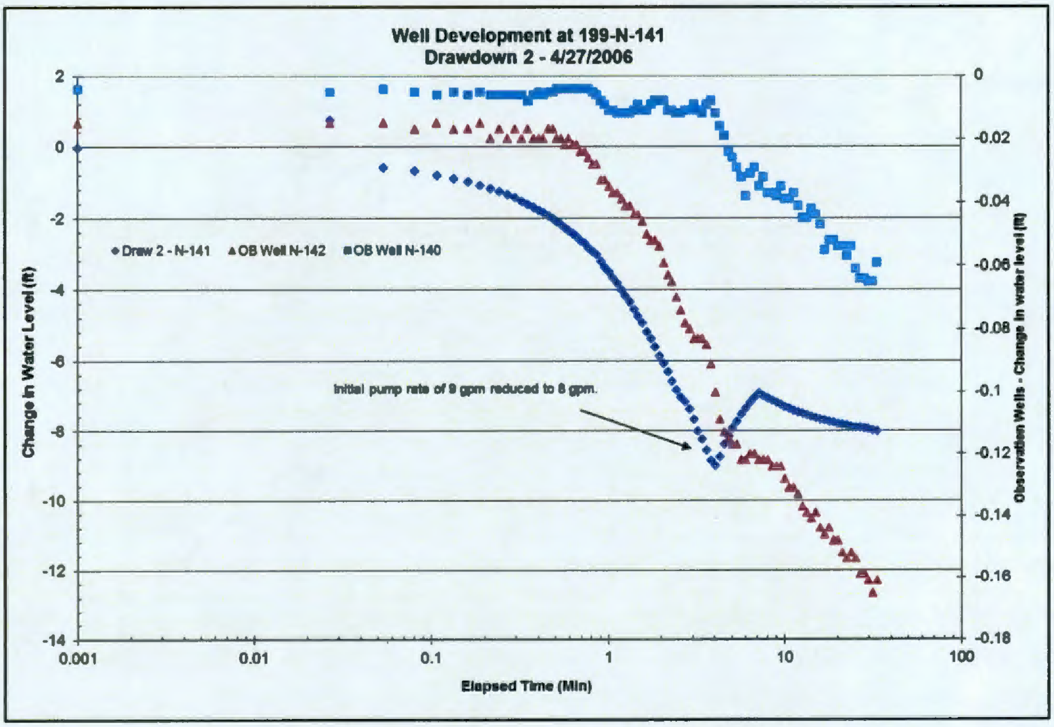


Figure 5-157. Drawdown 2 Data at 199-N-141

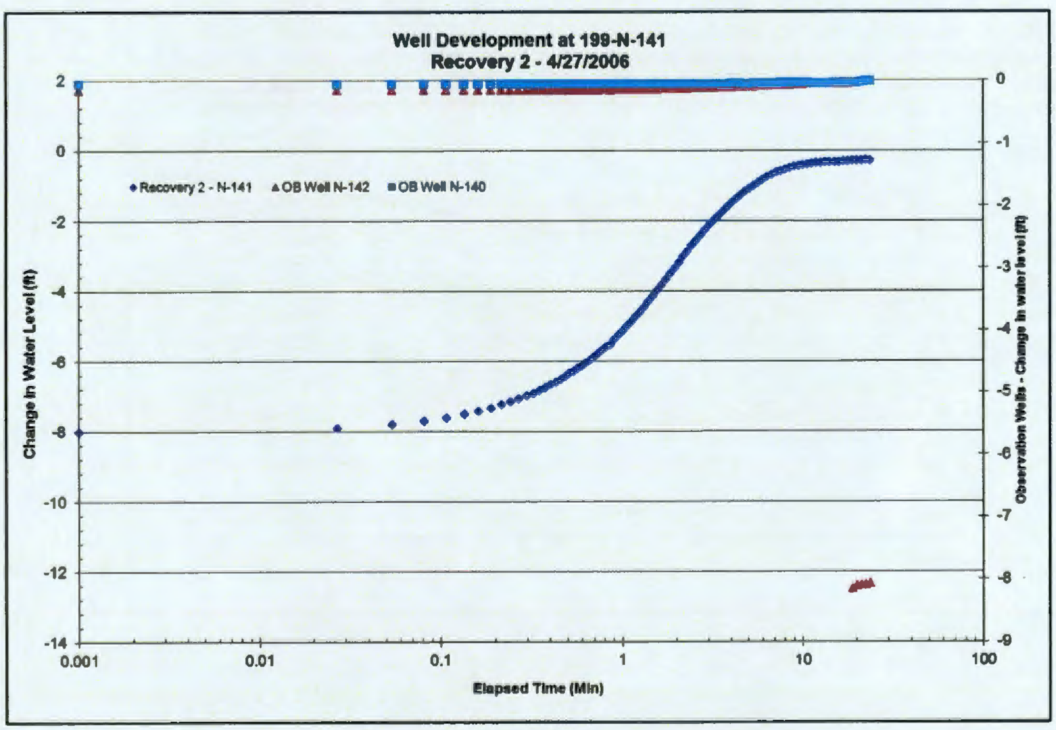


Figure 5-158. Recovery 2 Data at 199-N-141

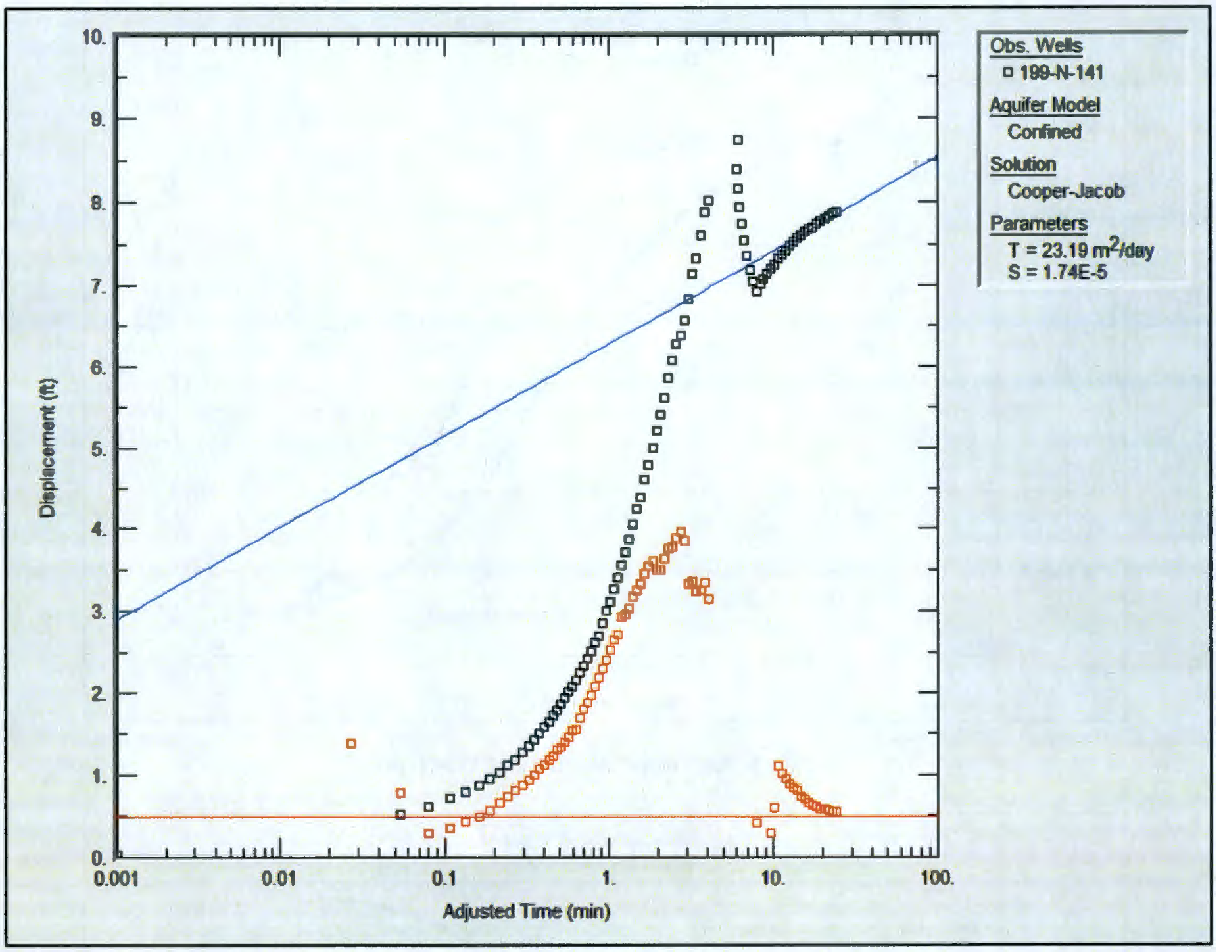


Figure 5-159. Cooper-Jacob Drawdown Analysis at 199-N-141

5.67 Analysis of Well Development Data at Well 199-N-142

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C5048_WD_199-N-142_2006-04-27.xls*.

5.67.1 Summary of available data

On April 27, 2006, the well was pumped for nearly 50 minutes at 10 gpm and allowed to recover. Water levels in the pumping well and two monitoring wells were monitored during the drawdown and recovery period, and changes in the water levels with time are shown in Figure 5-160 and Figure 5-161.

5.67.2 Analysis

Reasonably consistent transmissivities are estimated with the Cooper-Jacob analysis of the drawdown and recovery analysis for the pumping well. Plots of both analyses are included in Figures 5-162 and 5-163. The arithmetic average of the two analyses (75 m^2/d) is considered to be most representative of the properties of the aquifer at this location. Analyses have also been conducted for the observation wells; however, resulting transmissivity estimates are not consistent.

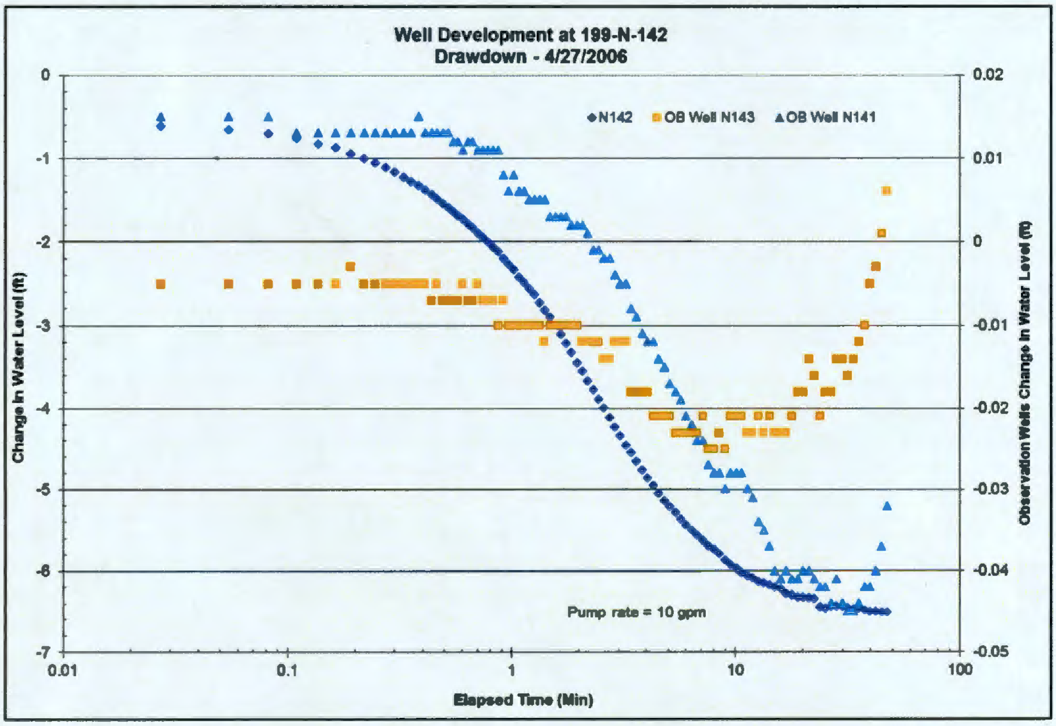


Figure 5-160. Drawdown Data at 199-N-142

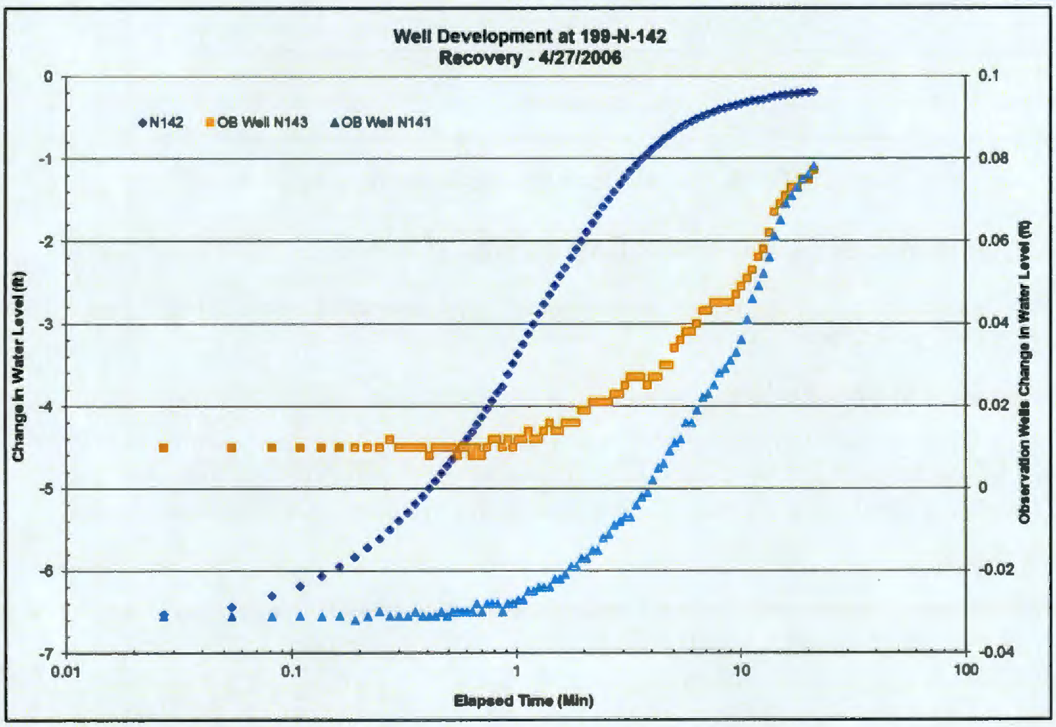


Figure 5-161. Recovery Data at 199-N-142

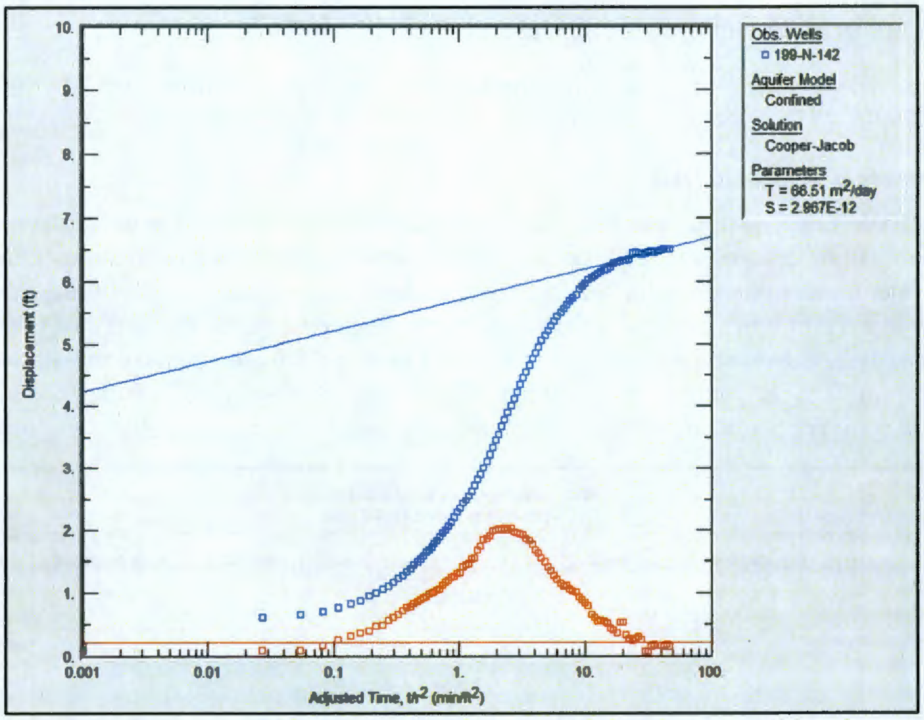


Figure 5-162. Cooper-Jacob Drawdown Analysis at 199-N-142

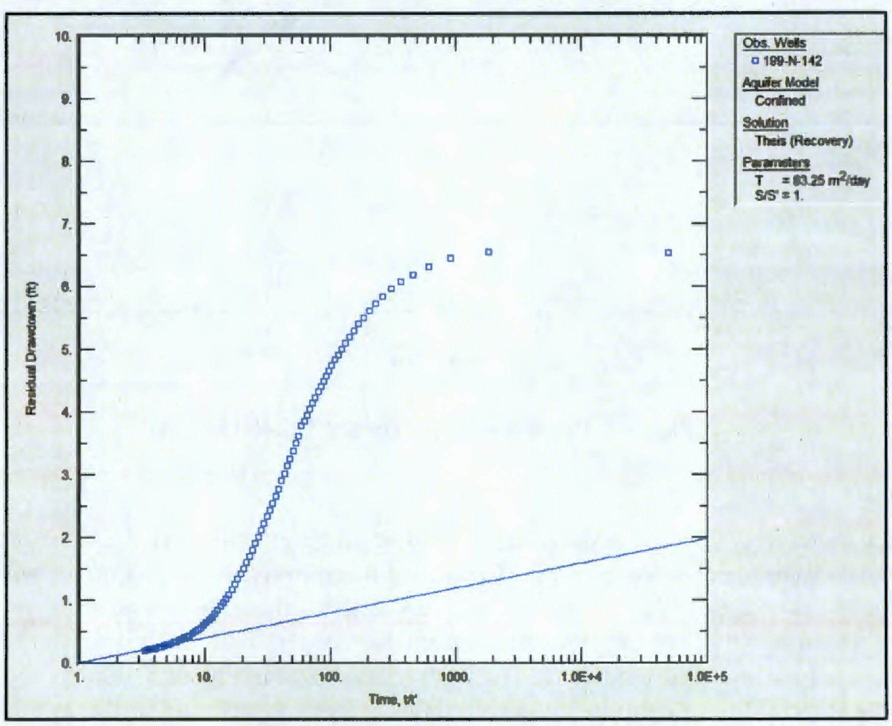


Figure 5-163. Theis Recovery Analysis at 199-N-142

5.68 Analysis of Well Development Data at Well 199-N-147

Drawdown and recovery data for the well development tests were received from CHPRC in the Excel file *C5116_WD_199-N-147_2006-04-21.xls*.

5.68.1 Summary of Available Data

On April 20, 2006, 12 gal of water and mud were pumped from the bottom of the well followed by surging of the well. Afterwards, the well was pumped at various rates for nearly 90 minutes and allowed to recover. Water levels in the pumping well and two neighboring monitoring wells during this drawdown and recovery period are shown in Figures 5-164 and 5-165, respectively. On the next day, the well was pumped for nearly 2.5 hours at rates ranging between 6.7 gpm and 8.6 gpm minutes and allowed to recover. Water levels in the pumping well and two neighboring monitoring wells during the second drawdown and recovery period are shown in Figures 5-166 and 5-167, respectively.

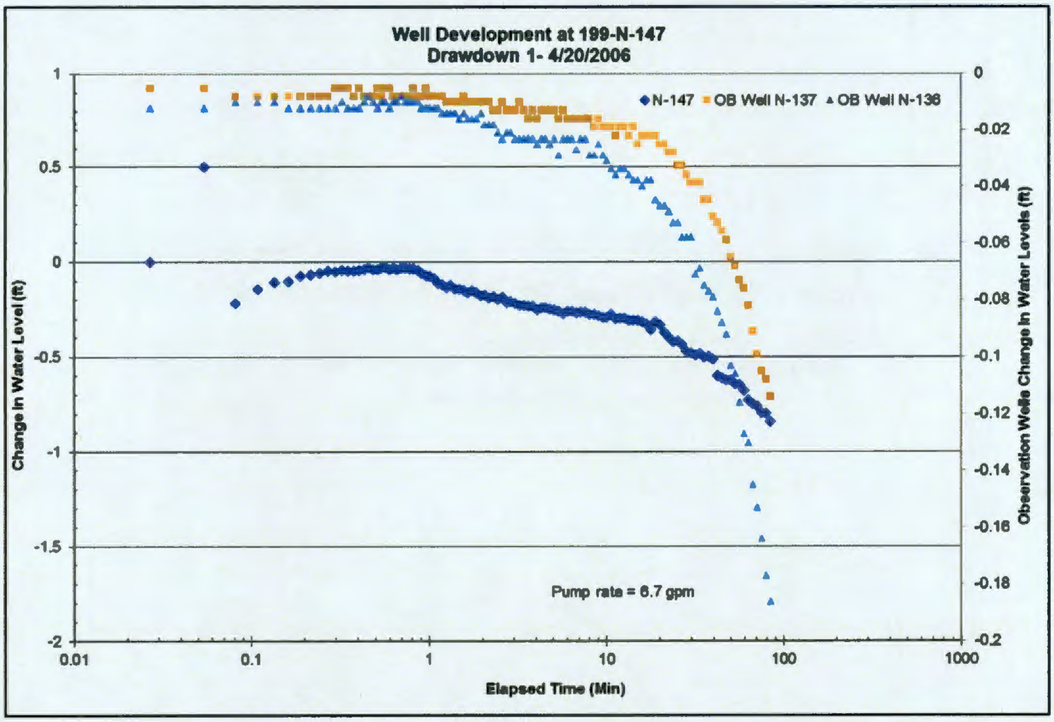


Figure 5-164. Drawdown 1 Data at 199-N-147

5.68.2 Analysis

Testing included monitoring of water level changes in adjacent observation wells. Emphasis is placed on analyses of the data from the observation wells. Consistent transmissivities are estimated with the Cooper-Jacob analyses of the drawdown and the recovery analysis from the second drawdown test. The estimate of transmissivity (340 m^2/d), obtained from the Cooper-Jacob analysis of the second drawdown test, is judged most representative. The analysis is shown in Figure 5-168. As shown in Figure 5-168, the slope of the straight line constructed through the observation well drawdowns is similar to the line that would be constructed through the pumping well drawdowns, with an offset accounting for additional well losses.

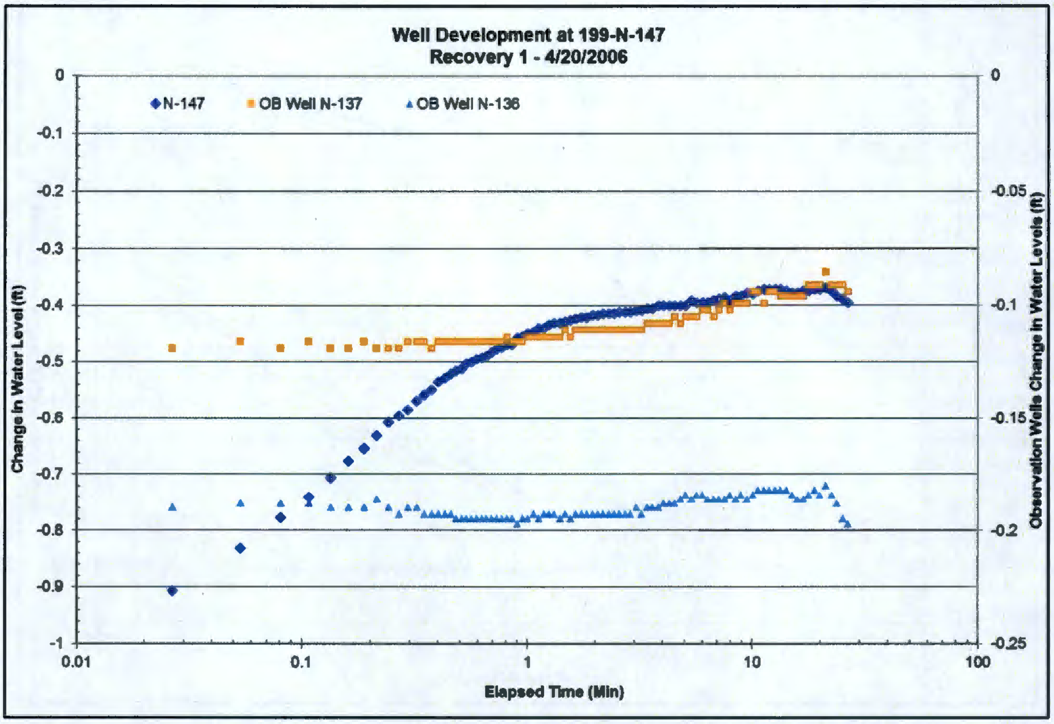


Figure 5-165. Recovery 1 Data at 199-N-147

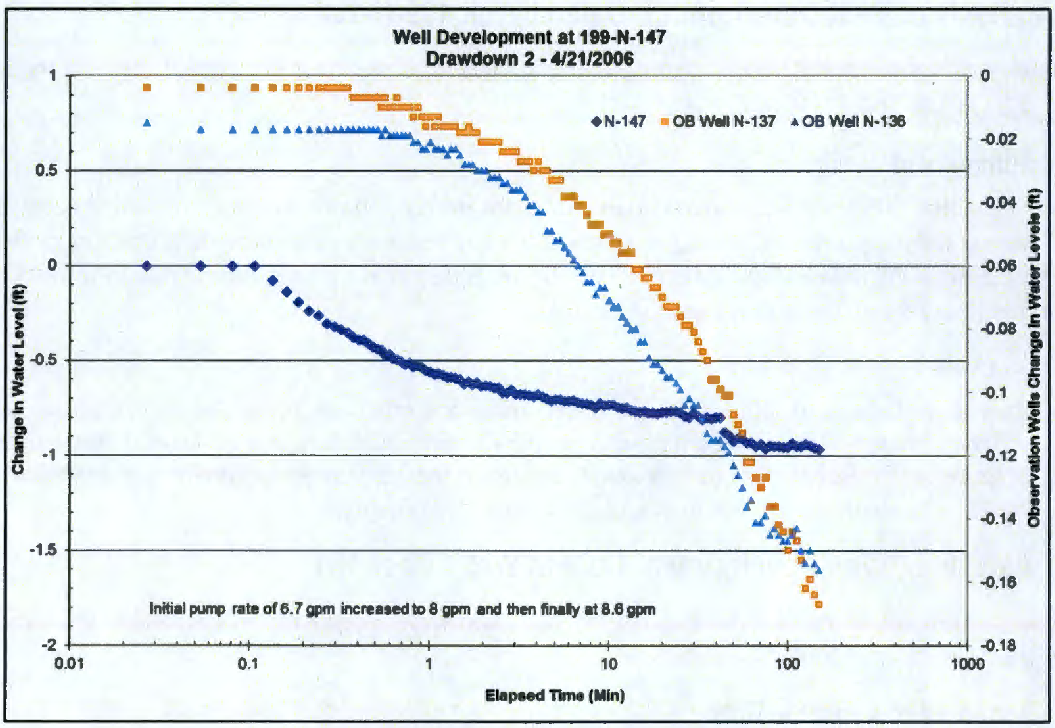


Figure 5-166. Drawdown 2 Data at 199-N-147

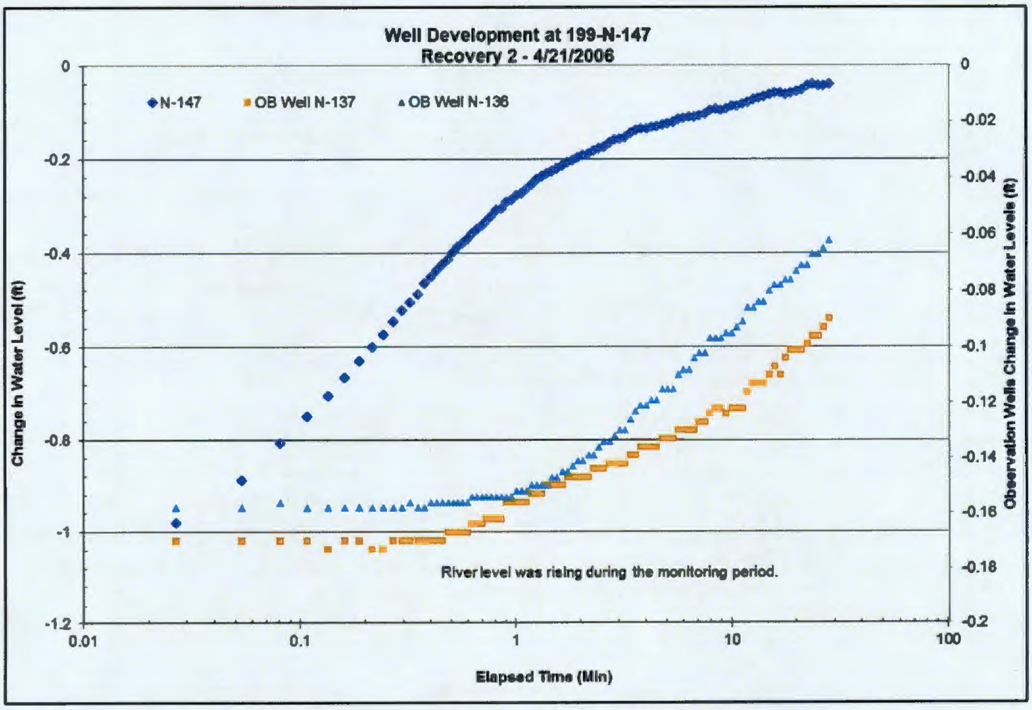


Figure 5-167. Recovery 2 Data at 199-N-147

5.69 Analysis of Well Development Data at Well 199-N-160

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C6178_WD_199-N-160_2008-04-29.xls*.

5.69.1 Summary of Available Data

On April 29, 2008, the pump was run at variable rates for nearly 130 minutes and allowed to recover. Water levels at the pumping well during this drawdown and recovery period are shown in Figure 5-169. Although the drawdown data show clear evidence of multiple pumping rates during the drawdown period, a single pumping rate of 7.5 gpm is noted in the FAR.

5.69.2 Analysis

The matches of all theoretical solutions to the observations are relatively poor. The most representative transmissivity estimate of 10 m^2/d is obtained from the Cooper-Jacob analysis of the drawdown data shown in Figure 5-170. Recovery data were analyzed using the Theis recovery method and yielded a transmissivity estimate that was very high and not considered reliable.

5.70 Analysis of Well Development Data at Well 199-N-161

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C6179_WD_199-N-161_2008-04-29.xls*.

5.70.1 Summary of Available Data

On April 29, 2008, the pump was run at 15 gpm for nearly 30 minutes and allowed to recover. Water levels at the pumping well during this drawdown and recovery period are shown in Figure 5-171.

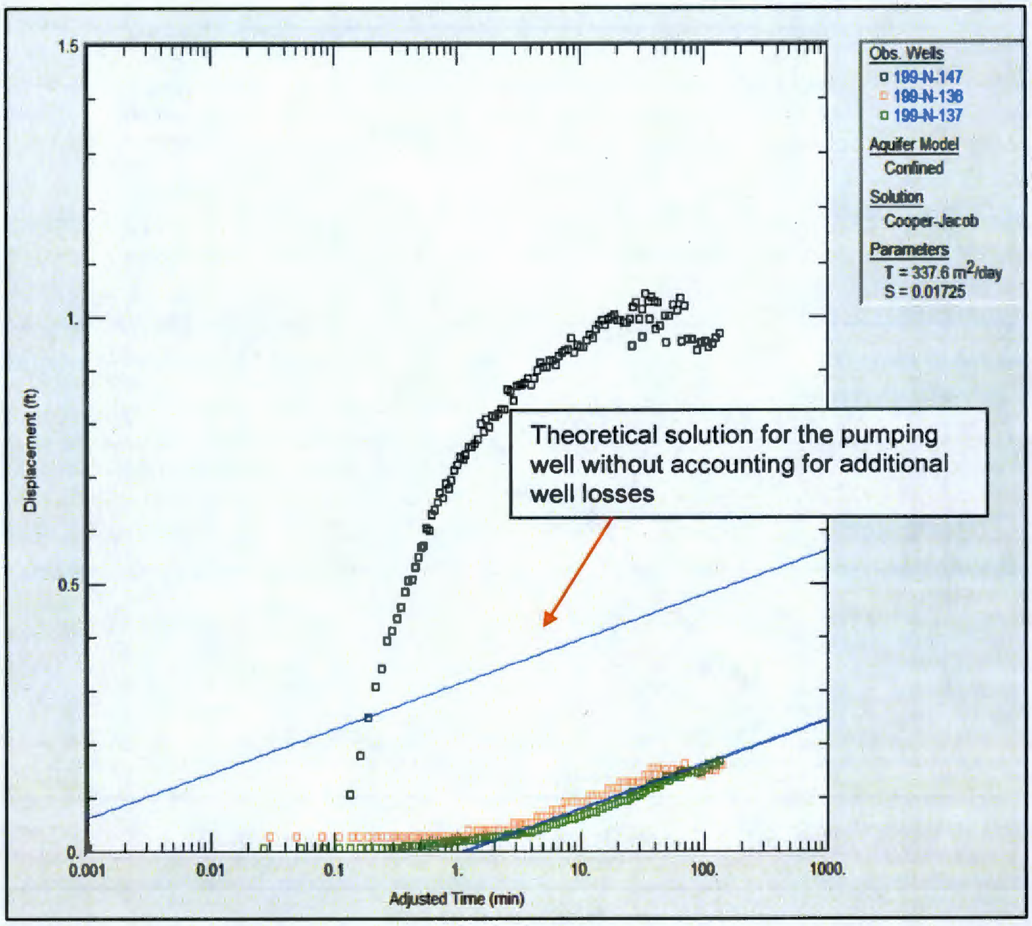


Figure 5-168. Cooper-Jacob Drawdown Analysis at 199-N-147

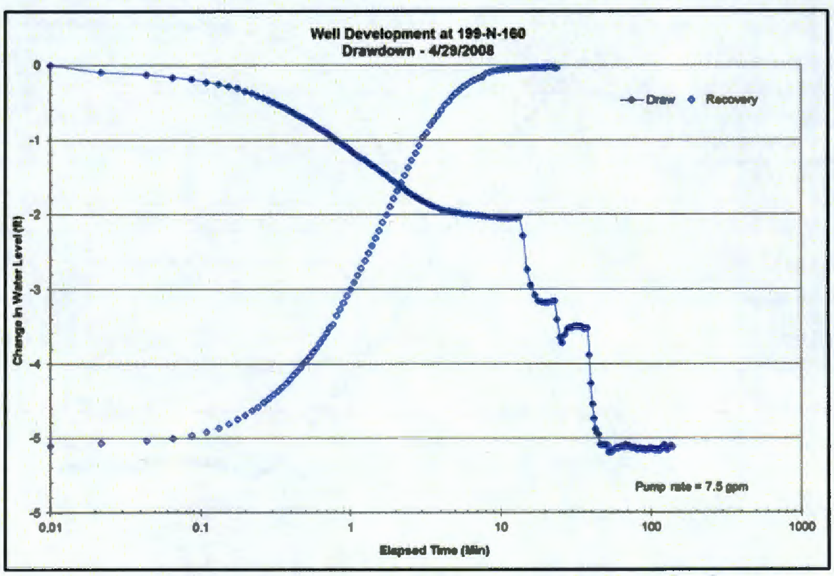


Figure 5-169. Drawdown 1 and Recovery Data at 199-N-160

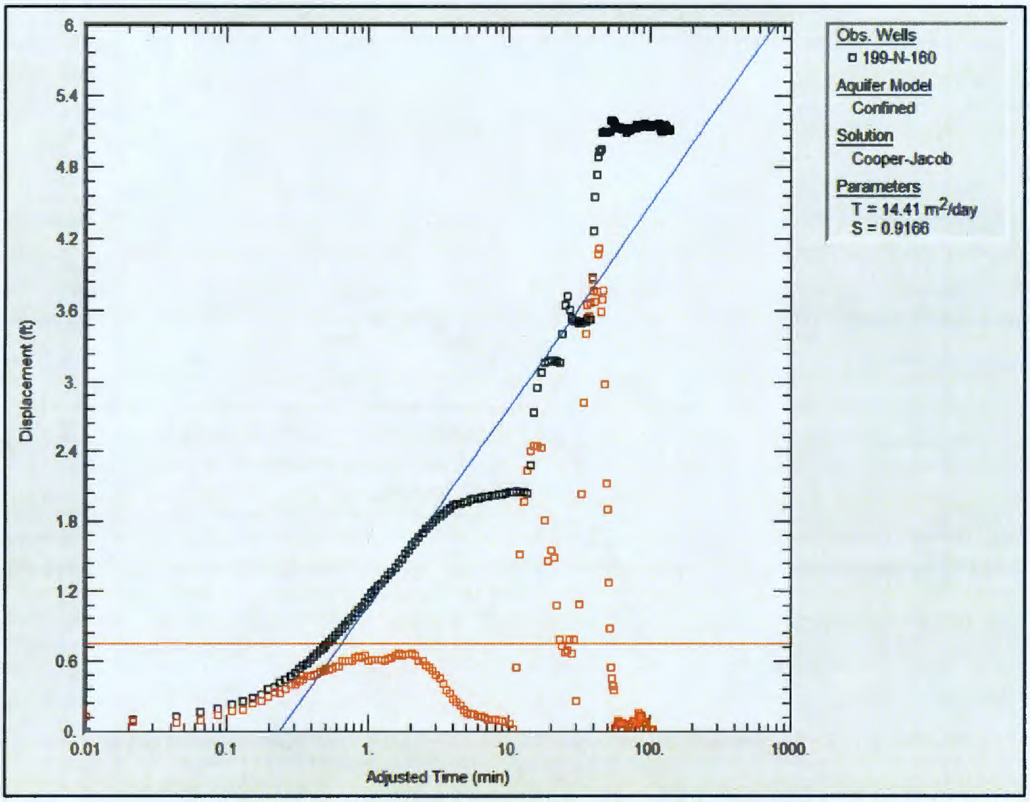


Figure 5-170. Cooper-Jacob Drawdown Analysis at 199-N-160

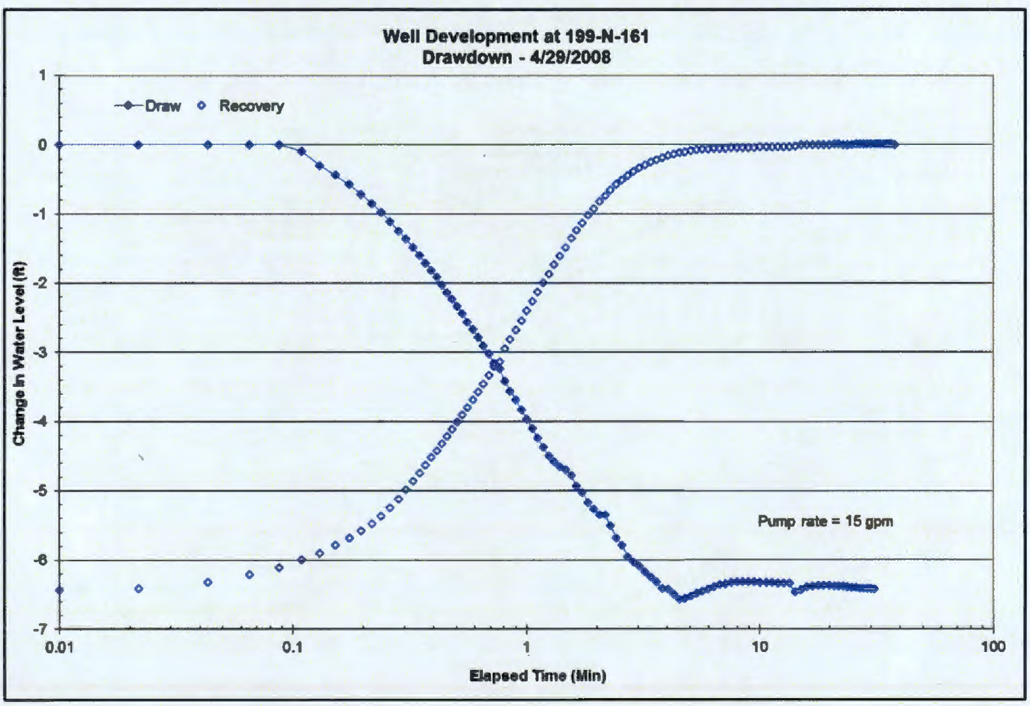


Figure 5-171. Drawdown and Recovery Data at 199-N-161

5.70.2 Analysis

Consistent transmissivity estimates are obtained with the match to the drawdown observations with the Papadopulos and Cooper solution and the Cooper-Jacob analysis. The most representative estimate is 160 m^2/d, obtained from the Cooper-Jacob analysis shown in Figure 5-172. Recovery data were analyzed using the Theis recovery method and yielded a transmissivity estimate that was 5 times higher and not considered reliable.

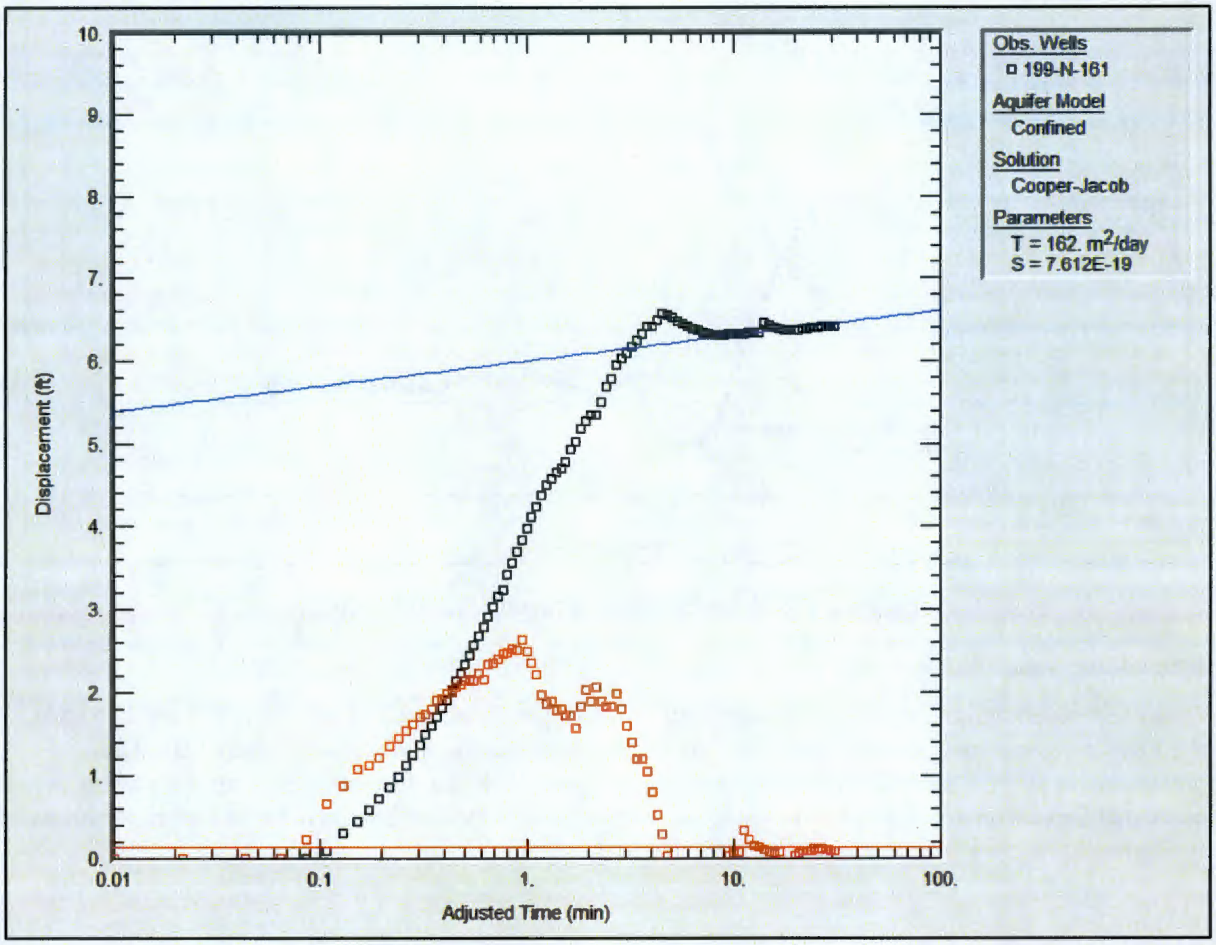


Figure 5-172. Cooper-Jacob Drawdown Analysis at 199-N-161

5.71 Analysis of Well Development Data at Well 199-N-162

Drawdown and recovery data for the well development test were received from CHPRC in the Excel file *C6180_WD_199-N-162_2008-04-28.xls*.

5.71.1 Summary of Available Data

On April 28, 2008, the pump was run for nearly 110 minutes and allowed to recover. Water levels in the pumping well during this drawdown and recovery period are shown in Figure 5-173. Although the drawdown data show clear evidence of multiple pumping rates during the drawdown period, a single pumping rate of 6.8 gpm is noted in the FAR.

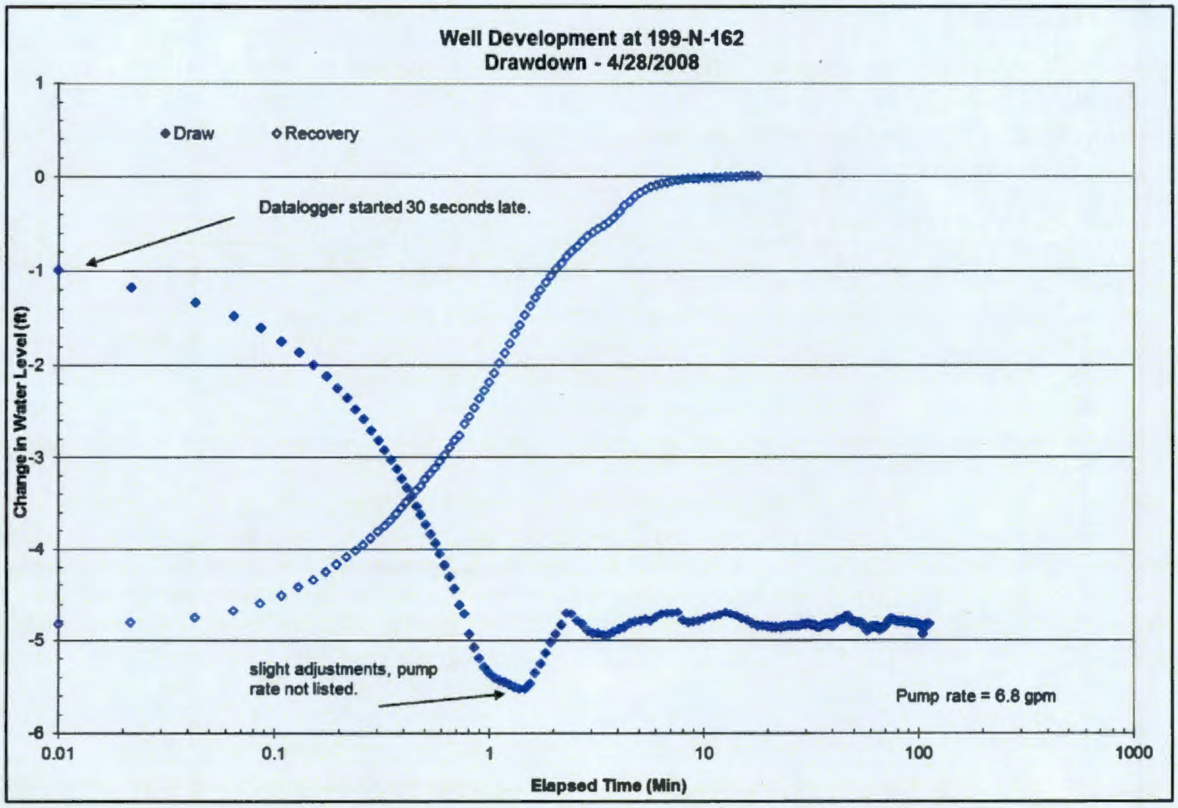


Figure 5-173. Drawdown and Recovery Data at 199-N-162

5.71.2 Analysis

Consistent transmissivity estimates are obtained with Cooper-Jacob analysis of the drawdown data and the Theis recovery analysis. However, the data suggest stabilization during the pumping period and premature recovery after the end of pumping. The analyses do not capture this trend; for this reason, the estimated transmissivity is potentially not reliable. Transmissivity is estimated to be 160 m^2/d, as shown in Figure 5-174.

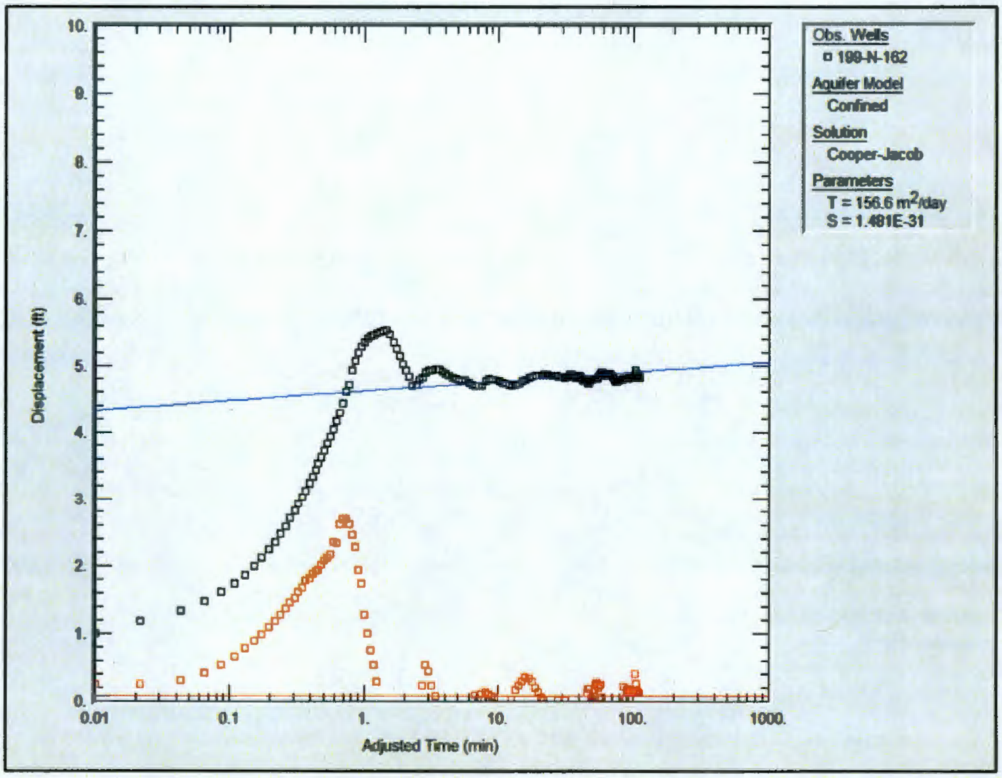


Figure 5-174. Cooper-Jacob Drawdown Analysis at 199-N-162 (1 of 2)

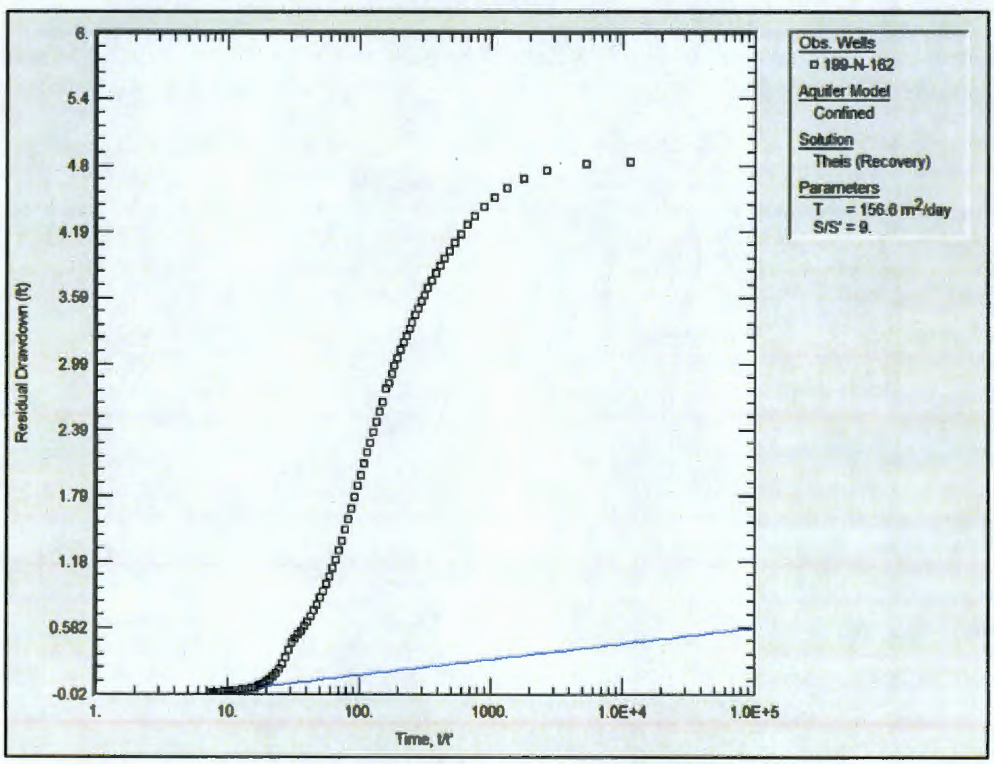


Figure 5-174. Theis Recovery Analysis at 199-N-162 (2 of 2)

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6 Summary of Analyses

Transmissivity estimates from the 71 well development analyses are summarized in Table 6-1 along with their corresponding SC estimates. Well development data at 120 additional wells (not part of the 71) were not interpretable, and only SC could be estimated. Transmissivity estimates for these wells were developed from SC estimates following the methodology presented in Appendix A. These estimates are tabulated on Table 6-2. Hydraulic conductivity values, calculated by dividing transmissivity with the saturated well screen thickness (on the date of well development), are also presented.

Estimated transmissivity values are plotted in Figure 6-1. Transmissivity values range from less than 1 m^2/d to greater than 10,000 m^2/d. The transmissivity estimates from drawdown/recovery analyses and SC calculations from Table 6-1 are plotted against each other in Figure 6-2 for the 71 wells that were subject to rigorous analyses. In this figure, transmissivity estimates from drawdown and recovery analyses are plotted on the Y-axis, and corresponding transmissivity estimates from SC calculations are plotted on the X-axis: a straight line representing equivalence between the first-cut transmissivity estimated from SC (i.e., $T = SC \, x \, 1.3$), and the more comprehensive analyses described in this report, are also shown. Data points that are distant from this line represent wells where drawdown in the pumping well differs significantly from what would be expected from the contribution of the aquifer itself: in some cases, these data points may indicate wells where near-well properties differ significantly from the surrounding formation.

Vertical and spatial distribution of hydraulic conductivities are shown in Figure 6-3. Except for two wells in the 100-HR-3 Area, all wells are screened in the sand and gravel units of the unconfined aquifer. In the western areas, the water table is typically in the fine grained unit E of the Ringold formation. An exception to this rule occurs in the 100-B Area where a buried channel of high conductivity passes through the southern portion of the area. To the east of the 100-D Area, Ringold unit E disappears and the water table is present in the coarse grained Hanford formation. Within the 100-F Area, Ringold E unit is present in some areas. Estimated hydraulic conductivities are generally consistent with this understanding of the site hydrogeology. However, a few outliers have been noticed that are discussed in the next paragraph.

To the west of the 100-K Area, transmissivity values greater than 3,000 m^2/d were estimated for 199-K-166 and 199-K-158. These values are order of magnitude higher than the surrounding values. An estimate of nearly 10,000 m^2/d was obtained at 199-K-151 in the area betwèen 100-K and 100-N. In the 100-D Area, transmissivity of 2,700 m^2/d was estimated at 199-D8-4. This well is surrounded by wells with estimates an order of magnitude smaller. Similarly, high transmissivity estimates (>4,500 m^2/d) were obtained at 199-D8-69, 199-D8-69, and 199-D8-70 to the north of 100-D. In 100-H, high transmissivity estimates were noted at 199-H3-4 and 199-H3-5, but these are located in an area known to be highly transmissive.

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Table 6-1. Summary of Well Development Analyses

Well Information							Transmissivity Estimation from Drawdown/Recovery Data				Transmissivity Estimation from Specific Capacity				
Well	Easting (m)	Northing (m)	Top of Screen Elevation (m)	Bottom of Screen Elevation (m)	Screen Diameter (in.)	Area	Transmissivity (m^2/d)	Analysis Method	Saturated Screen Length (m)	Hydraulic Conductivity (m/d)	Pumping Rate (gpm)	Drawdown (ft)	SC (gpm/ft)	SC (m^2/d)	Transmissivity (m^2/d)
199-B2-13	564086.52	145264.56	123.30	116.96	4	B	80	Theis Recovery	3.79	21	6.9	2.3	3.0	53	69
199-B3-46	565899.57	145369.04	121.20	114.86	4	B	310	Theis Recovery	5.36	58	14.9	15.0	1.0	18	23
199-D2-10	574470.87	153465.19	117.29	112.72	6	D	300	Theis Recovery	3.35	90	15.0	4.4	3.4	61	79
199-D3-4	572468.16	151170.97	118.17	109.04	6	D	630	Cooper-Jacob	8.23	77	31.0	4.1	7.6	135	176
199-D4-14	572839.81	151641.64	120.28	114.17	6	D	110	Theis Drawdown	4.10	27	35.0	7.5	4.7	83	108
199-D4-15	572936.64	151424.86	119.99	113.90	6	D	1,200	Theis Recovery	4.66	257	60.0	1.4	43.5	778	1,011
199-D4-29	572736.86	151510.69	118.65	114.07	6	D	30	Theis Recovery	3.50	9	13.0	8.3	1.6	28	36
199-D4-39	572747.45	151650.84	120.57	114.47	6	D	45	Theis Drawdown	3.04	15	20.0	9.5	2.1	38	49
199-D4-41	572834.11	151634.66	118.42	113.85	4	D	640	Cooper-Jacob	3.67	175	30.0	4.4	6.8	122	159
199-D4-62	572619.52	151351.07	117.71	110.14	6	D	50	Theis Drawdown	6.82	7	15.5	7.5	2.1	37	48
199-D4-68	572581.32	151299.84	118.52	109.39	6	D	350	Cooper-Jacob	7.79	45	30.0	4.9	6.1	109	142
199-D4-71	572556.29	151278.50	118.92	109.86	6	D	400	Cooper-Jacob, Theis Drawdown	8.22	49	31.0	2.1	14.8	264	343
199-D4-81	572484.36	151199.64	118.56	109.50	6	D	2,700	Theis Drawdown	7.59	356	31.0	0.3	91.2	1,631	2,120
199-D4-83	572859.43	151723.42	119.42	114.85	6	D	410	Theis Recovery	2.77	148	25.0	4.4	5.7	103	134
199-D4-99	572527.36	151377.08	119.47	110.32	6	D	100	Cooper-Jacob	6.42	16	23.0	4.8	4.8	87	113
199-D5-32	573372.04	151903.39	119.46	111.82	6	D	430	Theis Recovery	5.64	76	36.0	4.9	7.3	131	170
199-D5-34	573240.42	151554.12	120.32	112.69	6	D	870	Theis Recovery	5.98	145	37.0	3.4	10.8	193	251
199-D5-38	572996.82	151545.59	119.01	112.91	6	D	70	Cooper-Jacob	4.97	14	45.0	13.8	3.3	58	75
199-D5-39	573142.86	151428.43	119.59	113.48	6	D	140	Theis Recovery	4.45	31	50.0	10.8	4.6	83	108
199-D5-101	572943.04	151521.52	120.59	111.44	6	D	1,060	Cooper-Jacob	5.42	195	75.0	3.0	25.0	447	581
199-D5-126	573705.71	151843.28	119.24	110.10	4	D	330	Theis Drawdown	7.05	47	14.0	1.2	11.7	209	272
199-D5-128	573622.40	151237.35	119.40	113.30	6	D	890	Theis Recovery	3.91	228	20.0	1.7	12.0	215	280
199-D5-141	573243.43	151424.51	95.14	92.09	6	D	0.3	Cooper-Jacob	3.04	0.1	2.0	42.9	0.0	1	1
199-D6-2	574544.61	151970.20	119.40	111.77	6	D	2,600	Theis Recovery	4.78	544	44.0	5.4	8.1	146	190
199-D7-3	574151.38	152363.41	120.97	110.30	6	D	730	Theis Recovery	5.82	125	50.8	3.8	13.4	239	311
199-D8-71	573837.10	152429.39	119.70	110.55	6	D	150	Theis Recovery	6.43	23	97.0	8.8	11.0	197	256
199-D8-90	573948.64	152646.23	118.52	110.89	6	D	310	Theis Recovery	5.25	59	32.9	12.0	2.7	49	64
199-D8-91	574036.89	152741.44	117.52	111.42	6	D	270	Theis Recovery	4.70	57	29.9	5.6	5.3	95	124
199-D8-95	573611.96	152160.61	118.95	112.86	6	D	160	Theis Recovery	3.31	48	33.0	7.4	4.5	80	104
199-D8-96	573706.00	152152.24	119.12	113.02	6	D	300	Theis Recovery	3.26	92	38.8	11.3	3.4	61	79
199-D8-97	573859.56	152087.42	120.77	111.62	6	D	130	Theis Recovery	4.70	28	18.0	5.3	3.4	61	79
199-H1-5	574850.72	153090.30	119.09	111.47	6	H	790	Theis Recovery	5.15	153	71.8	9.7	7.4	132	172
199-H3-10	577545.14	152723.52	96.89	93.85	6	H	20	Theis Recovery	3.05	7	24.0	56.4	0.4	8	10
199-H3-27	577567.05	152811.14	117.45	111.36	6	H	1,200	Theis Recovery	3.51	342	37.0	9.1	4.1	73	95
199-H4-81	575236.93	153035.36	119.15	113.05	6	H	730	Theis Recovery	3.55	206	60.0	13.0	4.6	82	107

Table 6-1. Summary of Well Development Analyses

Well Information							Transmissivity Estimation from Drawdown/Recovery Data				Transmissivity Estimation from Specific Capacity				
Well	Easting (m)	Northing (m)	Top of Screen Elevation (m)	Bottom of Screen Elevation (m)	Screen Diameter (in.)	Area	Transmissivity (m^2/d)	Analysis Method	Saturated Screen Length (m)	Hydraulic Conductivity (m/d)	Pumping Rate (gpm)	Drawdown (ft)	SC (gpm/ft)	SC (m^2/d)	Transmissivity (m^2/d)
199-H4-82	574906.99	152677.72	119.65	113.58	6	H	1,300	Theis Recovery	2.79	465	38.8	4.8	8.1	145	189
199-H5-1A	577650.08	152257.72	117.56	112.75	4	H	650	Theis Recovery	2.19	296	13.2	1.5	8.8	157	204
199-K-119A	569661.80	147649.69	121.47	106.23	6	K	140	Theis Drawdown	12.33	11	68.0	12.3	5.5	99	129
199-K-125A	569712.87	147866.01	120.42	108.23	6	K	140	Theis Drawdown	11.04	13	45.0	6.6	6.8	122	159
199-K-126	570574.73	148509.65	120.09	114.00	6	K	100	Theis Recovery	5.30	19	17.0	8.0	2.1	38	49
199-K-131	570662.00	148903.85	118.62	109.47	6	K	120	Theis Recovery	8.52	14	22.0	2.2	10.0	179	233
199-K-132	568495.12	146670.82	120.71	113.09	6	K	200	Cooper-Jacob	4.70	43	35.0	11.2	3.1	56	73
199-K-137	568653.37	146374.51	127.16	111.92	6	K	160	Cooper-Jacob	8.12	20	26.0	6.4	4.1	73	95
199-K-143	570934.41	148088.28	119.53	108.88	6	K	3,400	Theis Recovery	9.53	357	17.6	1.3	13.5	242	315
199-K-146	570197.60	148379.78	119.88	112.26	6	K	60	Cooper-Jacob	5.52	11	10.5	5.3	2.0	35	46
199-K-147	570411.64	148558.07	117.39	111.29	6	K	420	Theis Recovery	6.10	69	22.5	4.5	5.0	89	116
199-K-148	570584.74	148767.86	119.83	107.64	6	K	4300	Theis Recovery	10.21	421	37.5	2.5	15.0	268	348
199-K-150	570787.67	149051.93	120.49	105.25	6	K	250	Theis Recovery	12.53	20	12.0	0.7	18.5	330	429
199-K-152	570736.25	148585.89	128.21	105.35	6	K	340	Theis Recovery	12.77	27	27.3	2.4	11.6	208	270
199-K-153	570530.04	148210.08	128.27	106.93	6	K	680	Theis Recovery	11.39	60	20.0	0.9	23.5	421	547
199-K-160	570919.58	149116.02	126.12	104.78	6	K	640	Theis Recovery	12.53	51	20.0	1.5	13.3	238	309
199-K-163	570230.66	147947.93	126.76	105.42	6	K	1800	Theis Recovery	12.92	139	31.6	2.1	15.4	276	359
199-K-164	571202.22	148903.74	127.90	106.57	6	K	300	Theis Recovery	11.41	26	15.8	1.1	14.1	252	328
199-K-165	568674.96	146342.42	128.39	94.86	6	K	640	Cooper-Jacob	24.54	26	20.0	0.5	40.0	715	930
199-K-166	568594.56	146342.97	124.43	93.95	6	K	3,300	Theis Drawdown	25.36	130	18.8	0.2	110.3	1,972	2,564
199-K-168	568544.37	146513.63	111.91	93.69	6	K	660	Cooper-Jacob	18.22	36	12.5	1.9	6.4	115	150
199-K-169	569988.97	147554.98	132.11	101.63	6	K	470	Theis Recovery	19.54	24	17.6	1.2	14.7	263	342
199-K-170	570009.01	147491.37	135.77	99.20	6	K	80	Theis Recovery	21.53	4	17.7	1.5	12.2	218	283
199-K-171	570544.03	147187.86	135.69	99.11	6	K	2,000	Theis Recovery	21.57	93	17.7	0.5	39.2	701	911
199-K-174	568915.38	146222.47	127.43	109.14	6	K	180	Theis Drawdown	10.88	17	17.6	2.0	8.8	158	205
199-K-179	569847.25	147481.92	127.04	96.55	6	K	160	Theis Recovery	24.55	7	40.0	2.9	13.8	247	321
199-K-180	571116.08	147449.14	127.66	100.24	6	K	620	Theis Recovery	20.15	31	19.4	2.0	9.7	173	225
199-K-182	571185.32	148350.24	125.88	106.05	6	K	160	Cooper-Jacob	12.29	13	23.1	3.8	6.2	110	143
199-K-198	569304.19	147551.86	119.39	107.19	6	K	290	Theis Drawdown	12.12	24	24.0	2.0	11.8	210	273
199-N-77	571309.79	149243.05	114.22	111.19	4	N	630	Theis Recovery	3.03	208	14.3	3.8	3.8	68	88
199-N-141	571303.97	149909.49	120.13	114.94	6	N	20	Cooper-Jacob	4.43	5	8.0	8.0	1.0	18	23
199-N-142	571310.19	149916.16	120.06	114.88	6	N	75	Theis Recovery, Cooper-Jacob	4.37	17	10.0	6.5	1.5	27	35
199-N-147	571338.34	149946.51	120.09	114.91	6	N	340	Cooper-Jacob	4.72	72	8.6	1.0	8.9	159	207
199-N-160	571333.43	149938.01	116.76	114.62	6	N	10	Cooper-Jacob	2.13	5	7.5	5.1	1.5	26	34
199-N-161	571326.49	149932.43	116.81	114.68	6	N	160	Cooper-Jacob	2.13	75	15.0	6.4	2.3	42	55

Table 6-1. Summary of Well Development Analyses

Well Information							Transmissivity Estimation from Drawdown/Recovery Data				Transmissivity Estimation from Specific Capacity				
Well	Easting (m)	Northing (m)	Top of Screen Elevation (m)	Bottom of Screen Elevation (m)	Screen Diameter (in.)	Area	Transmissivity (m²/d)	Analysis Method	Saturated Screen Length (m)	Hydraulic Conductivity (m/d)	Pumping Rate (gpm)	Drawdown (ft)	SC (gpm/ft)	SC (m²/d)	Transmissivity (m²/d)
199-N-162	571319.68	149926.60	117.00	114.87	6	N	160	Cooper-Jacob	2.13	75	6.8	4.8	1.4	25	33

Note: Transmissivity estimates from the specific capacity calculations were used in the parameterization of the 100 Area Groundwater Model (SGW-46279, *Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model*) because the well development analyses were not finalized at that point.

Table 6-2. Transmissivity Estimates from Specific Capacity Estimates

Well Name	Data File	Well Development Date	Easting (m)	Northing (m)	Top of Screen Elevation (m)	Bottom of Screen Elevation (m)	Pumping Rate during Drawdown Test (gpm)	Drawdown (ft)	Specific Capacity (SC, gpm/ft)	Transmissivity (T=1.3*SC, m²/d)	Calculated Saturated Screen Length (m)	Hydraulic Conductivity (m/d)	Used in Model‡
199-B4-9	A4560_WD_199-B4-9_1992-06-16.xls	6/16/1992	565395.64	144563.93	125.5	119.4	15	0.1	150.0	3,487	2.1	1,640.1	No
199-B5-2	A4562_WD_199-B5-2_1992-06-19.xls	6/19/1992	565405.43	144939.70	123.3	117.2	14.89	0.2	74.5	1,731	4.1	421.9	No
199-B9-3	A4566_WD_199-B9-3_1992-06-11.xls	6/11/1992	565667.36	144046.72	124.4	118.3	14.51	0.06	241.8	5,622	3.2	1,733.4	No
199-D2-12	C7090_WD_199-D2-12_2009-12-22.xls	12/22/2009	574343.45	153300.01	117.0	112.4	41	1.25	32.8	763	4.2	181.8	No
199-D4-85	C3317_WD_199-D4-85_2001-05-21.xls	5/21/2001	572486.16	151324.20	119.5	110.4	35	4.11	8.5	198	7.3	27.1	No
199-D4-95	C7083_WD_199-D4-95_2009-11-20.xls	11/20/2009	572612.82	151226.70	119.2	108.6	19	3.53	5.4	125	9.0	13.9	No
199-D4-96	C7084_WD_199-D4-96_2009-10-28.xls	10/28/2009	572777.03	151519.78	117.4	114.3	15	6.4	2.3	54	3.0	17.9	No
199-D4-97	C7085_WD_199-D4-97_2009-11-03.xls	11/3/2009	572906.23	151625.33	117.0	112.4	41	6.11	6.7	156	4.6	34.1	No
199-D4-98	C7086_WD_199-D4-98_2009-12-04.xls	12/4/2009	572574.52	151481.65	118.7	112.6	44.88	1.11	40.4	940	5.2	181.9	No
199-D5-104	C5400_WD_199-D5-104_2007-03-22.xls	3/22/2007	573265.48	151422.43	119.7	110.5	9.5	1.816	5.2	122	7.6	16.0	No
199-D5-127	C7591_WD_199-D5-127_2010-03-05.xls	3/5/2010	572992.26	151428.31	119.6	113.5	23	4.9	4.7	109	4.1	26.6	No
199-D5-129	C7600_WD_199-D5-129_2010-02-11.xls	2/11/2010	573735.50	151465.13	119.6	111.9	47.9	0.88	54.4	1,265	5.9	215.8	No
199-D5-130	C7590_WD_199-D5-130_2010-03-23.xls	3/23/2010	574039.20	151928.51	118.3	113.7	11	5.06	2.2	51	2.8	17.9	No
199-D5-131	C7601_WD_199-D5-131_2010-04-27.xls	4/27/2010	573684.39	152006.75	119.0	111.4	30	2.42	12.4	288	5.8	50.1	No
199-D5-20	A4577_WD_199-D5-20_1992-02-24.xls	2/24/1992	573239.97	152030.15	119.7	113.4	12.3	10.7	1.1	27	4.6	5.8	No
199-D5-92	C4583_WD_199-D5-92_2004-08-03.xls	8/3/2004	573131.93	152009.82	119.4	113.0	25	3.5	7.1	166.1	4.7	35.3	Yes
199-D5-97	C5390_WD_199-D5-97_2007-02-21.xls	2/21/2007	573250.11	151302.47	119.3	110.2	11	0.7	15.1	351.3	8.5	41.3	Yes
199-D5-98	C5391_WD_199-D5-98_2007-02-27.xls	2/27/2007	573369.56	151272.44	118.8	109.7	9	1.9	4.7	108.9	9.1	12.0	Yes
199-D7-6	C7611_WD_199-D7-6_2010-06-14.xlsx	6/14/2010	574429.20	152980.43	120.3	114.2	44.8	1.1	40.7	946.9	3.6	263.0	Yes
199-D8-101	C7852_WD_199-D8-101_2011-02-11.xlsx	2/11/2011	574069.46	152262.43	118.2	115.1	7.5	4.9	1.5	35.6	2.4	14.8	Yes
199-D8-53	A4581_WD_199-D8-53_1992-02-05.xls	2/5/1992	573889.86	152452.26	119.2	112.9	14.2	0.177	80.2	1,865	4.3	435.2	No
199-D8-6	A4585_WD_199-D8-6_1991-12-21.xls	12/21/1991	573434.69	152060.82	118.7	112.6	5.5	0.9	5.9	136	6.1	22.3	Yes
199-D8-68	B2772_WD_199-D8-68_1996-08-22.xls	8/22/1996	573711.67	152427.10	120.2	112.6	97	0.4	269.4	6,264.3	7.2	870.0	Yes

‡ This column indicates whether the specific capacity estimate was used in the parameterization of the 100 Area Groundwater Model.

Table 6-2. Transmissivity Estimates from Specific Capacity Estimates

Well Name	Data File	Well Development Date	Easting (m)	Northing (m)	Top of Screen Elevation (m)	Bottom of Screen Elevation (m)	Pumping Rate during Drawdown Test (gpm)	Drawdown (ft)	Specific Capacity (SC, gpm/ft)	Transmissivity (T=1.3*SC, m²/d)	Calculated Saturated Screen Length (m)	Hydraulic Conductivity (m/d)	Used in Model‡
199-D8-69	B2773_WD_199-D8-69_1996-08-22.xls	8/22/1996	573843.61	152552.20	119.2	113.1	97	0.2	485	11,275.8	4.3	2,622.3	Yes
199-D8-70	B2774_WD_199-D8-70_1996-08-22.xls	8/22/1996	573942.10	152508.74	119.5	110.3	101	0.5	202	4,696.3	7	670.9	Yes
199-d8-89	C7091_WD_199-D8-89_2009-11-03.xls	11/3/2009	573478.64	152249.65	117.7	114.6	19.4	4.9	4	92	2.3	40.0	Yes
199-D8-90	C7092_WD_199-D8-90_2010-01-28.xls	1/28/2010	573948.64	152646.23	118.5	110.9	32.9	11.9	2.8	64	5.2	12.2	No
199-D8-98	C7602_WD_199-D8-98_2010-04-23.xlsx	4/23/2010	574013.12	152123.02	120.4	112.7	27	5	5.4	125.8	4.7	26.8	Yes
199-D8-99	C7593_WD_199-D8-99_2010-04-22.xls	4/22/2010	574006.77	152364.37	119.8	112.2	45	12.2	3.7	86	7.6	11.3	Yes
199-F5-55	C7970_WD_199-F5-55_2011-02-18.xlsx	2/18/2011	581076.10	147797.57	114.7	111.7	10	2.3	4.3	99.4	2.7	36.8	Yes
199-F5-56	C7972_WD_199-F5-56_2011-02-23.xlsx	2/23/2011	580440.62	147556.36	115.3	112.2	9	1.3	6.7	156.1	1.7	91.8	Yes
199-H1-1	C7585_WD_199-H1-1_2010-09-28.xls	9/28/2010	576702.31	153384.49	118.0	113.5	72	0.3	240	5,579.8	4.3	1,297.6	Yes
199-H1-2	C7584_WD_199-H1-2_2010-09-28.xls	9/28/2010	576451.07	153378.26	117.3	114.3	3.7	4	0.9	22	3.0	7.3	No
199-H1-20	C7113_WD_199-H1-20_2010-06-02.xlsx	6/2/2010	575706.04	154183.61	117.6	111.5	83.7	0.4	214.6	4,989.6	5	997.9	Yes
199-H1-21	C7111_WD_199-H1-21_2010-06-03.xlsx	6/3/2010	575896.84	154163.80	116.2	111.6	80.7	5.1	15.8	367.9	4.6	80.0	Yes
199-H1-25	C7478_WD_199-H1-25_2010-05-26.xlsx	5/26/2010	576279.64	154069.97	119.4	113.3	71	7	10.1	236	2.5	94.8	No
199-H1-27	C7480_WD_199-H1-27_2010-05-25.xlsx	5/25/2010	576403.86	154024.21	119.2	113.1	24	6.6	3.6	85	2.6	32.4	No
199-H1-32	C7100_WD_199-H1-32_2010-05-21.xlsx	5/21/2010	576767.07	153766.00	120.6	114.5	6	1.8	3.3	77.5	2	38.8	Yes
199-H1-33	C7105_WD_199-H1-33_2010-05-27.xlsx	5/27/2010	576833.29	153716.23	119.1	114.5	30	2.3	13	303.2	2	151.6	Yes
199-H1-35	C7106_WD_199-H1-35_2010-05-24.xlsx	5/24/2010	576958.26	153628.14	117.8	113.2	15	0.4	37.5	871.8	2.9	300.6	Yes
199-H1-36	C7102_WD_199-H1-36_2010-05-19.xlsx	5/19/2010	576885.62	153486.51	118.4	113.9	6.7	1.8	3.7	86.5	2.4	36.0	Yes
199-H1-37	C7099_WD_199-H1-37_2010-05-14.xlsx	5/14/2010	577106.92	153641.63	118.3	113.7	56.8	4.9	11.6	269.5	2.8	96.3	Yes
199-H1-42	C7107_WD_199-H1-42_2009-10-02.xls	10/2/2009	577127.18	153391.65	116.0	113.0	14.9	1.2	12.1	281.6	3	93.9	Yes
199-H1-43	C7492_WD_199-H1-43_2009-10-02.xls	10/2/2009	577213.74	153384.28	115.6	112.5	67.3	1	67.3	1,564.7	3	521.6	Yes
199-H1-45	C7477_WD_199-H1-45_2009-09-28.xls	9/28/2009	577240.96	153062.41	116.1	111.5	63	1	63	1,464.7	4.6	318.4	Yes
199-H3-11	C7863_WD_199-H3-11_2011-02-10.xlsx	2/10/2011	577786.74	152490.41	117.4	114.3	12	1.7	7.1	164.1	2.5	65.6	Yes
199-H3-25	C7110_WD_199-H3-25_2009-09-24.xls	9/24/2009	577410.36	152978.49	117.5	111.4	60.1	0.2	300.5	6,986.3	3.5	1,996.1	Yes
199-H3-26	C7115_WD_199-H3-26_2009-09-22.xls	9/22/2009	577440.83	152846.50	116.6	112.1	67.3	0.3	232.1	5,395.4	4.3	1,254.7	Yes
199-H3-4	B2779_WD_199-H3-4_1996-08-01.xls	8/1/1996	577544.29	152293.21	120.1	112.4	105	0.1	1166.7	27,123.8	3.7	7,330.8	Yes
199-H3-5	B2780_WD_199-H3-5_1996-08-01.xls	8/1/1996	577454.70	152287.50	118.4	112.3	105	0.2	456.5	10,613.7	4.6	2,307.3	Yes
199-h4-63	B2776_WD_199-H4-63_1996-08-01.xls	8/1/1996	578185.83	152665.53	116.5	110.4	105	2.2	47.7	1,109.6	6	184.9	Yes
199-H4-64	B2777_WD_199-H4-64_1996-08-01.xls	8/1/1996	577946.11	153010.58	118.6	112.5	65	12.3	5.3	122.4	3.8	32.2	Yes
199-H4-69	C7485_WD_199-H4-69_2009-09-21.xls	9/21/2009	578014.05	152686.66	115.4	112.4	26.9	5.3	5.1	117.8	2.9	40.6	Yes
199-H4-70	C7483_WD_199-H4-70_2009-09-21.xls	9/21/2009	578003.82	152646.45	115.9	112.8	26.9	3.9	6.9	160.4	3	53.5	Yes
199-H4-71	C7487_WD_199-H4-71_2009-09-17.xls	9/17/2009	578010.64	152581.53	116.1	111.5	23.1	2.6	9.1	210.6	4.6	45.8	Yes
199-H4-72	C7488_WD_199-H4-72_2009-09-22.xls	9/22/2009	578036.28	152500.14	116.2	111.6	37.4	8.8	4.3	98.8	4.6	21.5	Yes
199-H4-73	C7484_WD_199-H4-73_2009-09-16.xls	9/16/2009	577940.58	152369.98	116.1	110.0	15.2	1.1	14.5	336.6	6.1	55.2	Yes
199-H4-74	C7598_WD_199-H4-74_2010-09-30.xlsx	9/30/2010	577239.07	152268.83	118.3	113.8	21	2.5	8.4	195.3	3	65.1	Yes
199-H4-76	C7587_WD_199-H4-76_2010-09-29.xlsx	9/29/2010	576787.32	152976.85	118.4	115.3	30	1.5	19.6	455.9	2.2	207.2	Yes

Table 6-2. Transmissivity Estimates from Specific Capacity Estimates

Well Name	Data File	Well Development Date	Easting (m)	Northing (m)	Top of Screen Elevation (m)	Bottom of Screen Elevation (m)	Pumping Rate during Drawdown Test (gpm)	Drawdown (ft)	Specific Capacity (SC, gpm/ft)	Transmissivity (T=1.3*SC, m^2/d)	Calculated Saturated Screen Length (m)	Hydraulic Conductivity (m/d)	Used in Model‡
199-H4-77	C7605_WD_199-H4-77_2010-09-29.xlsx	9/29/2010	576487.79	152975.43	118.0	114.9	6	2.5	2.4	57	0.9	63.8	No
199-H4-79	C7586_WD_199-H4-79_2010-09-21.xlsx	9/21/2010	575659.13	151989.31	119.4	113.3	44.8	1.8	25.6	595	3.2	183.1	No
199-H4-80	C7595_WD_199-H4-80_2010-06-24.xlsx	6/24/2010	575238.97	152568.16	119.8	109.2	68.8	1.3	52.9	1,230.4	10.1	121.8	Yes
199-K-114A	B2801_WD_199-K-114A_1996-10-04.xls	10/4/1996	570020.30	148280.55	119.3	114.7	85	2.2	38.6	898.3	3.5	256.7	Yes
199-K-115A	B2802_WD_199-K-115A_1996-10-04.xls	10/4/1996	569939.99	148135.42	120.2	111.1	38	12.9	2.9	68.5	7.3	9.4	Yes
199-K-116A	B2803_WD_199-K-116A_1996-10-16.xls	10/16/1996	569871.15	147960.50	120.5	103.7	82	0.7	124.2	2,888.5	15.8	182.8	Yes
199-K-118A	B2805_WD_199-K-118A_1996-10-23.xls	10/23/1996	569703.06	147865.90	120.4	108.1	34	2.8	12.1	281.5	12.3	22.9	Yes
199-K-120A	B2807_WD_199-K-120A_1996-10-15.xls	10/15/1996	569399.62	147518.48	120.4	97.6	50	1.5	34.2	796.2	22.9	34.8	Yes
199-K-124A	B2811_WD_199-K-124A_1996-10-02.xls	10/2/1996	569867.94	146991.67	125.7	115.0	10	14.36	0.7	16	5.1	3.1	No
199-K-127	C3662_WD_199-K-127_2002-02-06.xls	2/6/2002	569539.23	147539.00	120.0	101.7	52.5	7.3	7.2	167.2	17.9	9.3	Yes
199-K-130	C4120_WD_199-K-130_2003-02-24.xls	2/24/2003	570478.99	148661.18	119.7	110.5	20	3.7	5.4	126.7	9	14.1	Yes
199-K-138	C5113_WD_199-K-138_2006-09-13.xls	9/13/2006	568395.22	146616.64	119.5	108.8	28	2.8	10	232.5	10.7	21.7	Yes
199-K-139	C5114_WD_199-K-139_2006-09-14.xls	9/14/2006	568551.39	146518.39	123.4	112.8	29.7	4.5	6.7	154.8	6.5	23.8	Yes
199-K-141	C5303_WD_199-K-141_2007-01-03.xls	1/3/2007	569024.22	146818.49	119.3	108.7	33	5.9	5.6	130	10.7	12.1	Yes
199-K-142	C5304_WD_199-K-142_2007-01-19.xls	1/19/2007	569104.26	146870.94	119.8	111.3	18	25.6	0.7	16.3	8.4	1.9	Yes
199-K-143	C5305_WD_199-K-143_2007-01-04.xls	1/4/2007	570934.41	148088.28	119.5	108.9	17.6	1.3	13.5	315	10.3	30.5	No
199-K-145	C5361_WD_199-K-145_2008-04-14.xls	4/14/2008	569284.60	147425.66	120.0	89.5	10	0.6	16.2	377.4	30.4	12.4	Yes
199-K-149	C5365_WD_199-K-149_2007-11-14.xls	11/14/2007	570778.25	148970.74	120.2	108.0	16.5	2	8.3	191.8	9.7	19.8	Yes
199-K-151	C5367_WD_199-K-151_2007-12-13.xls	12/13/2007	570941.32	148686.44	126.2	104.9	43	0.1	430	9,997.1	14	714.1	Yes
199-K-154	C5370_WD_199-K-154_2007-11-20.xls	11/20/2007	570321.06	148027.01	124.4	106.1	18.8	0.2	98.7	2,294.3	13.2	173.8	Yes
199-K-158	C5484_WD_199-K-158_2007-01-19.xls	1/19/2007	568627.45	146164.41	126.6	112.9	30	0.2	150	3,487.3	8.4	415.2	Yes
199-K-159	C5937_WD_199-K-159_2007-10-26.xls	10/26/2007	570911.73	149159.61	126.9	105.6	21.4	1.9	11.3	261.9	17.1	15.3	Yes
199-K-161	C5939_WD_199-K-161_2008-01-04.xls	1/4/2008	570004.64	148202.30	119.3	111.7	30	4.2	7.1	166.1	6.8	24.4	Yes
199-K-172	C6747_WD_199-K-172_2008-08-26.xls	8/26/2008	570871.69	147166.37	134.5	104.0	14	1	13.5	313.3	21.7	14.4	Yes
199-K-173	C7016_WD_199-K-173_2008-09-27.xls	9/27/2008	568674.07	146266.88	126.4	108.1	15.7	0.9	16.7	388.3	13.5	28.8	Yes
199-K-181	C7464_WD_199-K-181_2009-10-08.xls	10/8/2009	568849.75	146892.82	125.0	106.7	17.6	0.8	23.2	538.4	11.1	48.5	Yes
199-K-196	C7696_WD_199-K-196_2011-09-27.xlsx	9/27/2011	568433.30	146639.26	123.0	94.0	54.5	3.7	14.7	342	23.5	14.6	No
199-K-199	C7699_WD_199-K-199_2011-03-22.xlsx	3/22/2011	569339.76	147585.30	105.4	96.3	24	7.735	3.1	72	9.1	7.9	No
199-K-29	A5480_WD_199-K-29_1991-10-03.xls	10/3/1991	569205.08	146790.13	122.7	116.6	8	3	2.7	62.2	4.7	13.2	Yes
199-N-14	A4664_WD_199-N-14_1992-08-04.xls	8/4/1992	571713.10	150243.37	120.4	114.3	10	1.1	9.2	213.3	4	53.3	Yes
199-N-159	C6177_WD_199-N-159_2008-05-01.xls	5/1/2008	571340.00	149942.84	116.8	114.7	8.1	7.4	1.1	25.6	2.1	12.2	Yes
199-N-20	A4670_WD_199-N-20_1993-04-06.xls	4/6/1993	571200.98	149660.67	136.5	116.3	5	1.3	3.9	91.5	1.4	65.4	Yes
199-N-201	C7326_WD_199-N-201_2009-10-30.xls	10/30/2009	571198.46	149759.46	118.1	116.0	1.2	0.6	2	47.3	1.5	31.5	Yes
199-N-209	C7318_WD_199-N-209_2009-11-02.xls	11/2/2009	571216.09	149791.71	118.0	115.8	1.3	1.3	1	22.7	1.6	14.2	Yes
199-N-21	A4671_WD_199-N-21_1992-08-07.xls	8/7/1992	571177.78	149629.41	135.9	115.9	11	3	3.7	86.7	2.3	37.7	Yes
199-N-248	C7341_WD_199-N-248_2010-01-22.xls	1/22/2010	571383.91	149997.93	117.0	114.8	1.2	0.5	2.5	58.4	2.1	27.8	Yes

Table 6-2. Transmissivity Estimates from Specific Capacity Estimates

Well Name	Data File	Well Development Date	Easting (m)	Northing (m)	Top of Screen Elevation (m)	Bottom of Screen Elevation (m)	Pumping Rate during Drawdown Test (gpm)	Drawdown (ft)	Specific Capacity (SC, gpm/ft)	Transmissivity (T=1.3*SC, m^2/d)	Calculated Saturated Screen Length (m)	Hydraulic Conductivity (m/d)	Used in Model‡
199-N-250	C7343_WD_199-N-250_2010-01-22.xls	1/22/2010	571388.88	150005.61	116.7	114.6	1.2	0.4	2.7	63.8	2.1	30.4	Yes
199-N-252	C7345_WD_199-N-252_2010-01-25.xls	1/25/2010	571394.10	150013.22	116.8	114.7	1.2	0.3	3.7	85	2.1	40.5	Yes
199-N-260	C7353_WD_199-N-260_2010-01-26.xls	1/26/2010	571413.69	150043.62	116.5	114.4	2.3	1	2.2	51.7	2.1	24.6	Yes
199-N-262	C7355_WD_199-N-262_2010-01-26.xls	1/26/2010	571418.51	150051.20	116.5	114.3	2.3	0.5	5	117.3	2.2	53.3	Yes
199-N-266	C7359_WD_199-N-266_2010-01-27.xls	1/27/2010	571428.76	150067.07	116.5	114.4	2.4	0.7	3.6	82.8	2.1	39.4	Yes
199-N-27	A4676_WD_199-N-27_1992-08-04.xls	8/4/1992	572052.62	149659.79	127.9	116.6	10	1	10.4	242.2	2.8	86.5	Yes
199-N-270	C7363_WD_199-N-270_2010-01-28.xls	1/28/2010	571438.52	150082.34	116.3	114.2	2.4	0.8	3	69.7	2.1	33.2	Yes
199-N-276	C7369_WD_199-N-276_2010-02-16.xls	2/16/2010	571450.74	150106.59	116.5	114.4	2.3	0.9	2.5	58.6	2.1	27.9	Yes
199-N-280	C7373_WD_199-N-280_2010-02-16.xls	2/16/2010	571457.93	150122.77	116.2	114.1	2.4	0.6	4.4	103.1	2.1	49.1	Yes
199-N-29	A4678_WD_199-N-29_1992-08-05.xls	8/5/1992	571841.35	149489.23	128.5	117.4	7	0.6	11.1	258.3	2.3	112.3	Yes
199-N-310	C7403_WD_199-N-310_2010-04-14.xls	4/14/2010	571542.79	150228.42	116.5	114.4	2	1.2	1.7	38.7	2.1	18.4	Yes
199-N-312	C7405_WD_199-N-312_2010-04-14.xls	4/14/2010	571548.23	150235.72	116.3	114.1	2	0.4	4.6	107.1	2.1	51.0	Yes
199-N-318	C7411_WD_199-N-318_2010-04-13.xls	4/13/2010	571563.67	150258.74	116.4	114.3	2	0.8	2.6	59.6	2.1	28.4	Yes
199-N-32	A4681_WD_199-N-32_1993-04-05.xls	4/5/1993	571907.62	149708.50	128.6	117.6	5	3.7	1.3	31.2	0.7	44.6	Yes
199-N-322	C7415_WD_199-N-322_2010-04-13.xls	4/13/2010	571572.74	150274.27	116.5	114.4	2	0.6	3.6	83	2.1	39.5	Yes
199-N-334	C7427_WD_199-N-334_2010-03-18.xls	3/18/2010	571600.32	150322.03	116.9	114.7	2.1	0.5	4.1	96.3	2.1	45.9	Yes
199-N-346	C7442_WD_199-N-346_2010-03-02.xls	3/2/2010	571203.32	149780.23	118.3	116.2	2.1	1.1	2	45.9	1.3	35.3	Yes
199-N-348	C7440_WD_199-N-348_2010-03-02.xls	3/2/2010	571248.28	149845.23	117.9	115.7	2.2	1.3	1.7	40	1.7	23.5	Yes
199-N-349	C7439_WD_199-N-349_2010-03-02.xls	3/2/2010	571267.16	149866.13	117.8	115.7	2	0.8	2.5	57.8	1.7	34.0	Yes
199-N-357	C7450_WD_199-N-357_2010-02-16.xls	2/16/2010	571456.35	150125.44	116.4	114.2	2.2	1.8	1.2	28.4	2.1	13.5	Yes
199-N-358	C7451_WD_199-N-358_2010-02-18.xls	2/18/2010	571466.28	150148.67	116.3	114.2	2.4	1.1	2.1	49.8	2.1	23.7	Yes
199-N-359	C7452_WD_199-N-359_2010-04-27.xls	4/27/2010	571484.18	150168.77	116.6	114.5	2.1	0.8	2.8	65.5	2.1	31.2	Yes
199-N-363	C7456_WD_199-N-363_2010-04-13.xls	4/13/2010	571554.65	150249.90	116.6	114.4	2.1	0.2	13.4	311	2.1	148.1	Yes
199-N-43	A5831_WD_199-N-43_1993-11-12.xls	11/12/1993	572366.18	150139.95	122.5	116.4	3	0.4	7.5	174.4	1.8	96.9	Yes
199-N-76	A4719_WD_199-N-76_1992-07-02.xls	7/2/1992	571560.08	150122.12	119.2	113.1	15.5	4.6	3.4	78	5.2	15.0	Yes

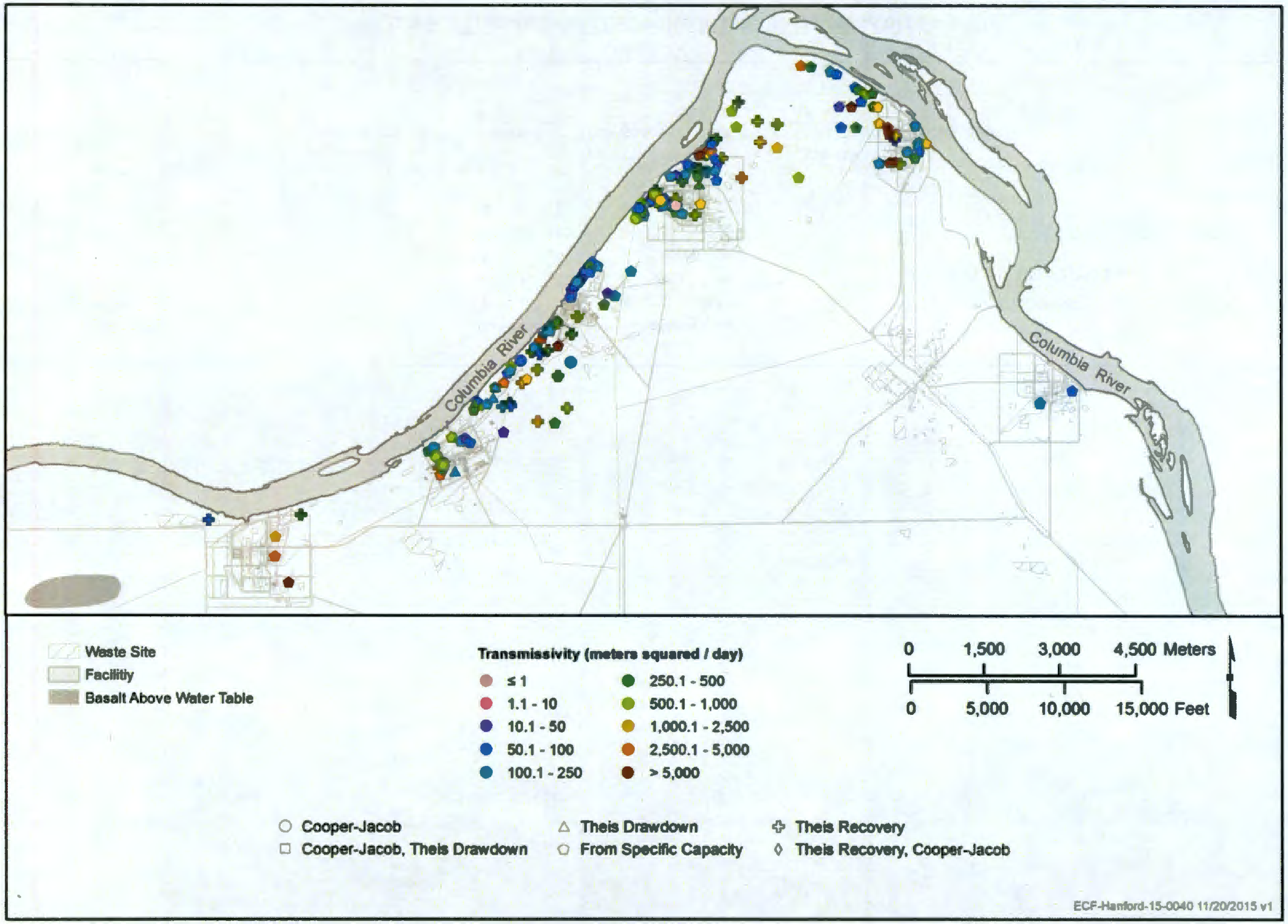


Figure 6-1. Transmissivity Estimates in the 100 Area (1 of 6)

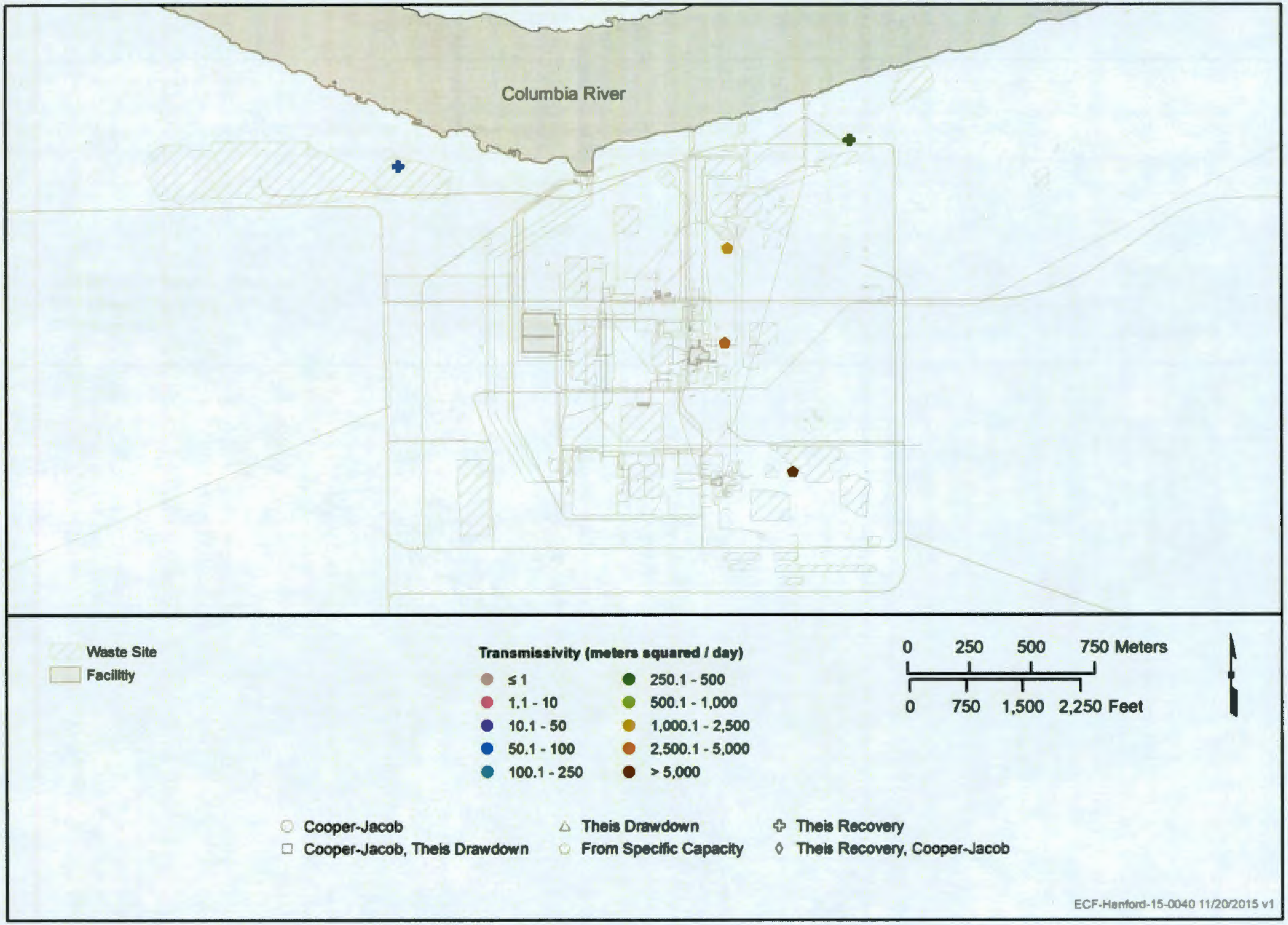


Figure 6-1. Transmissivity Estimates in the 100-B Area (2 of 6)

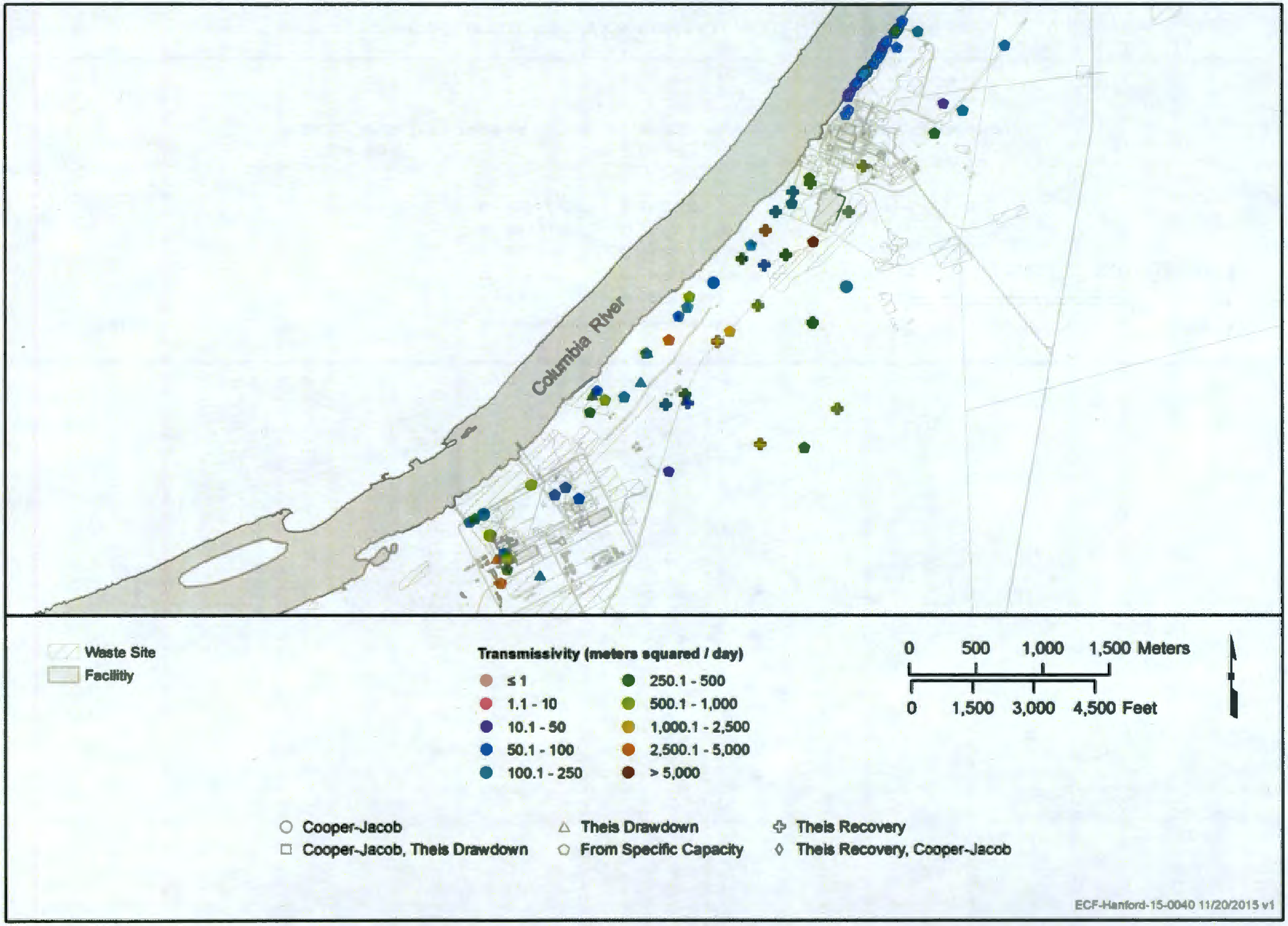


Figure 6-1. Transmissivity Estimates in the 100-K and 100-N Areas (3 of 6)

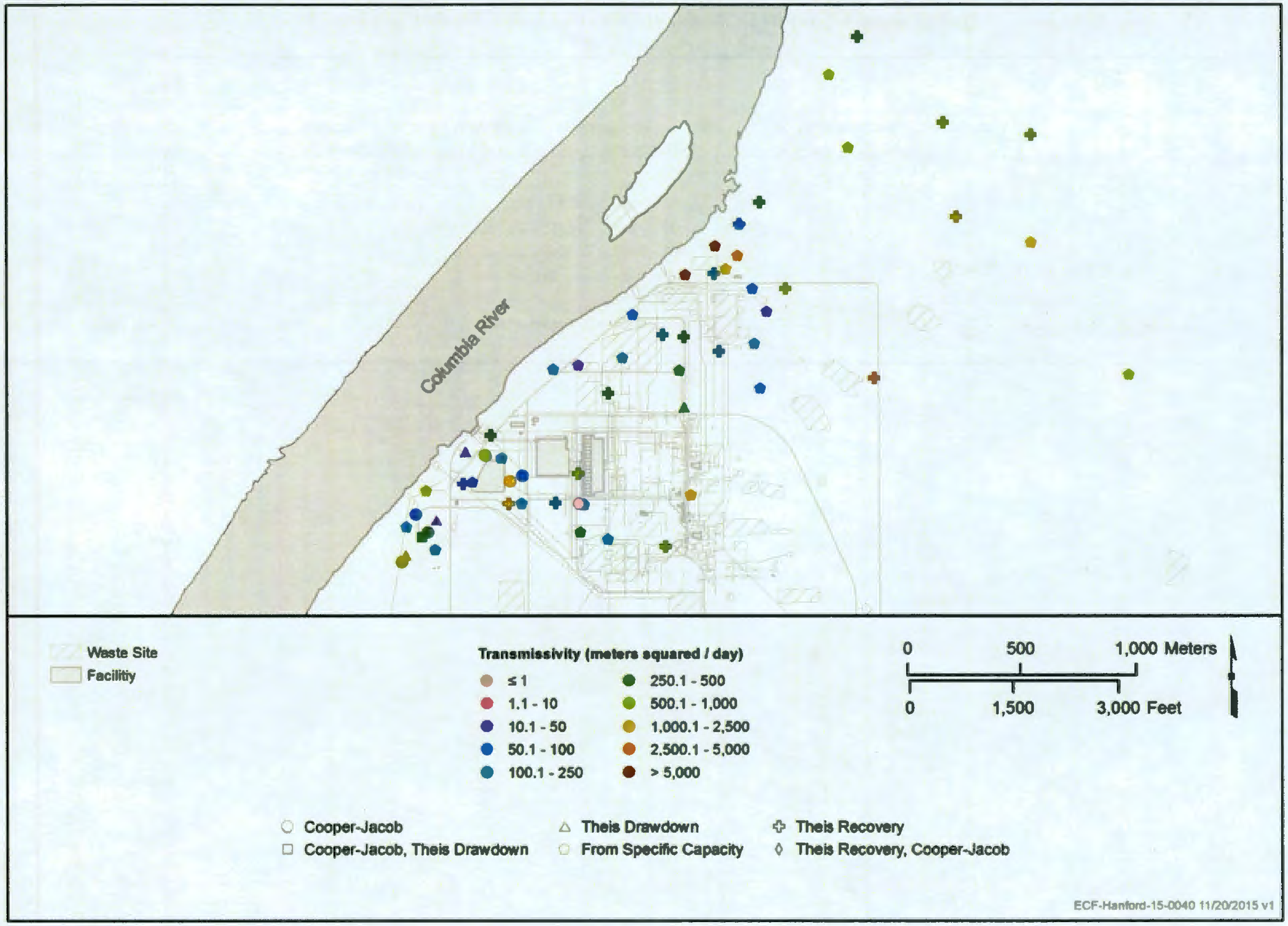


Figure 6-1. Transmissivity Estimates in the 100-D Area (4 of 6)

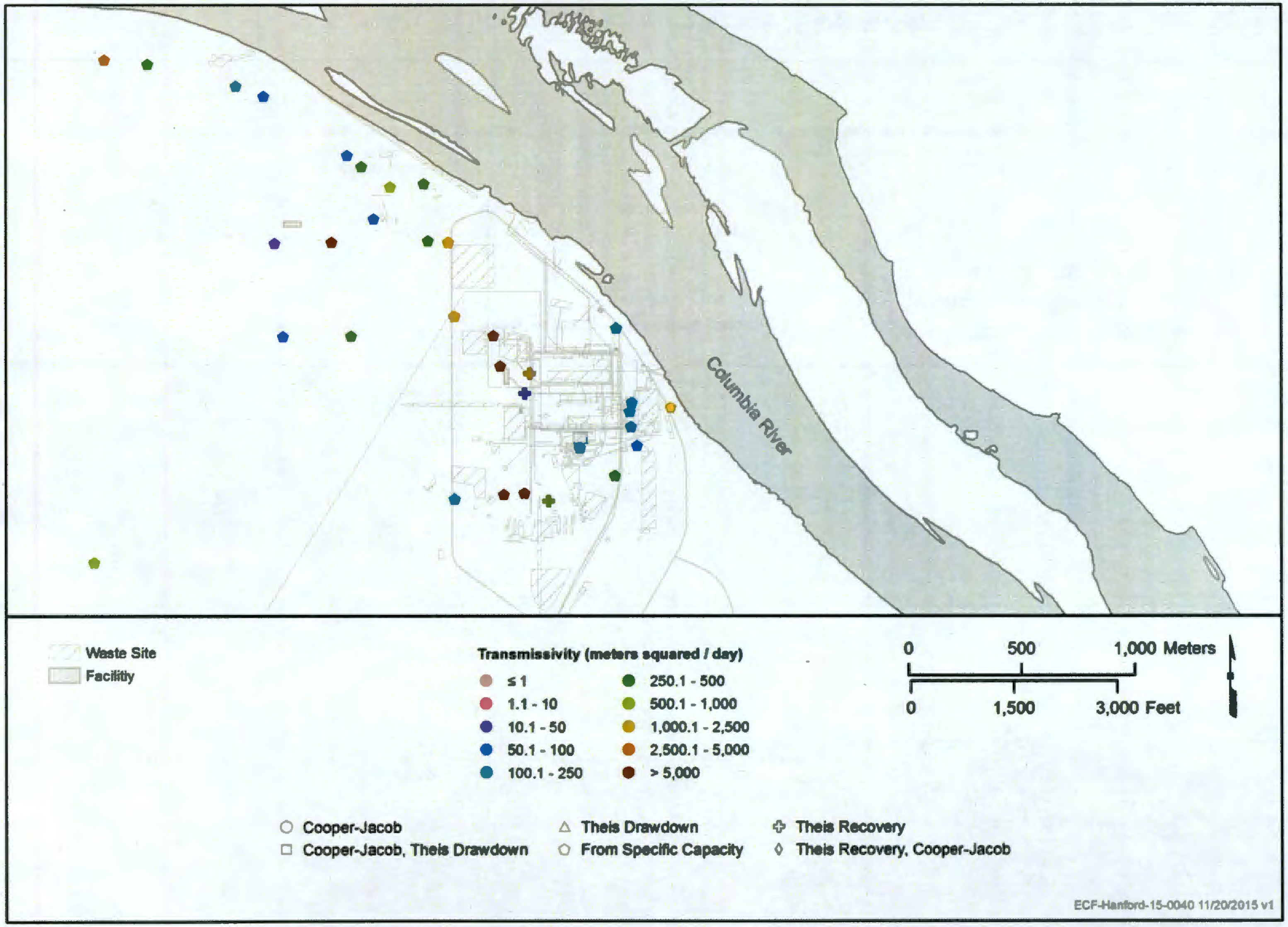


Figure 6-1. Transmissivity Estimates in the 100-H Area (5 of 6)

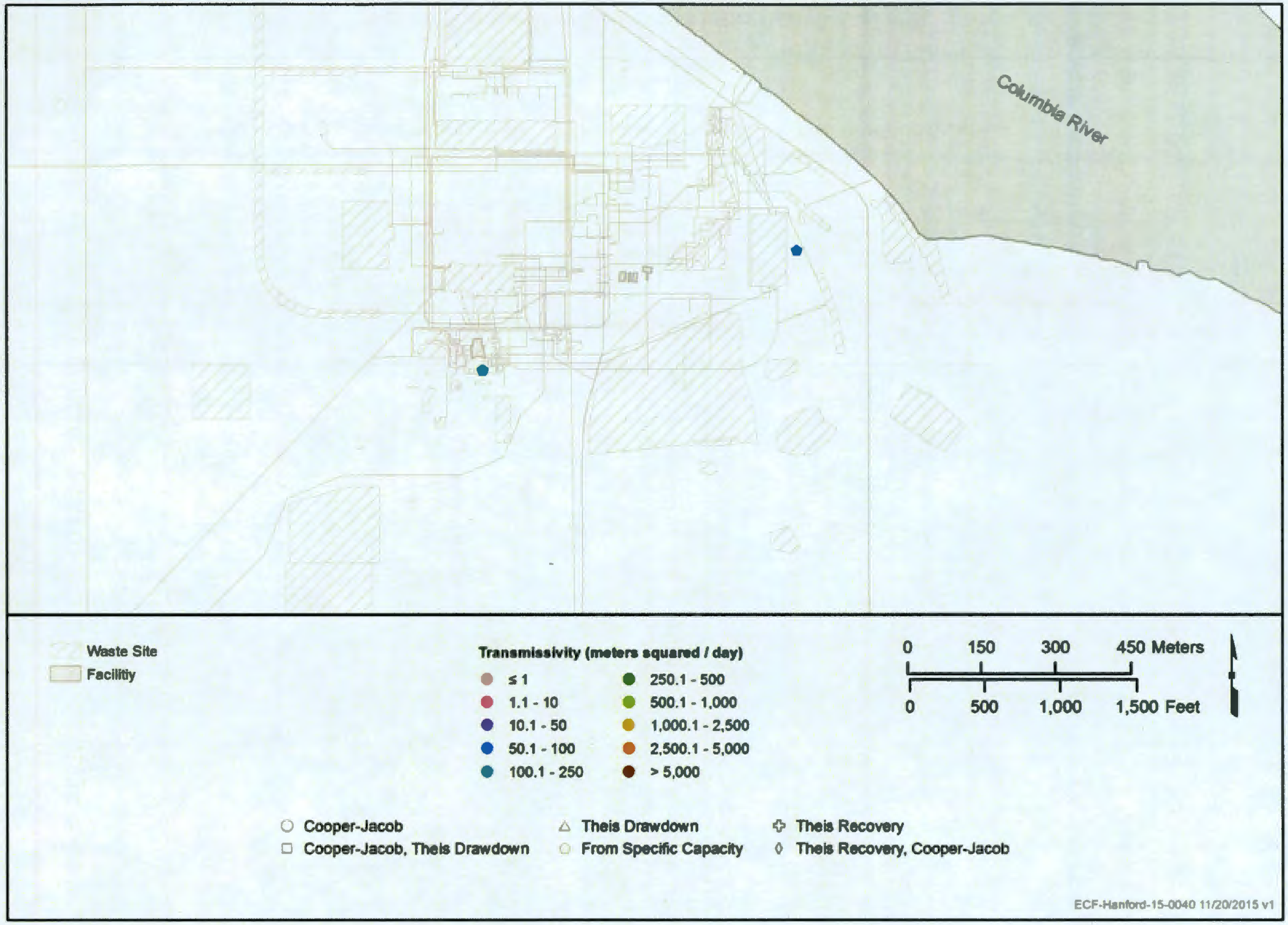


Figure 6-1. Transmissivity Estimates in the 100-F Area (6 of 6)

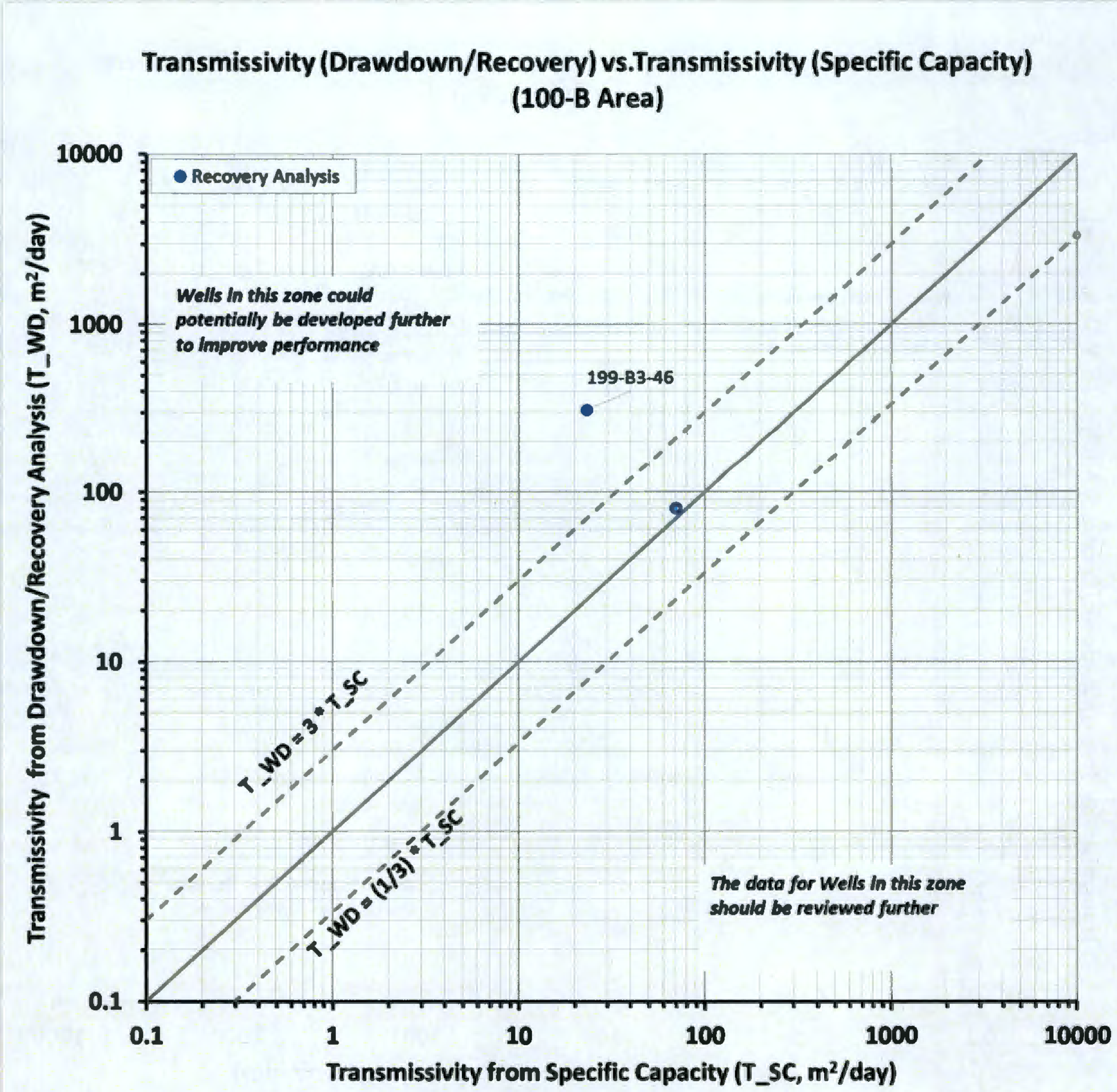


Figure 6-2. Transmissivity (Drawdown/Recovery) vs. Transmissivity (Specific Capacity) in the 100-B Area (1 of 5)

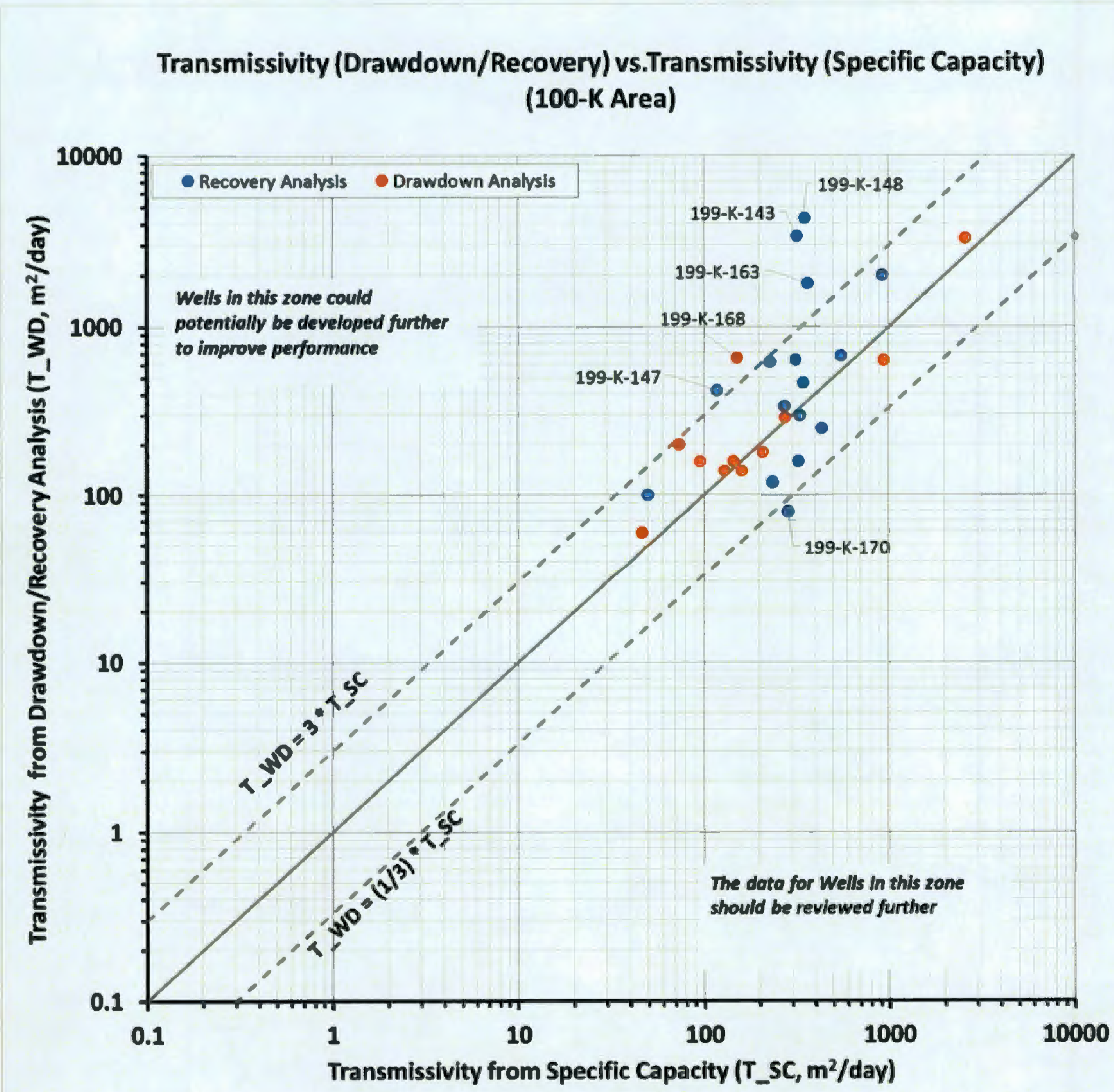


Figure 6-2. Transmissivity (Drawdown/Recovery) vs. Transmissivity (Specific Capacity) in the 100-K Area (2 of 5)

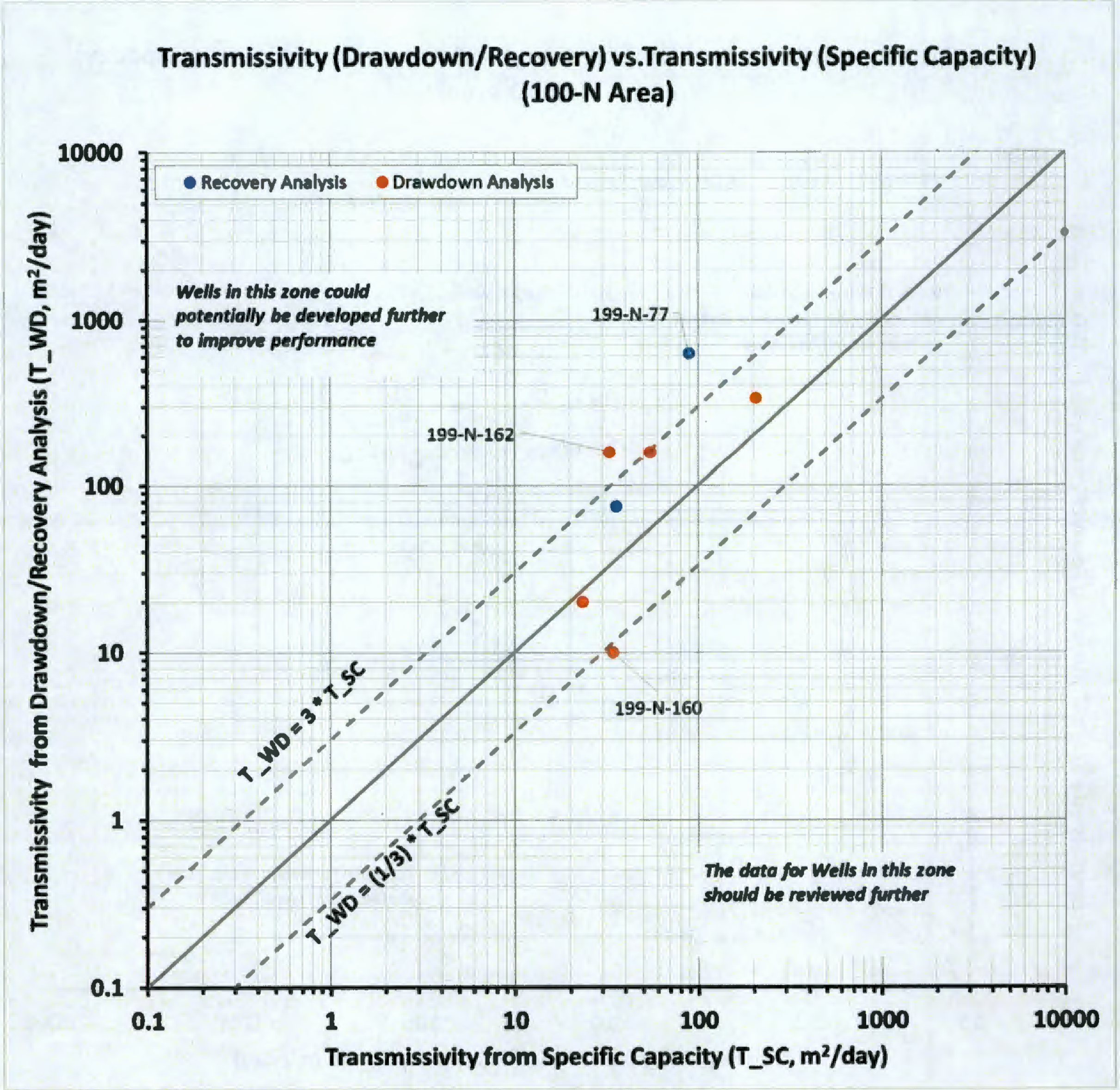


Figure 6-2. Transmissivity (Drawdown/Recovery) vs. Transmissivity (Specific Capacity) in the 100-N Area (3 of 5)

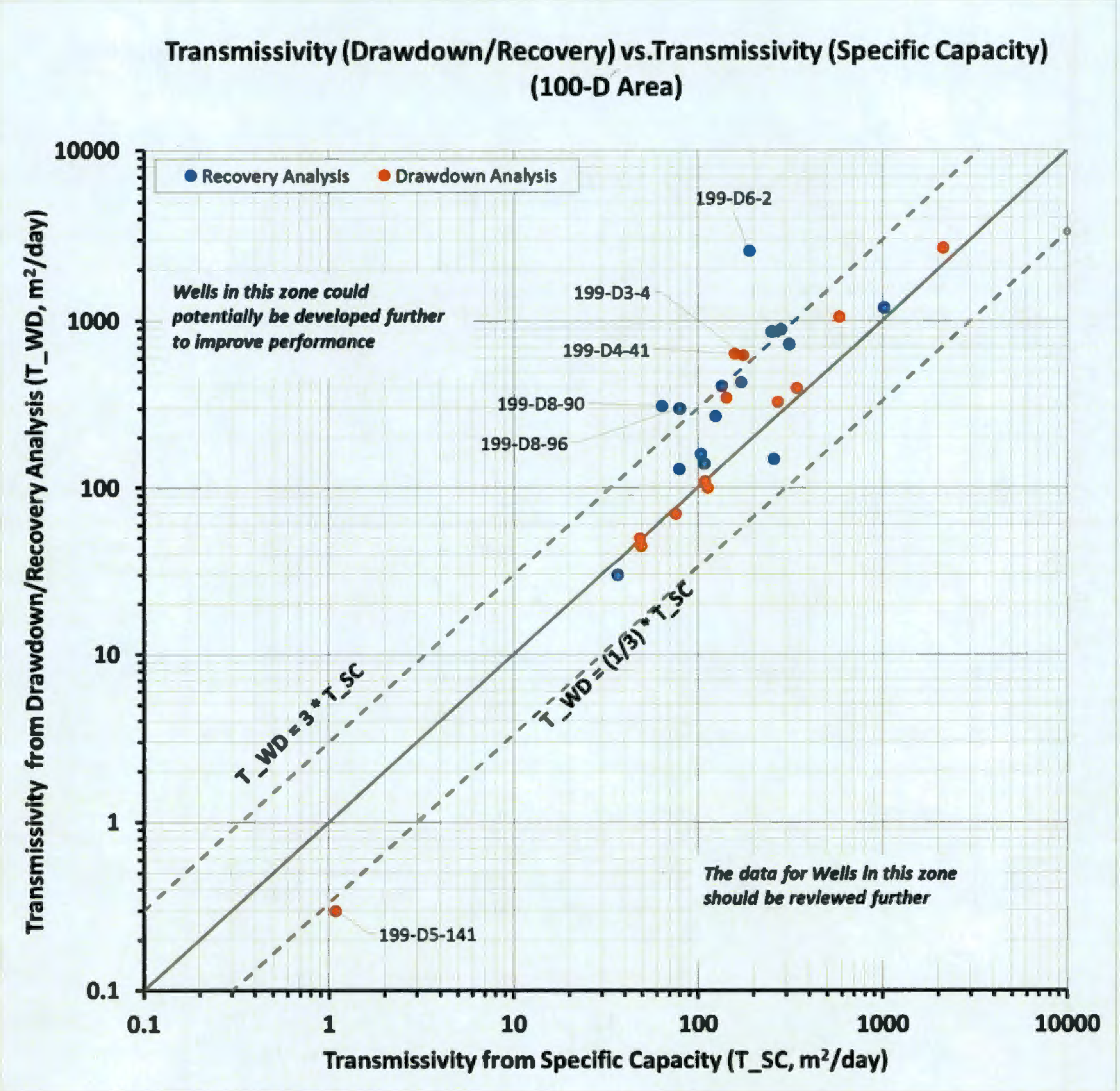


Figure 6-2. Transmissivity (Drawdown/Recovery) vs. Transmissivity (Specific Capacity) in the 100-D Area (4 of 5)

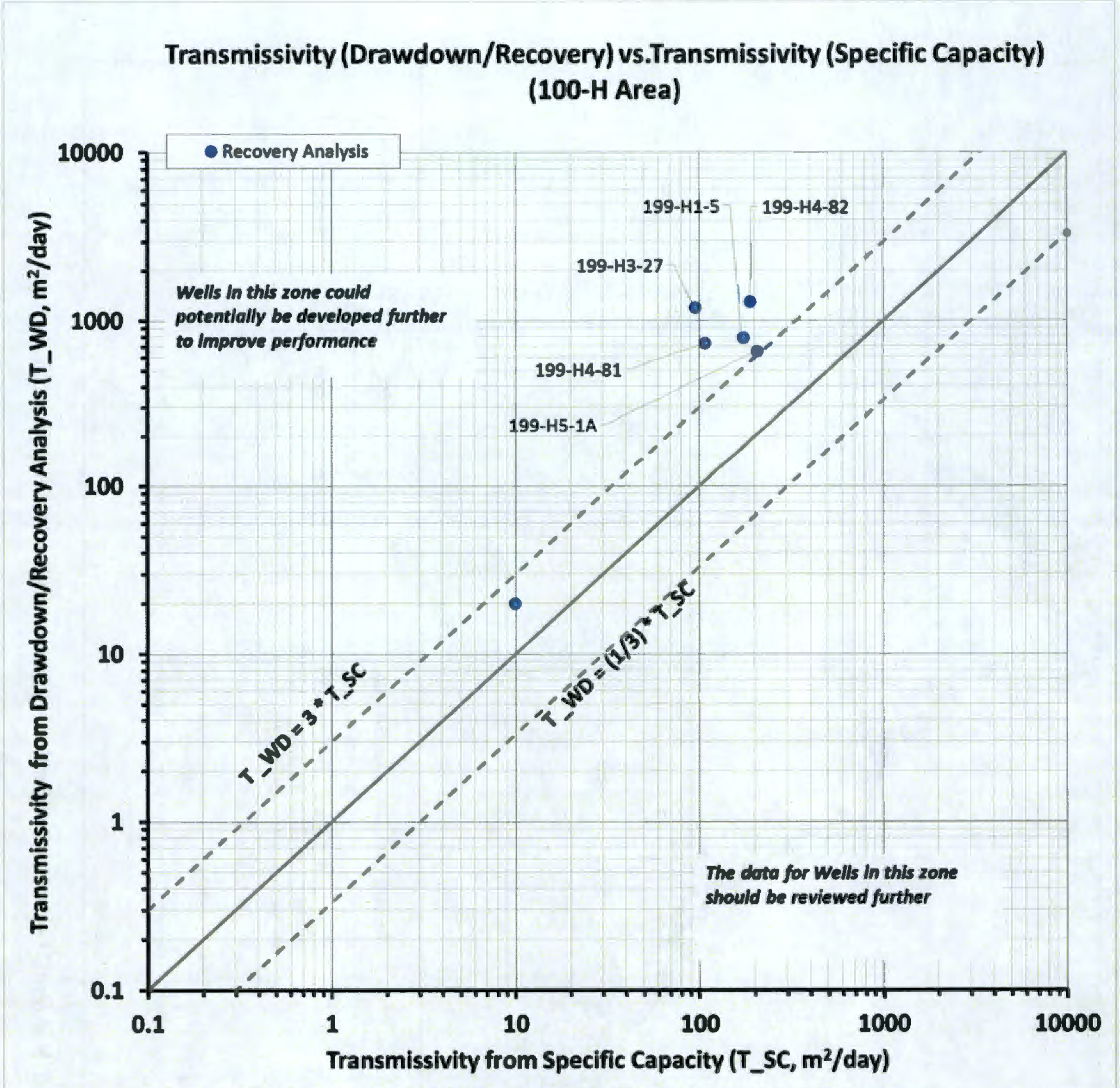


Figure 6-2. Transmissivity (Drawdown/Recovery) vs. Transmissivity (Specific Capacity) in the 100-H Area (5 of 5)

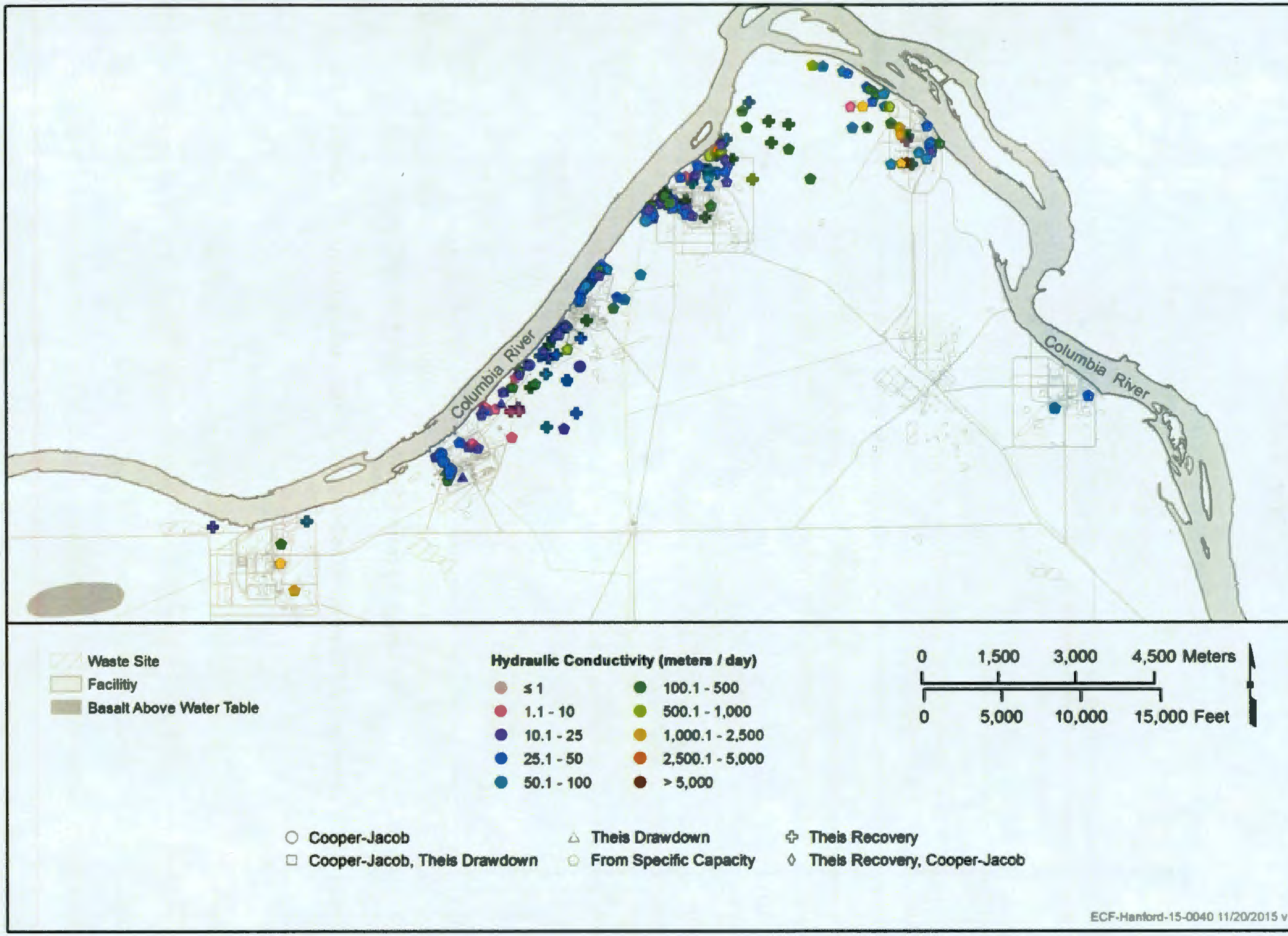
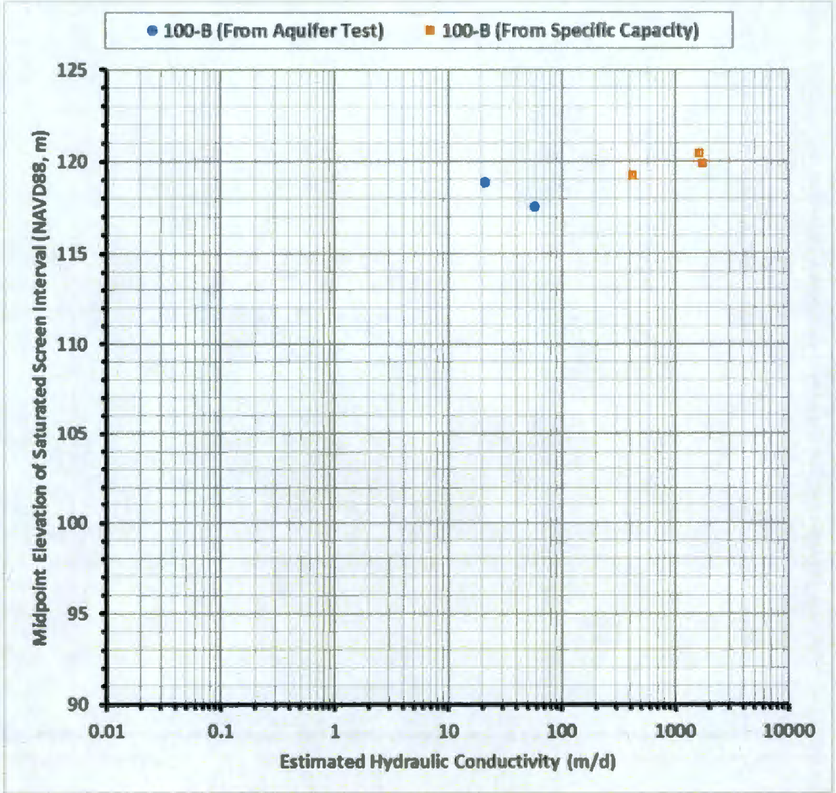


Figure 6-3. Horizontal Hydraulic Conductivity Estimates in the 100 Area (1 of 6)



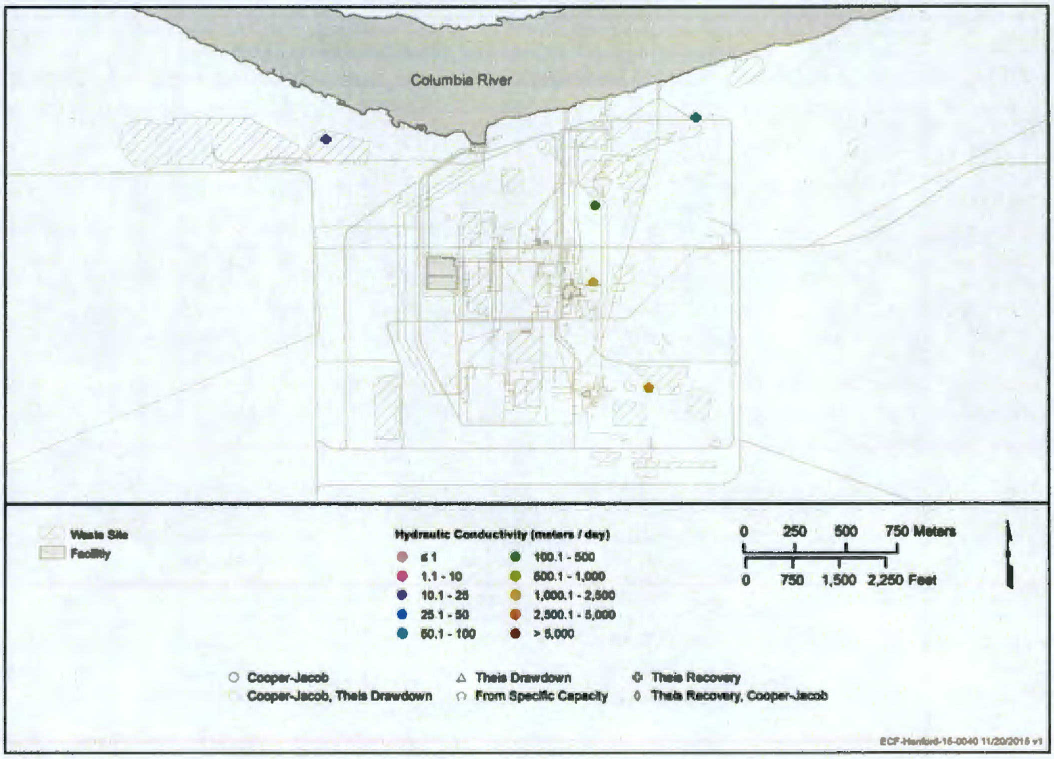
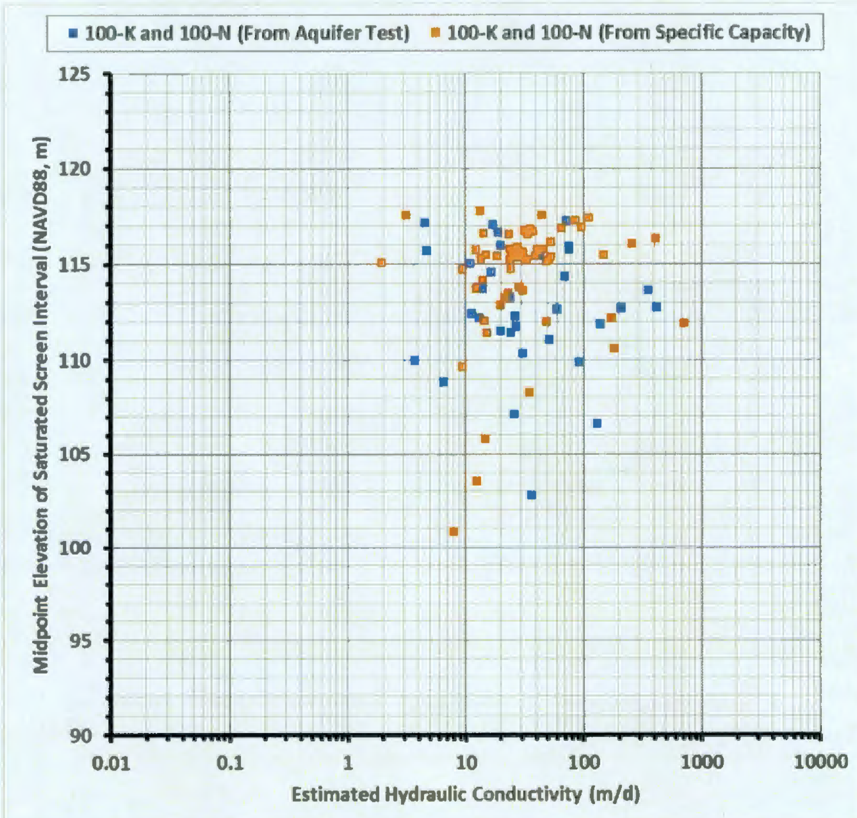


Figure 6-3. Horizontal Hydraulic Conductivity Estimates in the 100-B Area: Vertical Variation (Top) and Spatial Variation (Bottom) (2 of 6)



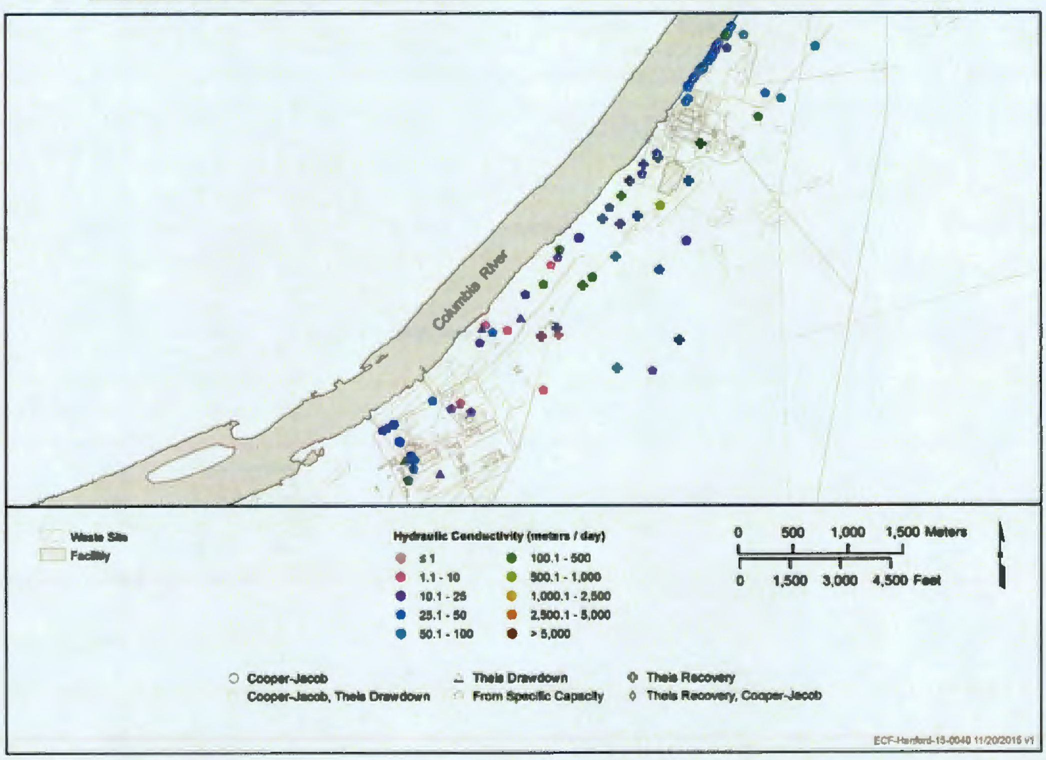
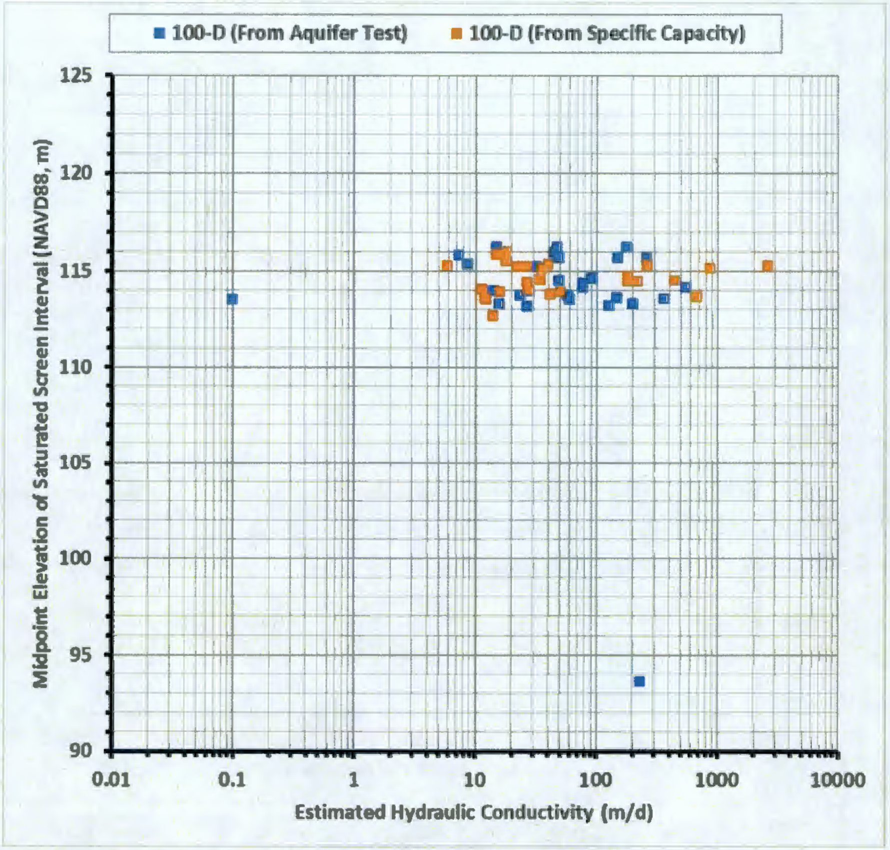


Figure 6-3. Horizontal Hydraulic Conductivity Estimates in the 100-K and 100-N Areas: Vertical Variation (Top) and Spatial Variation (Bottom) (3 of 6)



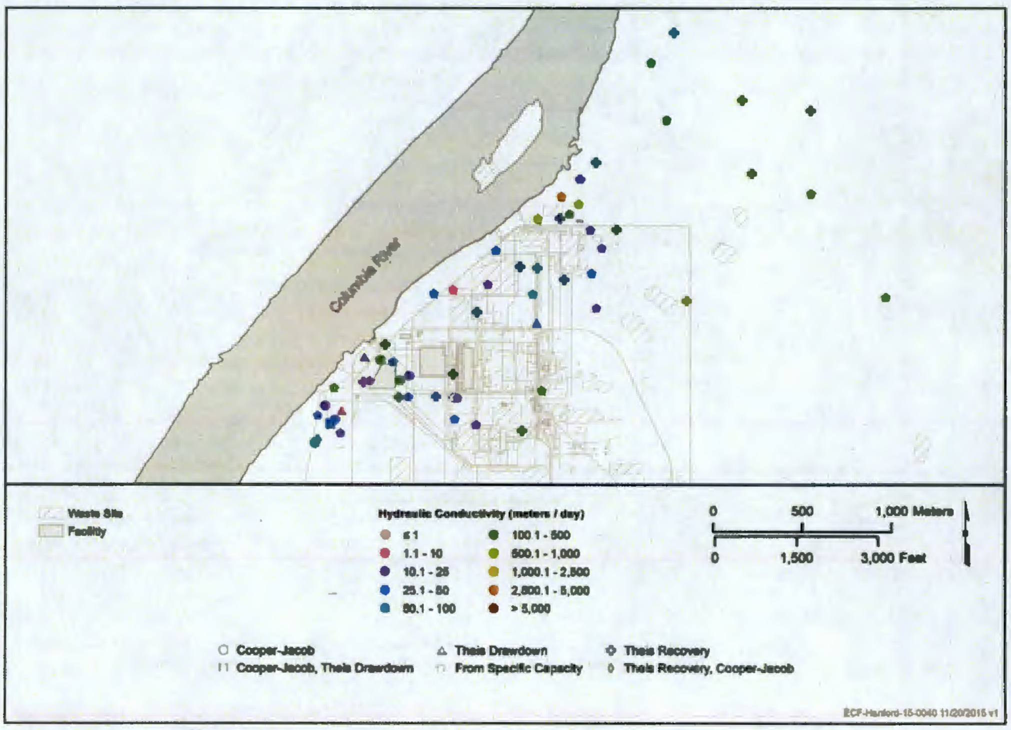


Figure 6-3. Horizontal Hydraulic Conductivity Estimates in the 100-D Area: Vertical Variation (Top) and Spatial Variation (Bottom) (4 of 6)

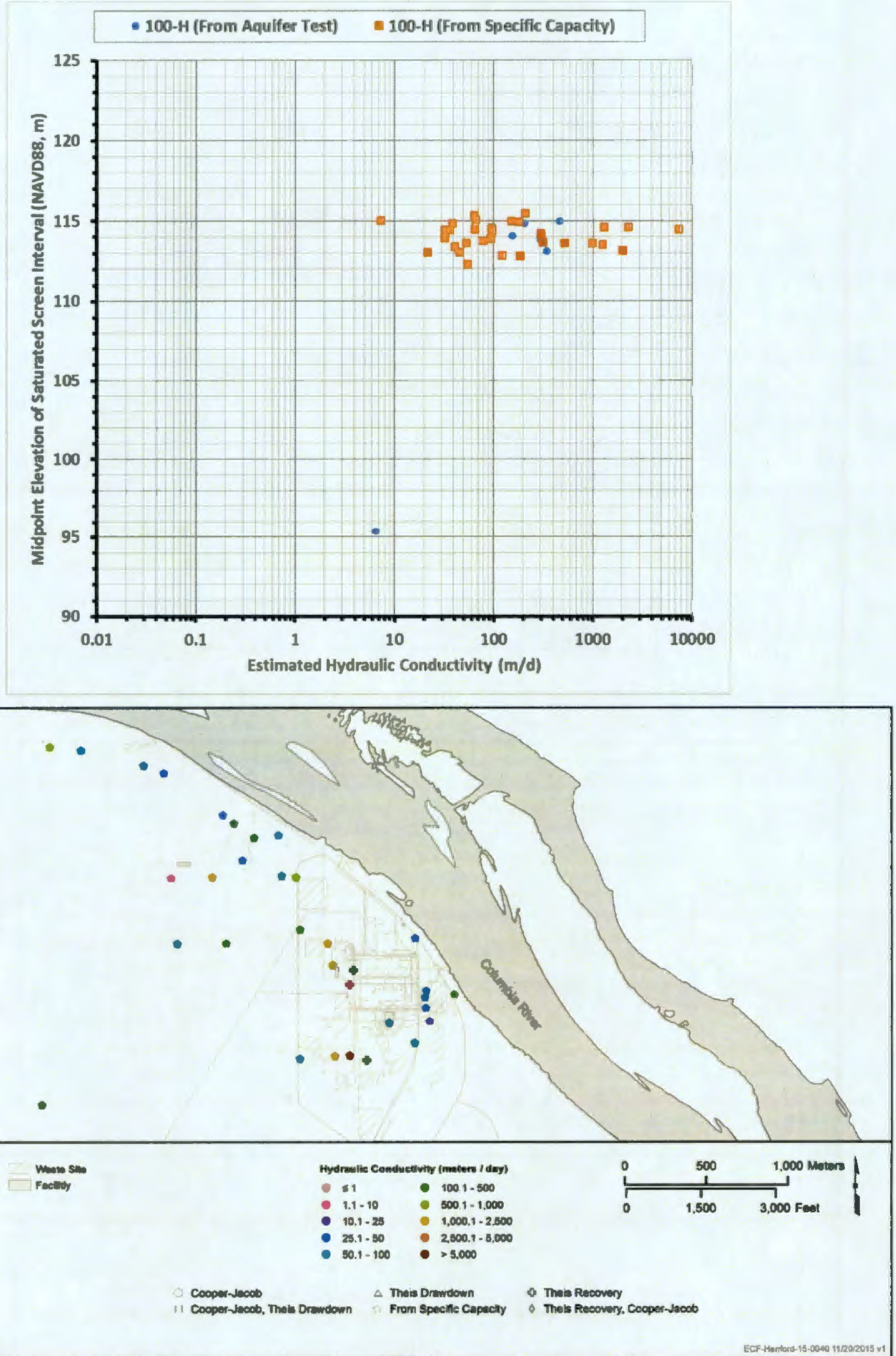


Figure 6-3. Horizontal Hydraulic Conductivity Estimates in the 100-H Area: Vertical Variation (Top) and Spatial Variation (Bottom) (5 of 6)

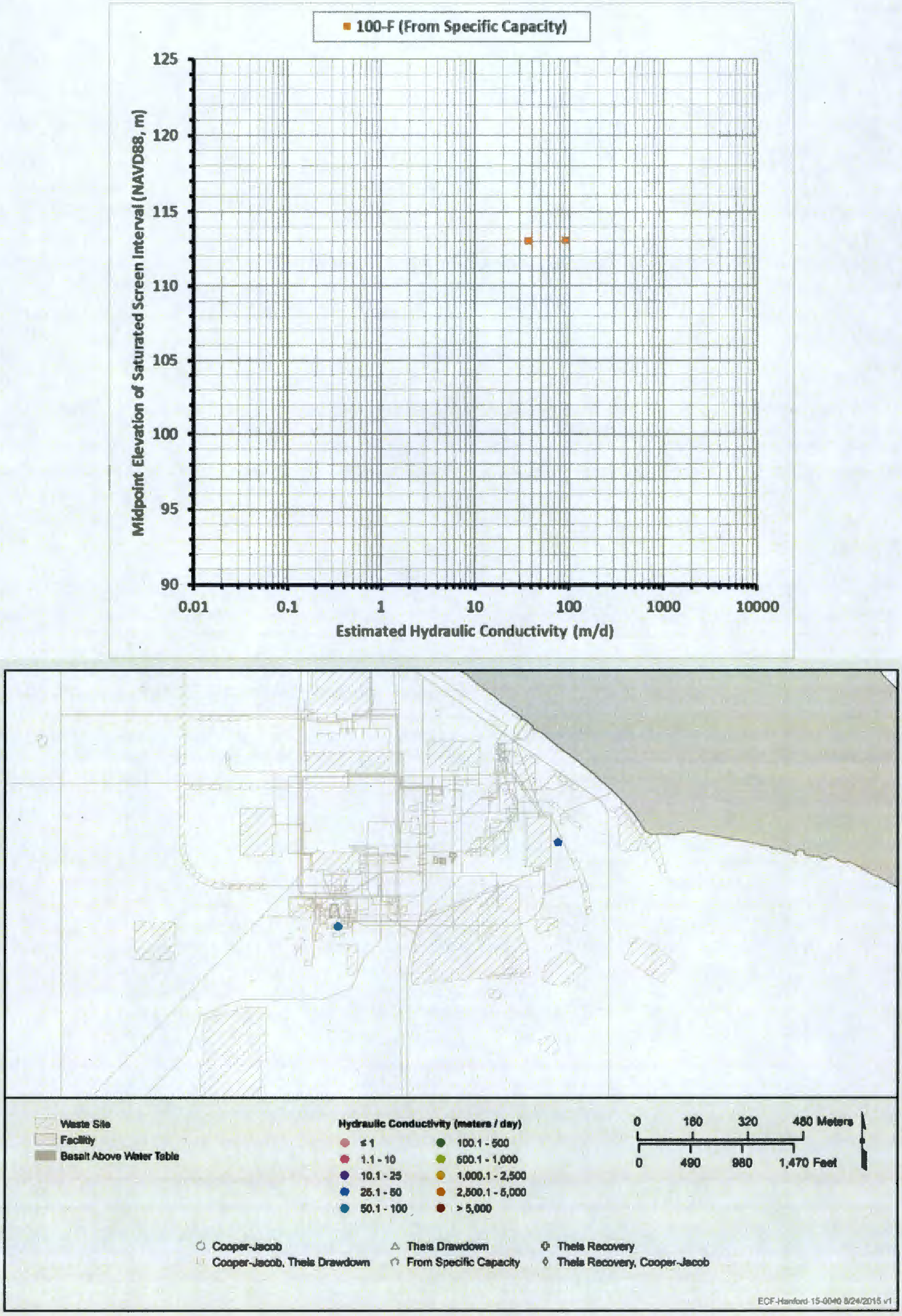


Figure 6-3. Horizontal Hydraulic Conductivity Estimates in the 100-F Area: Vertical Variation (Top) and Spatial Variation (Bottom) (6 of 6)

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7 References

CHPRC, 2013, Well Development Data, prepared by Kris Ivarson, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-01814, 2012, *AQTESOLV(TM) Software Management Plan*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

Cooper, H.H., Jr., and C.E. Jacob, 1953, "A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History," Ground Water Branch, Water Resources Division, Geological Survey, U.S. Department of the Interior, Washington, D.C. Available at: http://core.ecu.edu/geology/spruill/spruill/Groundwater%20Notes%20No.%207.pdf.

Hantush, M.S., 1961, "Drawdown Around a Partially Penetrating Well," *Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers* 87(HY 4):83-98.

Papadopulos, Istavros S. and Hilton H. Cooper, Jr., 1967, "Drawdown in a Well of Large Diameter," *Water Resources Research* 3(1):241-244.

PRC-PRO-IRM-309, 2014, *Controlled Software Management*, Revision 5, Change 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

SGW-46279, 2015, *Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model*, Rev. 3, CH2M HILL Plateau Remediation Company, Richland, Washington. Availible at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0076173H.

Theis, Charles V., 1952, "The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage," Ground Water Branch, Water Resources Division, Geological Survey, U.S. Department of the Interior, Washington, D.C. Available at: https://water.usgs.gov/ogw/pubs/Theis-1935.pdf.

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Appendix A

Estimation of Transmissivity from Specific Capacity Data

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$\Sigma^2\Pi$ **S. S. PAPADOPULOS & ASSOCIATES, INC.**
Environmental & Water-Resource Consultants

Memorandum

Date:	August 18, 2006 [Last update: December 19, 2013]
From:	Christopher J. Neville
To:	File
SSPA Project:	-
Re:	**Estimation of transmissivity from specific capacity data** *D:\Specific Capacity\Notes\Notes_1\Memorandum_Estimation of T from SC_text.docx*

1. Introduction

Transmissivity data are frequently limited in regional groundwater studies. Controlled pumping tests with observation wells are often available at only a few locations. The records for private water supply wells often contain information that can supplement the available data. In particular, these records generally include information collected during brief pumping periods after the well has been installed. This information can be used to calculate specific capacities for the wells, and transmissivity can be back-calculated using simple models such as the Theis solution. These calculations yield reconnaissance-level estimates of transmissivity. Where more detailed data are available, specific capacity values can also serve to provide simple check on the interpretations. This memorandum provides details on a method described in literature for estimating the transmissivity from specific capacity data.

2. Theory of specific capacity

The specific capacity (*SC*) is defined as the ratio of the pumping rate (*Q*) and the drawdown in the pumping well (s_w):

$$SC = \frac{Q}{s_w} \qquad (1)$$

If well losses and any effects of wellbore storage are neglected, the drawdown in the pumping well can be estimated by evaluating the Theis solution at the radius of the wellbore, r_w:

$$s_w = \frac{Q}{4\pi T} W\left(\frac{r_w^2 S}{4Tt}\right) \qquad (2)$$

In Equation (2), T and S designate the transmissivity and storage coefficient, t denotes the elapsed time of pumping at which the drawdown is measured, and $W\left(\frac{r_w^2 S}{4Tt}\right)$ is the Theis function, or exponential integral.

Equation (2) can be rearranged to obtain an expression for the specific capacity:

$$SC = \frac{Q}{s_w} = \frac{4\pi T}{W\left(\frac{r_w^2 S}{4Tt}\right)} \tag{3}$$

The transmissivity can be back-calculated from the estimated value of the specific capacity with known or assumed values for the well radius and storage coefficient:

$$T = \frac{1}{4\pi} W\left(\frac{r_w^2 S}{4Tt}\right) \times SC \tag{4}$$

3. Methodology for estimating transmissivity from the specific capacity

Equation (4) is an implicit function of the transmissivity T. Although it is possible to estimate T using a root-finding algorithm, Theis et al. (1963) developed a simple graphical method to estimate T. For a particular well size and duration of pumping, it is possible to use Equation (4) directly to plot the relation between the SC and T. The transmissivity can then be estimated directly from the plot.

For purposes of illustration, we assume that a typical private well has a screen diameter of 6 inches, and is pumped for 30 minutes after it is installed. The relationship between transmissivity and specific capacity for these values of r_w and t is plotted in Figure 1, for a typical range of storage coefficients for confined conditions ($S = 10^{-5}$ to 10^{-3}). The results plotted in Figure 1 demonstrate that the specific capacity is relatively insensitive to the value assumed for the storage coefficient.

The results shown in Figure 1 further demonstrate that the specific capacity relation is nearly linear over the transmissivity range of 1 to 10,000 m^2/day. This suggests that it might be appropriate to replace the graphical method by a simple correlation. The possibility of a simple correlation is examined in the next section.

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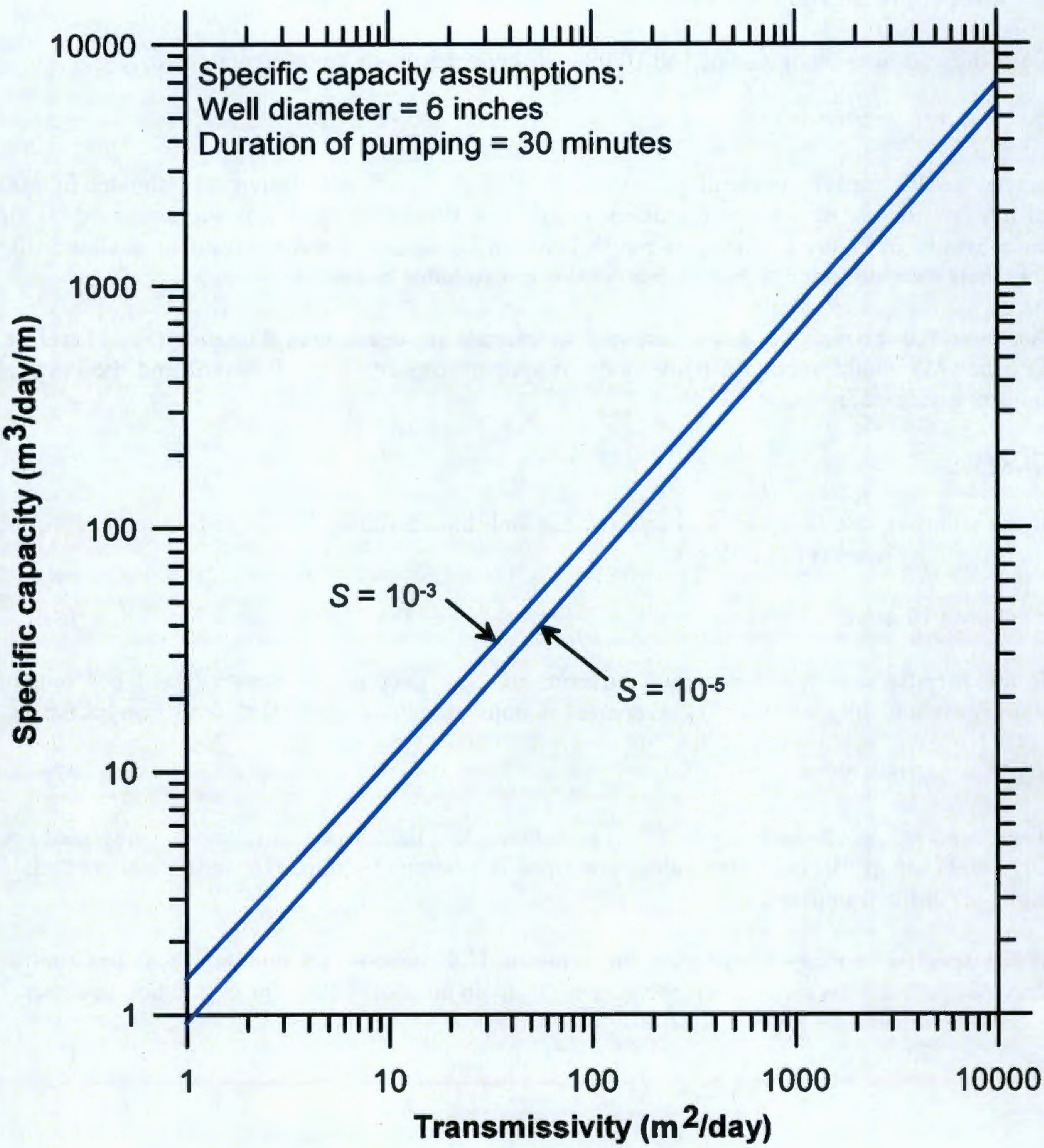

Figure 1. Relation between specific capacity and transmissivity

4. First-approximation of transmissivity from the specific capacity

Over the transmissivity range of 1 to 10,000 m^2/day we estimate from Figure 1 that:

$$T \approx 1.3 \times SC \qquad (5)$$

where specific capacity is specified in units of m^3/day/m, and transmissivity is estimated in units of m^2/day (that is, we assume consistent units). The simplified relation is superimposed on the exact results in Figure 2. The good match between Equation (5) and the results calculated with the Theis solution suggests that Equation (5) is a reasonable estimator.

As indicated above, we have assumed consistent in developing Equation (5). Therefore, Equation (5) would also hold if the units of specific capacity were ft^3/day/ft and the units of transmissivity were ft^2/day.

Other units

If the pumping rate is reported in units of L/s and the drawdown is reported in units of m, the transmissivity in units of m^2/day is:

$$T \approx 110 \times SC \qquad (6)$$

If the specific capacity is specified in terms of U.S. gallons per minute (gpm) per foot of drawdown, and the transmissivity is reported in units of gallons/day-ft, the correlation becomes:

$$T \approx 1870 \times SC \qquad (7)$$

The leading coefficient of 1870 is close to the value of 2000 presented in Driscoll (1986, p. 1021) and the values presented in Walton (1970, p. 318) for typical production wells in confined aquifers.

If the specific capacity is specified in terms of U.S. gallons per minute (gpm) per foot of drawdown, and we want to report the transmissivity in units of ft^2/day, the correlation becomes:

$$T \approx 250 \times SC \qquad (8)$$

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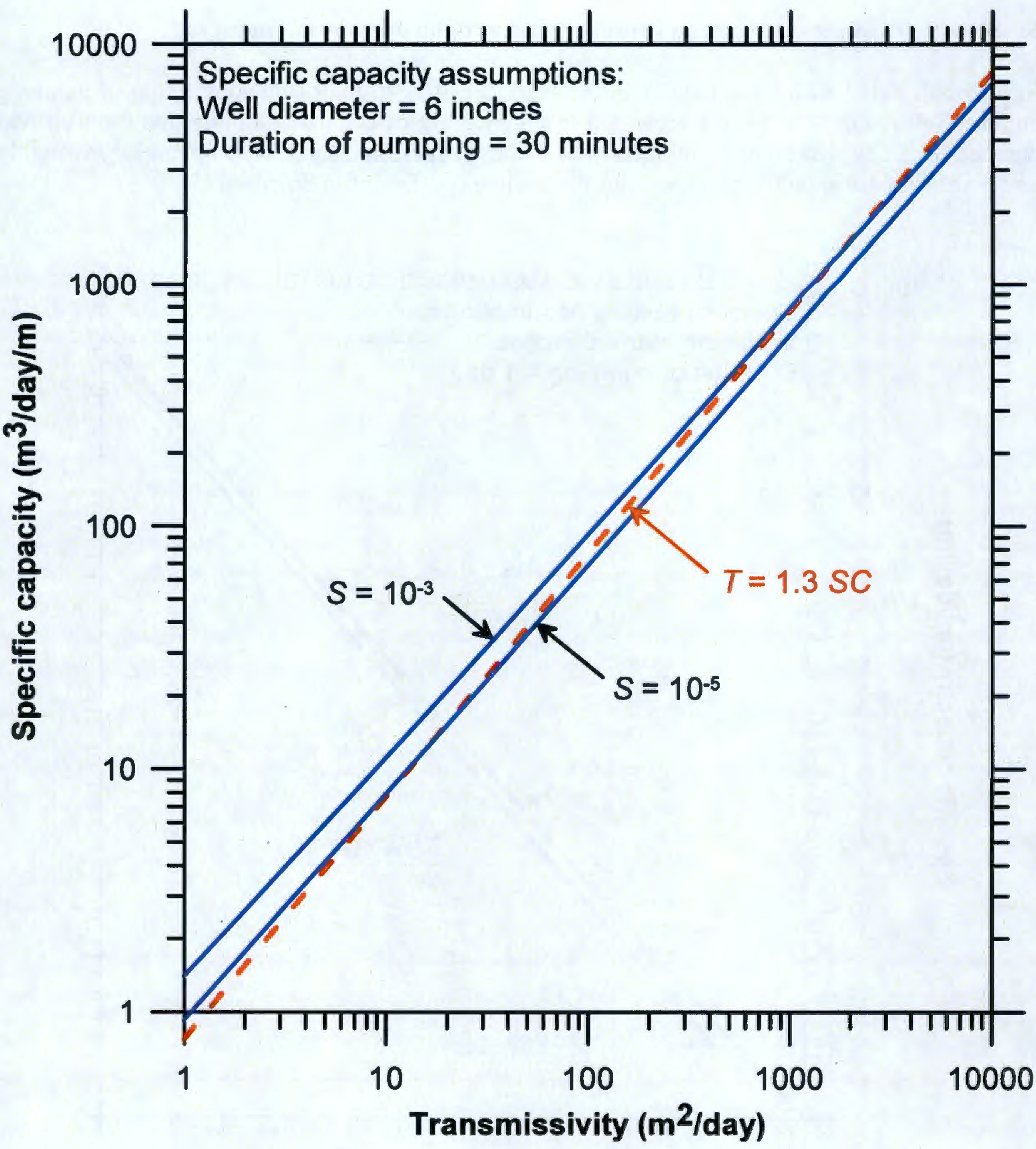

Figure 2. Simplified specific capacity-transmissivity relation

5. Sensitivity of the estimation of transmissivity to the duration of pumping

Results calculated with Equation (2) are not very sensitive to the assumed duration of pumping and the well radius. The results presented in Figure 3 are calculated assuming that the well was pumped for 1 day instead of 30 minutes. The results suggest that for 1 day of pumping, a slightly larger value of 1.6 should be assumed for the leading coefficient in Equation (5).

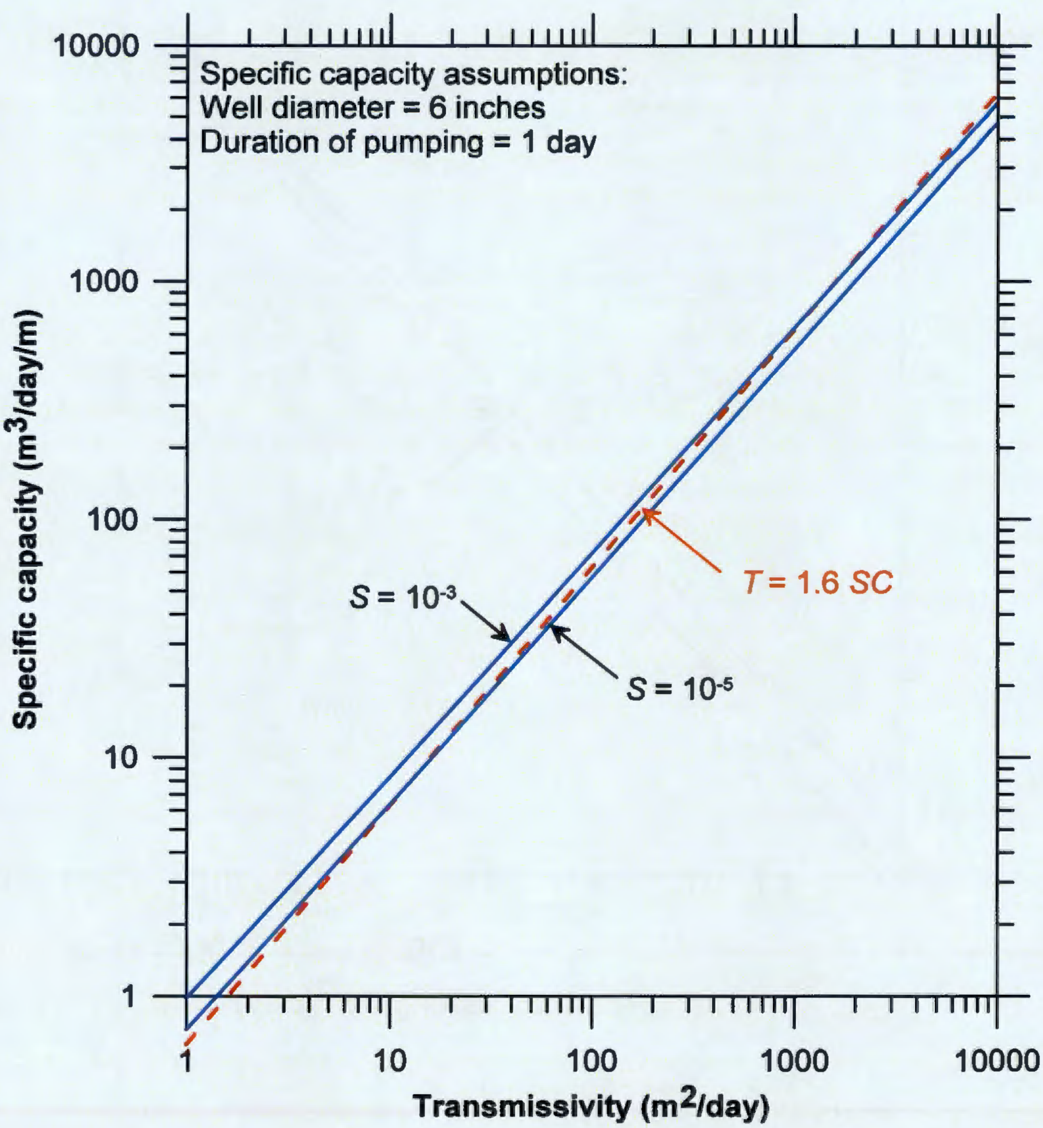

Figure 3. Simplified specific capacity-transmissivity relation for 1 day of pumping

6. Specific capacity-transmissivity correlation for unconfined aquifers

The storage coefficient for unconfined aquifers, that is, the specific yield (S_y), is several orders of magnitude larger than for confined conditions. For a typical sand and gravel unconfined aquifer with a S_y of 0.2, Theis calculations are performed by substituting the storage coefficient term in equation 4 with the specific yield. The results of these calculations are plotted in Figure 4. These results suggest that the leading coefficient for one day of pumping should be reduced slightly, from 1.6 to about 0.9.

If the specific capacity is specified in terms of U.S. gallons per minute (gpm) per foot of drawdown, and the transmissivity is reported in units of gallons/day-ft, Equation (5) with a leading coefficient of 0.9 becomes:

$$T \approx 1300 \times SC \qquad (9)$$

The leading coefficient of 1300 is close to the value of 1500 presented in Driscoll (1986, p. 1021) for a typical production well in an unconfined aquifer. Driscoll assumed a specific yield of 0.075 in his calculation.

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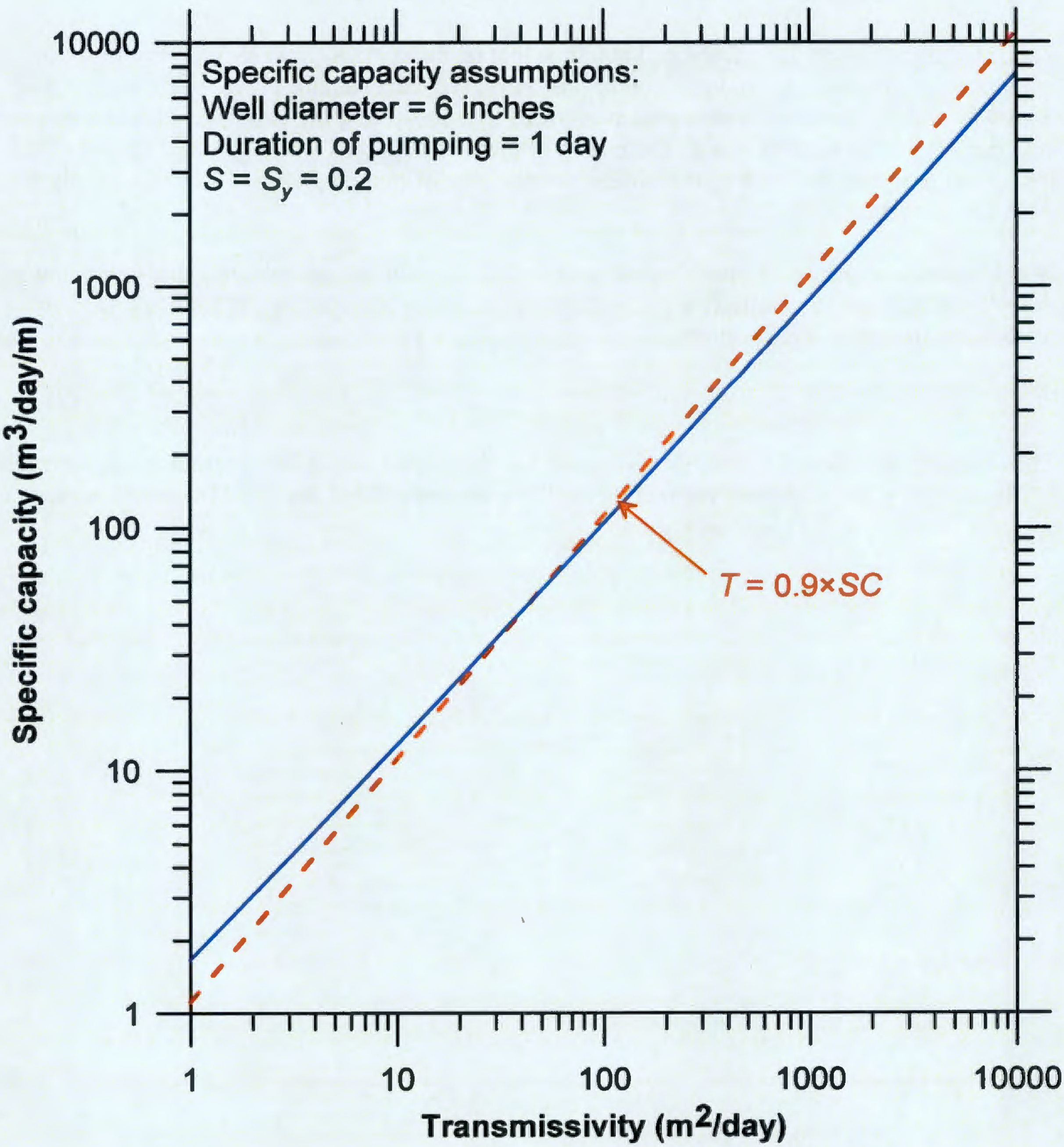

Figure 4. Specific capacity-transmissivity relation for an unconfined aquifer

7. Cautions on the estimation of transmissivity from specific capacity data

There are lots of ways the estimate of the transmissivity derived from specific capacity data may not be representative.

In a formation with relatively low transmissivity, the time required for wellbore storage effects to dissipate may be relatively long. A well must be pumped sufficiently long for these effects to dissipate before the transmissivity can be estimated.

In developing the relation between transmissivity and specific capacity, it has been assumed that the only source of drawdown is head losses in the formation. There are generally additional sources of drawdown in a pumping well. These sources may include disturbance of the formation due to drilling (the development of a wellbore skin), partial penetration of the formation, turbulent head losses in the formation immediately adjacent to the well, and nonlinear head losses within the well itself. Bradbury and Rothschild (1985) discuss approaches to estimate these additional head losses and account for them in the estimation of transmissivity. Additional factors like river/boundary fluctuations and pumping at neighboring wells can also cause water level changes in the pumping well. However, if sufficient information is available to identify and quantify these additional sources of drawdown, it is likely we can apply an analysis that is more comprehensive than Equation (5) to estimate the transmissivity.

At all times, we recommend that transmissivities estimated from values of specific capacity be regarded as first-cut, or reconnaissance-level estimates.

8. References

Bradbury, K.R., and E.R. Rothschild, 1985; A computerized technique for estimating the hydraulic conductivity of aquifers from specific capacity data, *Ground Water*, vol. 23, no. 2, pp. 240-246.

Driscoll, F.G., 1986: **Groundwater and Wells**, 2nd ed., Johnson Division, St. Paul, MN.

Theis, C.V., R.H. Brown, and R.R. Meyer, 1963: Estimating the transmissibility of aquifers from the specific capacity of wells, in *Methods of Determining Permeability, Transmissivity, and Drawdown*, R. Bentall (ed.), United States Geological Survey Water Supply Paper 1536-I pp. 331-341.

Walton, W.C., 1970: **Groundwater Resource Evaluation**, McGraw-Hill, New York, NY.