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Aquifer Test Analysis Results for 1993 200-UP-1 Groundwater Operable Unit

Environmental Excellence
HANFORD

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Bechtel Hanford, Inc.
Richland, Washington

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1.0 INTRODUCTION

This document reports the results of seven slug tests and two single-well pumping tests that were conducted in the uppermost unconfined aquifer in the 200 West Area in August and September 1993 (Figure 1). Aquifer testing was performed in support of the 200-UP-1 Groundwater Operable Unit. The purpose of aquifer testing was to fill in hydraulic conductivity data gaps in the western portion of 200 West Area and help refine the hydrogeologic conceptual model in this area. A more extensive aquifer testing program will be implemented in 1994, after the installation of new wells in the operable unit.

Aquifer testing is a required field activity in accordance with the *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit, Hanford Site, Richland, Washington* (DOE-RL 1994). Data quality objectives for aquifer testing are specified in this document. Field work was directed and controlled by a description of work released by Swanson (1993). Applicable field procedures are found in the *Environmental Investigations and Site Characterization Manual* (WHC 1988).

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2.0 DESCRIPTION OF TEST ACTIVITIES

Aquifer tests were conducted at seven existing wells, which included single-well slug tests at all of the wells and single-well pumping tests at two wells. Even though multiple-well pumping tests were originally planned at 699-37-82A and 299-W22-41, these wells were not tested because of a very short screen section (<5 ft) at 699-37-82A, and because of *Resource Conservation and Recovery Act* compliance monitoring at well 299-W22-41. Table 1 lists the originally planned test wells and the criteria that were used to select them. Aquifer tests were performed in existing wells and at the top of the unconfined aquifer (which corresponds to the Ringold Formation gravel unit E).

Most of the wells were constructed of carbon steel casing and perforated at the top of the water table, although some had wire-wrap stainless steel screen. A pre-test site visit and well assessment was conducted to verify the adequacy of the wells for testing.

On the basis of these assessments and actual attempts to conduct aquifer tests, several wells were found to be unusable. In particular, a slug test could not be successfully conducted at well 299-W14-10 because the slugging rod repeatedly hung up on the top of the "doglegged" well screen. Testing therefore was moved to alternate well 299-W14-8A. However, the field crew could not access this well because the well casing extended about 6 ft in the air. A successful slug test was finally completed at the next alternate well, 299-W19-4. A long perforated interval in well 299-W19-4 required placement of a packer 20 ft below the top of the water table (so that the test results would reflect aquifer conditions at the top of the unconfined per Table 1 requirements).

Figure 1. Location for the Aquifer Test Wells in the 200 West Area.

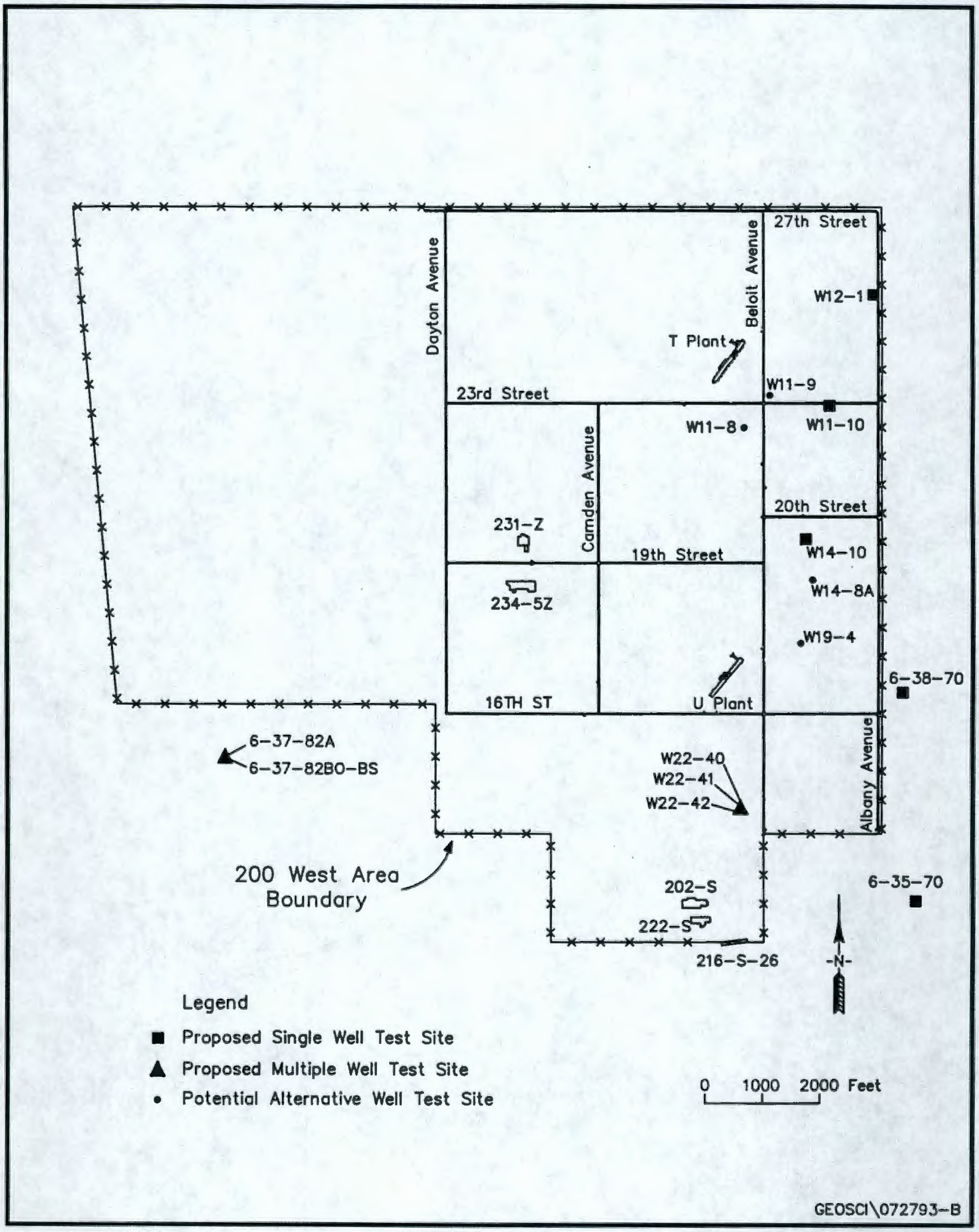

Table 1. Summary Table of Criteria for Selecting Test Wells (after Swanson 1993).

Selection criteria	299-W12-1	299-W11-10	299-W14-10	299-W22-41	699-38-70	699-35-70	699-37-82A
Existing well	X	X	X	X	X	X	X
Screened at top of aquifer	X	X	X	X	X	X	X
Near U-1/ U-2 Crib			X	X	X	X	
Confirms conductivity				X			X
Fills data gap	X	X	X		X	X	X
Eastern side of 200 West Area	X	X	X		X	X	
Defines high conductivity area			X				X
Multiple wells				X			X

Alternate test wells were picked for the constant rate discharge tests: 299-W11-10 and 299-W12-1, because of conditions at 699-82A and 299-W22-41 as noted above. Observation wells were not available at these alternate test sites. Wells 299-W11-10 and 299-W12-1 were selected for the pumping tests based on the criteria listed in Table 1 (taken from Swanson 1993). In general, the wells were located in areas where additional aquifer properties are needed for refinement of the 200 West Area hydrogeologic model. The low hydraulic conductivities, determined from the slug test results, simplified the handling of purgewater. All purgewater in the 200 West Area must be contained, which is problematic in highly transmissive formations where large volumes are removed over short periods of time.

3.0 DATA ANALYSIS AND RESULTS

This section describes the analyses that were performed and the aquifer test results for the seven slug tests and two single-well pumping tests. Table 2 summarizes the calculated hydraulic properties and other relevant test information. Analysis plots are attached in Appendix A. The raw test data were released in a separate supporting document (Swanson 1994).

Table 2. Summary of Test Results for the Single-Well Slug Tests.

Well[a]	Test date	Rod volume (ft^3)	Hydraulic conductivity (ft/d)	Comments
W11-10	8/16/93	0.194	6	Double slope[b]
W12-1	8/12/93	0.194	21	Double slope[b]
W19-4	10/25/93	0.396	20	--
W22-41	8/11/93	0.194	14	--
35-70	8/10/93	0.194	175	--
37-82A	8/19/93	0.760	190	Graph concave downward
38-70	8/10/93	0.194	435	--

[a] Well names with a "W" have a 299- prefix; all others have a 699- prefix.
[b] See text for a description of this phenomenon.

3.1 ANALYSIS METHODS

The single-well slug test data were analyzed using the Bouwer and Rice method (1976, 1989) and, in one instance, the Cooper et al. method (1967) (for comparison only). The computer software package ISOAQX (a trademark of HydraLogic, Missoula, Montana) was used for part of the data analysis.

The pumping test data were evaluated using semi-log data plots. As seen in Figures 2 and 3, there was considerable scattering of the data toward the end of the test. The reason for the data scatter was a malfunctioning generator that fed inconsistent electrical energy to the submersible pump, which produced a variable discharge rate. The quality of the data was such that it was unreasonable to calculate a hydraulic conductivity.

3.2 ANALYSIS RESULTS

Hydraulic conductivities calculated from the slug test data ranged from 6 ft/d to 435 ft/d (Table 2). Typical slug test analysis plots are shown in Figures 4 and 5. The withdrawal portion of the slug tests produced more consistent data and for this reason was used to estimate the hydraulic conductivity (instead of the slug injection data). Slug injection data are usually less consistent because of the "splashing" effect accompanying injection of the slug rod, and so these data are not reported.

Some of the slug test data show the "double-curve" phenomenon discussed by Bouwer (1989) for filter-packed wells (Figure 6). Interestingly, this phenomenon was not observed in the 4-in. filter-packed well (299-W22-41) but was observed in the 8-in. wells, 299-W11-10 and 299-W12-1. It is presumed that the double slope is produced by a finite amount of water stored in the annular space outside of the well casing. The true formational response

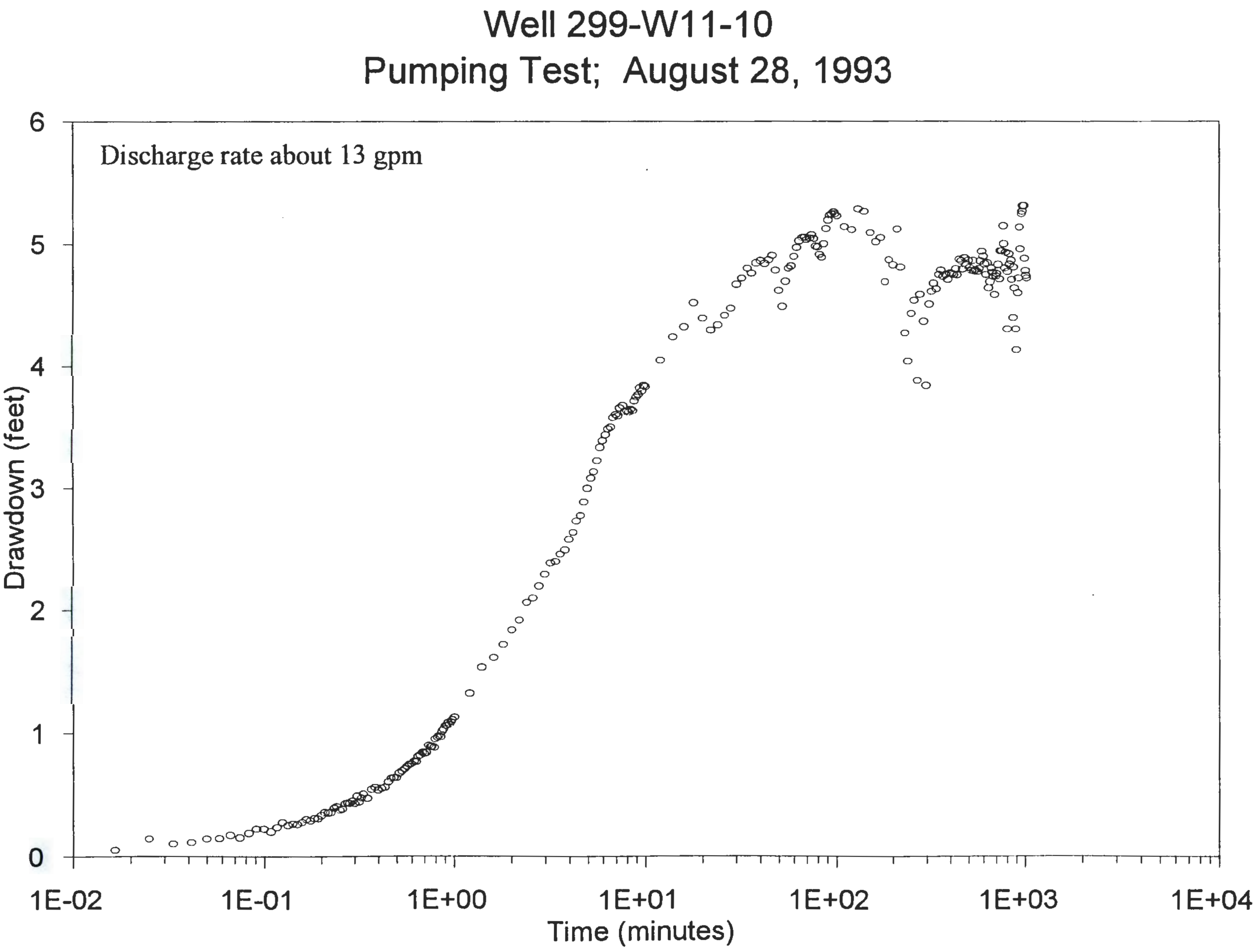

Figure 2. Pumping Test Data for Well 299-W11-10.

Well 299-W12-1
Pumping Test; August 30, 1993

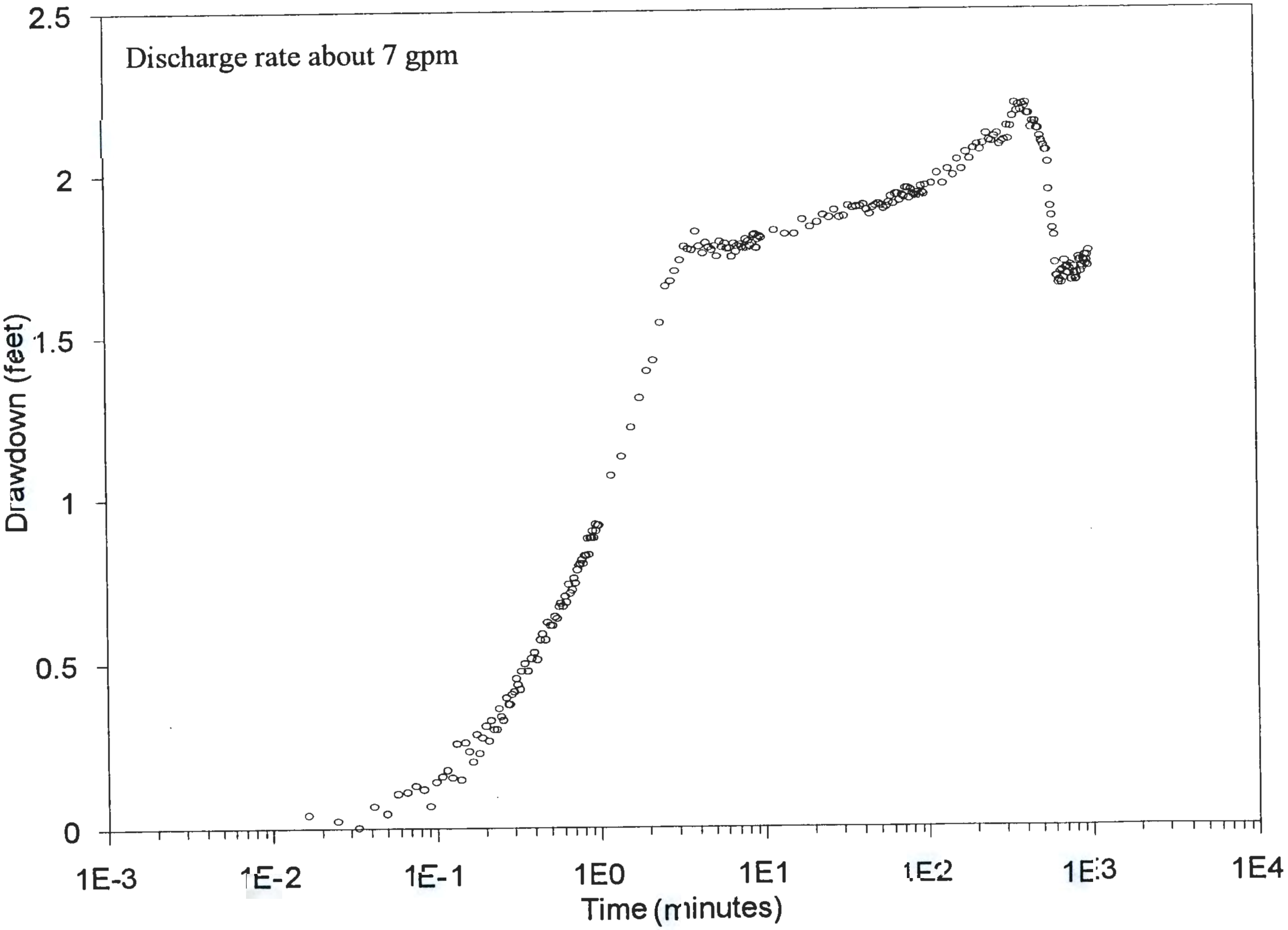

Figure 3. Pumping Test Data for Well 299-W12-1.

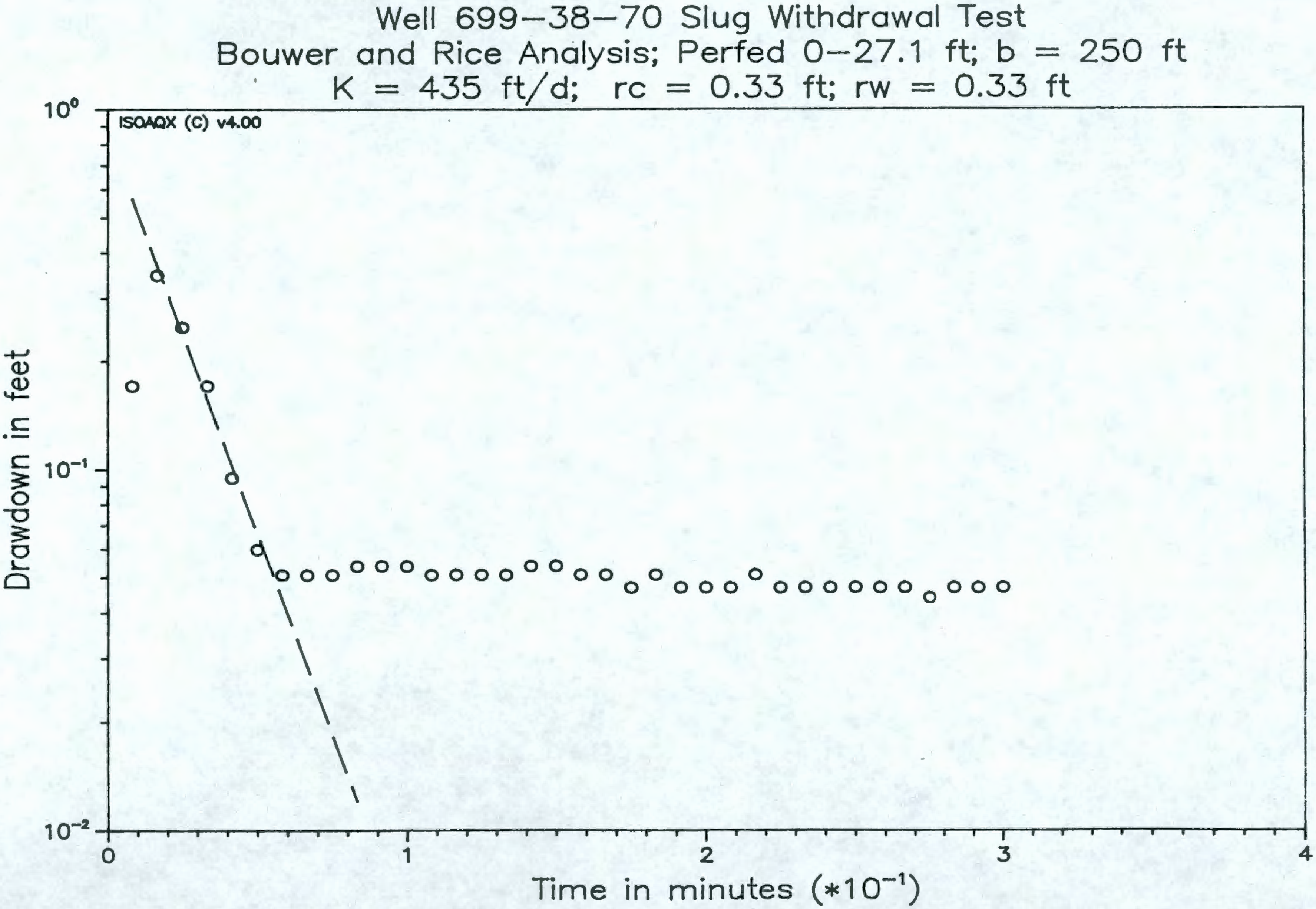

Figure 4. Slug Test Analysis for Well 699-38-70.

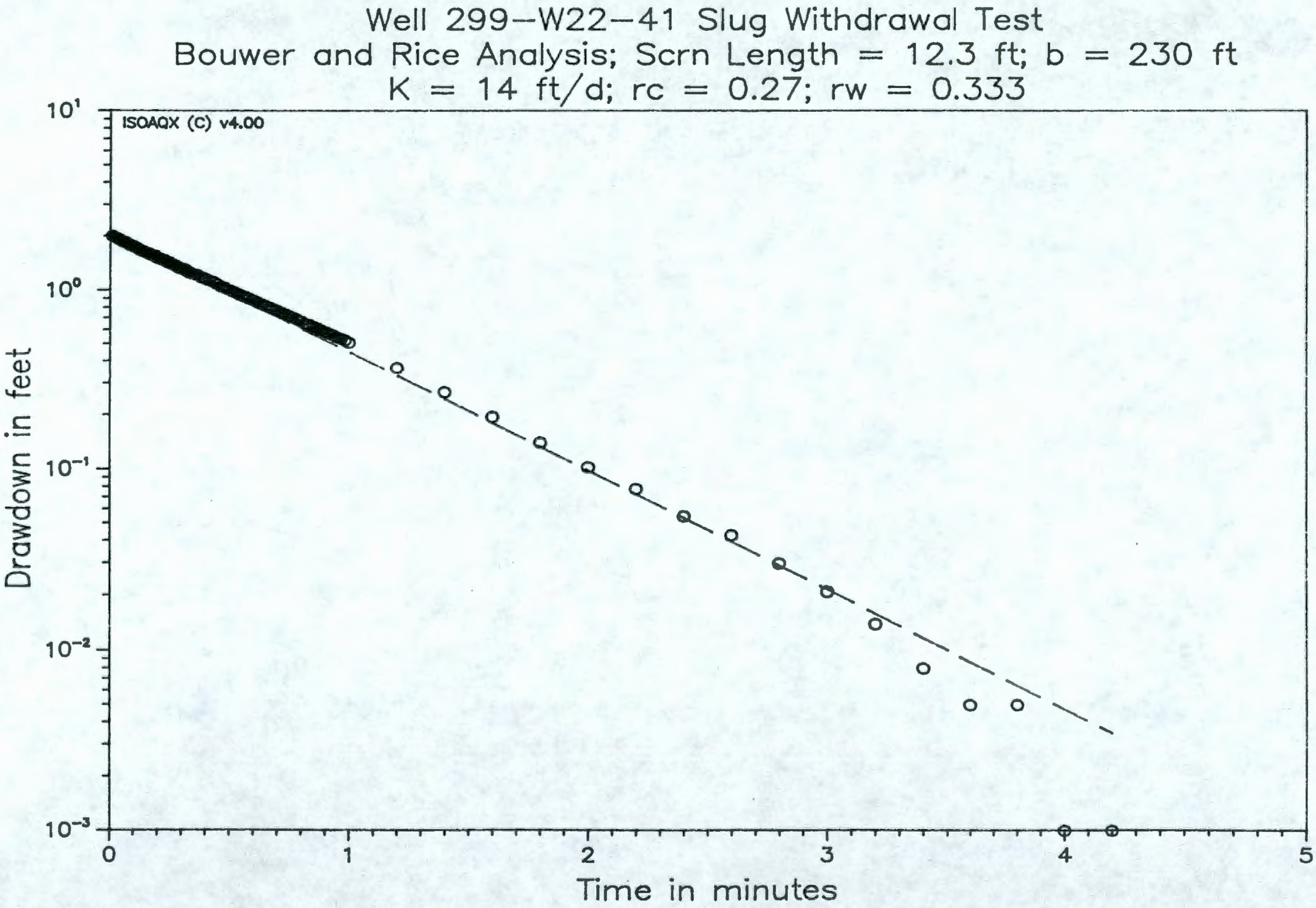

Figure 5. Slug Test Analysis for Well 299-W22-41.

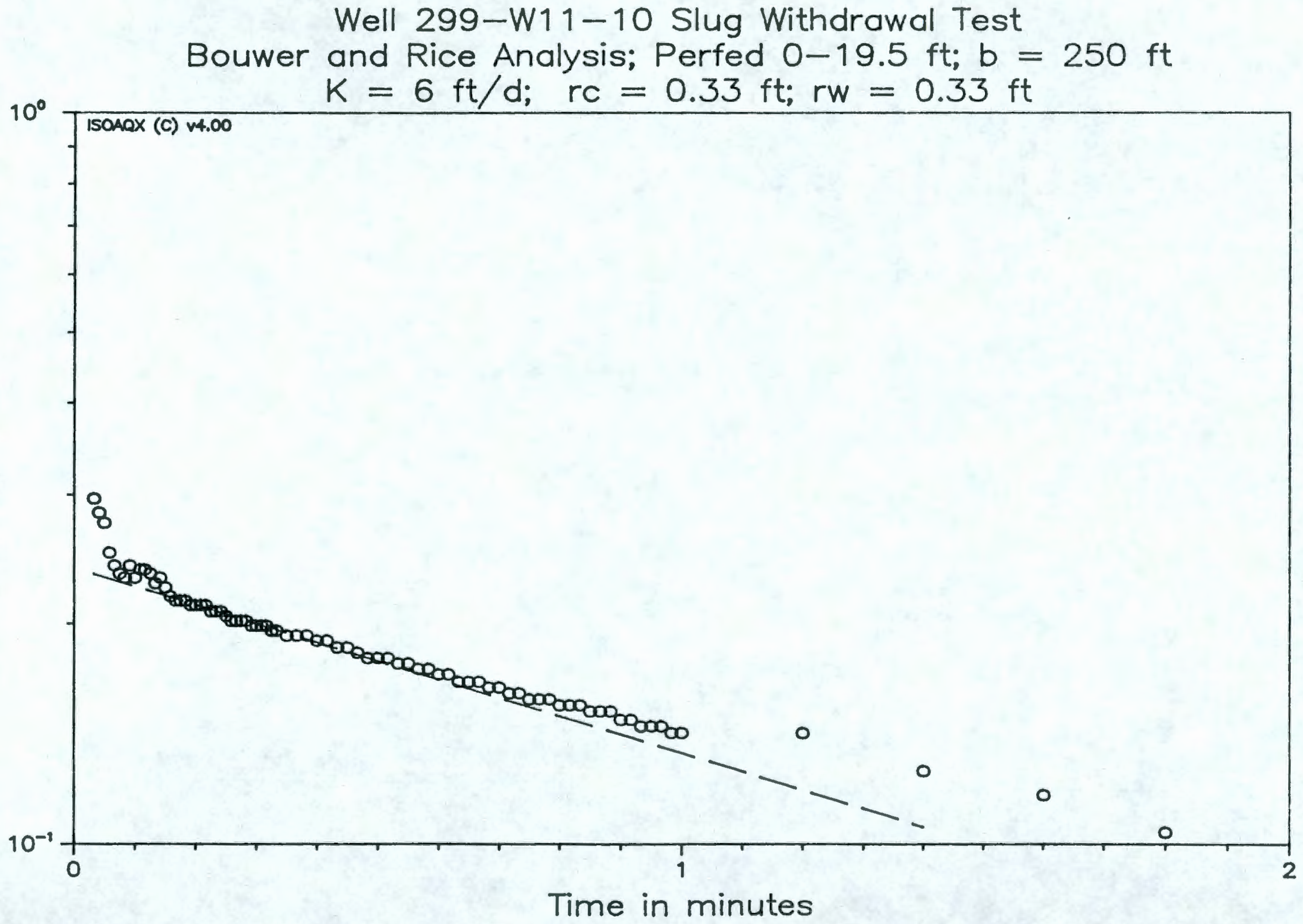

Figure 6. Slug Test Analysis for Well 299-W11-10.

becomes dominant after depletion of this annular storage reservoir. This double-slope phenomenon appeared in wells with low hydraulic conductivities, and may be more significant under these conditions.

The slug test data at well 699-37-82A are unusual, because of the non-typical concave shape (generally the data are convex in form with an early-time straight-line section). This response may be related to the significant amount of mud present in the bottom of the well, which could have caused plugging. The slugging rod was not fully submerged during the test since there was only 5 ft of water in the well.

Both the Bouwer and Rice (1976) and the Cooper et al. (1967) analysis methods were used for estimating aquifer parameters at well 299-W19-4 (Figures 7 and 8). If the transmissivity (535 to 665 ft^2/d) calculated using the Cooper method is divided by the test interval of 20.5 ft (perforated screen length), the resultant hydraulic conductivity range (26 to 32 ft/d) is close to the hydraulic conductivity of 20 ft/d estimated using the Bouwer method. The Cooper method was developed specifically for confined aquifers but, as demonstrated here, can produce reasonable results under water table conditions.

A very high hydraulic conductivity (435 ft/d) was calculated for well 299-38-70. During the withdrawal portion of the slug test, the water level recovered to static levels in less than 3.5 seconds (Figure 4).

3.2.1 Correction to Well Radius

The input parameters for the analyses are listed on each analysis plot. Slightly more detailed computations were needed to estimate the effective radius of the well casing for the 4-in. filter-packed well (299-W22-41). When the rise of the water level during a slug test is in the screened section of a filter-packed well, Bouwer (1989) recommends correcting the casing radius term. The corrected casing radius can be calculated from the equation:

$$r_{ce} = [(1-n)r_c^2 + nr_w^2]^{1/2}$$

where

r_{ce} = effective casing radius (corrected r_c)
r_c = inside casing diameter (well screen)
r_w = borehole radius, and
n = filter sand porosity.

This correction accounts for the thickness and porosity of the filter pack. The effective casing radius was calculated as 0.27 ft for a standard 20-40 mesh filter pack material with a porosity of about 40%.

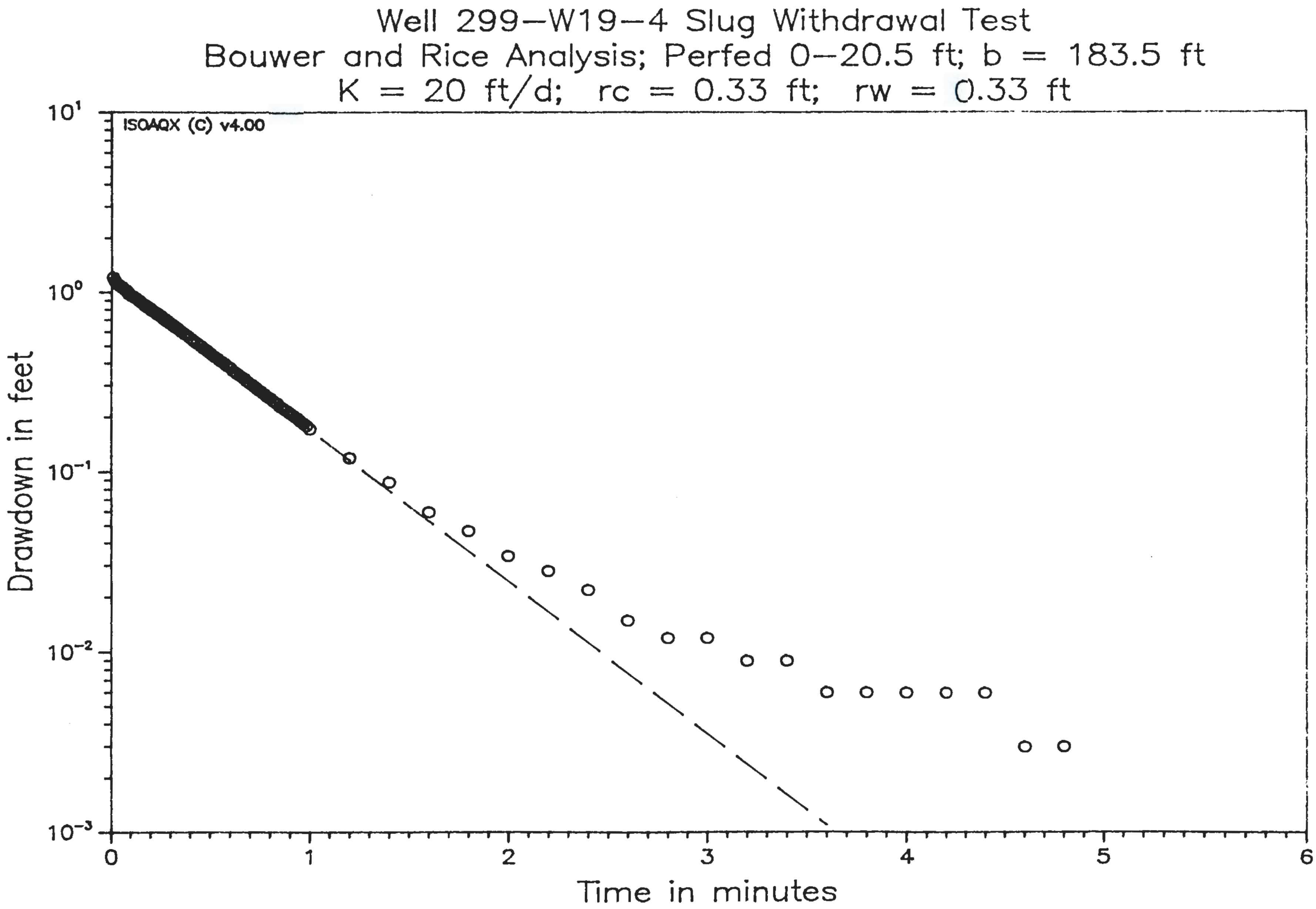

Figure 7. Slug Test Analysis for Well 299-W19-4, Bouwer and Rice Analysis Method (1976).

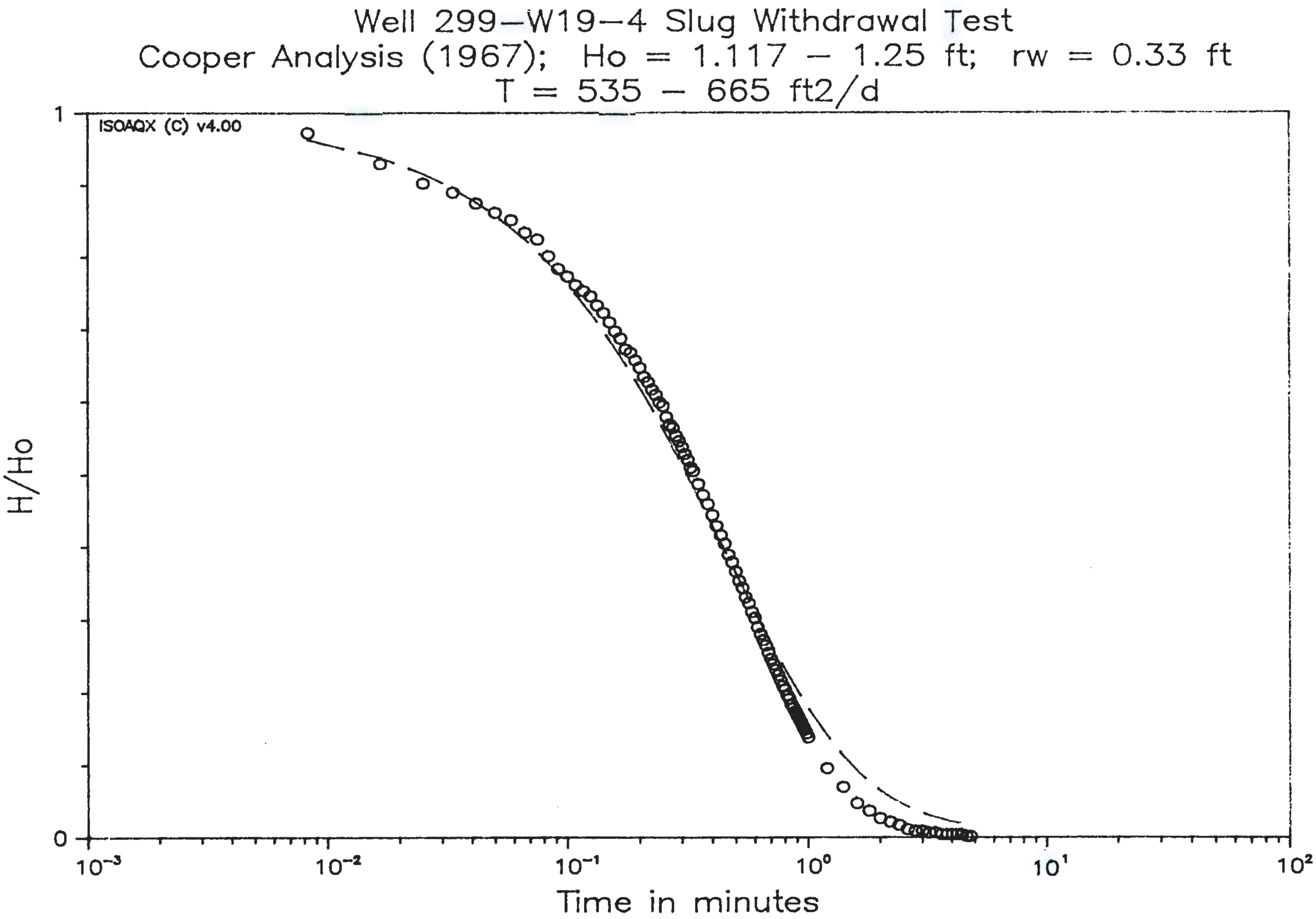

Figure 8. Slug Test Analysis for Well 299-W19-4, Cooper et al. Analysis Method (1976).

3.3 SLUG TEST LIMITATIONS

Hydraulic properties calculated from the single-well slug tests should be used cautiously because of certain inherent limitations related to the testing method. Slug tests stress a relatively small portion of the aquifer immediately around the borehole. Consequently, the test results may be influenced by local formational heterogeneities, borehole skin effects created by drilling operations, incomplete well development, and filter pack effects (well 299-W22-41 was the only well with a filter pack).

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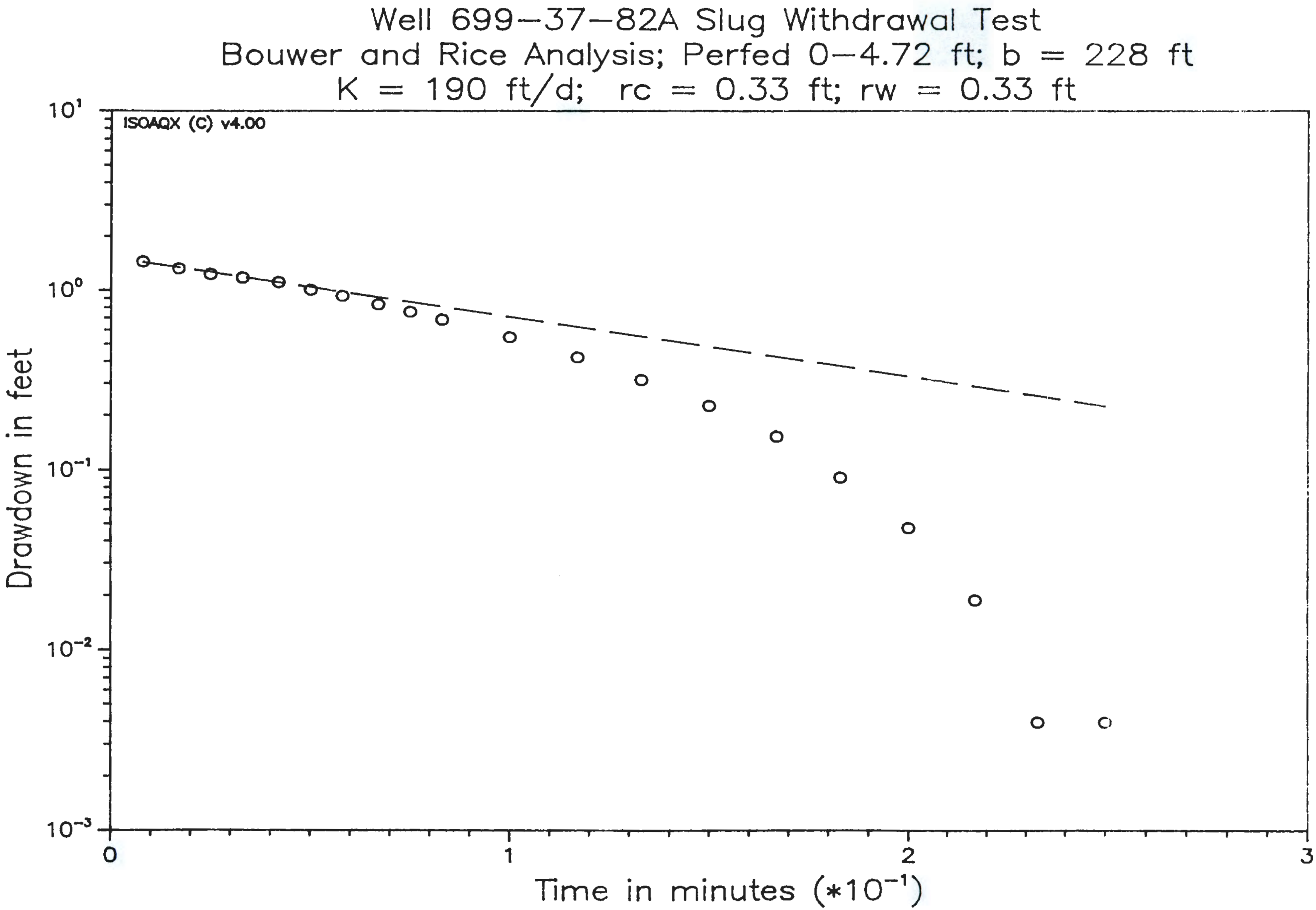
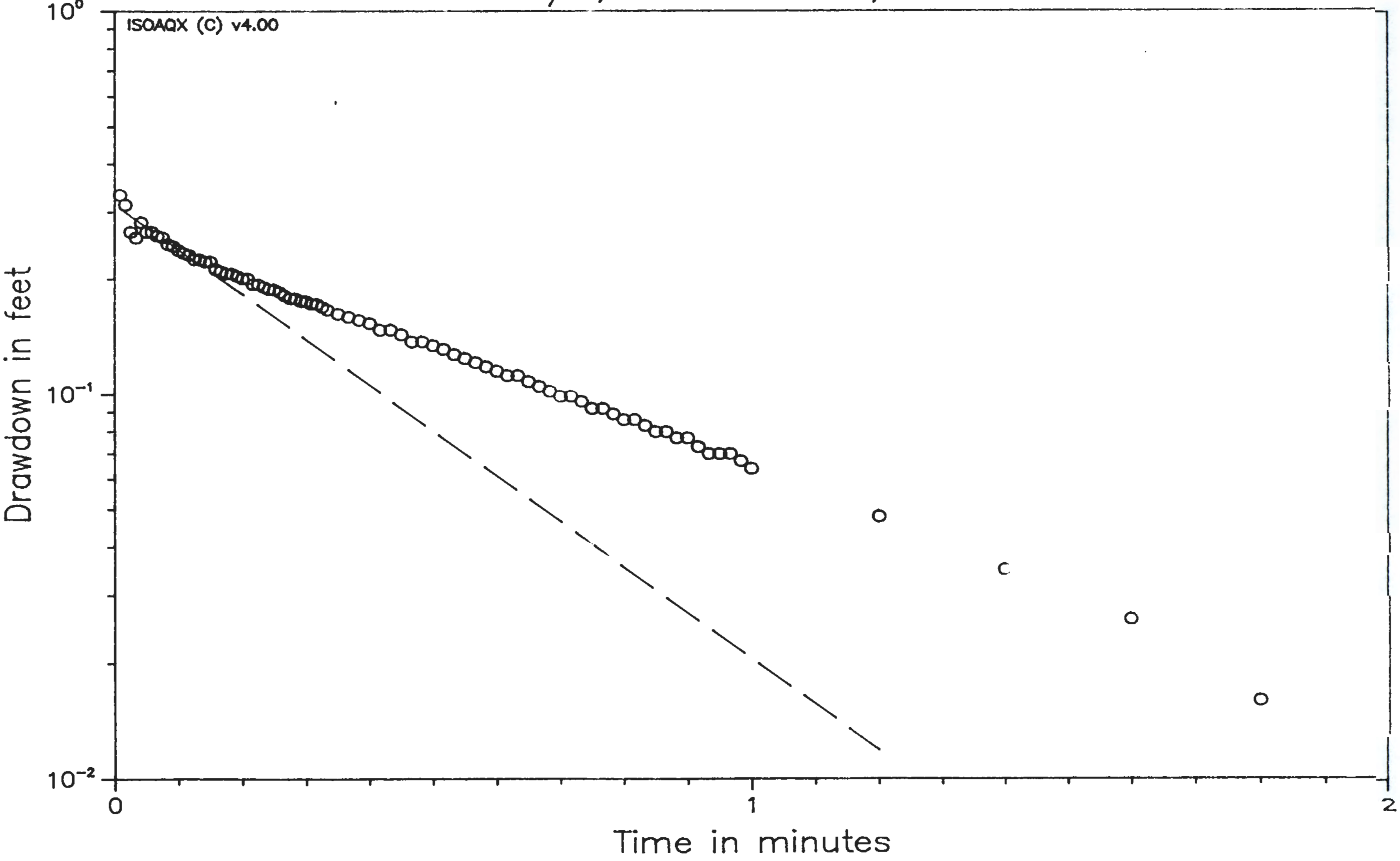
APPENDIX A

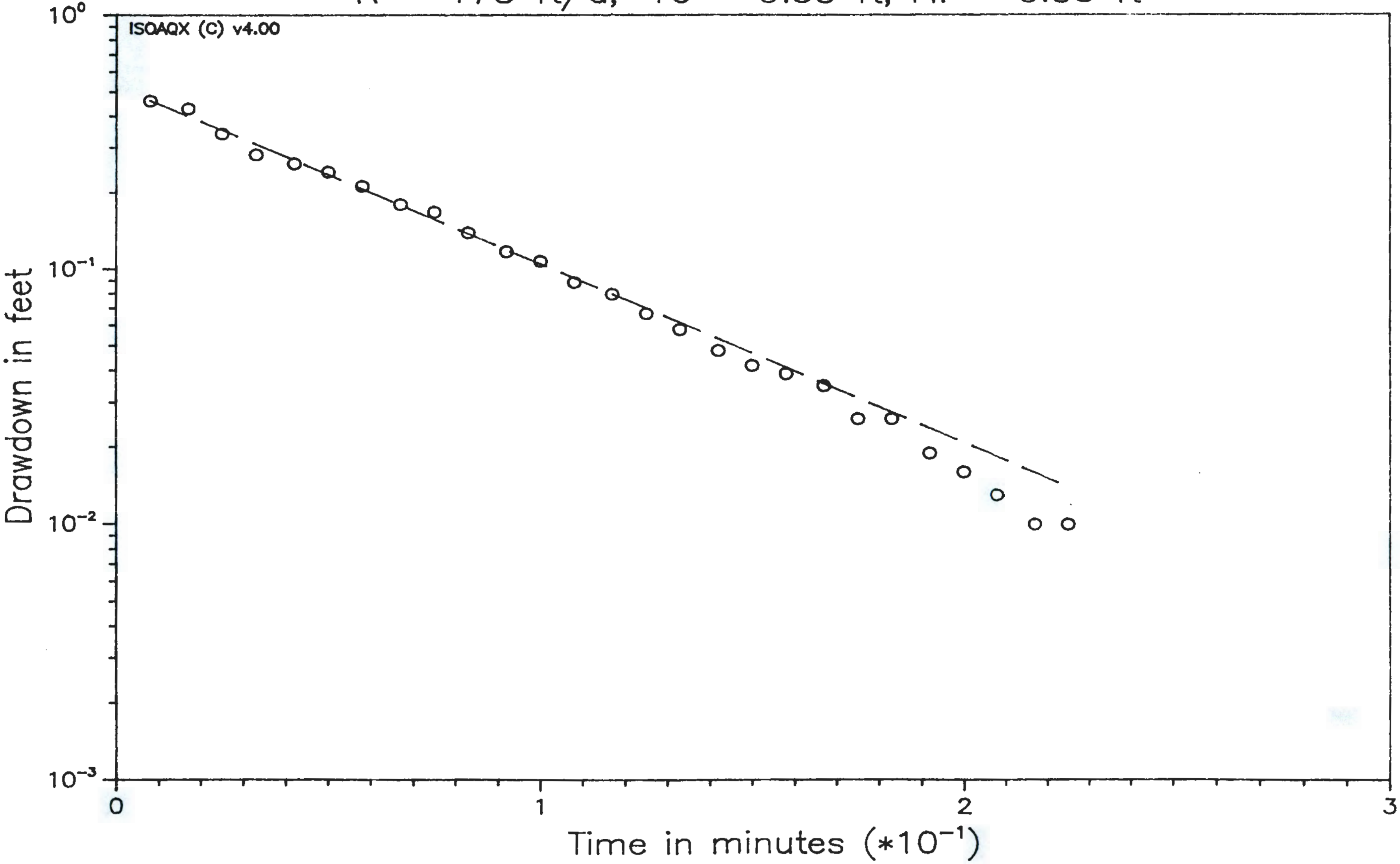
SLUG TEST ANALYSIS PLOTS


Well 699-37-82A Slug Withdrawal Test
Bouwer and Rice Analysis; Perfed 0-4.72 ft; b = 228 ft
K = 190 ft/d; rc = 0.33 ft; rw = 0.33 ft
ISOAQX (C) v4.00
Drawdown in feet
10^1
10^0
10^-1
10^-2
10^-3
0
1
2
3
Time in minutes (*10^-1)

Well 299-W12-1 Slug Withdrawal Test
Bouwer and Rice Analysis; Perfed 0-29.3 ft; b = 250 ft
K = 22 ft/d; rc = 0.33 ft; rw = 0.33 ft



Well 699-35-70 Slug Withdrawal Test
Bouwer and Rice Analysis; Perfed 0-18.9 ft; b = 250 ft
K = 175 ft/d; rc = 0.33 ft; rw = 0.33 ft



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