

Memo

To: File

From: Mat Weaver *MW*

Date: January 17, 2012

RE: Review of the recommended diversion rate from the Beneficial Use Field Exam for the City of Nampa's municipal RAFN WR Permit 63-33022 dated November 26, 2010.

The Department received a beneficial use field exam report for reasonably anticipated future needs (RAFN) water right permit 63-33022 on December 3, 2010, *less than 14 months* after the permit was issued. Idaho Code §42-217 (4) indicates that for RAFN permits a revised estimate of the RAFN, a revised description of the service area, and a revised planning horizon, together with appropriate supporting documentation shall be provided with the proof of beneficial use for review. Submitted with the proof of beneficial use was the field exam report, including a revised 'gap' analysis, a copy of the RAFN analysis submitted at permitting, a revised service area exhibit map, and a revised portfolio of the existing water rights and permits intended to serve the City's integrated potable water supply system. The RAFN analysis was *not* updated to reflect a revised population forecast, a revised RAFN demand, or a revised planning horizon, so I have assumed that they did not change in the limited time that elapsed since permitting.

The beneficial use field examination report (report) does not include discussion identifying the installed capacity of well #16 (POD for the permit). Nor does the report include sufficient material (i.e. measurements or pump curves) or information (i.e. pump column diameter, system pressure, or impeller diameter) to determine the installed capacity of the well. The report does acknowledge that the current installed capacity does not provide for the report's recommended diversion rate of 4.50 cubic feet per second (CFS), which when combined with 4.00 CFS of diversion rate associated with existing water right (WR) 63-12543 will provide a combined diversion rate of 8.50 cfs from the same well. My estimation of pumping capacity, which used what information was provided in the report and pump curves obtained from the manufacturer,¹ indicates a diversion rate of approximately 3.12 CFS as currently configured. Refer to the attached technical evaluation of current pumping capacity including pump curves and spreadsheet calculations. A flow rate of 3.12 CFS is not even enough to support the existing water right licensed for this well (63-12453), indicating that beneficial use under the current permit had not occurred by the time the field exam was conducted.

The report correctly points out that the standard for RAFN municipal WRs is not necessarily installed capacity. Rather the standard is reasonably anticipated future needs with some showing of physical commitment to the future RAFN condition.² The following is an excerpt from the field exam report.

¹ Curve number E6614RCPC0 that characterizes the performance of 250 hp, 5 stages, Goulds Submersible Pump, model number 14RJHC, with an assumed impeller diameter of 8.75 inches.

² The appropriate criteria for determining whether "the full capacity of the system [has been] constructed or used in accordance with the original permit" are the degree to which the full capacity of the system has been constructed and the consistency of the constructed capacity with a definitive plan for fully constructing the system, both of which can only be evaluated on a case by case basis. (AP Memo #63 June 15, 1999)

Under the Administrative Memo #63 guidance, the “capacity of the system” diversion rate is not necessarily limited to the physically constructed system if there is tangible evidence of the applicant’s commitment to complete the diversion and delivery system and divert the water to beneficial use during the planning horizon. In this case, the tangible evidence of the City’s commitment to complete the diversion is the fact that the well has been constructed with a capacity of 8.5 CFS.

Although I agree with the sentiments of the above excerpt, I am not convinced that it has been adequately shown that the well, as constructed assuming some future modified pumping configuration, can support a future diversion rate of 8.5 CFS. My first concern is that a diversion rate of 8.5 CFS was never reached during the step-drawdown test performed on the well and included with the report. The maximum achieved pumping rate was approximately 7.98 CFS. Furthermore, at the maximum pumping rate achieved during the step-drawdown test, it is not altogether obvious that stabilization of drawdown ever occurred. The maximum pumping rate from the test lasted for approximately 90 minutes and there is a significant negative slope across much, if not all, of that time period. It might be argued that at the very end of the pump test, drawdown stabilizes, but if so, that claim would be based on approximately 10 minutes of a 410 minute pump test and from the graph presented that conclusion is not starkly clear. Refer to my attached copy of the step-drawdown test results with handwritten notes. At best I think we can safely assume that the well was constructed to support a higher diversion rate than the current pumping configuration achieves (~3.12 CFS). However, from the evidence provided, it is hard to determine with any certainty what the higher future diversion rate may be.

I have identified several licensing options before the Department. We could accept the field exam at face value and assume the well can achieve a future diversion capacity of 8.5 CFS, and license the permit for the full permitted amount of 4.5 CFS. A slightly more conservative interpretation would be to limit the diversion rate to the maximum diversion capacity physically achieved during the step-drawdown test, regardless of the lack of evidence for drawdown stabilization. This would result in a licensed diversion rate of 3.98 CFS (7.98 CFS – 4.00 CFS). A third option, and the most conservative, would be to limit the diversion rate to the rate sustained over a separate 24 hour constant-rate pump test conducted for DEQ as part of the ‘Well Completion Report’ (WCR) as required in accordance with the Idaho Rules of Public Drinking Water Systems (IDAPA 58.01.08 Section 510.05 and 510.06).³ The WCR verifies a diversion rate of 6.72 CFS (3,015 gallons per minute) was sustained for 24 hours during the constant-rate pump test summarized in the report. Recognizing a maximum diversion rate of 6.72 cfs would lead to a licensed diversion rate of 2.72 CFS (6.72 CFS – 4.00 CFS).

³ ‘Report, City of Nampa Well 16 Drilling Construction, and Test Report and Predesign Report for an Ammonia, Hydrogen, Sulfide, and Manganese Removal System for Well 16’ prepared for DEQ by CH2MHill as signed and sealed by Kevin Boggs on April 6, 2008. It should be noted that the WCR does not make any recommendations for the design, as-constructed or maximum delivery capacity of the well.

[Read Me](#)

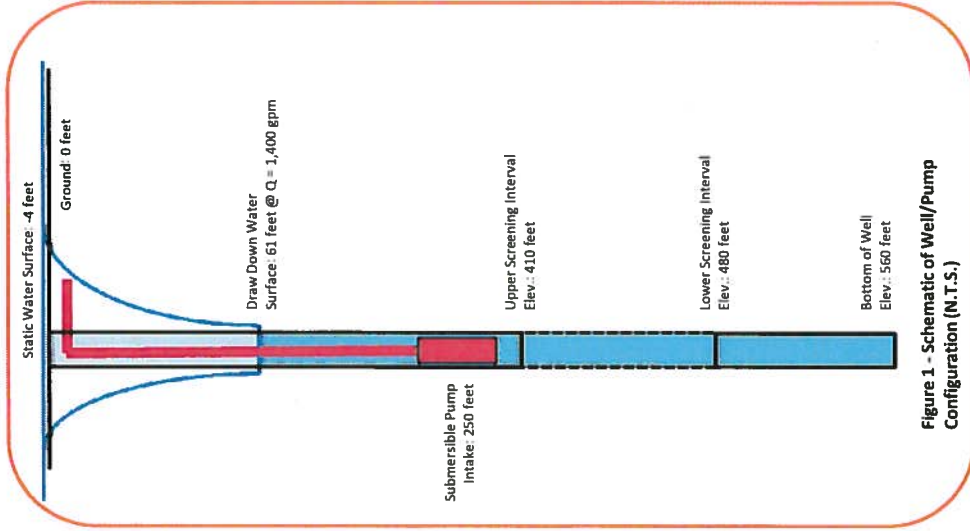


Figure 1 - Schematic of Well/Pump Configuration (N.T.S.)

Relevant Well Completion Elevations

Grade:	0.0	feet (ground surface elevation)
SWE:	-4.6	feet (static water surface elevation)
DDE:	56.1	feet (draw down water surface elevation)
USE:	410.0	feet (upper screening interval elevation)
LSE:	480.0	feet (lower screening interval elevation)
PIE:	250.0	feet (pump intake elevation)
BoW:	560.0	feet (bottom of well)

Specific Capacity (Sc = Q/D) Data from CHM2Hill Step-Drawdown Test

Q =	4026.0	gpm (pumping rate)
D =	175.3	feet (draw down)
Sc =	23.0	gpm/ft

Total Dynamic Head Calculation

Vertical Head:	56.1	feet
Pressure Head:	40.0	psi
	92.4	feet
Friction Head:	8.50	feet
Velocity Head:	0.0	feet (assumed to be zero)
Minor Losses:	0.0	feet (assumed to be zero)
TDH:	157.04	feet

Summary of Pump Operating Condition

Goulds 250 hp Turbine Submersible Pump
14RJHC (5 stages)
Impeller Diam. 8.75 inches (assumed)
Pump Line = 8 inch diameter (assumed)
TDH = 157.0 feet
From Pump Curves Q = ~1,400 gpm (i.e. 3.12 cfs)

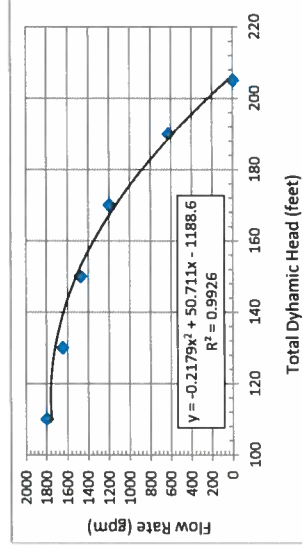
Notes/Comments

With an assumed impeller diameter (middle value) and pump line diameter the pumping capacity of the pump and well as currently configured appears to be approximately 3.12 cfs.

Pump Performance Curve Summary Table

Flow GPM	Speed rpm	H/Stage feet	H feet	Pump % eff	Power bhp	NPSHr ft
0	--	41	205	--	--	--
625	--	38	190	--	--	--
1200	--	34	170	--	--	--
1475	--	30	150	--	--	--
1650	--	26	130	--	--	--
1800	--	22	110	--	--	--

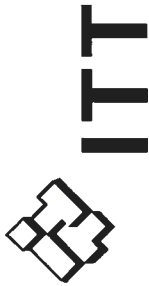
*Flow and TDH values interpolated from pump performance curve E3042-2



TDH, x = 157.04 feet
Q, y = 1401.30 gpm

Summary of Iterative Calculations

Iterations	DD (ft)	TDH (ft)	Q (gpm)	% Δ
#1	60.96	157.04	1401.30	0.1%
#2	61.02	157.39	1395.07	0.4%
#3	60.74	157.04	1401.30	0.4%
#4	61.02			100.0%
#5	0.0			
#6	0.0			
#7	0.0			
#8	0.0			
#9	0.0			



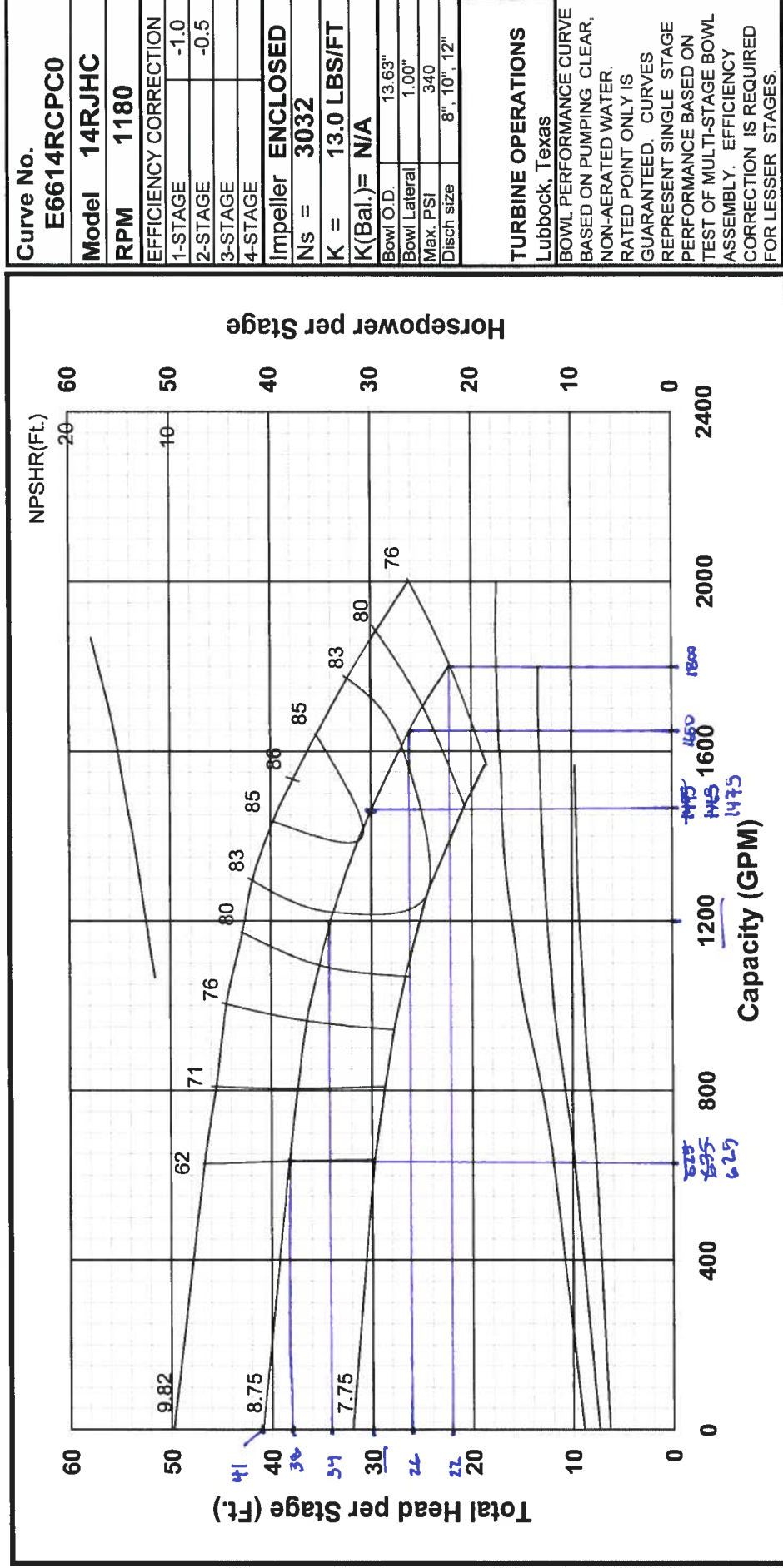
Turbine

Goulds Pumps

Model 14RJHC

(Effective June 1, 2006)

GOULDS PROPOSAL NO.	GOULDS S.O. NO.	INQUIRY NO.	CUSTOMER P.O. NO.	P.O. DATE	ITEM NO.	CUSTOMER
PROJECT			SERVICE	GPM CAPACITY		FT. TDH
					% EFFICIENCY	RPM



Goulds Pumps is a brand of ITT Corporation.

www.goulds.com



Engineered for life

APPROXIMATE
WELL
ACQUIRED
Q₁₀ = 7.98 cfs

City of Nampa
Well 16 Step Test 03/10/2008

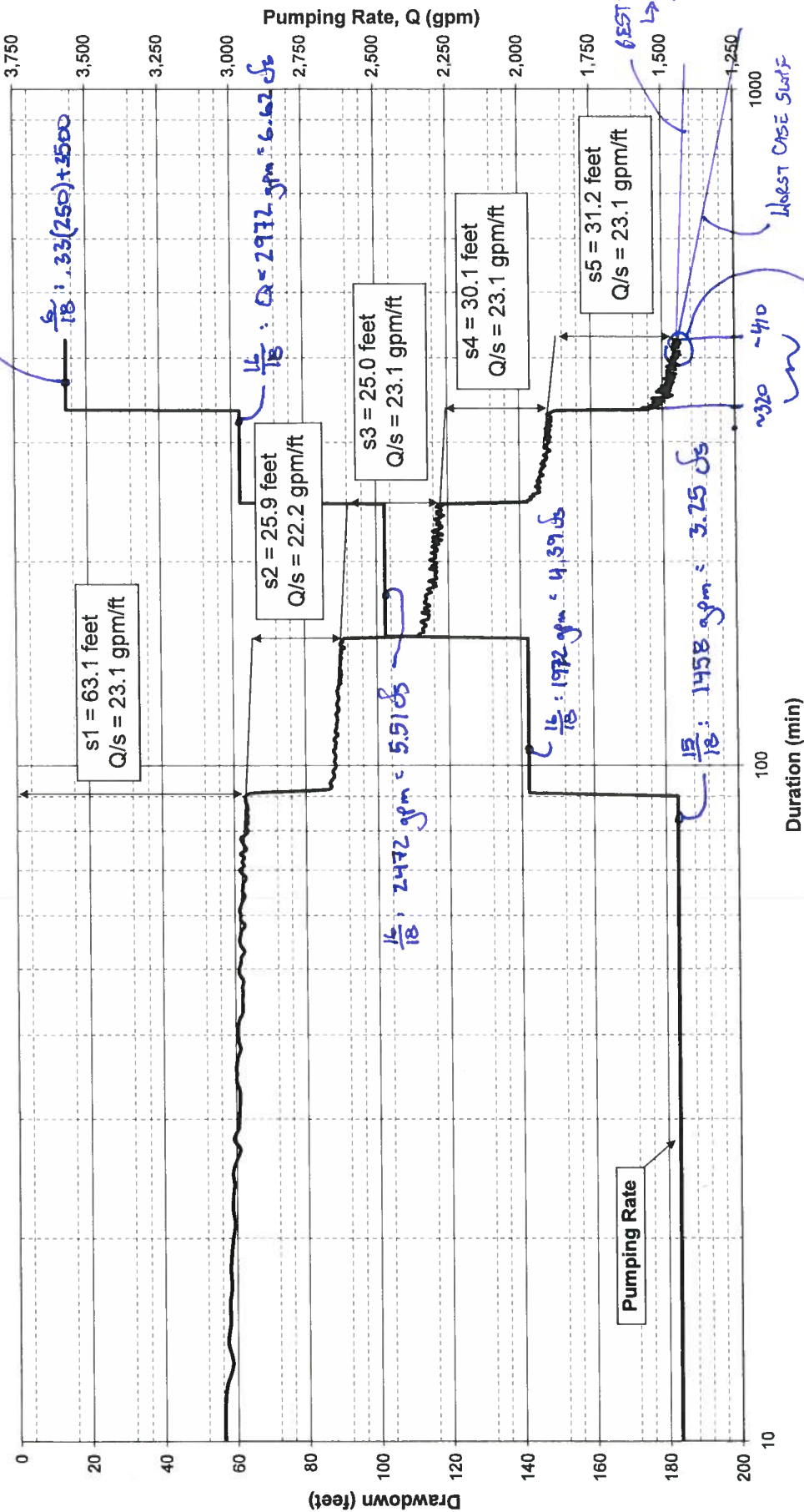


Figure 4-2
Well 16 Drilling Construction and Testing
City of Nampa

Well Report

APPROVED
By: Michael Lee May
IDAHO DEQ
Boise Regional Office
Date: June 6, 2008

Report

**City of Nampa Well 16
Drilling, Construction, and Testing Report
and
Predesign Report for an Ammonia, Hydrogen
Sulfide, and Manganese Removal System for
Well 16**

E.R. APPROVED
By: Michael Lee May
IDAHO DEQ
Boise Regional Office
Date: June 9, 2008

Prepared for

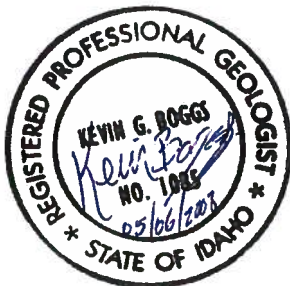


City of Nampa, Idaho

Prepared by



322 East Front Street
Suite 200
Boise, Idaho 83702



May 2008

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Acronyms and Abbreviations

bgs	below ground surface
ft	feet
gpd	gallons per day
gpm	gallons per minute
IDWR	Idaho Department of Water Resources
µg/L	micrograms per liter
mg/L	milligrams per liter
MCL	maximum contaminant level
MTI	Materials Testing Incorporated
psi	pound per square inch
Riverside	Riverside Incorporated
S	Storativity
SP	spontaneous potential

4.0 Aquifer Testing

Aquifer testing of Well 16 consisted of a 7.5-hour step-rate discharge test and a 24-hour constant-rate discharge test. The step-rate test was performed to assess the discharge capacity of the well and well efficiency. The constant-rate test was performed to evaluate the transmissivity and storativity of the aquifer, and to screen for any hydrogeologic boundary conditions which could impact future operation of the well.

Water levels were continuously measured in the pumping well (Well 16) and periodically in the existing City production well on site (Well 13) (Figure 1-2). The water levels were measured using an electronic water level indicator in combination with a downhole electronic pressure transducer connected to a data logger in Well 16. The pressure transducer used in Well 16 was vented, and had an operating range of up to 100-pounds per square inch (psi). The data logger/transducer system was manufactured by In-Situ, Incorporated. The discharge was monitored using an in-line flow meter/totalizer.

A water level hydrograph for the pumping well over the course of the step-rate and constant-rate discharge tests and the recovery period is provided (Figure 4-1).

4.1 Background Water Level Fluctuations

Water level response to barometric pressure change is not evident from transducer data obtained from Well 16. If present, any water level response to barometric pressure is apparently minor (negligible). Therefore, barometric pressure is not shown on the hydrographs or other aquifer test analysis graphs in this section.

There is no evidence of pumping or other stresses to the aquifer in the area that could cause background water level fluctuations.

4.2 Step-Rate Discharge Test

A 7.5-hour step-rate discharge test was performed on March 10, 2008. The discharge rate was sequentially increased over five different rates, each lasting 90 minutes (1.5 hours): 1,460 gpm; 1,975 gpm; 2,470 gpm; 2,970 gpm; and 3,570 gpm. These rates represent average rates based on totalizer readings taken throughout each 90-minute step during the step-rate test. The pumping rate and water level drawdown are illustrated in Figure 4-2. The field data are provided in Appendix E.

The specific capacity of a well is not constant but decreases as pumping continues due to continually increasing drawdown in the aquifer. The specific capacity also decreases with increasing pumping rate due to increased hydraulic head loss in the well. The drawdown in a well can be defined as a function of aquifer and well head loss coefficients by the following equation (Jacob, 1947):

$$s = B(r_{ew}, t)Q + CQ^2 \quad [4-1]$$

where:

- s = Drawdown in the pumped well (feet)
- $B(r_{ew}, t) = B_{1(rw, t)} + B_2$
- $B_{1(rw, t)}$ = Linear aquifer-loss coefficient (feet/gpm²)
- B_2 = Linear well-loss coefficient (feet/gpm²)
- C = Non-linear well-loss coefficient (feet/gpm)
- r_{ew} = Effective radius of the well (feet)
- r_w = Actual radius of the well (feet)
- Q = Pumping rate (gpm)
- t = Time since pumping started (min)

The various linear head loss terms at the well were combined into a single term, r_{ew} , the effective radius of the well; defined as the distance measured radially from the axis of the well at which theoretical drawdown equals the drawdown just outside the well screen (Jacob, 1947). Because the storativity (S) of the aquifer must be known to determine the effective radius of the well (r_{ew}), and because research has determined that considerable variations in the flows inside and outside of wells exist, the following modification to equation 4-1 was proposed (Rorabaugh, 1953):

$$s = BQ + CQ^P \quad [4-2]$$

where P ranges from 1.5 to 3.5, depending on the flow rate of the well. Jacob's proposed value of P being equal to 2 is generally accepted.

The method of Hantush-Bierschenk (Hantush, 1964 and Bierschenk, 1963) can be used to determine B and C using equation [4-2]. Plotting s/Q versus Q on an arithmetic graph results in a straight line with the y-intercept representing B and the slope representing C . The Q , s , and calculated s/Q for use in the Hantush-Bierschenk analysis is tabulated in the table below, using a P value of 2 in equation [4-2]. Incremental drawdown per the pump rate versus the pump rate (s/Q versus Q) is plotted in Figure 4-3.

TABLE 4.1
Well 16 Efficiency
Well 16 Drilling, Construction, and Testing Report

Step	Incremental Drawdown [s] (feet)	Cumulative Drawdown [s] (feet)	Pump Rate [Q] (gpm)	s/Q (ft/gpm)	Well Efficiency [E] (percent)
1	63.1	63.1	1460	0.0432	90
2	25.9	89.0	1975	0.0451	87
3	25.0	114.0	2470	0.0462	84
4	30.1	144.2	2970	0.0485	81
5	31.2	175.3	3570	0.0491	79

From Figure 4-3, B is calculated to be 0.0392 ft/gpm and C is calculated to be 3.00×10^{-6} ft/gpm². Factors contributing to linear well-loss, B, include extra head loss due to any formation damage in the vicinity of the well bore (e.g., residual mud), head loss in the gravel pack, and head loss in the screen entrance. Factors contributing to non-linear well-loss, C, include head loss due to turbulent flow in the well.

The efficiency of a well, E, can be determined for various discharge rates once B and C are known using the following formula:

$$E = \frac{BQ}{BQ + CQ^2} \times 100$$

or, simplified,

$$E = \frac{1}{1 + \left(\frac{C}{B}\right)Q} \times 100 \quad [4-3]$$

The predicted drawdown (at 90 minutes), aquifer loss, and well efficiency as a function of discharge rate in Well 16 were calculated (Figure 4-4).

4.3 Constant-Rate Discharge Test

The constant-rate discharge test was performed on March 11 and 12, 2008 for a 24-hour period at an average discharge rate of 3,015 gpm. The water level and pumping rate data for Well 16 are provided in Appendix E.

Pumping Well

This section describes the procedure for calculating the aquifer transmissivity for Well 16 pumping (Figure 4-5) and recovery (Figure 4-6) data. Figure 4-5 is a semi-log plot of drawdown versus time in Well 16 during the constant rate discharge test. Figure 4-6 is a graph of residual drawdown versus time for Well 16 during the recovery period after the 24-hour constant rate discharge test. The specific capacity of the well was approximately 21 gpm/ft at 100 minutes, 19 gpm/ft at 500 minutes, and 18 gpm/ft at 1,000 minutes.

Drawdown during pumping was sensitive to slight variations in pumping rate, likely due to consistent motor frequency fluctuations (Figure 4-1). Although no correction was made for these flow rate variations, they were considered in analyzing the pumping data.

Transmissivity (T) can be calculated using the Cooper-Jacob method (Cooper and Jacob, 1946) for pumping drawdown data:

$$T = \frac{264Q}{\Delta s} \quad [4-4]$$

Where: T = Transmissivity (gallons/day/ft [gpd/ft])
Q = Pumping Rate (gallons per minute [gpm])

Δs = Water level drawdown (feet) per log cycle of time, t (min) since pumping started (from Figure 4-5).

The transmissivity is the product of the hydraulic conductivity (K) and the saturated thickness of the aquifer (b), where:

$$T = bK \quad [4-5]$$

The best-fit straight line shown in Figure 4-5 for the drawdown data from Well 16 results in a transmissivity of 36,981 gpd/ft (4,944 ft²/day) calculated using a pumping rate of 3,015 gpm and a drawdown of 21.5 feet/log cycle. Assuming a saturated aquifer thickness of 60 feet, the hydraulic conductivity of the aquifer is calculated to be about 82 feet per day.

Transmissivity can also be calculated using the Theis recovery method (Theis, 1935) for residual drawdown data during recovery:

$$T = \frac{264Q}{\Delta s'} \quad [4-6]$$

Where:

T	= Transmissivity (gallons/day/ft [gpd/ft])
Q	= Pumping rate (gallons per minute [gpm])
$\Delta s'$	= Residual drawdown per log cycle of t/t' from Figure 4-6 (dimensionless)

Where:

t	= time since pumping started
t'	= time since pumping stopped

The Theis recovery method has an advantage over the Cooper-Jacob drawdown method because the well is no longer subject to water level sensitivity from pumping variations. The best fit straight line shown in Figure 4-6 for the drawdown data results in a transmissivity of 38,739 gpd/ft (5,179 ft²/day) calculated using an average pumping rate of 3,015 gpm and a residual drawdown of 20.5 ft/log cycle. Assuming a saturated aquifer thickness of 60 ft, the calculated hydraulic conductivity is 86 ft per day.

The transmissivity calculated using the Cooper-Jacob drawdown method (4,944 ft²/day) agrees well with the transmissivity calculated using the Theis recovery method (5,179 gpd/ft).

City of Nampa Well 16 Hydrograph Well Discharge Testing

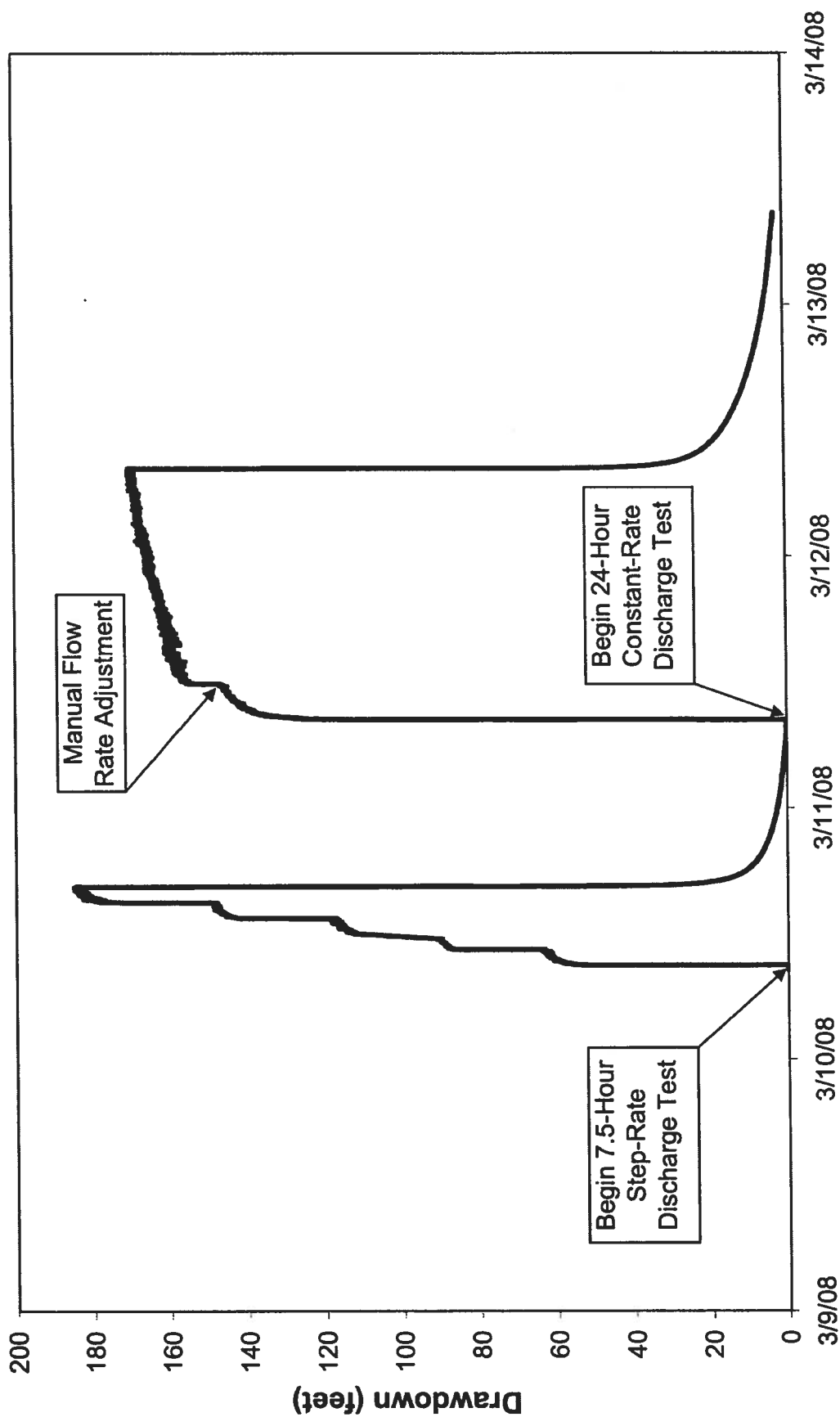
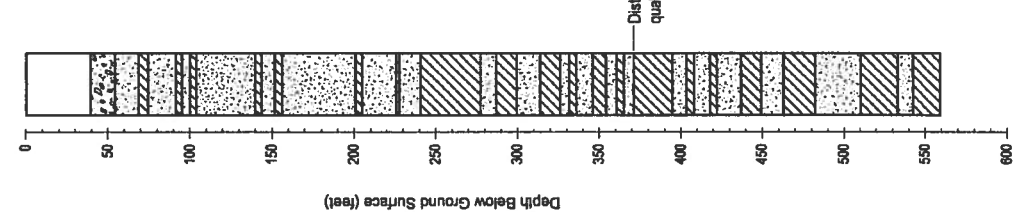
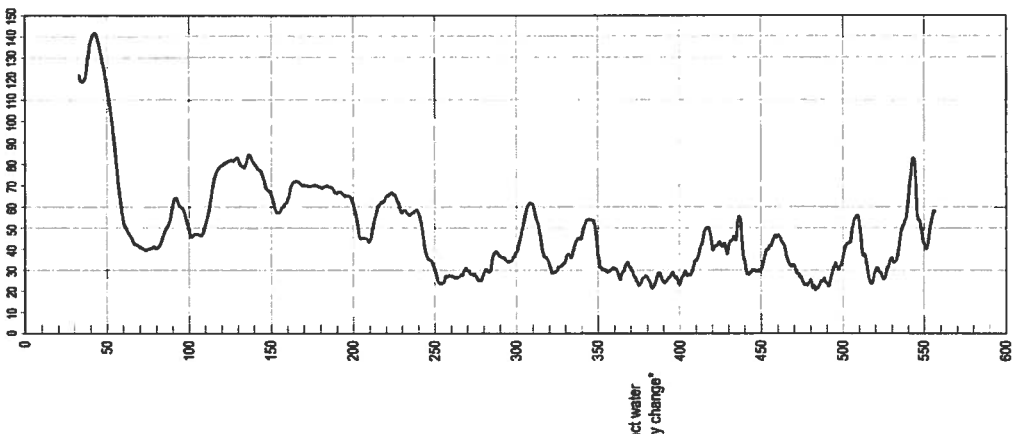


Figure 4-1
Well 16 Drilling, Construction, and Testing
City of Nampa

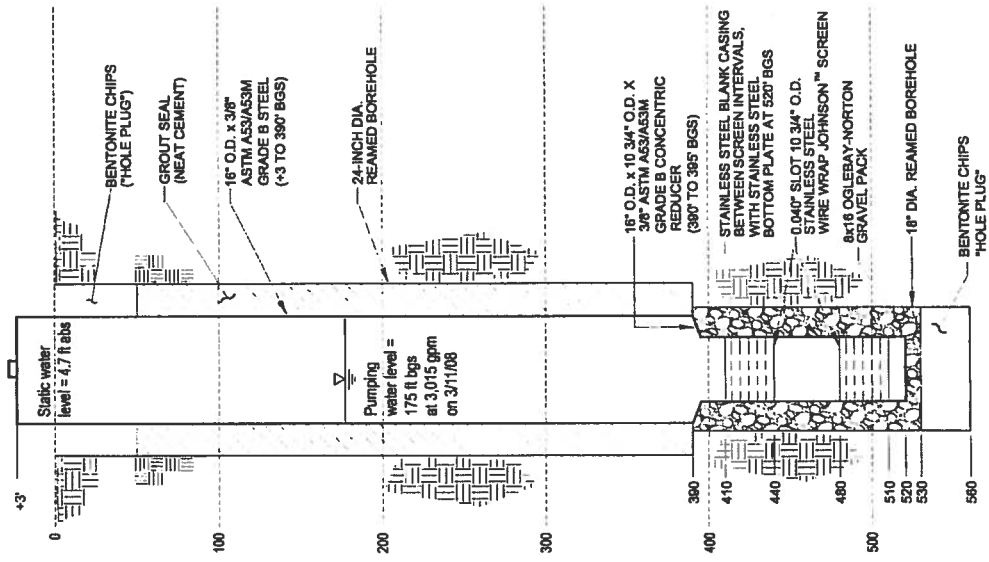
Generalized Lithologic Log



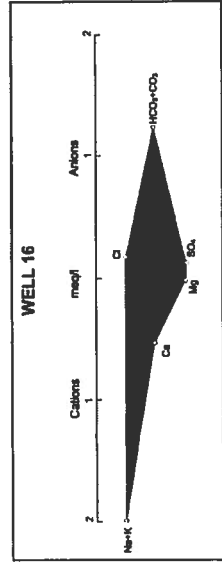
Electrical Resistivity Log (Guard)



As-Built Well



GEOCHEMISTRY DATA CONSTANT-RATE-AQUIFER TEST



WELL 16 PERFORMANCE

Final Flow Rate of Step-Rate Aquifer Test
 Q = 3,570 gpm
 s = 175.3 ft of drawdown
 Static water level = 4.7 ft abs
 Specific Capacity = 20.4 $\frac{\text{ft}}{\text{ft}^2}$

End of Constant Rate Aquifer Test
 Q = 3,015 gpm
 s = 170 ft of drawdown
 Static water level = 4.7 ft abs
 Specific Capacity = 17.7 $\frac{\text{ft}}{\text{ft}^2}$

AQUIFER PARAMETERS

Well ID	Status	Analytical Method	T (gpd/ft)	b (feet)	K (N/day)
Well 16	Pumping	Cooper-Jacob	38,981	60	82
	Recovery	Theis Recovery	38,738	60	86

Q = average pumping rate sustained during pump testing
 s = total drawdown during aquifer test
 T = transmissivity
 b = length from the water table to the bottom of the well screen
 K = hydraulic conductivity
 gpm = gallons per minute
 gpd/ft = gallons per day per foot
 ft/day = feet per day
 ft abs = feet above ground surface
 ft bgs = feet below ground surface

* Elevated concentrations of ammonia, iron, manganese, and hydrogen sulfide below approximately 380 ft bgs. There is an elevated concentration of uranium in shallow sediments (see report for details).

Figure 2-1
 Well 16 As-Built Well Construction Diagram,
 Generalized Lithologic Log, and Geochemistry Data

City of Nampa
Well 16 Step Test 03/10/2008

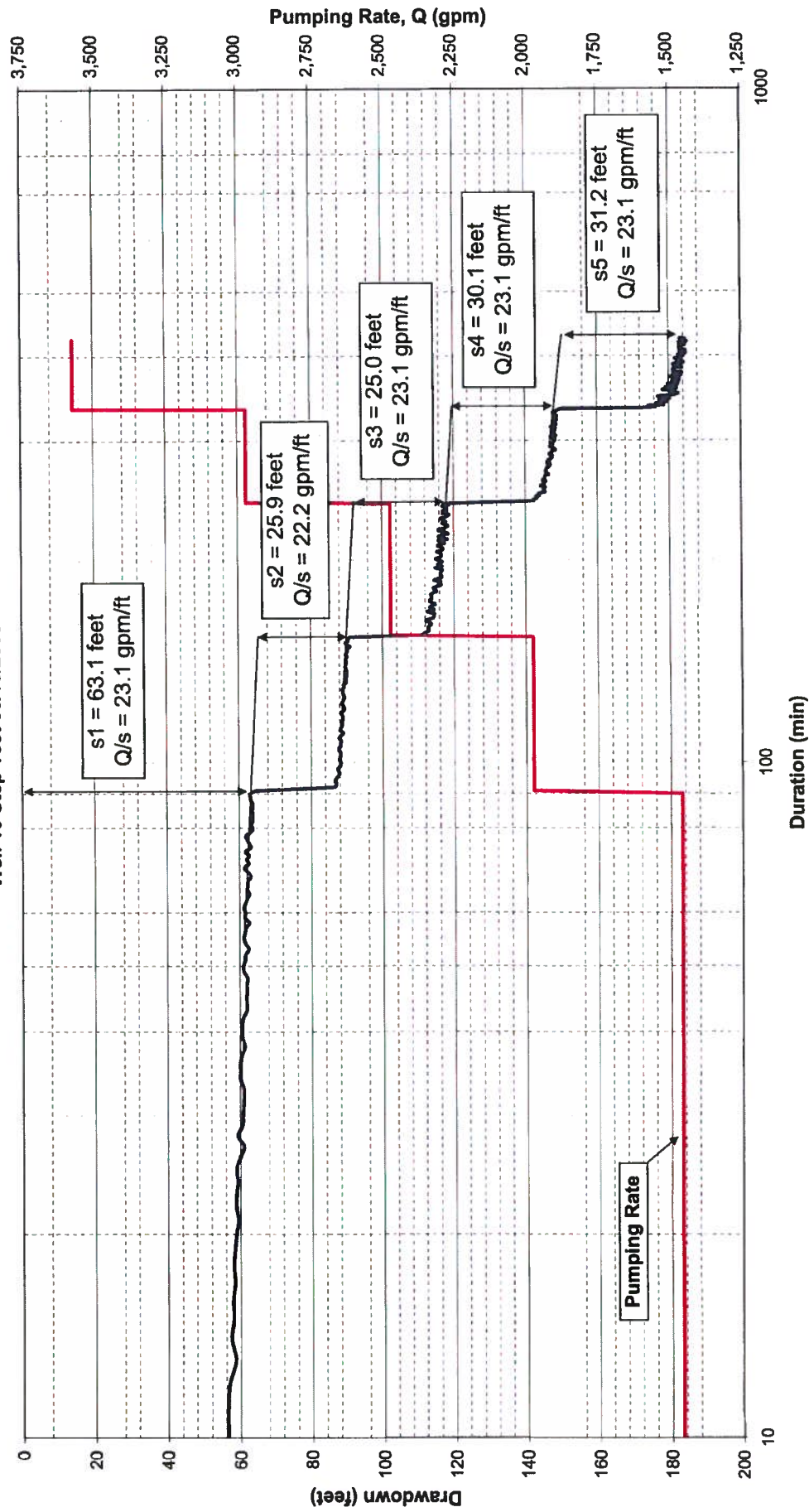


Figure 4-2
Well 16 Drilling Construction and Testing
City of Nampa

City of Nampa Well 16
s/Q vs. Pumping Rate
Step-Rate Discharge Test

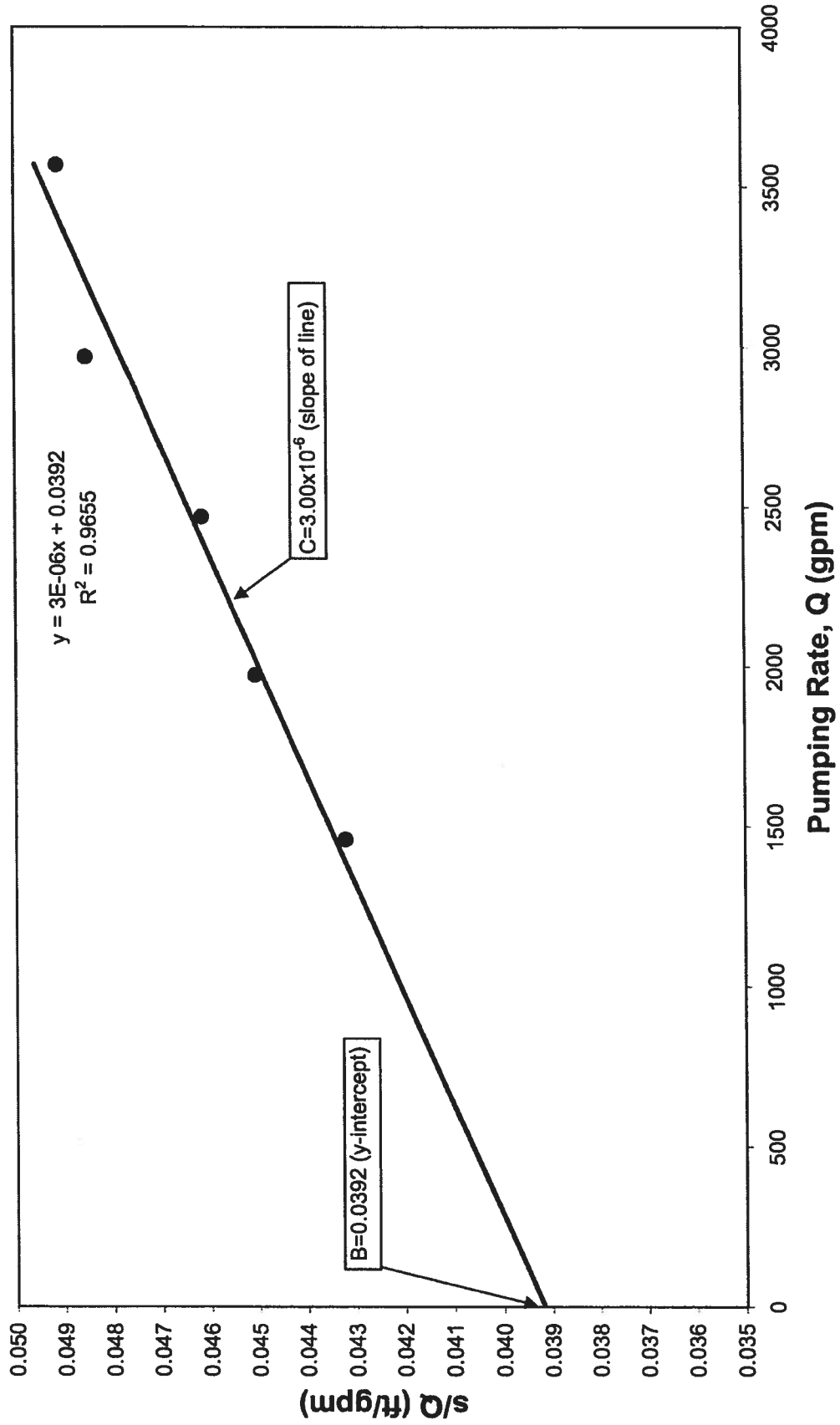


Figure 4-3
Well 16 Drilling, Construction, and Testing
City of Nampa

City of Nampa Well 16 Specific Capacity and Efficiency Diagram Step-Rate Discharge Test

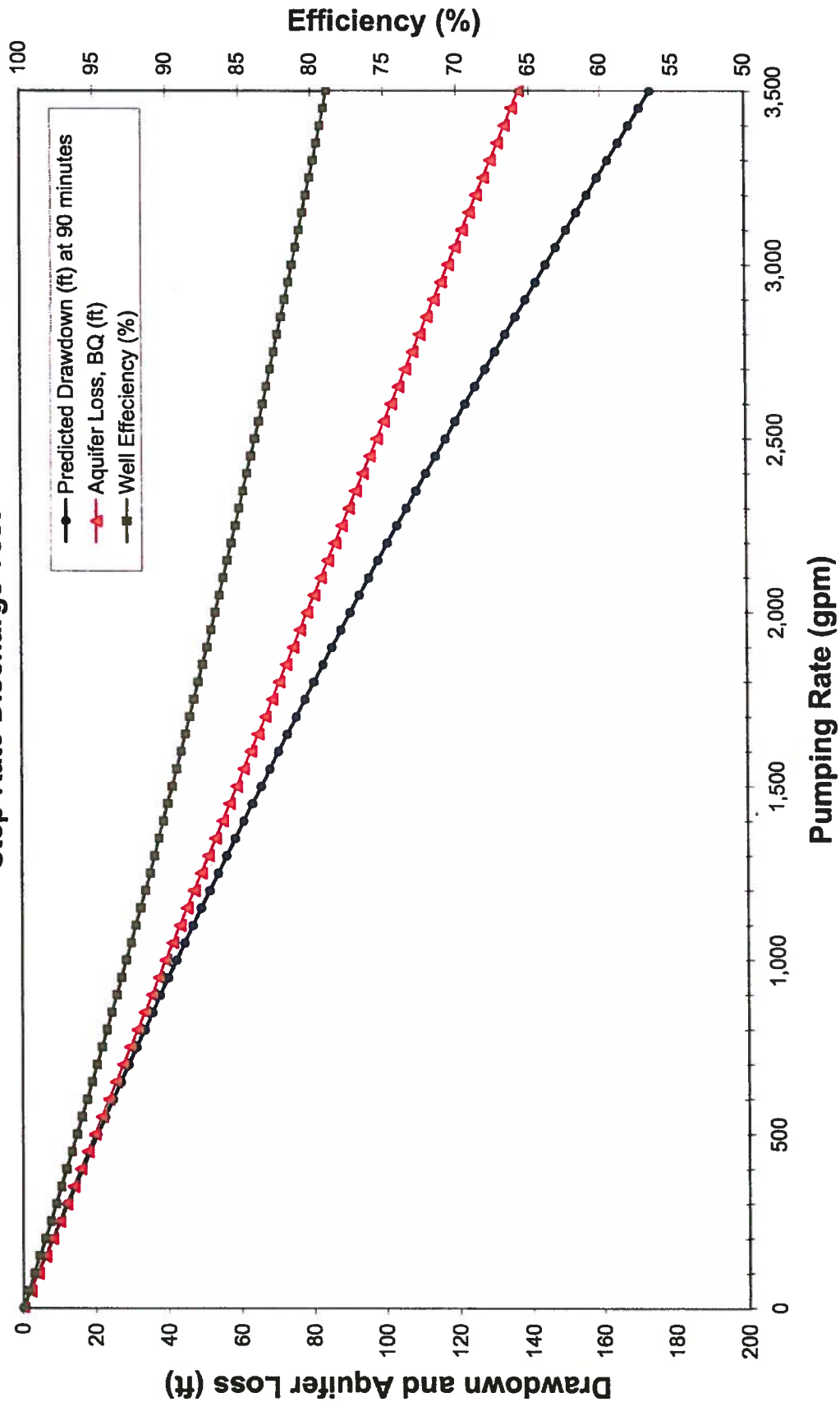


Figure 4-4
Well 16 Drilling, Construction, and Testing
City of Nampa

Figure 4-6 Well 16 Theis Recovery Analysis

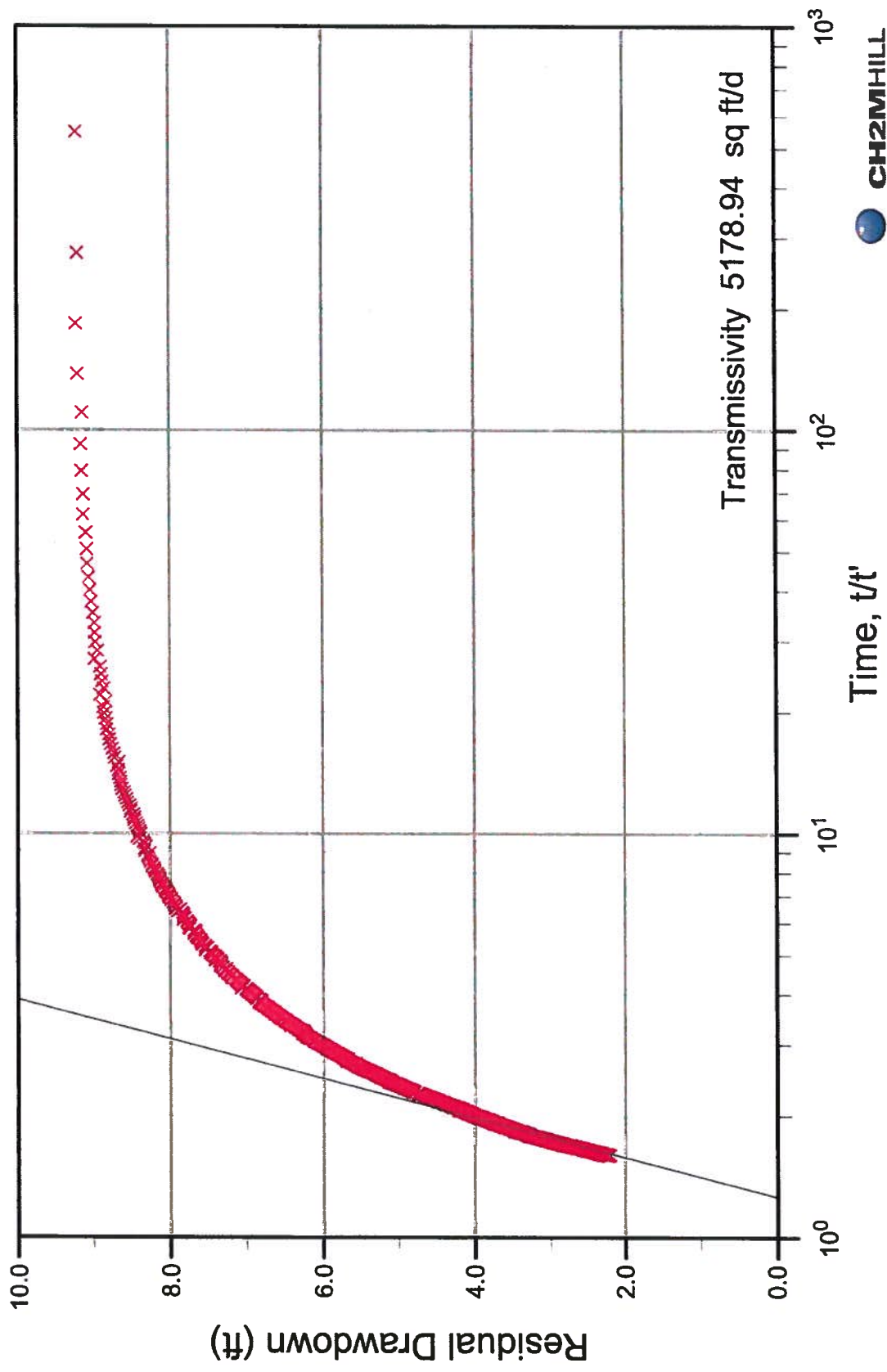


Figure 4-5 Well 16 Cooper-Jacob Analysis

