Well Test Analysis and Estimation of Long Term Drawdown in Valley Fill Aquifer due to Pumping at the Recompleted Well NC-EWDP-4PD

Prepared for:

Nye County Nuclear Waste Repository Project Office

Prepared by:

Norwest Corporation

January 2012

Introduction

Nye County is proposing to use Valley Fill Aquifer (VFA) well NC-EWDP-4PD (4PD) to supply water for its Amargosa Valley Science and Technology Park (AVSTP), located at Lathrop Wells, Nevada. The County is currently changing the point of diversion for an 80 acre-feet/year water right from a converted monitoring well at the AVSTP to 4PD. Analyses of pumping test results and water level measurements taken from monitoring wells between 4PD and Devil's Hole during a recent well test were used to estimate potential drawdown in the VFA from pumping well 4PD. Well locations are shown on Figure 1.

Background

Nye County well NC-EWDP-4PD (4PD) was drilled during Phase IV of the Nye County Early Warning Drilling Program (EWDP) in July 2008. The well was completed as a multiple screen monitoring well.

Short term packer testing of individual screened zones was conducted in 2009, and a long-term (4 weeks) pumping test was conducted in 2010 with a packer set to isolate the screens in Zones 1 and 2 from the lower screened zones in the well. Water was produced from Zones 1 and 2 during the long term pumping test.

Well 4PD has since been recompleted by plugging back the lower screened intervals so that only the screens in Zones 1 and 2 are open for water production. A three day pumping test was conducted on the recompleted well in December 2011. Water levels were monitored in 4PD and in nearby Nye County VFA wells (4PA, 4PB, Washburn 1X, 5SB, STP-2 and AeroPark) during the recent test. Well completion information is shown in Table 1, and completion diagrams are contained in Appendix A.

Table 1. Well Completion Information.

Well	Screened Interval (ft, BGS)	Equivalent 4PD Zone
4PD	318 – 398; 498 – 639	Zone 1; Zone 2
4PA	405 – 485	between Zone 1 and Zone 2
4PB	739 – 839	Below Zone 2
Washburn 1X Deep	420 – 480	between Zone 1 and Zone 2
5SB	379-389	Zone 1
STP-2	538-755; 836-957; 1079-1240	Zone 2 and below
AeroPark	100 – 725	Above Zone 1 to below Zone 2

Well Testing

A long term pumping test was conducted starting August 30, 2010 and continuing through September 24, 2010 with a packer set in the well to isolate pumping from Zones 1 and 2. Datalogging pressure transducers were set in 4PD and nearby EWDP

monitoring wells 4PA and 4PB. Manual water level measurements were taken in EWDP well Washburn 1X during the long term test. Figure 2 shows water levels in 4PD, 4PA, and 4PB during the pumping and recovery periods. Figure 3 shows water levels in Washburn 1x compared with barometric pressure from the near by Desert Research Institute (DRI) Community Environmental Monitoring Program (CEMP) Amargosa Valley Station over the pumping and recovery period of the 4PD long term test.

Well 4PD was subsequently recompleted by plugging back the lower intervals below Zone 2. A three day pumping test was conducted on the recompleted well during period from December 19 to December 22, 2011. Datalogging pressure transducers were set in 4PD, nearby EWDP monitoring well 4PB, and AeroPark during the entire pumping and recovery period. Manual water level measurements were taken in wells 4PA, Washburn 1X, STP-2 and 5SB during the three day test. In addition, continuous water level measurements were collected in Washburn 1X and AeroPark during the recovery period with datalogging pressure transducers. Figures 4 – 6 show drawdown and recovery in 4PD, 4PA, and 4PB. Figure 7 through 10 show water levels in Washburn 1X, AeroPark, 5SB, and STP-2 during the pumping and recovery periods compared with barometric pressure from the DRI CEMP Amargosa Valley Station.

The water levels and barometric pressure data for Washburn 1X, the AeroPark, 5SB, and STP-2 well show that these wells were not affected by pumping well 4PD during the long term test and/or the December 2011 test. Although a study of the barometric efficiency of wells completed in the Valley Fill Aquifer is beyond the scope of this report, Figure 3 and Figures 7 through 10 indicate that the water level changes at Washburn 1X, AeroPark, 5SB, and STP-2 were likely due to changes in barometric pressure.

Well Test Analysis

The 4PD well tests were analyzed with the commercially available well test package AQTESOLV from Hydrosolve, Inc. The Dougherty-Babu (1984) solution for a pumping test in a confined aquifer for a finite-diameter well with wellbore storage and wellbore skin was used to analyze the well test results in terms of the hydraulic properties of the screened intervals.

A gross transmissivity of Zones 1 and 2 of 1,100 ft^2/day and a well skin of 2.25 were determined from analysis of the 4PD long term test drawdown and recovery data. Results of the 4PD long term test and short term tests of individual zones are presented in a previous Nye County 4PD Well Test Report.

A gross transmissivity of recompleted well 4PD of 620 ft^2/day and a well skin of 17.85 were determined from the analysis of the December 2011 pumping test indicating some damage to the well during recompletion.

Single well tests do not provide reliable estimates of aquifer storage properties. Since observation wells 4PA and 4PB are not completed over the same intervals as the screens in Zones 1 and 2 in well 4PD a value specific storage (2×10^{-6} /ft) determined from

multi-well pumping tests conducted by the USGS in the VFA at Frenchman Flat was used in the drawdown predictions discussed in the next section.

The Dougherty-Babu type curve fits to the two 4PD well tests are found in Appendix B.

Estimation of Potential Drawdown

Transmissivity (620 ft^2/d) determined from the long term pumping test at well 4PD and specific storage (2 x 10^{-6} /ft) determined from multi-well pumping tests conducted by the USGS in the alluvial aquifer at Frenchman Flat were entered into a simple analytical aquifer model to estimate potential drawdown due to pumping well 4PD continuously at a rate of 50 GPM (80 ac-ft/yr) which represents the entire amount of the 80 acre-ft/year water right for well 4PD. Drawdown over a period of 200 years was estimated at Nye County wells NC-GWE-8PA and NC-GWE-GF-3PA, and also, at a distance equal to the distance from well 4PD to Devil's Hole (Figure 9). The analysis predicts 100 year drawdowns of 7.9 feet, 5.0 feet, and 3.5 feet at 8PA, 3PA, and at the distance from 4PD to Devil's Hole, respectively. Note that for reasons discussed below these drawdowns are likely overestimates of the actual effects of use of well 4PD.

The simple analytical model assumes an infinite homogeneous aquifer with no lateral changes in hydraulic properties and no vertical flow. Wells 4PD, 8PA, and GF-3PA are completed in the alluvial aquifer and Devils Hole is a carbonate aquifer feature; thus the model overestimates the effect at Devils Hole. There are also several geologic structures between well 4PD and Devils Hole which would inhibit drawdown due to pumping at well 4PD, most notably the Gravity Fault (Nye County will be conducting a study of the hydrogeology of the Gravity Fault in the vicinity of well GF-3PA during 2012.). These structures are not incorporated in the analytical model; therefore, the drawdowns shown in Figure 9 are highly conservative.

Nye County wells 8PA and GF-3PA are located between well 4PD and Devils Hole (about 3 and 10 miles from 4PD, respectively). Nye County routinely monitors water levels in well 8PA and GF-3PA; it is expected that any pumping effects from well 4PD will be detected in these wells. In addition, the National Park Service also has wells in its monitoring network (GF-1 and GF-2) between the Nye County wells and Devils Hole. Well locations are shown in Figure 1.

Figures

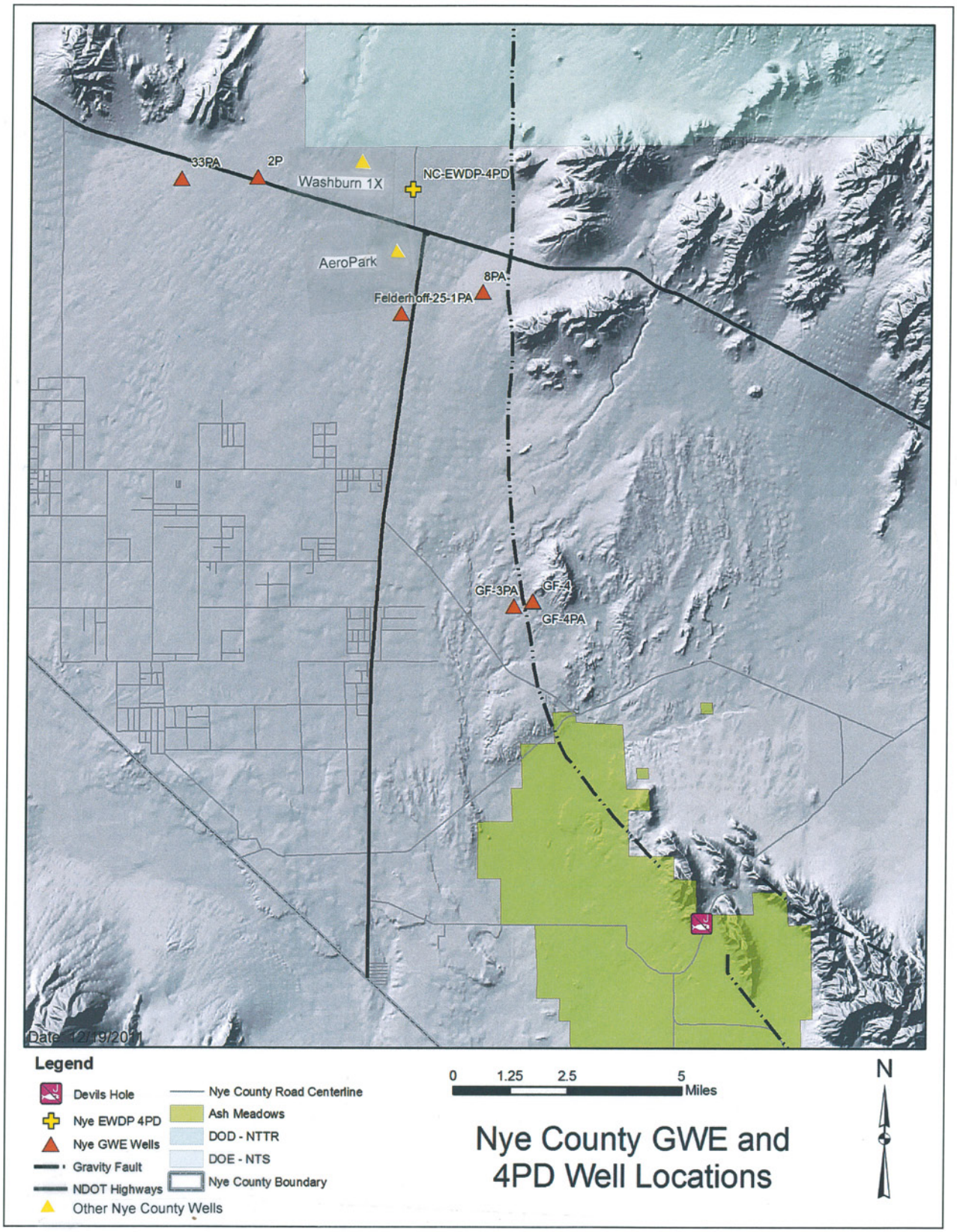

33PA
2P
Washburn 1X
NC-EWDP-4PD
AeroPark
8PA
Felderhoff-25-1PA
GF-3PA
GF-4
GF-4PA
Date: 12/19/2011
Legend
Devils Hole
Nye EWDP 4PD
Nye GWE Wells
Gravity Fault
NDOT Highways
Other Nye County Wells
Nye County Road Centerline
Ash Meadows
DOD - NTTR
DOE - NTS
Nye County Boundary
0 1.25 2.5 5
Miles
N
Nye County GWE and
4PD Well Locations

Figure 1.

Figure 2. Response of Site 4 wells during 4PD long term pumping test.

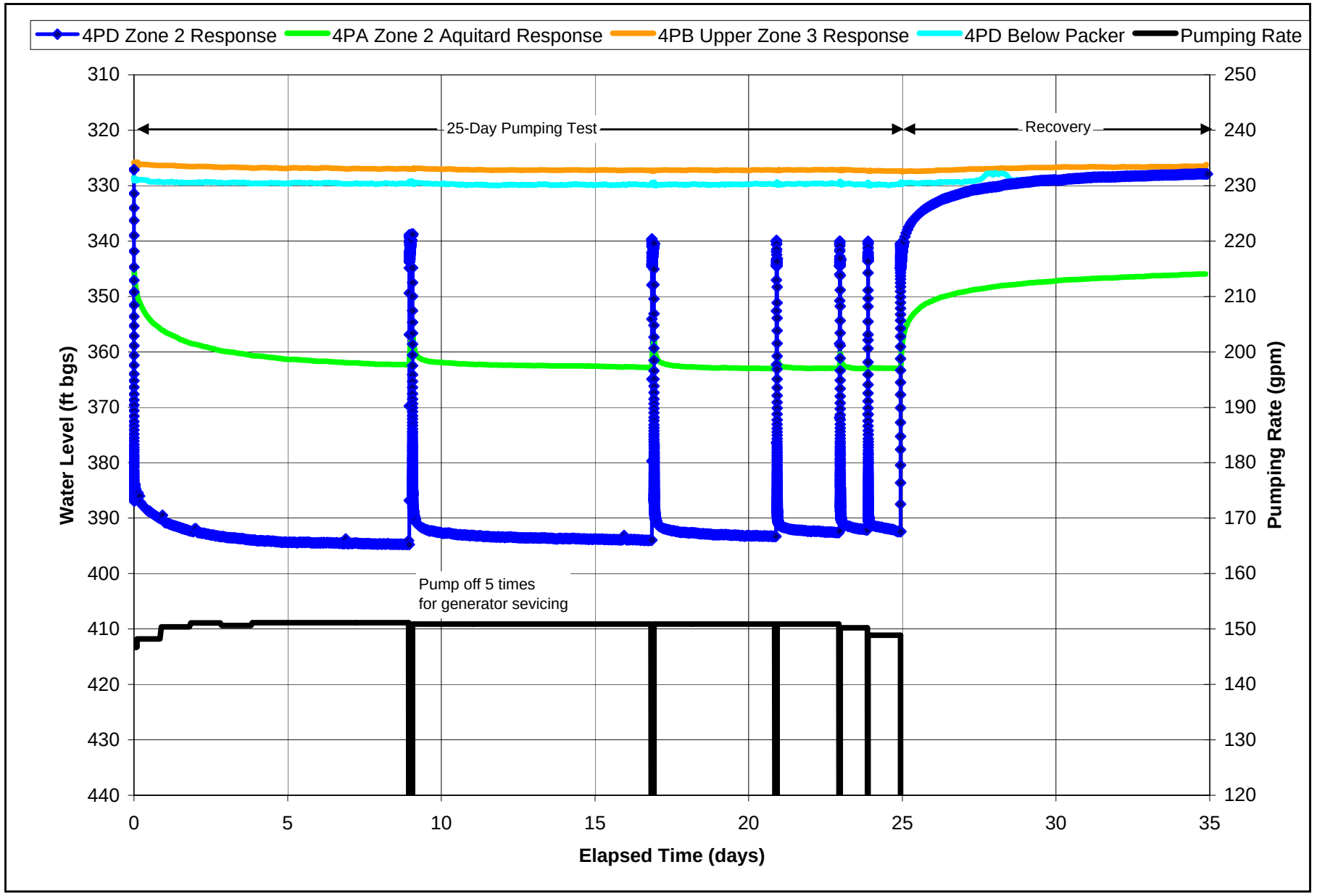


Figure 3. Water level measurements at well Washburn 1X during long term pumping test at well 4PD.

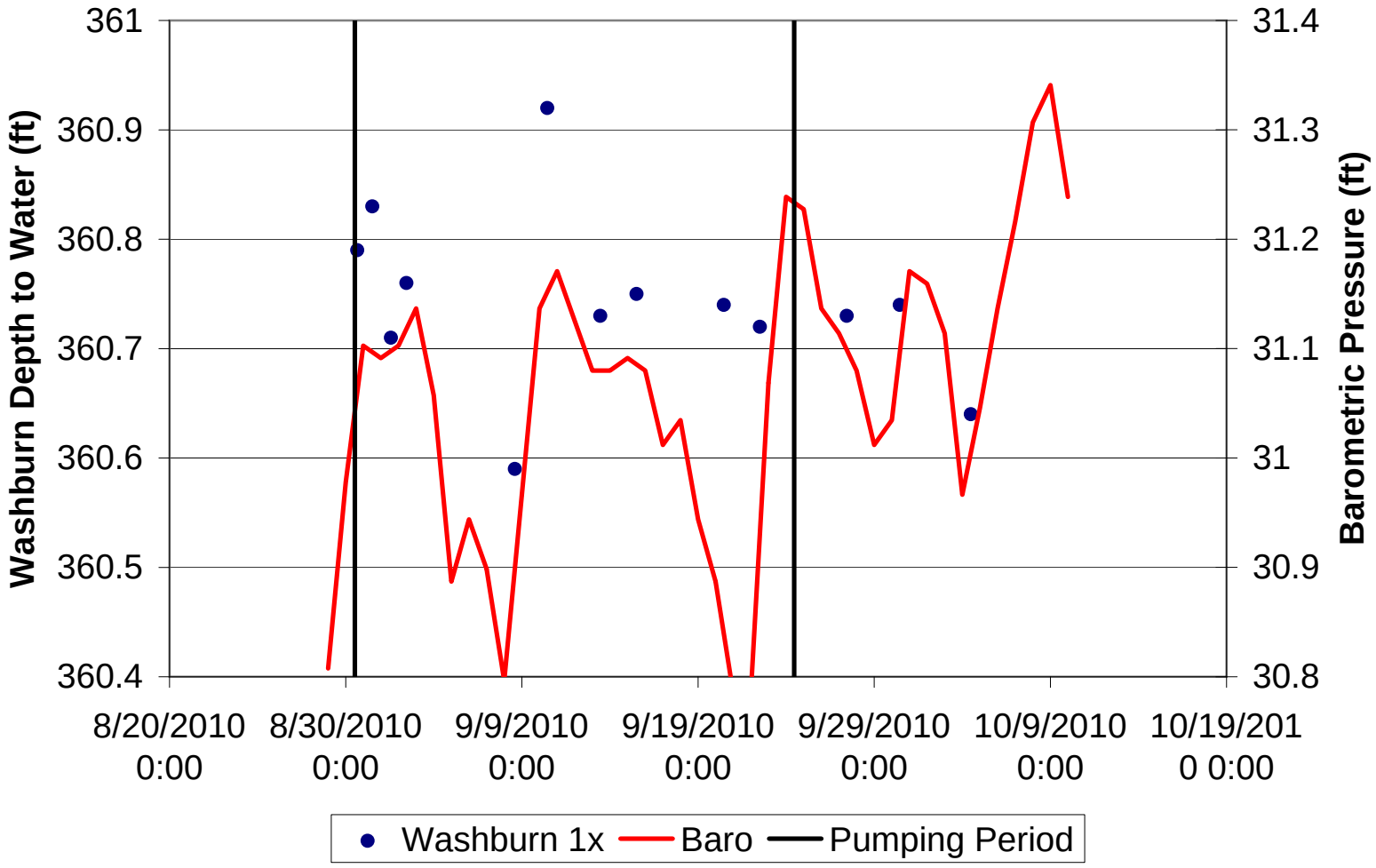


Figure 4. Drawdown in recompleted well 4PD.

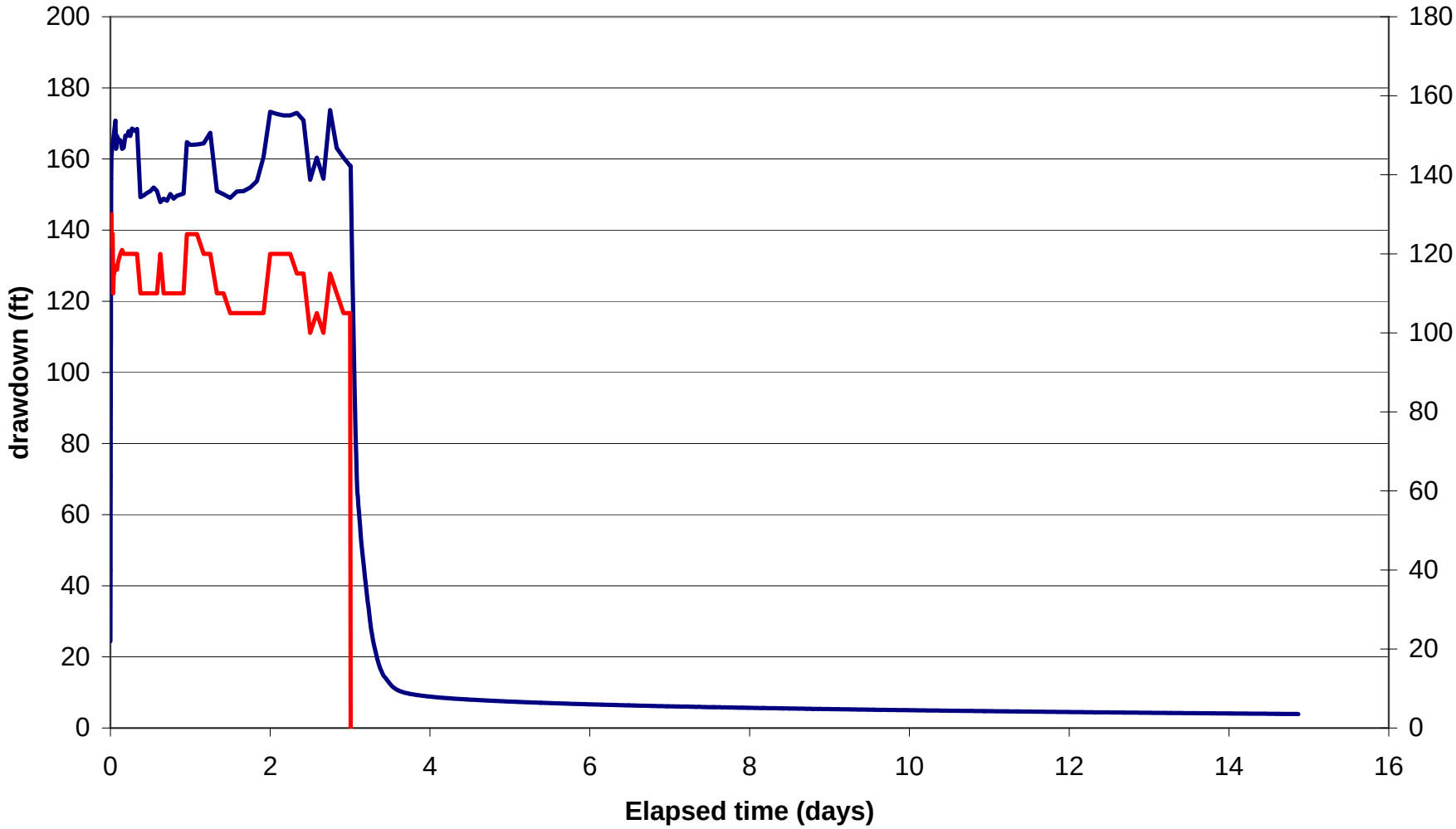


Figure 5. Drawdown in 4PA during test of recompleted well 4PD.

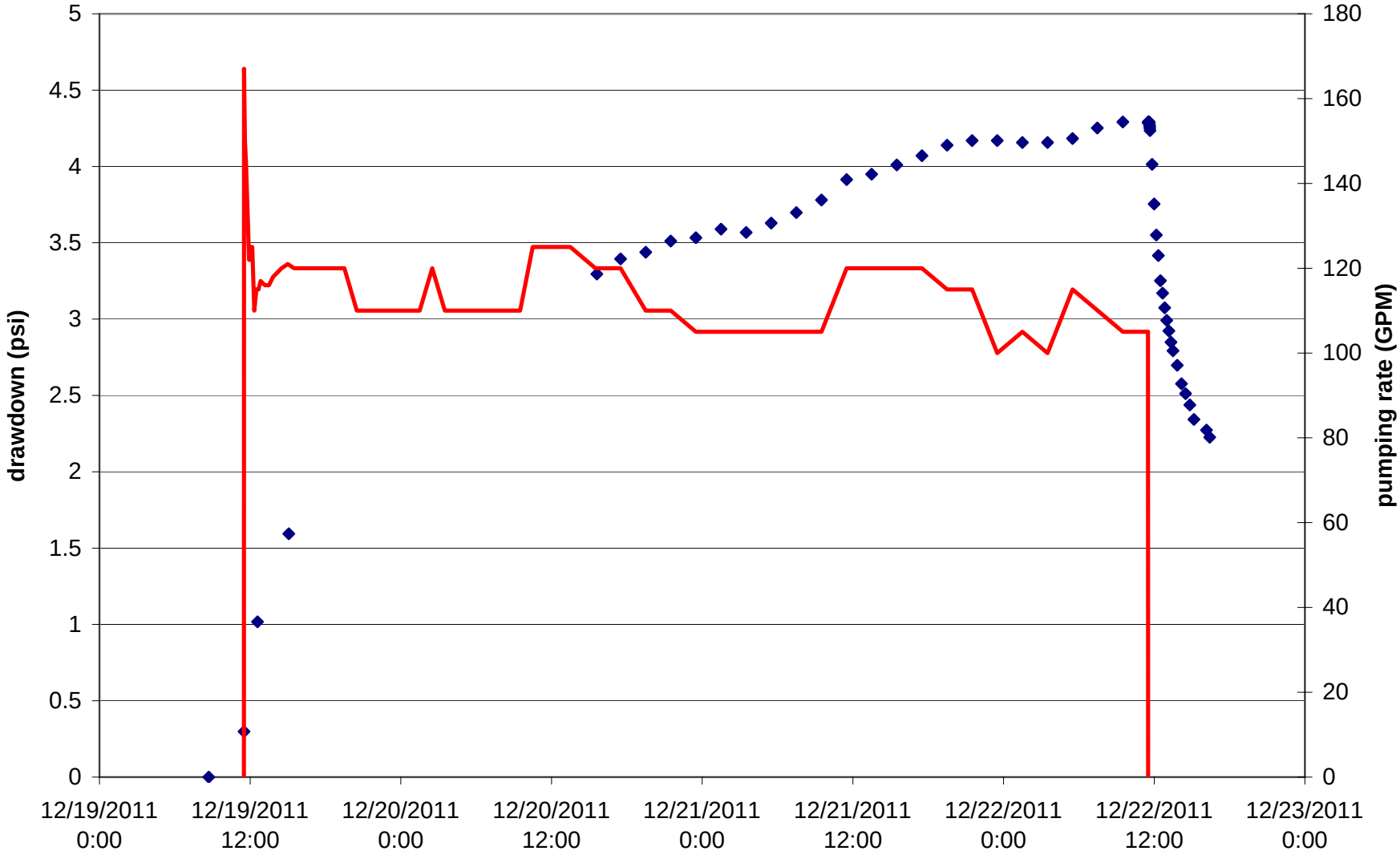


Figure 6. Drawdown in 4PB during test of recompleted well 4PD.

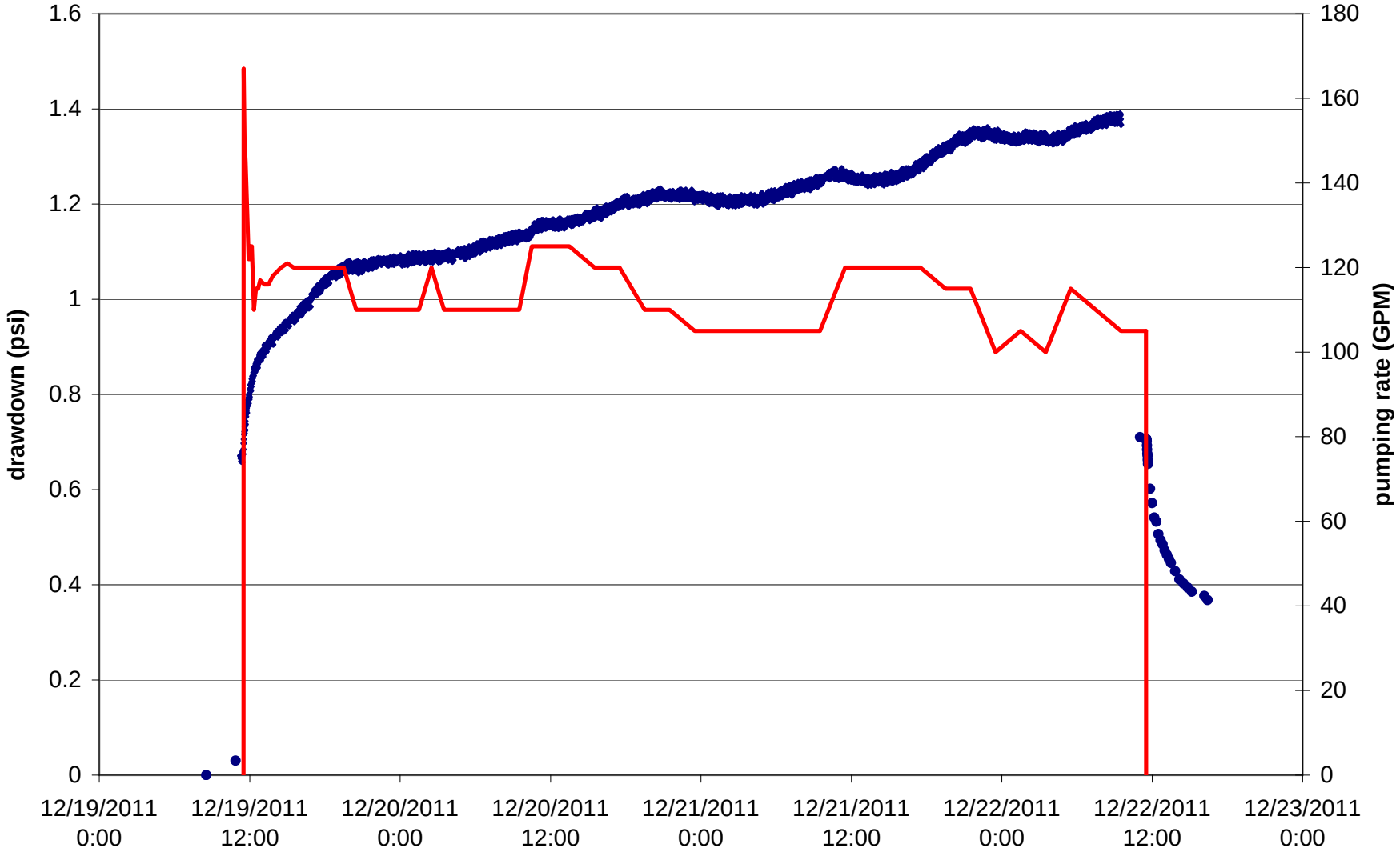


Figure 7. Washburn 1X Water Levels

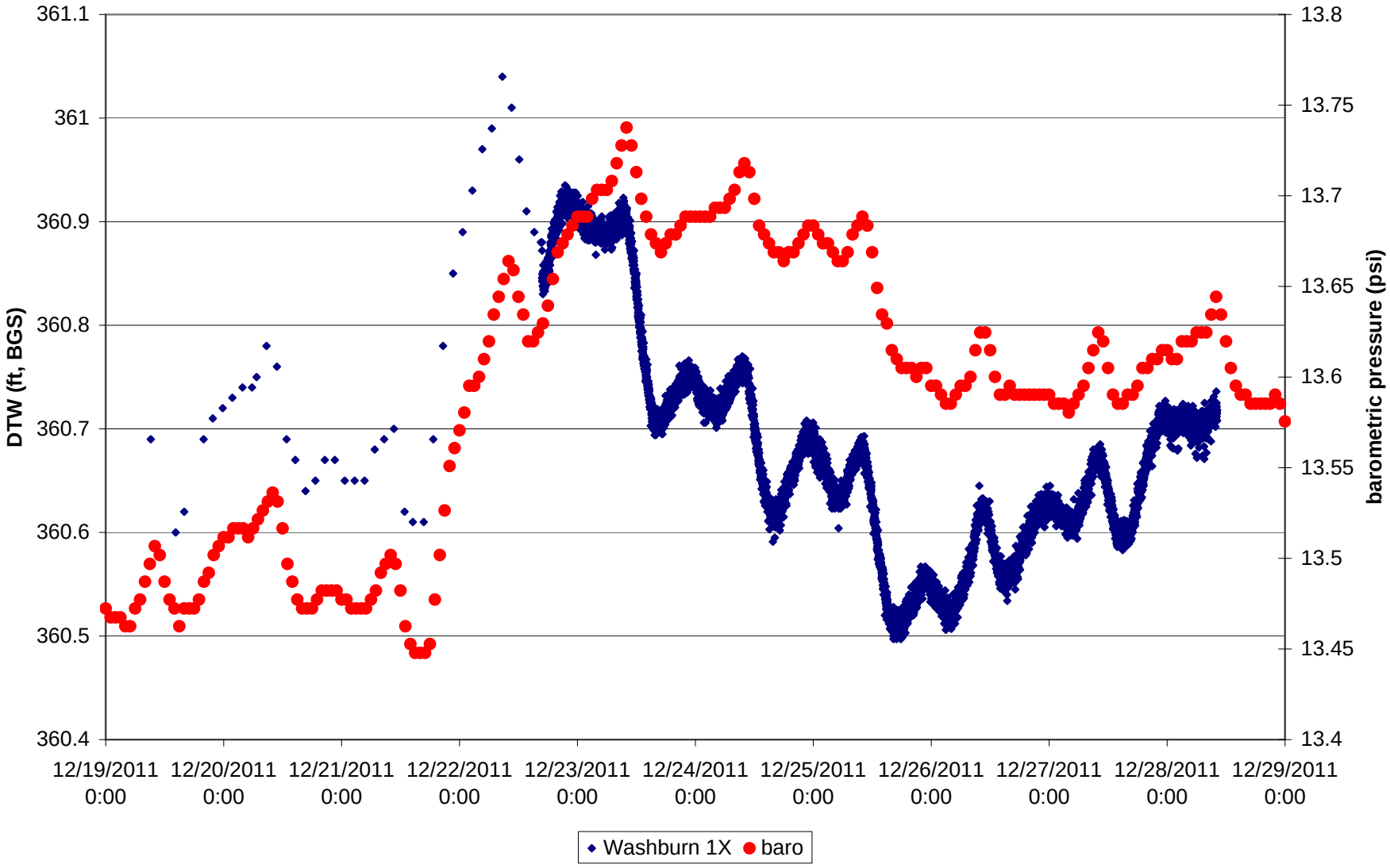


Figure 8. AeroPark Well Water Levels

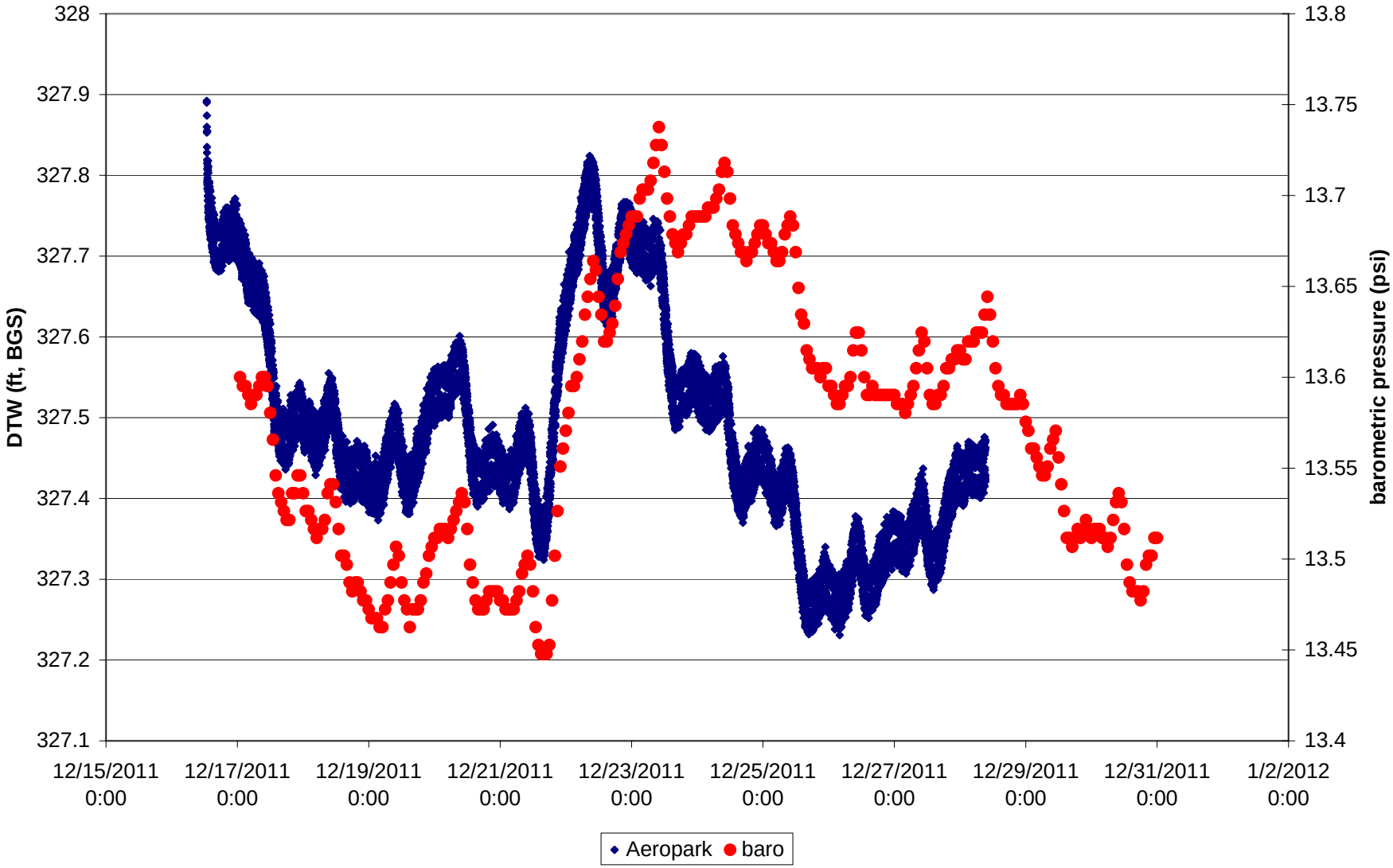


Figure 9. Well 5SB Water Levels

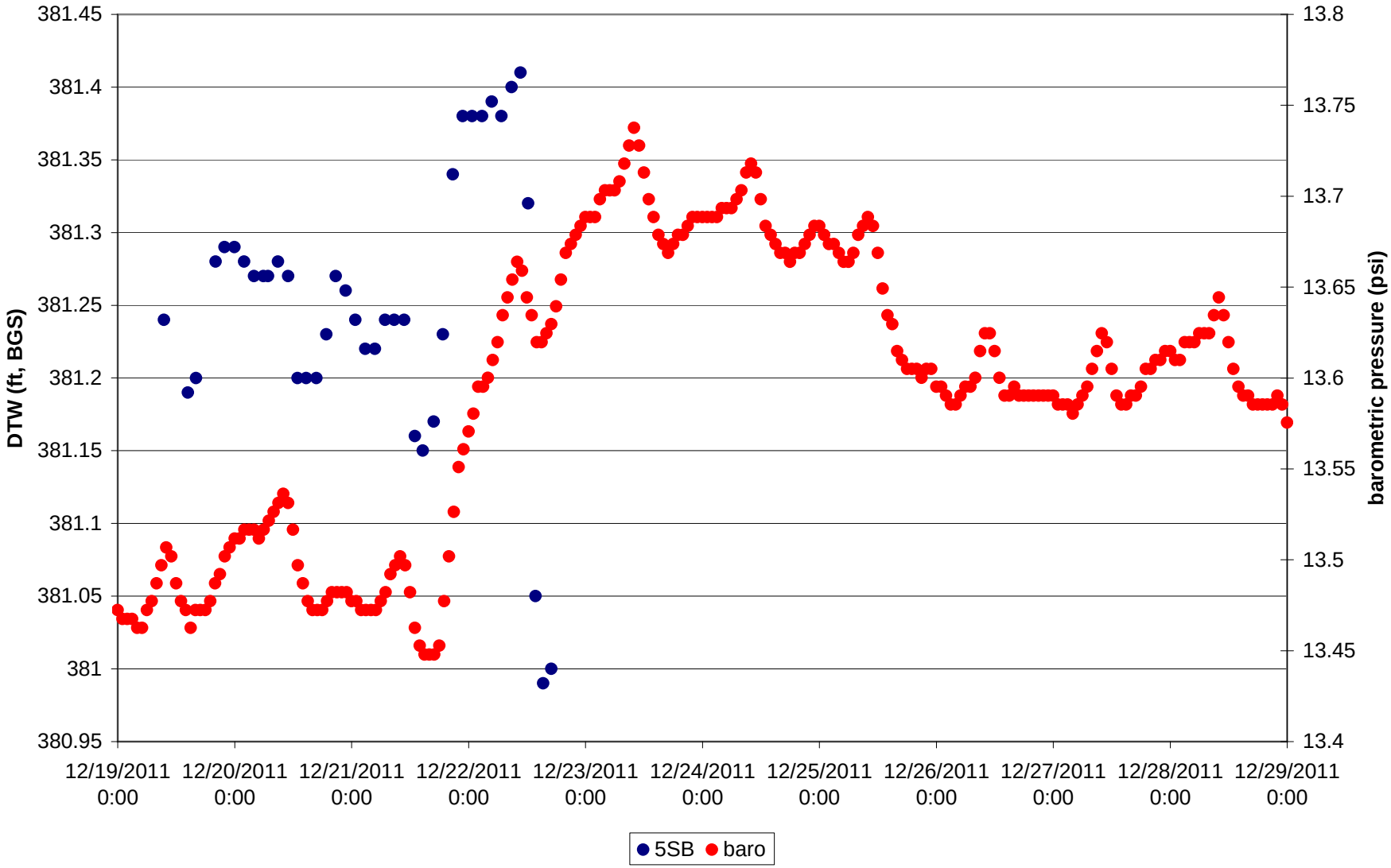


Figure 10. Well STP-2 Water Levels

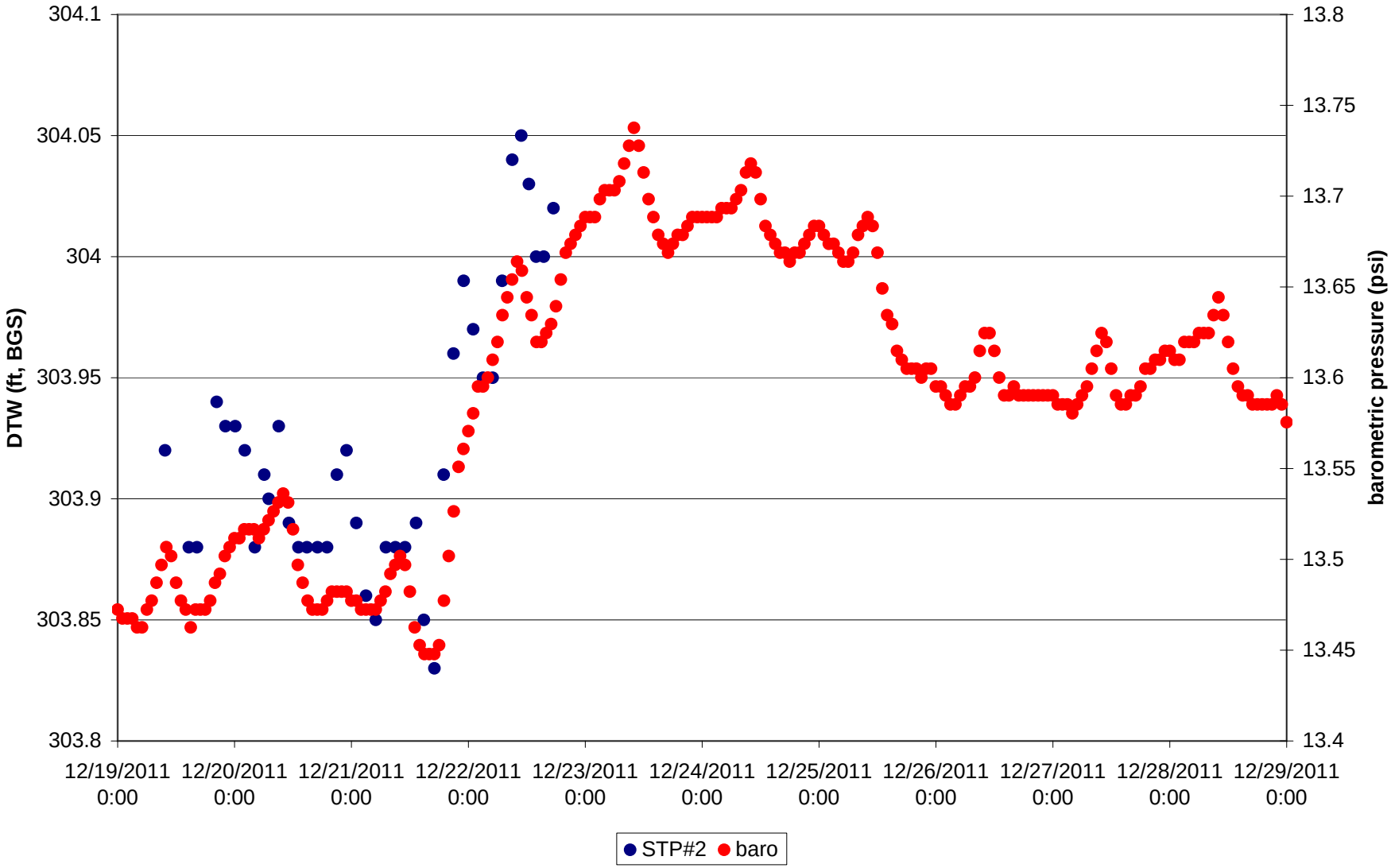
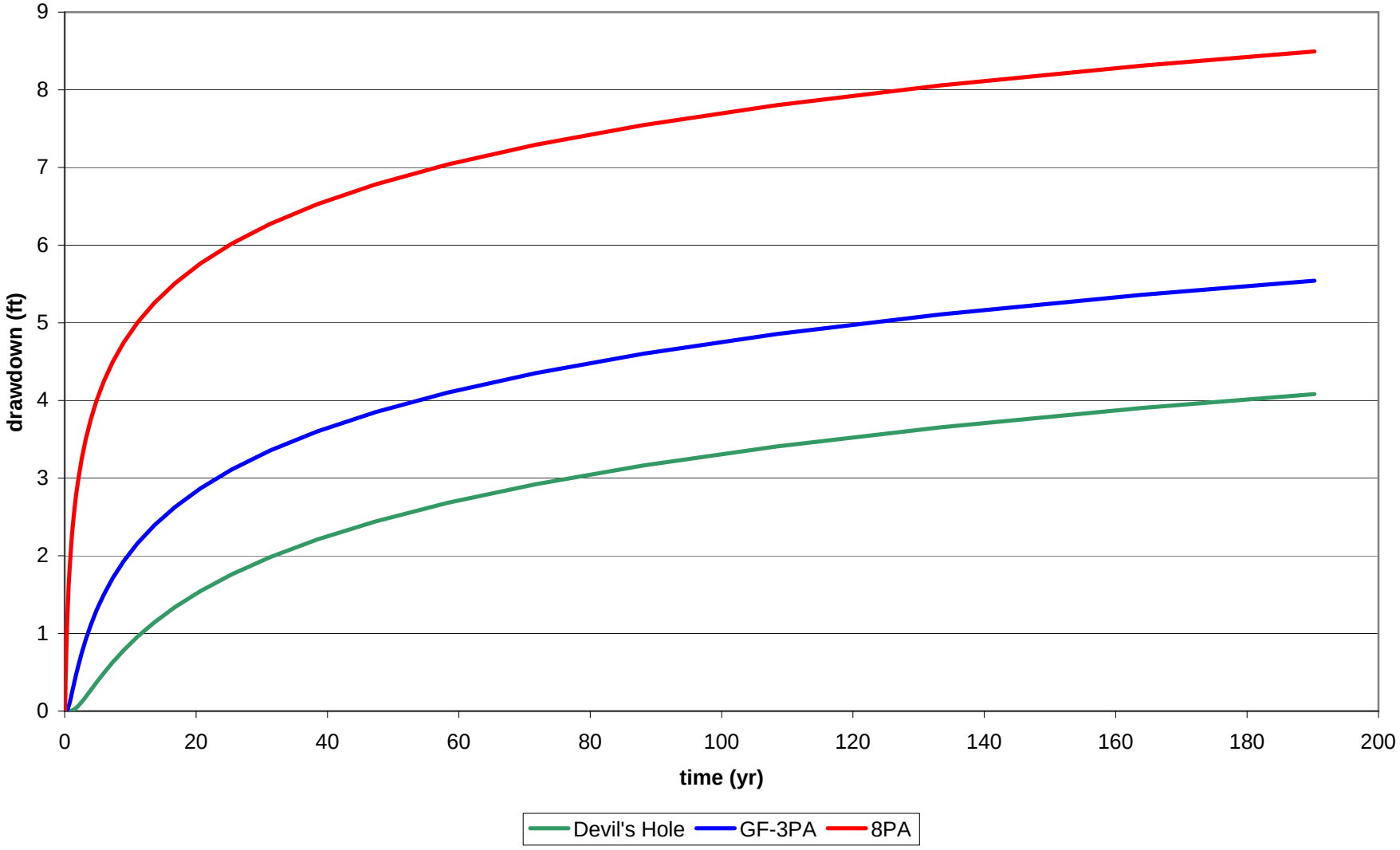
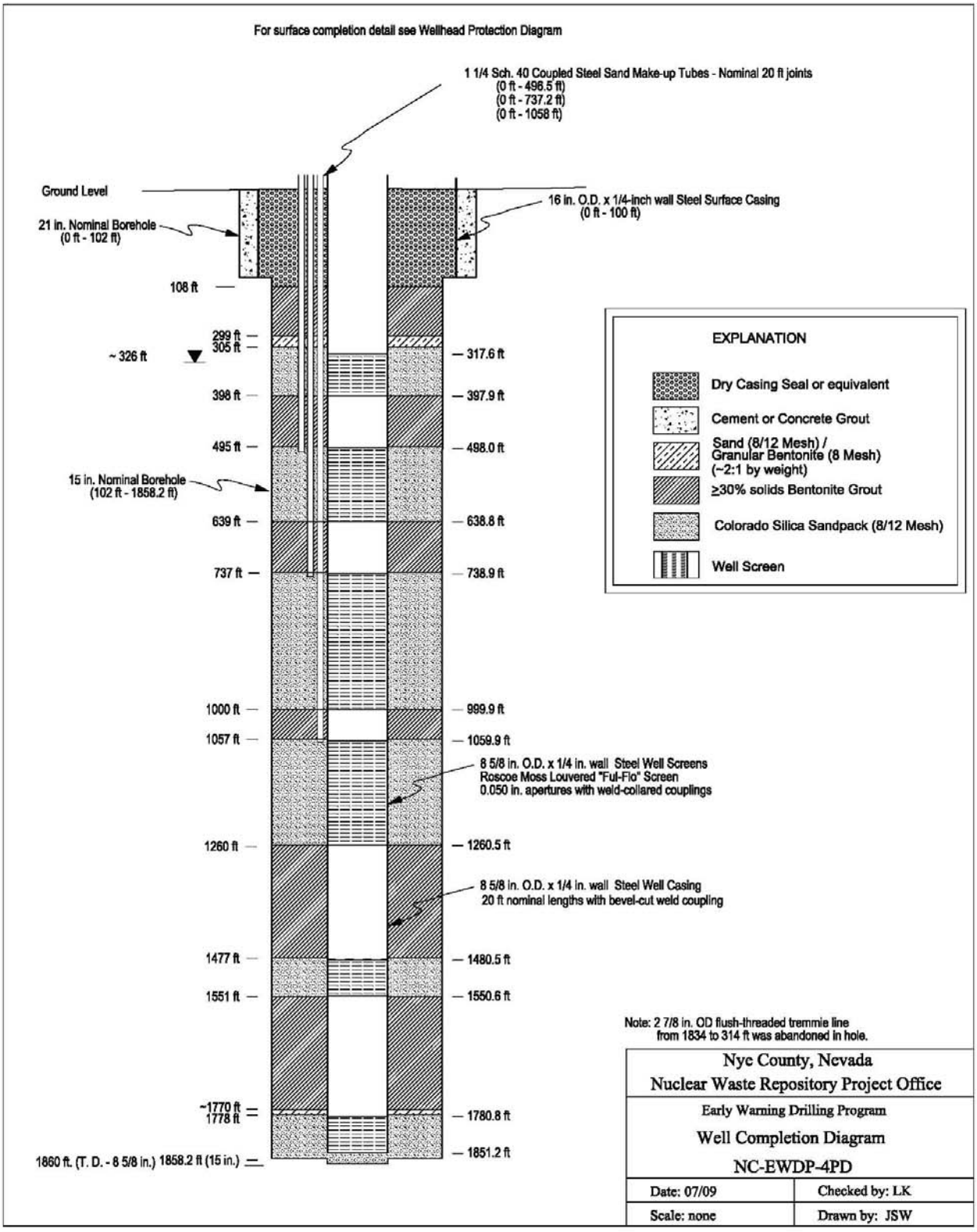


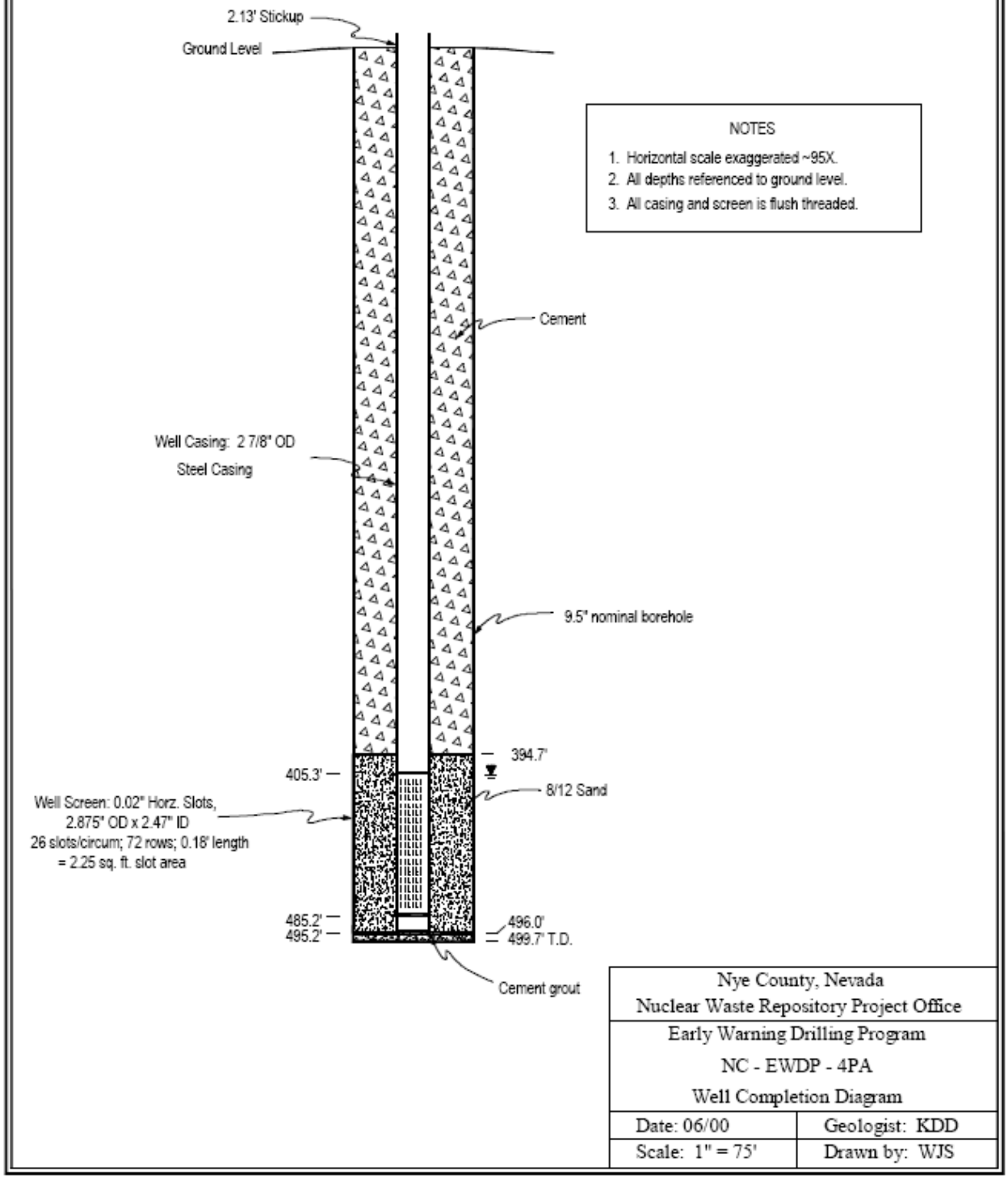
Figure 11. Estimated drawdown in an infinite homogeneous aquifer due to pumping recompleted Nye County Well 4PD at 50 GPM

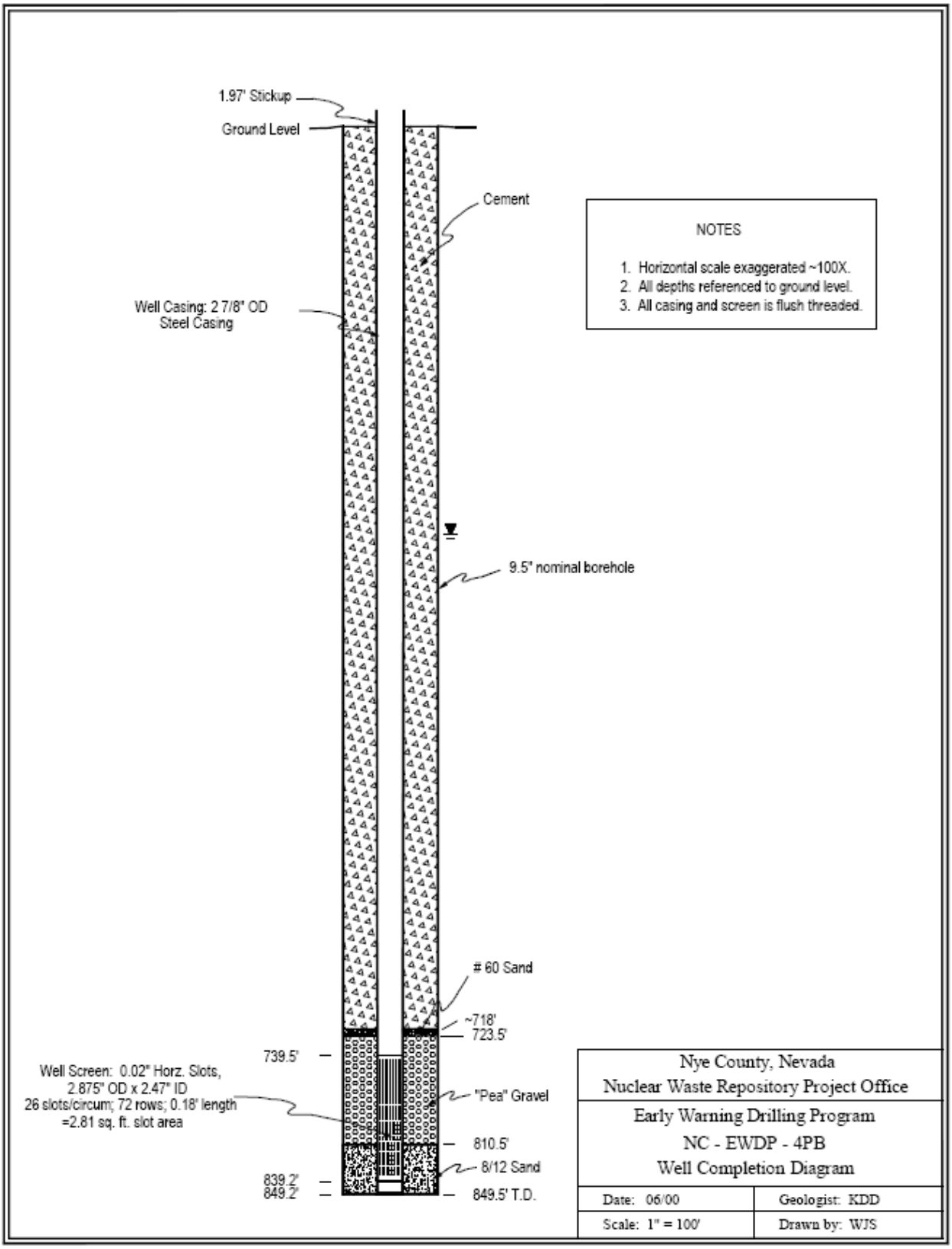


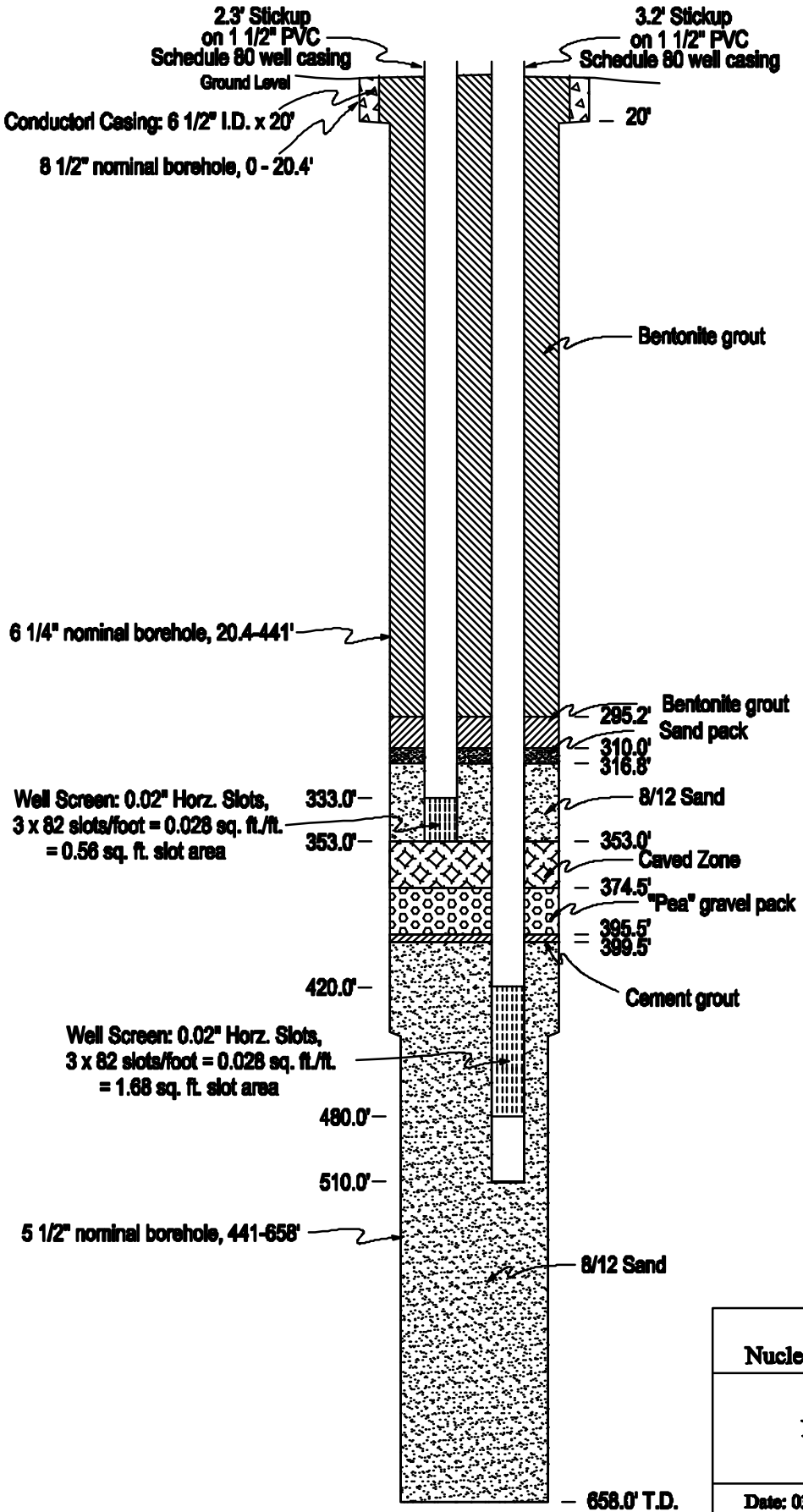
Appendix A

Well Completion Information


For surface completion detail see Wellhead Protection Diagram
1 1/4 Sch. 40 Coupled Steel Sand Make-up Tubes - Nominal 20 ft joints
(0 ft - 496.5 ft)
(0 ft - 737.2 ft)
(0 ft - 1058 ft)
Ground Level
16 in. O.D. x 1/4-inch wall Steel Surface Casing
(0 ft - 100 ft)
21 in. Nominal Borehole
(0 ft - 102 ft)
108 ft
299 ft
305 ft
~ 326 ft
317.6 ft
398 ft
397.9 ft
495 ft
498.0 ft
15 in. Nominal Borehole
(102 ft - 1858.2 ft)
639 ft
638.8 ft
737 ft
738.9 ft
1000 ft
999.9 ft
1057 ft
1059.9 ft
8 5/8 in. O.D. x 1/4 in. wall Steel Well Screens
Roscoe Moss Louvered "Ful-Flo" Screen
0.050 in. apertures with weld-collared couplings
1260 ft
1260.5 ft
8 5/8 in. O.D. x 1/4 in. wall Steel Well Casing
20 ft nominal lengths with bevel-cut weld coupling
1477 ft
1480.5 ft
1551 ft
1550.6 ft
~1770 ft
1778 ft
1780.8 ft
1851.2 ft
1860 ft. (T. D. - 8 5/8 in.) 1858.2 ft (15 in.)
EXPLANATION
Dry Casing Seal or equivalent
Cement or Concrete Grout
Sand (8/12 Mesh) / Granular Bentonite (8 Mesh) (~2:1 by weight)
≥30% solids Bentonite Grout
Colorado Silica Sandpack (8/12 Mesh)
Well Screen
Note: 2 7/8 in. OD flush-threaded tremmie line from 1834 to 314 ft was abandoned in hole.
Nye County, Nevada
Nuclear Waste Repository Project Office
Early Warning Drilling Program
Well Completion Diagram
NC-EWDP-4PD
Date: 07/09
Checked by: LK
Scale: none
Drawn by: JSW


2.13' Stickup
Ground Level
NOTES
1. Horizontal scale exaggerated ~95X.
2. All depths referenced to ground level.
3. All casing and screen is flush threaded.
Cement
Well Casing: 2 7/8" OD
Steel Casing
9.5" nominal borehole
394.7'
405.3'
8/12 Sand
Well Screen: 0.02" Horz. Slots,
2.875" OD x 2.47" ID
26 slots/circum; 72 rows; 0.18' length
= 2.25 sq. ft. slot area
485.2'
495.2'
496.0'
499.7' T.D.
Cement grout
Nye County, Nevada
Nuclear Waste Repository Project Office
Early Warning Drilling Program
NC - EWDP - 4PA
Well Completion Diagram
Date: 06/00
Geologist: KDD
Scale: 1" = 75'
Drawn by: WJS


1.97' Stickup
Ground Level
Cement
Well Casing: 2 7/8" OD
Steel Casing
9.5" nominal borehole
60 Sand
~718'
723.5'
739.5'
Well Screen: 0.02" Horz. Slots,
2.875" OD x 2.47" ID
26 slots/circum; 72 rows; 0.18' length
=2.81 sq. ft. slot area
"Pea" Gravel
810.5'
8/12 Sand
839.2'
849.2'
849.5' T.D.
NOTES
1. Horizontal scale exaggerated ~100X.
2. All depths referenced to ground level.
3. All casing and screen is flush threaded.
Nye County, Nevada
Nuclear Waste Repository Project Office
Early Warning Drilling Program
NC - EWDP - 4PB
Well Completion Diagram
Date: 06/00
Geologist: KDD
Scale: 1" = 100'
Drawn by: WJS



NOTES

1. Horizontal scale exaggerated 75X.
2. All depths referenced to ground level.
3. All casing and screen is flush threaded.
4. Sand pack is a mixture of #30 and 10-20 sand.
5. 395.8 - 395.5 is 8/12 Sand.
6. 12 joints (240') of 3/4" tremie pipe left in annular space above 295.2'.

Nye County, Nevada Nuclear Waste Repository Project Office	
Early Warning Drilling Program NC - EWDP - Washburn-1X Well Completion Diagram	
Date: 03/99	Geologist: MC/JSW
Scale: 1" = 75'	Drawn by: JSW

WELL LOG AND REPORT TO THE STATE ENGINEER OF NEVADA

Log No. 3074
Rec. Feb. 3 19 55
Well No.
Permit No. 14067

PERMIT 22582

Do not fill in

Owner Henry H. Records
Driller B & B Drilling Co.
Address Lathrop Wells, Nevada
Address Beaver, Utah Lic. No. 193
Location of well: NE¼ NW¼ Sec. 19, T. 16 N/S, R. 49 E, in Nye County
or
Water will be used for Irrigation Total depth of well 725
Size of drilled hole 22 inch
Weight of casing per linear foot 25#
Thickness of casing 3/16
Temp. of water
Diameter and length of casing 14 inch to 526 ft. 8 inch 526 to 725 ft.
(Casing 12" in diameter and under give inside diameter; casing 12" in diameter give outside diameter.)
If flowing well give flow in c.f.s. or g.p.m. and pressure
If nonflowing well give depth of standing water from surface 7 ft.
If flowing well describe control works
(Type and size of valve, etc.)
Date of commencement of well Feb. 3, 1955 Date of completion of well Feb. 15, 1955
Type of well rig Rotary

LOG OF FORMATIONS

From feet	To feet	Thickness feet	Type of material
0	3		Surface
3	5		Hard Pan
5	11		Sand
11	23		Clay
23	41		Sand Gravel
41	49		Clay
49	76		Sand Gravel
76	107		Clay
107	129		Sand
129	148		Clay
148	164		Sand Gravel
164	177		Clay
177	199		Sand Gravel Boulders
199	221		Clay
221	241		Sand Gravel Boulders
241	262		Clay
262	278		Sand Gravel
278	294		Clay
294	320		Sand Gravel
320	337		Clay
337	348		Sand Gravel
348	372		Clay
372	387		Boulders Gravel
387	403		Clay
403	426		Sand Gravel
426	439		Clay
439	452		Sand Gravel Boulders
452	469		Clay

Water-bearing Formation, Casing Perforations, Etc.

Chief aquifer (water-bearing formation)
from 177 to 199 ft.
Other aquifers

First water at 70 feet.

Casing perforated
from 100 to 725 ft.

Size of perforations
160 mesh

(OVER)

919

LOG OF FORMATIONS—*Continued*

From feet	To feet	Thickness	Type of material
469	482		Sand
[illegible]82	488		Hard Clay
488	502		Sand Gravel Boulders
502	521		Clay
521	539		Sand Gravel Boulders
539	565		Sand Gravel Boulders
565	587		Clay
587	604		Clay
604	626		Sand Gravel Boulders
626	643		Clay
643	661		Sand Gravel Boulders
661	679		Clay
679	701		Sand Gravel Boulders
701	711		Clay
711-	718		Sand Gravel
718	726		Clay

CASING RECORD

Diam. casing	From feet	To feet	Length	"Remarks"—Seals, Grouting, Etc.

GENERAL INFORMATION—Pumping Test, Quality of Water, Etc.

WELL DRILLER'S STATEMENT

This well was drilled under my jurisdiction and the above information is true to my best information and belief.

Signed B & B Drilling Co Inc
Well Driller

By Ronald Bradshaw

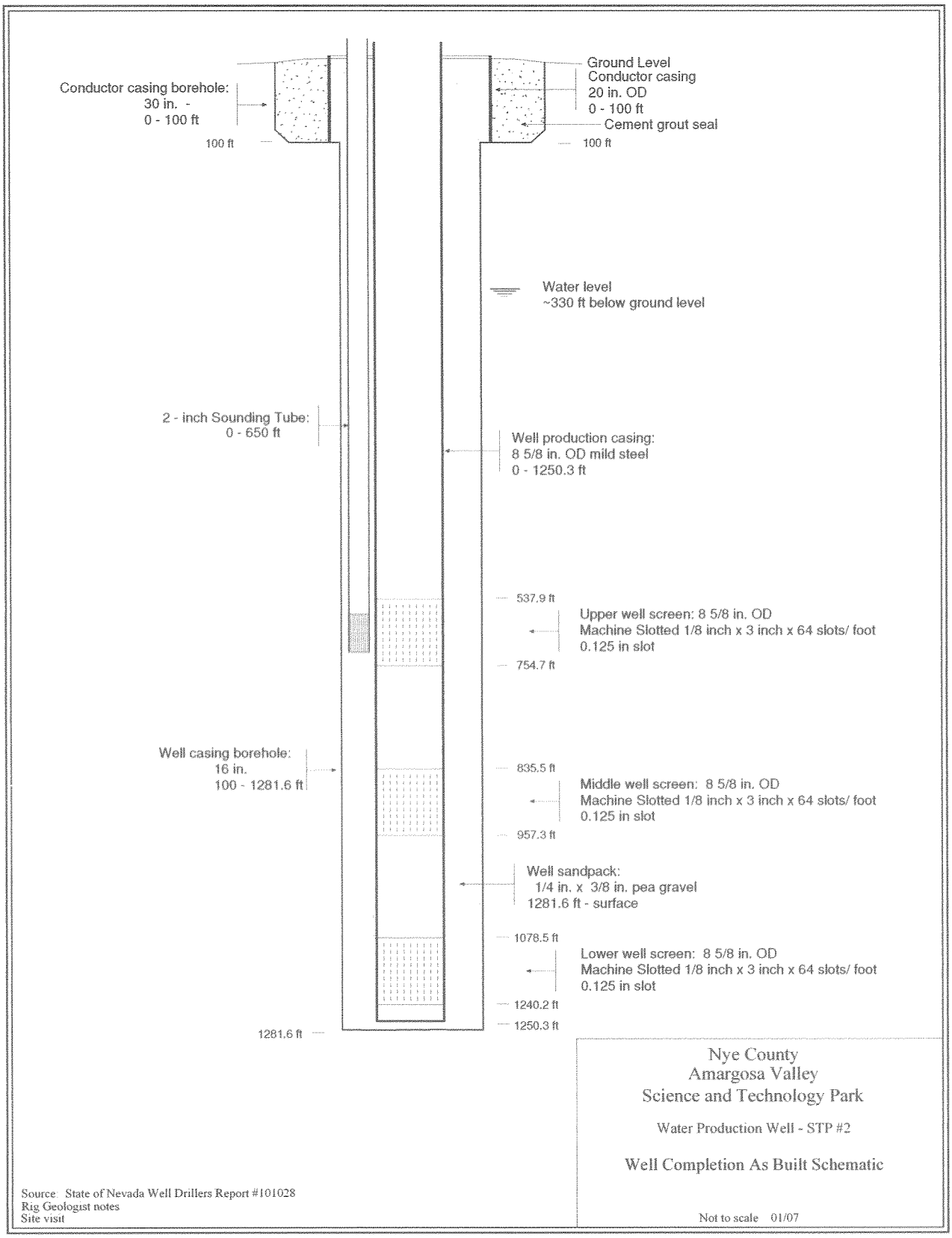
License No. 193

Date ....., 19.....

(Not to be filled in by Driller)

OFFICE
STATE ENGINEER

1955 AUG 3 AM 9 31



Nye County
Amargosa Valley
Science and Technology Park

Water Production Well - STP #2

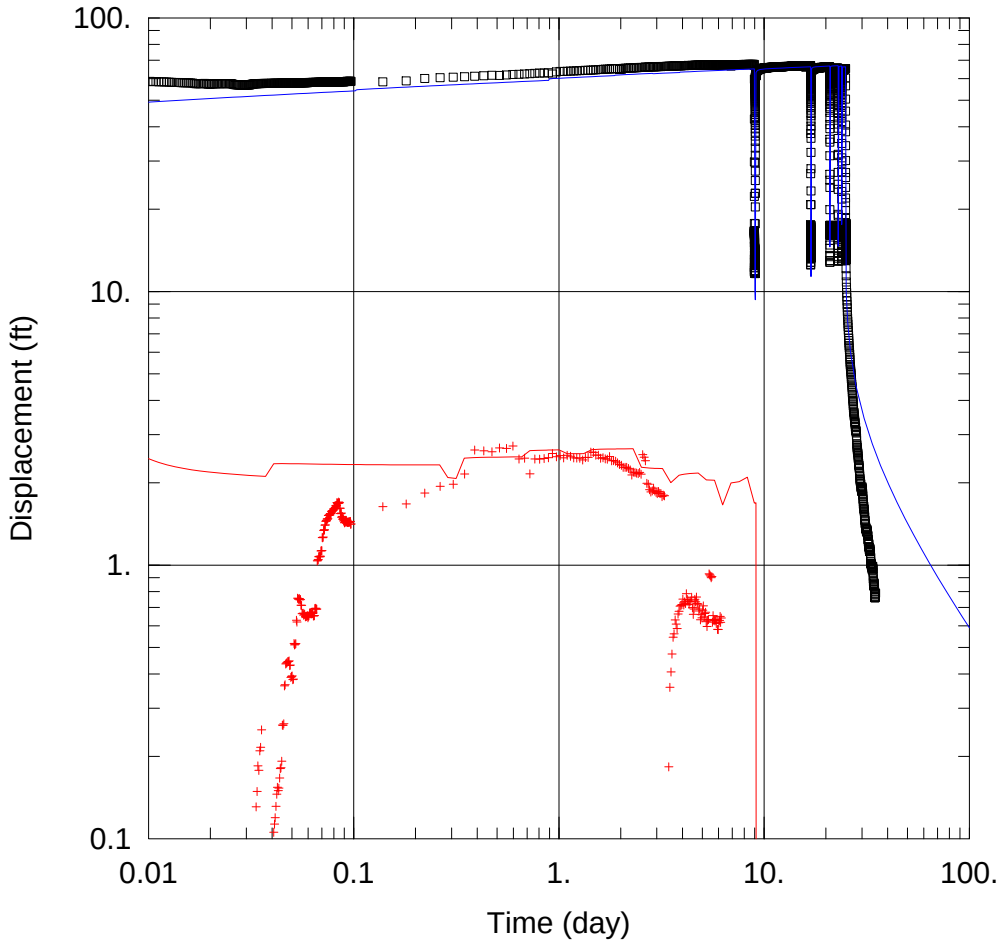
Well Completion As Built Schematic

Not to scale 01/07

Source: State of Nevada Well Drillers Report #101028
Rig Geologist notes
Site visit

Appendix B

Type Curve Fits to 4PD Well Tests



4PD ZONE 2_25-DAY WELL TEST ANALYSIS

Data Set: S:\...\Well 4PD Zone 2 LT Test_Dougherty-Babu Confined.aqt
Date: 01/30/12 Time: 23:42:35

PROJECT INFORMATION

Company: Norwest Corporation
Client: Nye County, NV
Project: 4010-00078
Location: EWDP
Test Well: NC-EWDP-4PD
Test Date: 08/30/2010

AQUIFER DATA

Saturated Thickness: 215. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
4PD ZONE 2	576768.956	694168.38

Observation Wells

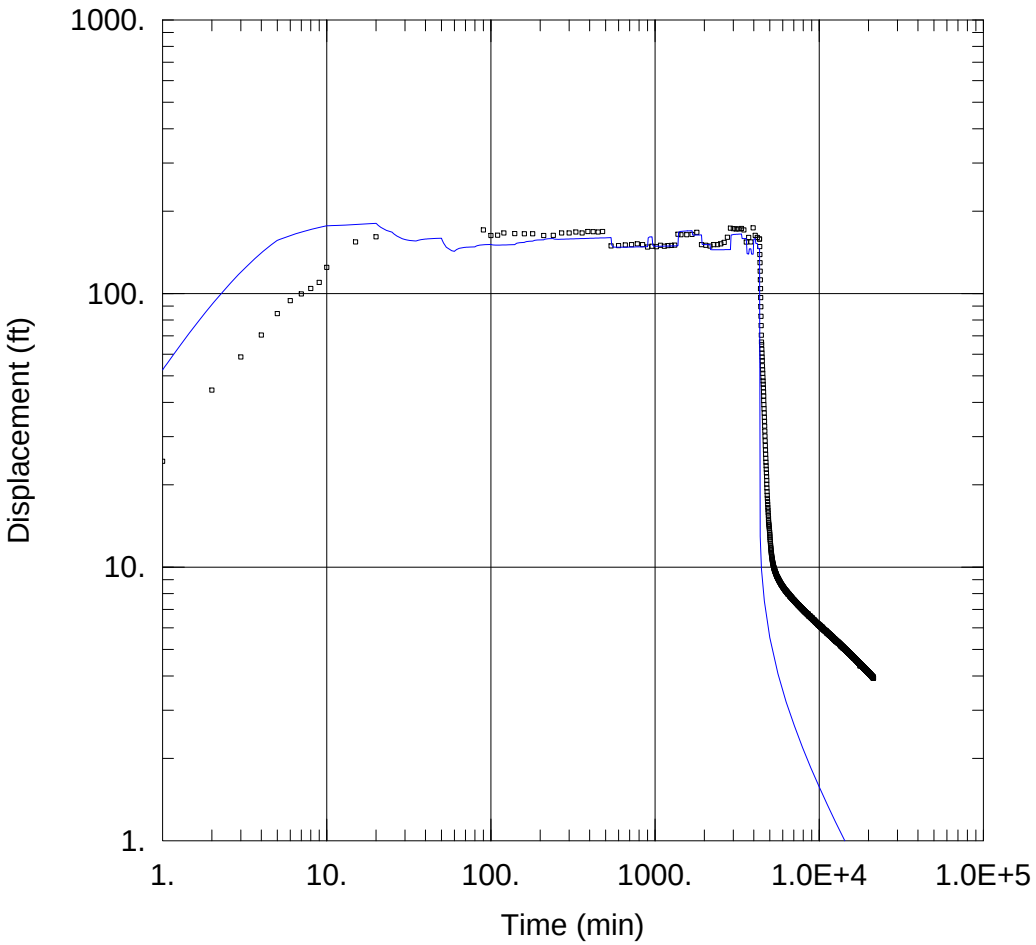
Well Name	X (ft)	Y (ft)
▫ 4PD ZONE 2	576768.956	694168.38

SOLUTION

Aquifer Model: Confined
Solution Method: Dougherty-Babu

T = 1111.8 ft^2/day
Kz/Kr = 1.
r(w) = 0.34 ft

S = 4.565E-7
Sw = 2.25
r(c) = 0.34 ft



WELL TEST ANALYSIS

Data Set: C:\...\4PD 12-11 test recovery analysis D-B manual.aqt
Date: 01/30/12 Time: 23:43:07

PROJECT INFORMATION

Company: Norwest
Client: Nye County
Project: 78
Location: 4PD
Test Well: 4PD

AQUIFER DATA

Saturated Thickness: 100. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
4PD	576768.956	694168.38

Observation Wells

Well Name	X (ft)	Y (ft)
▫ 4PD	576768.956	694168.38

SOLUTION

Aquifer Model: Confined Solution Method: Dougherty-Babu

T = 621.4 ft^2/day S = 4.561E-5
Kz/Kr = 1. Sw = 17.85
r(w) = 0.34 ft r(c) = 0.34 ft