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Analysis of Well ER-18-2 Testing, Western Pahute Mesa - Oasis Valley FY 2000 Testing Program

Revision No.: 0

September 2002

Prepared for U.S. Department of Energy under Contract No. DE-AC08-97NV13052.

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IT CORPORATION
P.O. Box 93838
Las Vegas, Nevada 89193

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Approved by: Signature Approved Date: 9-13-02

Janet N. Wille, UGTA Project Manager
IT Corporation

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List of Acronyms and Abbreviations

A	Amps
bgs	Below ground surface
BN	Bechtel Nevada
Br	Bromide
C	Carbon
°C	Degrees Celsius
Ca	Calcium
CAU	Corrective Action Unit
CD	Compact disc
CO_2	Carbon dioxide
DIC	Dissolved inorganic carbon
DO	Dissolved oxygen
DOE	U.S. Department of Energy
DOP	Detailed Operating Procedure
DRI	Desert Research Institute
EC	Electrical conductivity
ESP	Electrical Submersible Pump
FMP	Fluid Management Plan
FS	Full scale
ft	Foot (feet)
ft/d	Feet per day
ft^2/d	Square feet per day
ft/log	Feet per log
FY	Fiscal year
gpm	Gallons per minute
He	Helium
HSU	Hydrostratigraphic unit
hz	Cycles per second (hertz)
in.	Inch(es)
ITLV	IT Corporation, Las Vegas Office
K	Potassium
LANL	Los Alamos National Laboratory
LiBr	Lithium bromide

List of Acronyms and Abbreviations (Continued)

LLNL	Lawrence Livermore National Laboratory
m	Meter
m/bar	Millibar
mL	Milliliter
mg/L	Milligram per liter
Na	Sodium
NDEP	Nevada Division of Environmental Protection
NDWS	*Nevada Drinking Water Standard*
nm	Nanometer
NNSA/NV	U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office
NTU	Nephelometric turbidity units
od	Outside diameter
pCi/L	Picocuries per liter
psi	Pounds per square inch
psig	Pounds per square inch gauge
PXD	Pressure transducer
redox	Reduction oxidation
S	Storage coefficient
SQP	Standard Quality Practice
T	Transmissivity
TDH	Total dynamic head
UGTA	Underground Test Area
VSD	Variable speed drive
WDHTP	Well Development and Hydraulic Testing Plan
WPM-OV	Western Pahute Mesa - Oasis Valley
µmhos/cm	Micromhos per centimeter
µg/L	Micrograms per liter

1.0 Introduction

This report documents the analysis of the data collected for Well ER-18-2 during the Western Pahute Mesa - Oasis Valley (WPM-OV) well development and testing program that was conducted during fiscal year (FY) 2000. The data collection for that program is documented in Appendix A, *Western Pahute Mesa - Oasis Valley, Well ER-18-2 Data Report for Development and Hydraulic Testing*.

1.1 Well ER-18-2

Well ER-18-2 is one of eight groundwater wells tested as part of FY 2000 activities for the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Operations Office (NNSA/NV), Underground Test Area (UGTA) Project. Figure 1-1 shows the locations of the WPM-OV wells. Drilling and well construction information was obtained from a draft of the *Completion Report for Well ER-18-2* (Townsend, 2002).

Hydraulic testing and groundwater sampling were conducted at Well ER-18-2 to provide information on the hydraulic characteristics of hydrostratigraphic units (HSUs) and the chemistry of local groundwater. Well ER-18-2 is constructed with one completion interval which extends over a vertical distance of about 1,136 feet (ft) and accesses one HSU (i.e., the Ammonia Tanks Tuff).

1.2 WPM-OV Testing Program

The testing program for Well ER-18-2 was much less elaborate than the programs run on the other WPM-OV wells because the single completion interval and restricted screen length did not provide appropriate conditions for the vertical head measurements and flow-logging activities. The testing program included:

1. Well development and step-drawdown tests
2. Eight-day constant-rate pumping test and subsequent recovery
3. Collection of composite groundwater characterization samples

The form for this report differs from the reports for the other WPM-OV ER-EC Wells reports in that sections which would discuss data that was not collected for Well ER-18-2 have been omitted.

1.3 Analysis Objectives and Goals

The testing program was designed to provide information about the local hydrologic conditions and HSU hydraulic parameters for use in the Corrective Action Unit (CAU)-scale flow and transport model. In addition, groundwater quality information from the groundwater characterization was intended for use in geochemistry-based analyses of hydrologic conditions and groundwater flow as well as to detect the presence of any radionuclides. The primary objective for this analysis was to evaluate all of the data collected and derive the maximum information about the hydrology. A secondary objective was to evaluate the functionality of the well design for use in future investigation and testing activities, and also evaluate this well for use in future monitoring.

General goals for the analysis were to determine representative hydraulic parameter(s) for the formation accessed by the completion interval, and to determine representative groundwater quality for the formation in the completion interval. With regard to well function, specific goals included determination of the well hydraulics under pumping conditions and the effectiveness of development and testing methodologies.

Section 2.0 of this report discusses the nonpumping natural-gradient well hydrologic data, and evaluates opportunities for deriving hydraulic parameters for the completion intervals from that data. Section 3.0 discusses the well hydraulics during pumping and the flow-logging results. Hydraulic parameters derived for the formation in the completion interval are presented. This section is completed with comments on operating and testing a deep well such as ER-18-2. Section 4.0 discusses the groundwater sample that was collected and the analytical results, as well as how this information fits into the general geochemistry of the groundwater in the area. Finally, concerns pertinent to the future use of Well ER-18-2 for monitoring are discussed.

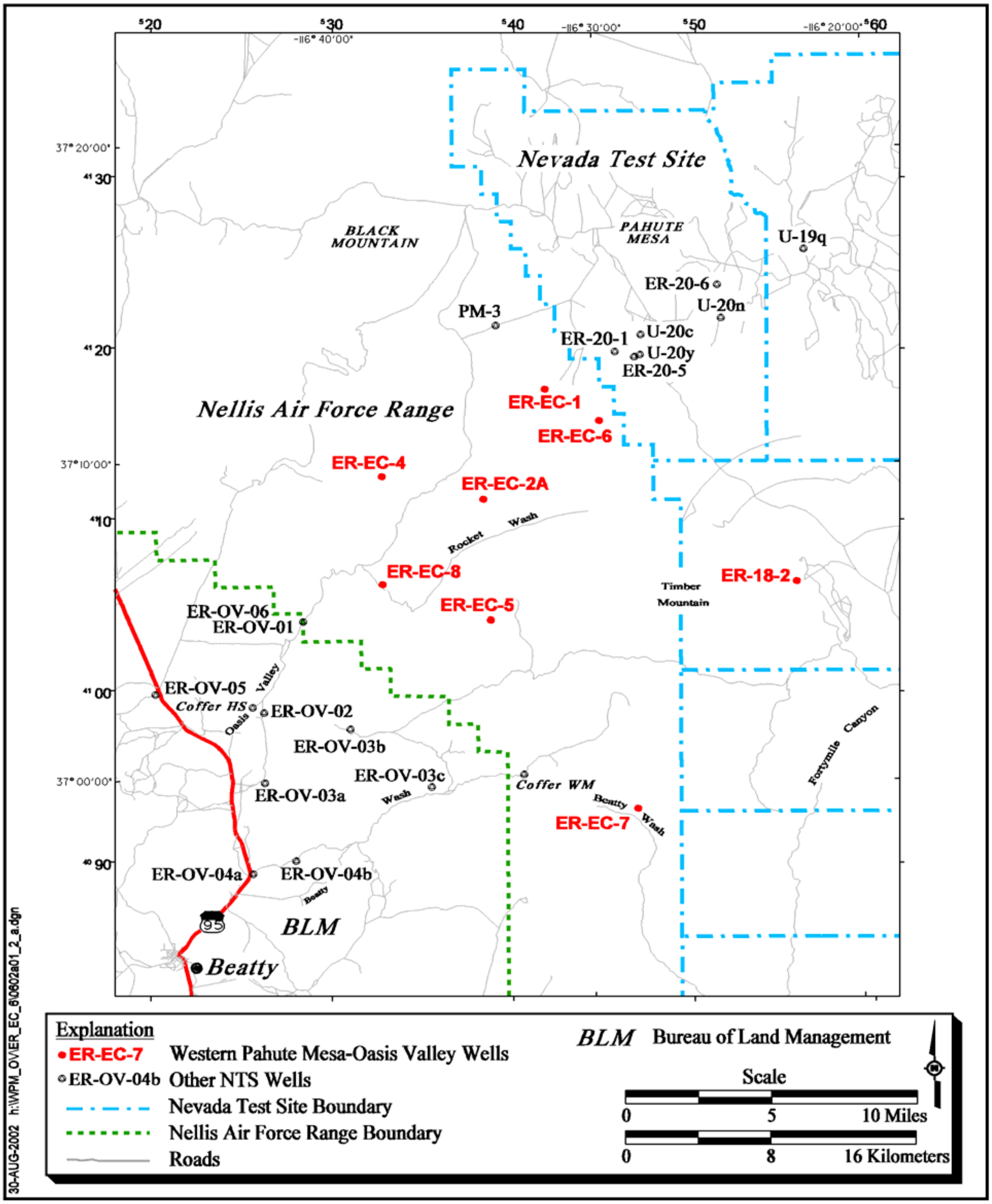


Figure 1-1
Location Map for WPM-OV ER Wells

2.0 Equilibrium Well Hydraulics

This section discusses Well ER-18-2 hydrology for the equilibrium, nonpumping condition. This material updates the initial analysis of the data in Appendix A and further develops some of the concepts and concerns that were presented in that report.

This well has only one long completion interval (1,136 ft) which is accessed by a relatively short interval of screens (210 ft) just below the middle of the completion interval. There is no way to isolate discrete vertical intervals of the borehole to measure vertical head differences, or to collect any information on vertical flow in the borehole. Consequently, no measurements were made relating to vertical head gradient or flow, and no analysis is presented. There is little information on the nonpumping hydrology of this well.

2.1 Composite Equilibrium Water Level

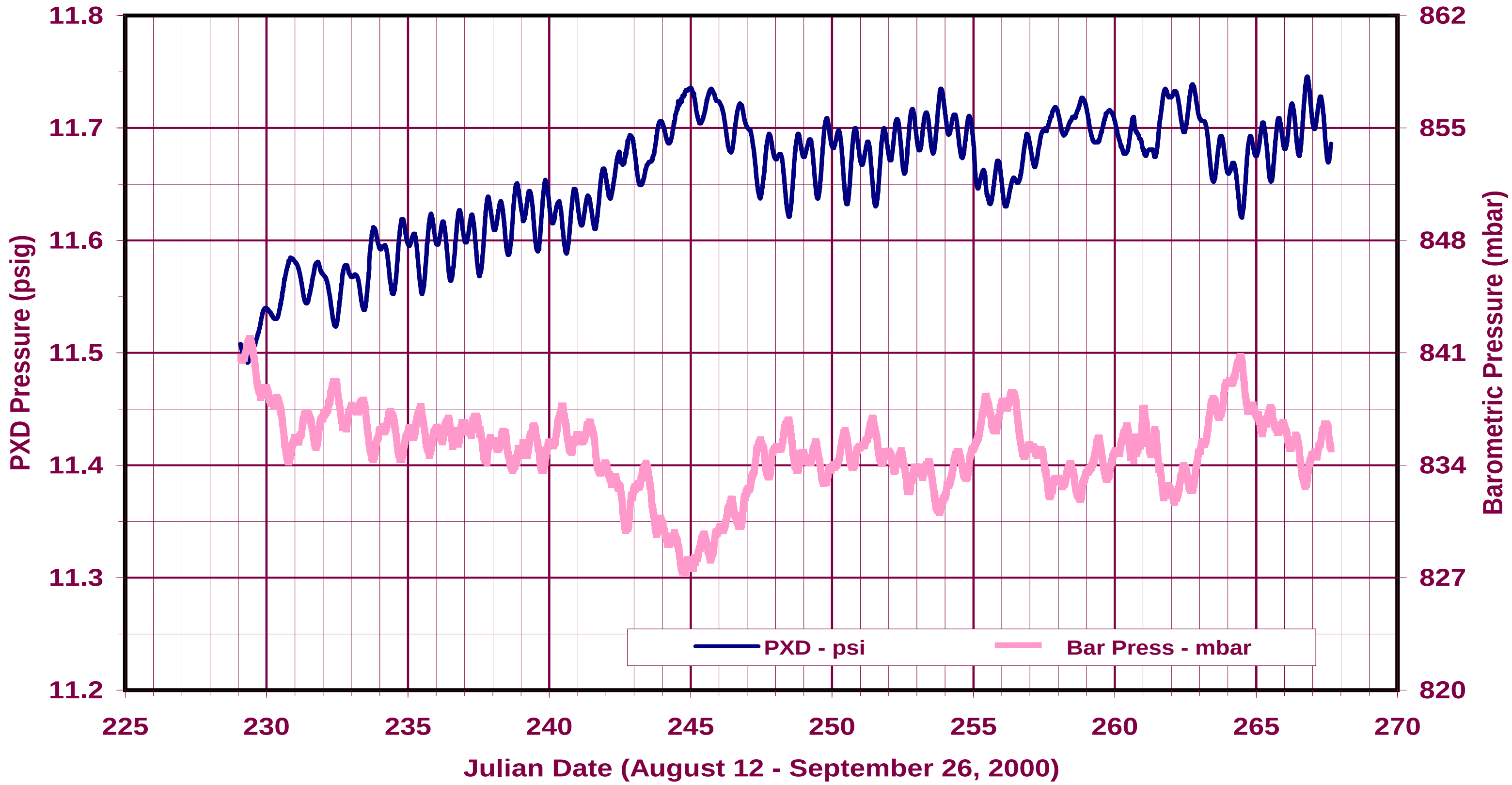
Table A.2-2, Section A.2.0, Appendix A, presents all of the measurements of composite water level (depth-to-water) made during the testing program. The measurements reported in that table were very consistent. There was no further information collected during the testing program to indicate that these values are not representative.

2.2 Barometric Efficiency

The methodology used for determining barometric efficiency involves overlaying a graph of the barometric pressure onto a graph of the water-level record (as pressure transducer [PXD] pressure) after converting the barometric data to consistent units and inverting the trace. The processed barometric trace is then trended and scaled until a best-fit match to the water-level record is determined. The trending removes water level trends not due to bariometric response; the scaling factor is equal to the barometric efficiency. This method assumes that the well is in basic equilibrium with the groundwater head, and that long-term trends in groundwater levels can be represented by a linear trend. The final requirement for applying this methodology to a record is that the record must contain changes in barometric pressure that occur on a scale greater than several days and substantially exceed the magnitude of diurnal and semidiurnal fluctuations. This requirement is necessary to separate the barometric response of the well from earth tide-related responses.

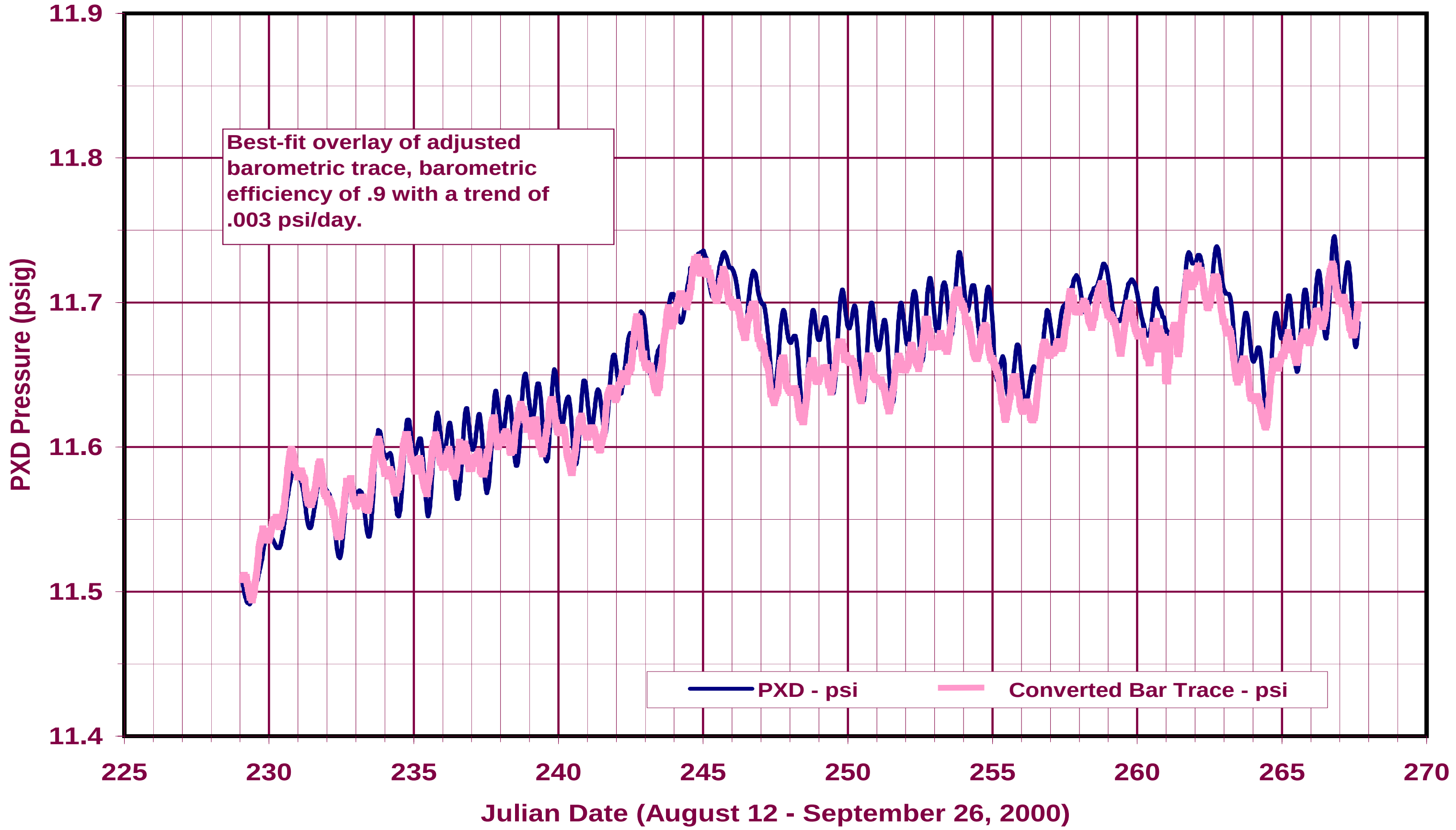
The long-term predevelopment water level monitoring record was the only equilibrium record collected that was suitable for determining barometric efficiency. Figure 2-1 shows the records of both the PXD pressure and barometric pressure during the monitoring period from August 16 through September 24, 1999. Figure 2-2 shows the best match of the converted barometric trace to the PXD pressure record, yielding a barometric efficiency of 0.9. Examination of the record in detail finds that there is both a small-scale and a larger-scale variation with time. Barometric efficiency was derived from the larger-scale variation, which represents the well response to barometric pressure changes. The well response slightly lags the barometric changes. The small-scale variation is composed of semidiurnal oscillations in both the PXD pressure and barometric pressure that track closely. These semidiurnal oscillations probably combine both earth-tide effects, which do not reflect the well response to barometric pressure changes, and barometric changes due to atmospheric heating/cooling cycles. Note that for the small-scale variation, the PXD pressure variation is greater than the corresponding barometric pressure variation.

Figure 2-3 shows the PXD pressure record for the predevelopment water level monitoring record corrected for the barometric pressure variation during that period. The result shows that there was a long-term upward trend in the water level.



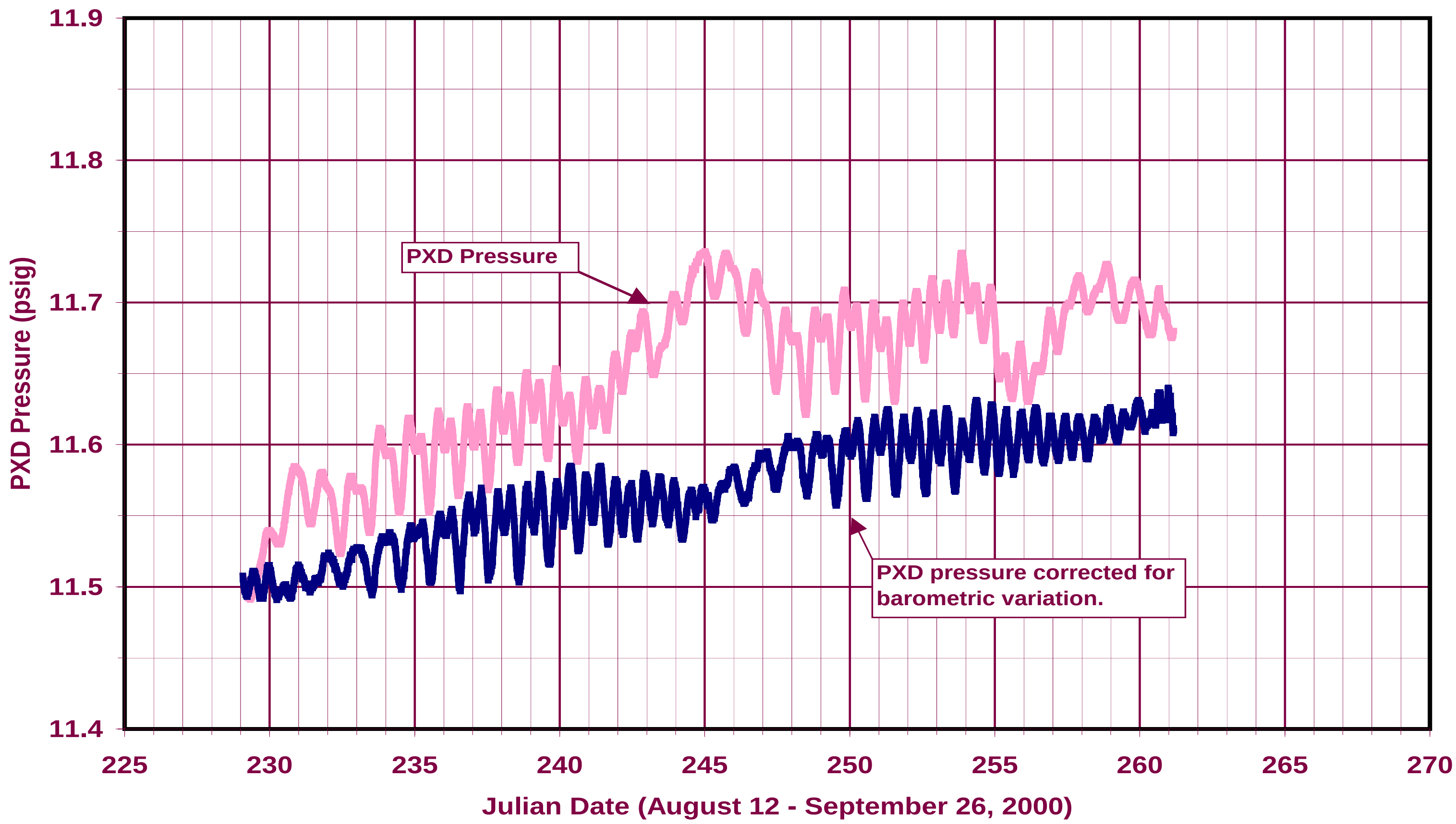
psig - Pounds per square inch gauge
mbar - Millibars
PXD - Pressure transducer

Figure 2-1
Long-Term Water Level Monitoring Record



psig - Pounds per square inch gauge
mbar - Millibars
PXD - Pressure transducer

Figure 2-2
Best-Fit Overlay of Barometric Record



psig - Pounds per square inch gauge
mbar - Millibars
PXD - Pressure transducer

Figure 2-3
Long-Term Record Corrected for Barometric Variation

3.0 Pumping Well Hydraulics

The hydraulic testing of the well has been analyzed to determine the transmissivity of the well and the hydraulic conductivity of the formation. Flow logging was not conducted in this well because the well construction does not provide continuous access to the formation, which is required to measure depth-correlated production. Since flow logging was not conducted, there is no analysis of flow logs or interval-specific hydraulic conductivity. However, a lower bound for the hydraulic conductivity of the formation in the completion interval can be derived based on the full length of the completion interval.

3.1 Well Losses

The drawdown observed in the well is comprised of aquifer drawdown and well losses resulting from the flow of water from the formation into the well and up to the pump. Aquifer drawdown can be observed directly in observation wells near a pumping well, but observation wells were not available near Well ER-18-2. During the WPM-OV testing program, step-drawdown tests were generally conducted and the results are used to determine the linear (laminar) and exponential (turbulent) components of flow losses. The laminar component of the losses are generally considered to approximate the aquifer losses. In conjunction with an analysis of internal flow losses, the well losses could be apportioned along the producing interval and a vertical profile of aquifer drawdown derived. This information can be used to calculate hydraulic conductivity variations using vertically discrete production information.

However, step-drawdown tests were not conducted during Well ER-18-2 testing because the low productivity of the well and slow recovery precluded running such tests properly within time constraints. The more limited hydraulic analysis for this well did not require the information derived from step-drawdown testing. The low production rate for the test also did not warrant the calculation of flow losses for flow through the casing in the analysis. Such losses would have been insignificant relative to the magnitude of the drawdown, and would not be a significant adjustment factor in determining the actual transmissivity and hydraulic conductivity.

3.2 Constant-Rate Test

The constant-rate test provided the data for the hydraulic analysis to determine transmissivity and hydraulic conductivity. Figure 3-1 shows a graph of the constant-rate drawdown and recovery data as processed for analysis. Please refer to Section A.3.3 of Appendix A for information about the test protocol and data collection. The constant-rate test was begun before the well had completely recovered from development due to time constraints. To correct the dataset for the continuing recovery, the raw data was subtracted from the projected recovery curve according to the principle of superposition.

3.2.1 Cooper-Jacob Analysis

Figure 3-2 shows the drawdown portion of the test in log-time so that the detail in the early-time data can be seen. Water flow did not register at the flowmeter until 0.008 days after the start of pumping based on drawdown monitoring. The check valve above the pump did not work properly, and the pump production tubing at the start of the constant-rate test was apparently empty above the well static water level. Based on the volume of the tubing and hose that had to be filled before water reached the flowmeter, the initial pumping rate averaged about 33.9 gallons per minute (gpm) or more than three times the long-term pumping rate, and declined to the 10.2 gpm average long-term pumping rate as water reached the flowmeter and the total dynamic head for pumping stabilized. The high initial pumping rate is the result of the lower head that the pump works against. The effect of this changing pumping rate can be seen in Figure 3-2 as the greater initial drawdown rate. The calculated time for the pumping rate to stabilize is 0.014 days, which corresponds to the transition to the long-term drawdown curve. Casing storage effects lasted until at least 0.36 days.

The assumptions and conditions for applying this analysis are: (1) the aquifer is confined, seemingly infinite in extent, homogeneous, isotropic, and of uniform thickness; (2) the initial piezometric surface is horizontal; (3) the well is fully penetrating and the well receives water through horizontal flow; (4) the well is pumped at a constant rate; (5) flow to the well is unsteady; and (6) the values of u are small ($u<0.01$). While the assumptions and conditions about the aquifer and flow in the aquifer are not perfectly satisfied, it is believed that they were sufficiently satisfied during the step-drawdown test to provide a reasonable result. The test was conducted according to the required protocol.

During the latter part of the pumping period, from approximately day 3 through day 8, the drawdown appears is a straight line in log-time. During this period, the change in head was about 147 feet per log (ft/log) cycle, yielding a transmissivity of 2.45 square feet per day (ft^2/d).

Figure 3-3 shows the recovery data in t/t' log-time and the early-time effect of casing storage and the check valve malfunction. The water in the pump discharge tubing above the water level in the well ran back into the well when the pump was shut down and caused an initial water level rise exceeding actual recovery in the formation. The latter part of recovery followed a straight line in log-time, yielding a transmissivity of 2.5 ft^2/d, almost the same as from the drawdown plot.

3.2.2 Papadopulos-Cooper Solution

The constant-rate test was analyzed using the AQTESOLV® program (HydroSOLVE, Inc., 1996-2000). The Papadopulos-Cooper solution for pumping from a confined aquifer in a large-diameter well was selected as the best model for this test. This solution includes the effect of casing storage, which was significant in this case because of the large well diameter and low pumping rate. The assumptions and conditions for applying this model are the same as those stated for the Cooper-Jacob analysis in Section 3.2.1 with the addition that water is released from storage instantaneously. The test was modeled with two pumping rates; a higher initial rate as described in the previous section and the long-term average constant rate. Recovery was not included in the fitting the solution since it was affected by reinjection of produced water due to malfunction of the check valve. Figure 3-4 shows the best-fit solution honoring the total drawdown. This solution yields a transmissivity (T) of 4.8 ft^2/d.

Since this was a single-well test, the observation well data was the drawdown in the pumping well. As a result, the storage coefficient (S) does not reflect any information about the producing formation. The value for S was set to 0.9, which is the water-filled fraction of the cross-section of the casing where dewatering occurs during drawdown. Using the pumping well drawdown combines both formation losses and well losses in calculating the formation transmissivity. This would underestimate the transmissivity in the proportion of well losses to total drawdown. However, at the very low pumping rate used for this test, especially with respect to the great length of formation open to production, well losses would be expected to be very low. With respect to the great amount of drawdown that occurred, the proportion of well losses should be negligible.

There is no information with which to determine the variation of production of water from the formation in the completion interval water during testing; therefore, it must be generally assumed that the entire exposed formation produces uniformly. This assumption allows computation of hydraulic conductivity that should be considered a general lower bound. The thickness of the formation in the completion interval is 1,136 ft, yielding an estimate of hydraulic conductivity of 0.004 feet per day (ft/d).

3.2.3 Moench Dual-Porosity Solution

The constant-rate test was also analyzed using the Moench solution for pumping from a fractured aquifer with slab-shaped blocks (1984 [HydroSOLVE, Inc., 1996-2002]). The assumptions and conditions for this model are the same as the Papadopulos-Cooper model with the addition that the aquifer is fractured and acts as a dual-porosity system consisting of low conductivity primary porosity blocks and high conductivity secondary porosity fractures. This is consistent with characterization of the formation during drilling.

This model has many parameters that interact and can produce a variety of solutions, especially without observation well data. In order to determine the most appropriate solution with respect to K (fracture hydraulic conductivity), values for

K' (matrix hydraulic conductivity) and Ss and Ss' (fracture and matrix specific storage) were constrained as much as possible. Ranges of possible values for those parameters were determined based upon typical properties for the rock type. Specific storage values were based on typical porosity and compressibility values.

A spacing of 3.3 ft (approximately 1 m) was used since specific fracture information was not available. Figure 3-5 shows the best fit solution honoring total drawdown. This solution fits the major characteristics of the drawdown response better than the Papadopulos-Cooper solution. The estimated fracture hydraulic conductivity is 0.002 ft/d. Using the full length of the completion interval to calculate transmissivity yields 1.9 ft^2/d. This compares to 4.8 ft^2/d for the Papadopulos-Cooper model and 2.5 ft^2/d for the Cooper-Jacob model. The specific storage values for this solution are very high, especially the matrix specific storage. However, these values are interactive with the well radius used for the solution, and since the drawdown data from the production well was used, these results are unreliable.

3.3 Comments on the ER-18-2 Well Design

The single-completion well design of this well extending over great vertical depth does not allow vertically-discrete measurements of head, so the vertical gradient cannot be determined. The use of a few screens located together in the middle of the completion interval does not provide continuous access to the formation to allow flow logging to determine the profile of depth versus production. Consequently, the values for transmissivity and hydraulic conductivity determined from analysis of the constant-rate test are necessarily lower bounds, and the distribution of production from the formation is undefined.

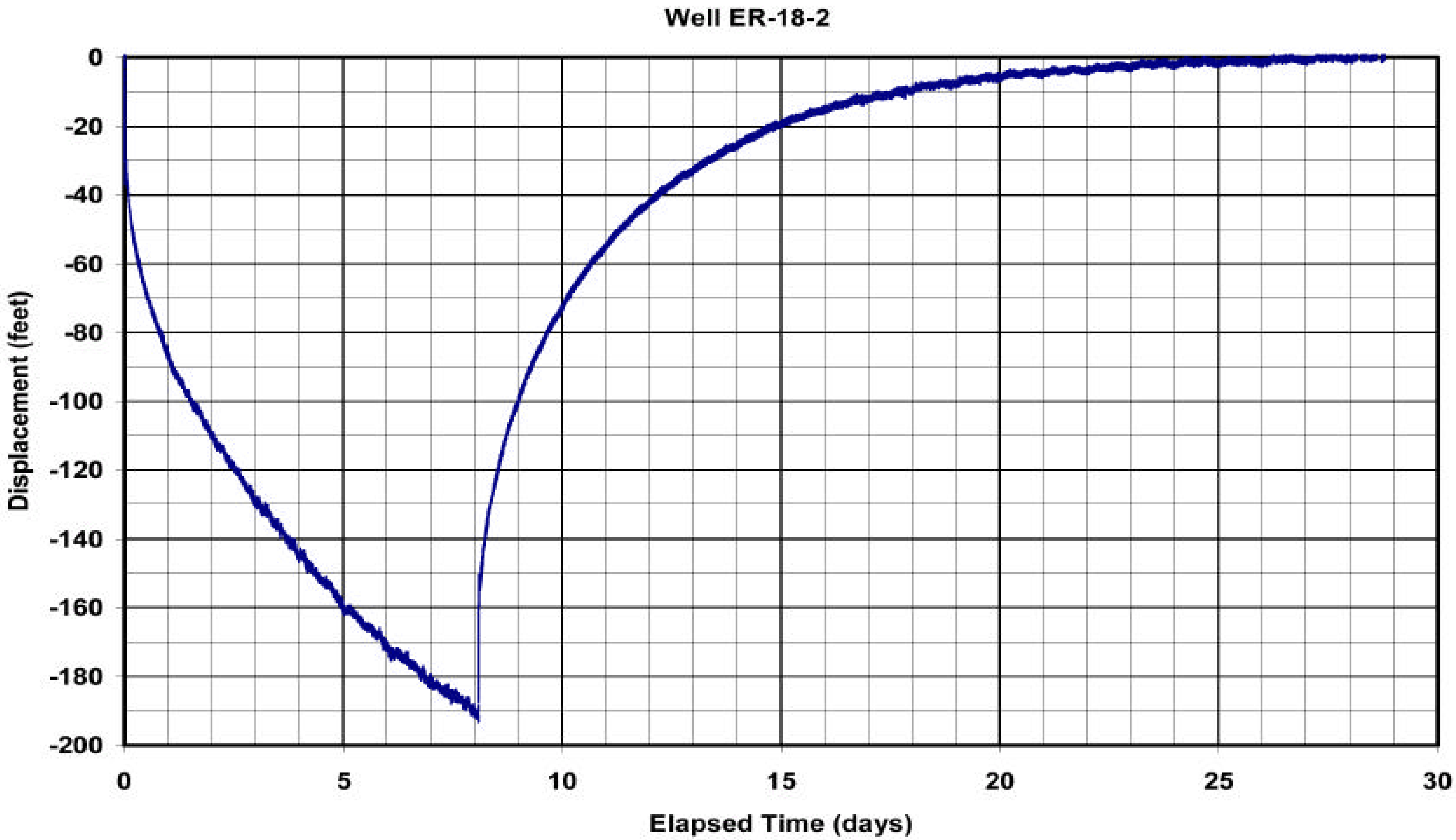


Figure 3-1
Constant-Rate Test Corrected for Recovery Trend

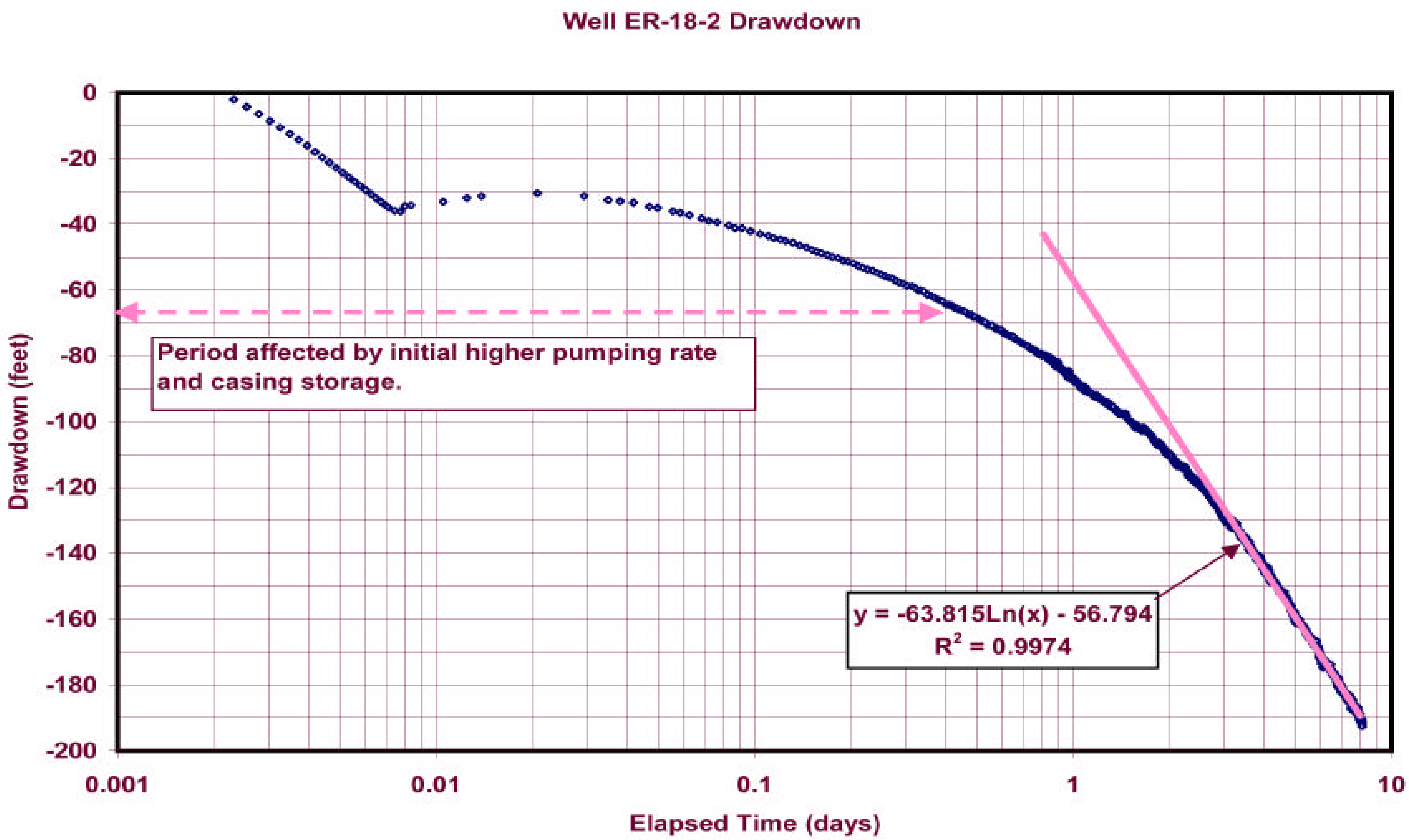


Figure 3-2
Drawdown Record Detail and Cooper-Jacob Analysis

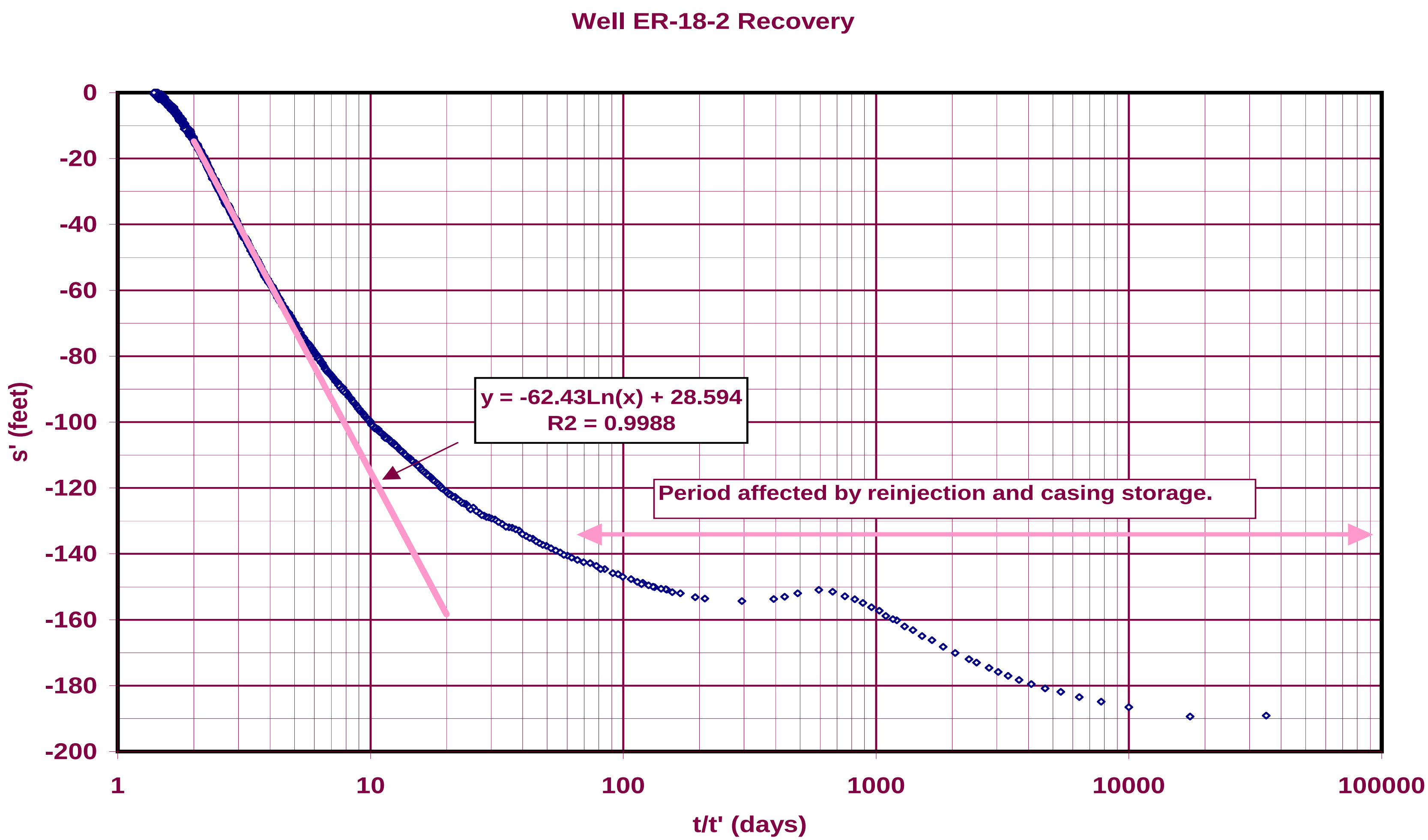


Figure 3-3
Recovery Record Detail and Cooper-Jacob Analysis

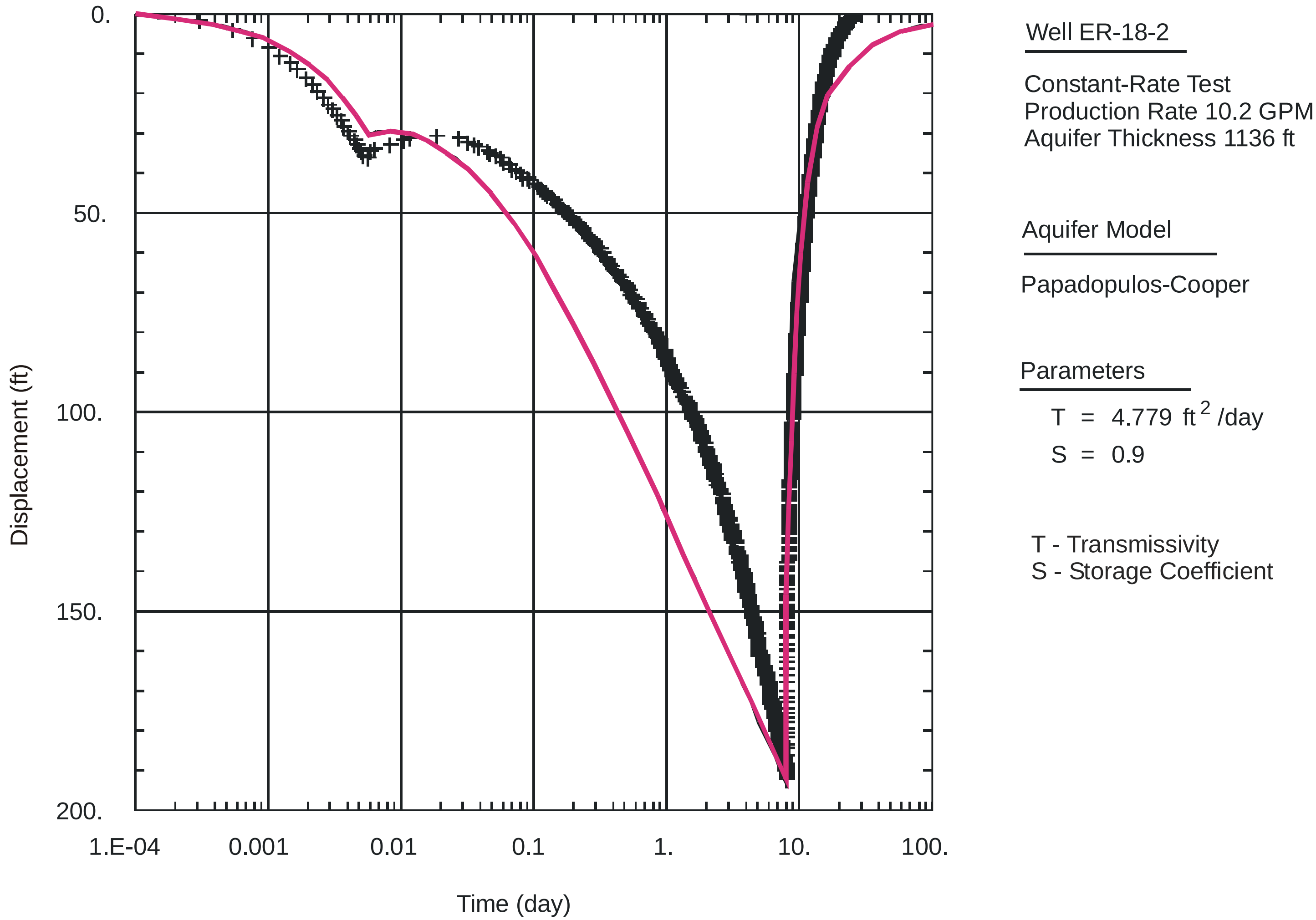
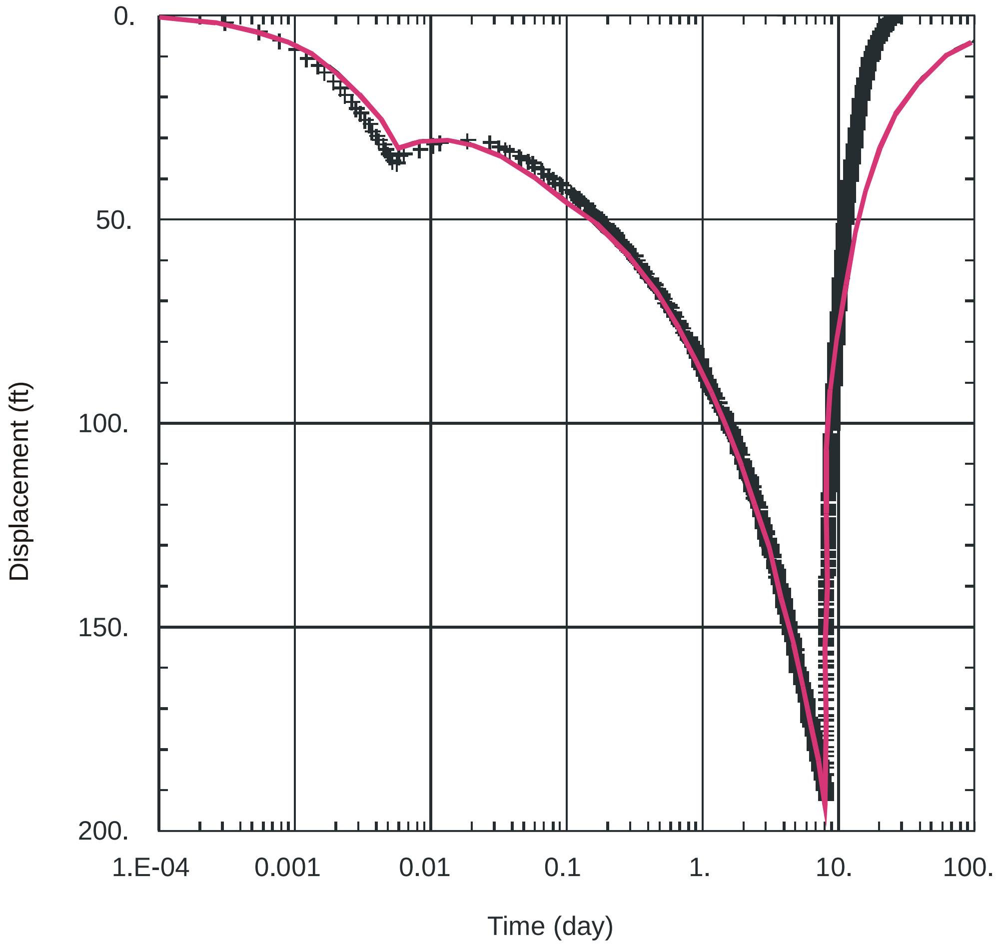


Figure 3-4
Papadopulos-Cooper Solution for the Constant-Rate Test



Well ER-18-2

Constant-Rate Test
Production Rate 10.2 GPM
Aquifer Thickness 1136 ft

Aquifer Model

Dual-Porosity
Moench w/slab blocks

Parameters

K = 0.001679 ft/day
Ss = 0.0003835 ft^{-1}
K' = 0.06667 ft/day
Ss' = 0.0187 ft^{-1}
Sw = 0.
Sf = 0.004751

K - Fracture Hydraulic Conductivity
Ss - Fracture Specific Storage
K' - Matrix Hydraulic Conductivity
Ss' - Matrix Specific Storage
Sw - Well Skin
Sf - Fracture Skin

Figure 3-5
Moench Dual-Porosity Solution

4.0 Groundwater Chemistry

This section presents an evaluation of the analytical results for a groundwater characterization sample collected during well development and hydraulic testing activities at Well ER-18-2. It was determined that this well would be adequately characterized with only a composite groundwater characterization sample. Discrete bailer samples were not collected since the well has only one completion interval and the screens were only distributed in a short section of the interval. The purpose of a composite groundwater sample is to obtain a sample that is representative of as much of the well as possible. The results of the groundwater characterization sample were used to examine the overall groundwater chemistry of the well and to compare this groundwater chemistry to that of other wells in the area. The groundwater chemistry results were evaluated to establish whether Well ER-18-2 was sufficiently developed to restore natural groundwater quality in the formation around the well.

4.1 Discussion of Groundwater Chemistry Sampling Results

The groundwater chemistry of Well ER-18-2 will be discussed in this section and then compared to the groundwater chemistry of other nearby sites.

4.1.1 ER-18-2 Groundwater Characterization Sample Results

On March 21, 2000, beginning at 10:45 AM, a composite groundwater characterization sample (#18-2-032100-1) was collected from the wellhead sampling port directly into sample bottles. A constant production rate of 10.2 gpm was maintained during the sampling event; the same rate used during the constant rate-pumping test. At the time of sampling, approximately 223,000 gallons of groundwater as recorded by the magnetic flowmeter had been pumped from the well during development and testing activities (see Section A.2.10.2 of Appendix A). The results from the composite groundwater sample are presented in Table ATT.3-1 and Table ATT.3-2 in Attachment 3 of Appendix A.

In Table ATT.3-1 it can be seen that sodium is by far the predominate cation with lesser amounts of calcium and potassium. It can also be seen from the table that bicarbonate is the predominate anion with lesser amounts of sulfate and chloride. Further inspection of the table reveals that the composite groundwater sample has a slightly basic pH of 7.9, a total dissolved solids value of 910 milligrams per liter (mg/L), and a relatively high 19 mg/L concentration of dissolved silica. Examination of the table also reveals that a significant number of the analytes in the “Metals” and the “Radiological Indicator Parameters” sections of the table were not detected at the given detection limits, as indicated by the 'U' qualifier.

Inspection of the “Age and Migration Parameters” section of the table reveals several interesting things. For example, Lawrence Livermore National Laboratory (LLNL) (2001) stated that the helium-4 (^4He) concentration (1.70×10^{14} atoms/milliliter [mL]) in Well ER-18-2 is approximately one order of magnitude greater than previously observed in wells and springs of the Pahute Mesa-Oasis Valley flow system. Elevated ^4He concentrations may be derived from the *in situ* α-decay of naturally occurring radioactive elements in the rock, and generally indicate long crustal residence times. LLNL (2001) also stated that Well ER-18-2 contains anomalously high levels of ^3He (6.8×10^8 atoms/mL). The $^3He/^4He$ ratio ($R = 4.01 \times 10^{-6}$) is greater than the atmospheric ratio ($R_a = 1.38 \times 10^{-6}$), giving a R/R_a value of 2.90. In the absence of tritium, high R/R_a values suggest the presence of a mantle-derived ^3He component. Elevated R/R_a values have also been noted for wells and springs in Oasis Valley. A possible explanation for these helium-isotope inconsistencies is that major faults in the area have roots extending deep into the crust providing a conduit for the upward flow of deep fluids, and Well ER-18-2 is located along the structural margin of the Timber Mountain caldera (LLNL, 2001). It can also be seen from the table that the carbon-14 (^{14}C) value of dissolved inorganic carbon is 1.6 percent modern, and LLNL (2001) stated that this value is lower than previously observed at other locations in the Pahute Mesa-Oasis Valley flow system. This results in an uncorrected ^{14}C apparent age of 34,081 years. Further inspection of the data in Table ATT.3-1, Attachment 3, Appendix A reveals that Well ER-18-2 also contains a high dissolved inorganic carbon (DIC) concentration and a high $\delta^{13}C$ value. LLNL (2001) stated that low ^{14}C, high $\delta^{13}C$, and high DIC values are generally observed in groundwater from the Paleozoic carbonate aquifer. This is interesting because Ca^{2+} is usually the dominant cation in carbonate aquifer groundwaters whereas Na^+ is the dominant cation in the Well ER-18-2 groundwater. LLNL (2001) states that if the water originated from a deep carbonate aquifer, it must have chemically evolved once it entered the volcanic aquifer. They state that one possible mechanism for this is ion exchange of Ca^{2+} for Na^+ on clay, zeolite, or feldspar minerals. However, LLNL (2001) stated that an alternate possibility is that the groundwater itself is not of “deep” origin, but that carbon dioxide (CO_2) and helium gas are rising into the groundwater along deep structural features.

Table ATT.3-2, Attachment 3, Appendix A presents the results of the colloid analyses for Well ER-18-2. It can be seen in the table that the composite groundwater characterization sample had a total colloid concentration of 4.76×10^7 particles per milliliter (particles/mL) for colloids in the size range of 50 to 1,000 nanometers (nm). The table also reveals that the smaller particle size ranges have the greatest colloid concentrations. In fact, it can be seen from the table that the first five particle size ranges account for approximately 75 percent of the total colloid concentration for the entire sample. Further inspection of the table reveals that the colloid concentrations, in general, decrease at a fairly uniform rate as the particle size range increases.

4.1.2 Radionuclide Contaminants

Radiological indicator parameters were not detected in the groundwater characterization sample from Well ER-18-2.

4.1.3 Comparison of ER-18-2 Groundwater Chemistry to Surrounding Sites

Table 4-1 presents the groundwater chemistry data for Well ER-18-2 and for samples recently collected from sites in close proximity to Well ER-18-2. Shown in the table are the analytical results for selected metals, anionic constituents, field measurements, and several radiological parameters. The data in this table were used to construct the trilinear diagram shown in Figure 4-1. Trilinear diagrams contain three different plots of major-ion chemistry and are used to show the relative concentrations of major ions in the groundwater. The triangular plots in Figure 4-1 show the relative concentrations of major cations and anions. The diamond-shaped plot in the center of the figure combines the information from the adjacent cation and anion triangles. The concentrations in all three plots are expressed in percent milliequivalents per liter and are used to illustrate various groundwater chemistry types and the relationships that may exist between the types. It can be seen from the figure that the dominant cation type for Well ER-18-2 and the surrounding sites is Na+K, with minor amounts of calcium and magnesium. It can be seen that the cation concentrations for most of the sites tend to plot fairly close to each other. However, inspection of the anion diagram reveals that there is a greater spread among the anionic constituents than seen in the cation diagram. Even though there is a greater spread among the sites' anion concentrations, almost all of the sites can be classified as bicarbonate type water with increasing amounts of sulfate and chloride. Figure 4-1 shows that the groundwater chemistry for Well ER-18-2 is of similar type to surrounding sites, at least in terms of the major ion constituents, but even more of an end member.

The data in Table 4-1 were also used to construct Figure 4-2. The figure shows the stable oxygen and hydrogen isotope composition of groundwater for Well ER-18-2 and selected sites within ten miles of Well ER-18-2. Also plotted on Figure 4-2 are the weighted averages of precipitation for various sites on Buckboard Mesa, Pahute Mesa, Rainier Mesa, and Yucca Mountain, based on data from Ingraham et al. (1990) and Milne et al. (1987). As expected, the figure shows the precipitation data lie along the local and global meteoric water lines of Ingraham et al. (1990) and Craig (1961), respectively. However, it can be seen from the figure that there is a significant amount of scatter associated with the stable isotopic compositions for groundwater from Well ER-18-2 and the surrounding sites. Inspection of the data in Table 4-1 and Figure 4-2 finds that groundwater from at least one site (Well ER-30-1) has a stable isotopic composition that is likely influenced by atmospheric recharge as evidenced by its stable isotopic composition plotting near precipitation data. Groundwater at another site (Well WW-8) appears to be slightly influenced by recharge, but not to as great as an extent as Well ER-30-1. However, the stable isotopic compositions of wells ER-18-2, UE-18r, and U-19v suggest no evidence for recent recharge. In fact, a comparison between the stable isotopic composition of precipitation and groundwater at Well ER-18-2 indicates that groundwater was recharged at higher

Table 4-1
Groundwater Chemistry Data for Well ER-18-2 and Surrounding Sites

Analyte	ER-18-2		ER-30-1-1	ER-30-1-2	U-19az	U-19v (Almendro)	U-20n PS#1 DDH (Cheshire)	UE-18r	UE-18t	UE-19fs	UE-20n #1	WW-8
	(Wellhead Composite)											
	Total	Dissolved										
Metals (mg/L)												
Aluminum (Al)	U 0.097	U 0.084	< 0.0532	< 0.0532			0.97	< 0.06		0.02	4.6	0.0022
Arsenic (As)	0.044	0.04	0.009	0.01			J 0.0089	< 0.1				0.00171
Barium (Ba)	B 0.015	B 0.015	B 0.0046	B 0.0046			< 0.02	20				0.00009
Cadmium (Cd)	UJ 0.005	UJ 0.005	< 0.0024	< 0.0024			< 0.002					< 0.000016
Calcium (Ca)	5.4	5.6	5.64	5.32	19.9		3	21.5	22.2	11	7	7.8
Chromium (Cr)	U 0.01	B 0.00065	B 0.0054	< 0.0041			< 0.01				0.36	0.00018
Iron (Fe)	U 0.099	U 0.081	0.0964	0.209		0.06	0.58	< 0.02			480	0.0125
Lead (Pb)	U 0.003	U 0.003	0.006	B 0.0013			< 0.003	< 0.01				0.000033
Lithium (Li)	0.26	0.26	B 0.0647	B 0.0616			0.11	0.08		0.02		0.029
Magnesium (Mg)	UJ 0.054	UJ 0.051	0.555	0.502	1.8		0.45	0.92	1	1.6	0.7	1.23
Manganese (Mn)	0.023	0.023	0.0101	0.015		0.004	0.15	< 0.03		0.03		0.0012
Potassium (K)	3.7	3.7	0.938	1.235	5.78		B 2	3.49	8.16	3	0.5	3.23
Selenium (Se)	U 0.005	U 0.005	< 0.01	< 0.01			< 0.005	< 0.01				0.00074
Silicon (Si)	19	19	11	11.3			25.6	21.6		56		
Silver (Ag)	U 0.01	U 0.01	< 0.0059	< 0.0059			< 0.01					0.00001
Sodium (Na)	340	350	65.11	59.6	102		61	73.1	141	29	1.6	30.8
Strontium (Sr)	0.21	0.21	B 0.019	B 0.0193		0.0009	B 0.015	0.08		0.02		0.0059
Uranium (U)	U 0.2	U 0.2	< 0.106	< 0.106		0.001	< 0.3	0.0035		0.0021		0.00035
Mercury (Hg)	B 0.00011	U 0.000077	< 0.0001	< 0.0001			< 0.0001					
Inorganics (mg/L)												
Chloride (Cl)	13		6.75	6.71	94.4		13.8	6.9	64.4	6.3		7.1
Fluoride (F)	13		1.39	1.46			4.8	3		3.6		0.7
Bromide (Br)	J 0.12		< 0.25	< 0.25			0.4					0.054
Sulfate (SO4)	55		13.2	12	18.7		34	23	10.8	9		15
pH	J 7.9		8.79	8.93	7.97	8.26	8.8	8.05	8.63	8.1		7.37
Total Dissolved Solids (TDS)	J 910		186	200		93	251	208	776	186		99.8
Carbonate (CO3) as CaCO3	U 100		18.1	20.1								
Bicarbonate (HCO3) as CaCO3	730		113	85	145	60	88	227	331	86		77.8
Age and Migration Parameters (pCi/L) - unless otherwise noted												
Carbon-13/12 (per mil)	+0.5 +/- 0.2		-7.4	-8.2		-9.2		-1.4				-9.5
Carbon-14, Inorganic (pmc)	1.6		44.68	44.5		21	160450	6.7+/-0.06				24.86
Carbon-14, Inorganic age (years)*	34081											
Chlorine-36	1.33E-04						0.4966	0.0001342				0.0001796
Helium-3/4, measured value (ratio	4.01E-06		9.77E-07	9.79E-07			0.2168					
Helium-3/4, relative to air (ratio)	2.9		0.71	0.71			160000	1.128+/-2				
Oxygen-18/16 (per mil)	-14.6 +/- 0.2		-11.8	-11.9		-14.7	-15	-14.7				-13.5 +/- 0.2
Strontium-87/86 (ratio)	0.708606 +/- 0.00003		0.70829	0.70825			0.71009 +/- 2E-5	0.70909				0.71027
Uranium-234/238 (ratio)	0.000695		0.000135	0.000142			0.000223					
Hydrogen-2/1 (per mil)	-109 +/- 1.0		-89	-91		-109	-124	-110				-103 +/- 1
Radiological Indicator Parameters-Level I (pCi/L)												
Tritium	U 110 +/- 170		-220	-154	50.016	200000000	J 69409830	8 +/- 1.9	< 7260			< 7720
Gross Alpha	J 51.8 +/- 8.1						< 22.3509					< 11.1
Gross Beta	U 2.4 +/- 2.7						J 1246.545			3.2		34.9 +/- 24.5%
Radiological Indicator Parameters-Level II (pCi/L)												
Carbon-14	U 310 +/- 200						< 304					
Strontium-90	U 0.33 +/- 0.19		0.31	0.29			J 202.2122					< 3.09
Plutonium-238	U -0.004 +/- 0.016		-0.01	0.006								< 0.181
Plutonium-239	U -0.002 +/- 0.016			-0.001								< 0.203
Iodine-129	U -0.04 +/- 0.66		0.106	0.149			< 0.714					
Technetium-99	U 4.5 +/- 2.4		1.4	1.51		< 5		< 5				< 5

U = Result not detected at the given minimum detectable limit or activity.
B = The result is less than the contract-required detection limit, but greater than the instrument detection limit.
J = The result is an estimated value.
N/A = Not Applicable for that sample
mg/L = Milligrams per liter pCi/L = Picocuries per liter
pmc = Percent modern carbon
* = The carbon-14 age presented is not corrected for reactions along the flow path.

elevations, at higher latitudes, or in a different climatic regime than exists today. However, based on the data available, the stable isotopic composition of Well ER-18-2 appears to be typical for the area.

4.2 Restoration of Natural Groundwater Quality

A primary purpose for well development was to restore the natural groundwater quality of the completion intervals so that groundwater samples would accurately represent the water quality of the producing formations. The formation exposed in each completion interval had potentially been affected by drilling and completion operations as well as crossflow from other completion intervals occurring under the natural head gradient.

4.2.1 Evaluation of Well Development

Water quality monitoring of the well discharge was conducted during pumping to provide information on water chemistry and to indicate when natural groundwater conditions predominate in the pumping discharge. The concentrations of certain geochemical parameters (e.g., pH, turbidity, dissolved oxygen) were expected to decline and stabilize as development progressed. This would indicate natural groundwater quality as opposed to water affected by drilling and completion activities. These results from the water quality monitoring were examined in a previous report (Appendix A), but the composite groundwater characterization sample analyses can also help to address the effectiveness of well development. During drilling operations for Well ER-18-2, the makeup water was tagged with a lithium bromide (LiBr) tracer to help determine such things as the static water level and the water production during drilling. The makeup water was tagged with LiBr in concentrations ranging from 10-50+ mg/L. This relatively high concentration of bromide ions (Br^-) injected into the well bore also provides another means to further ascertain the effectiveness of the well development. If the groundwater characterization sample contained a relatively high bromide concentration after well development, it would suggest that the development was not sufficient to achieve natural water quality. It can be seen in Table A.3-1, Attachment 3, Appendix A that the dissolved concentration of bromide for the groundwater characterization sample was approximately 0.12 mg/L. This value is more than two orders of magnitude lower than the concentration of bromide injected into the well. Table 4-1 shows a high Br^- concentration of 0.4 mg/L and a low of 0.054 mg/L for other nearby wells. The relatively low Br^- ion concentration in Well ER-18-2 likely indicates that the well was sufficiently developed to restore groundwater quality back to approximately its natural condition. This conclusion only pertains to the formation producing water during pumping.

4.2.2 Evaluation of Flow Between the Completion Intervals

Due to the fact that the well has only one completion interval and that the completion interval only penetrates the Ammonia Tanks Tuff (Appendix A), there is no information on vertical flow in the well. Consequently, there is no discussion on the effects of any such flow on water chemistry in the completion interval.

4.2.3 Source Formation(s) of Groundwater Samples

Well ER-18-2 was drilled in May 1999 and completed across 1,136 ft of formation from a depth of 411.9 meters (m) (1,351.4 ft) to a total depth of 758 m (2,487 ft). Groundwater is produced through three slotted sections of casing located at depths of 588 to 597 m (1,930 to 1,960 ft), 610 to 619 m (2,000 to 2,030 ft), and 631 to 640 m (2,071 to 2,101 ft) below the ground surface. The primary stratigraphic formation penetrated by the well is the Ammonia Tanks Tuff. As a result, the source formation for the groundwater characterization sample is attributed to the mafic-rich Ammonia Tanks Tuff.

4.3 Representativeness of Water Chemistry Results

The information presented indicates that the single completion interval of Well ER-18-2 has been substantially restored to natural formation water quality, and consequently groundwater samples from this well are fairly representative of the formation water. With the exception of several isotopic constituents, concentrations of chemical parameters are within the range expected for the groundwater environment at the Nevada Test Site.

4.4 Use of ER-18-2 for Future Monitoring

Well ER-18-2 has only one completion interval; therefore, all of the water produced can be attributed to that interval. However, as discussed in Section 3.0, there is no information with which to determine the vertical profile of production from this long completion interval. Consequently, it is not known if the entire vertical extent of the completion interval produces water or whether production is more limited. The results from monitoring this well for vertically discrete contaminants would be uncertain with regard to the entire vertical extent of the completion interval.

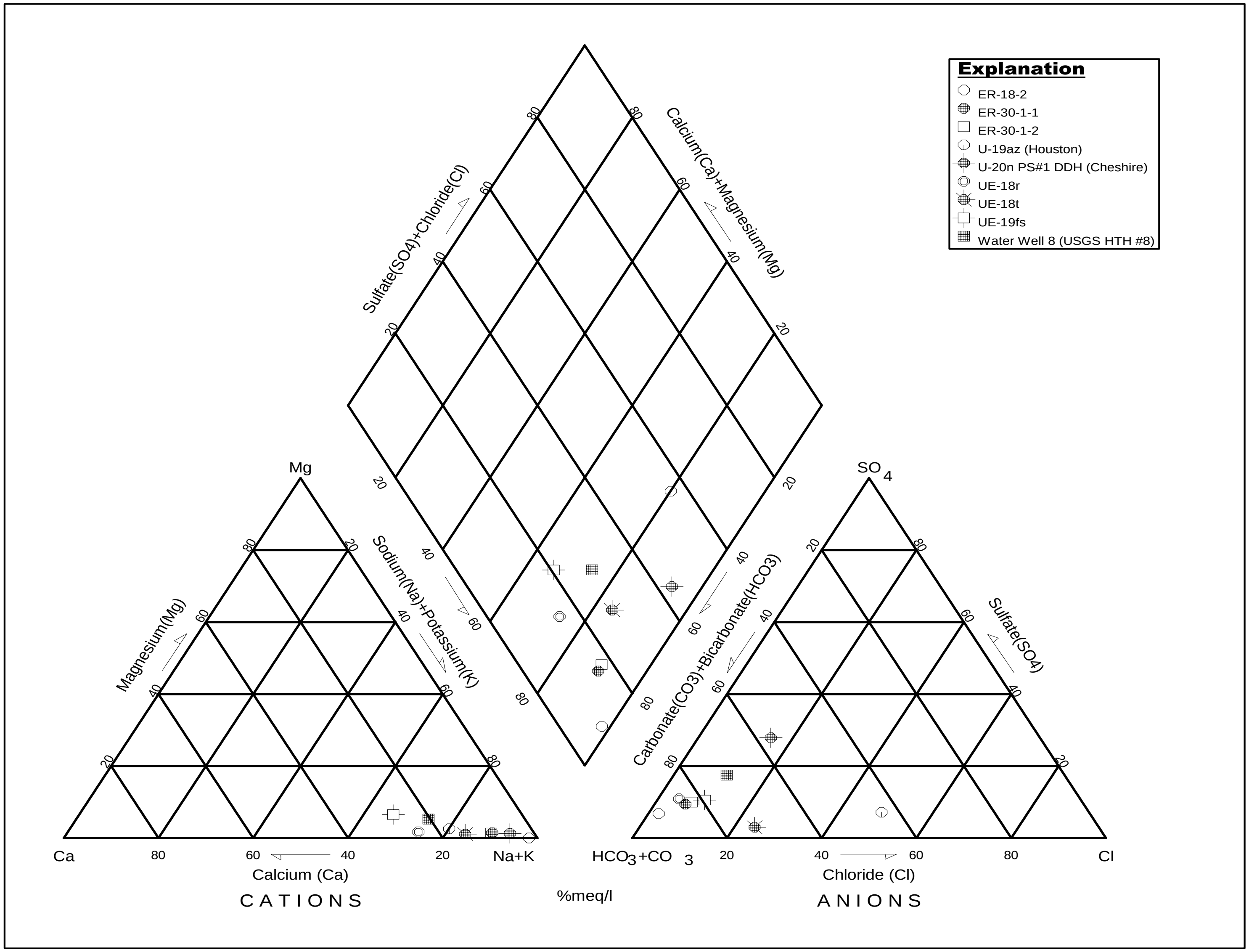


Figure 4-1
Piper Diagram of Groundwater Chemistry

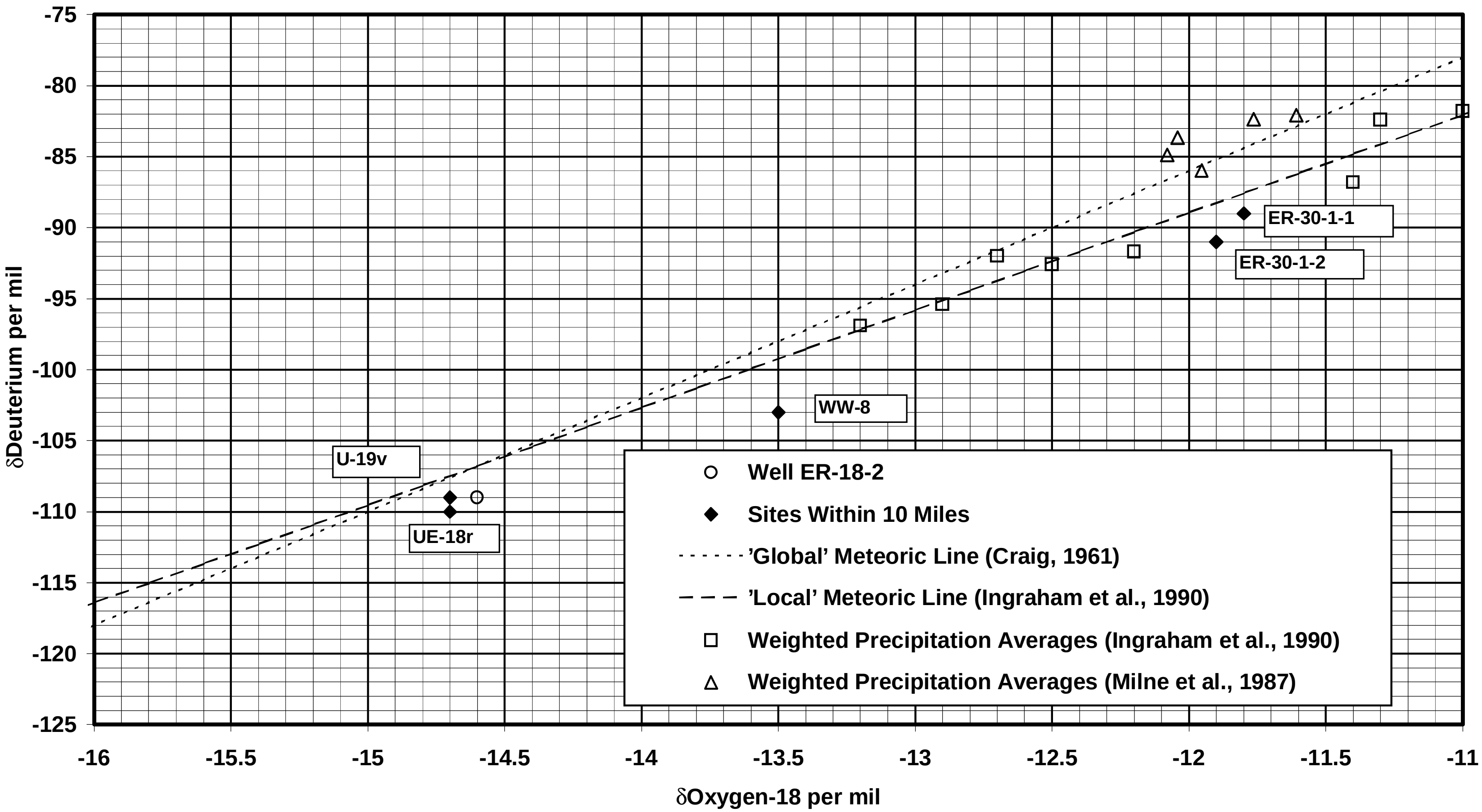


Figure 4-2
Stable Isotope Composition of Groundwater for Well ER-18-2 and Nearby Sites

5.0 References

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Appendix A

Western Pahute Mesa - Oasis Valley Well ER-18-2 Data Report for Development and Hydraulic Testing

A.1.0 Introduction

Well ER-18-2 is one of seven groundwater wells that were completed as part of Fiscal Year (FY) 1999 activities for the U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office (NNSA/NV), Underground Testing Area (UGTA) Project. Figure A.1-1 shows the location of the Western Pahute Mesa - Oasis Valley (WPM-OV) wells. Hydraulic testing and groundwater sampling were conducted at Well ER-18-2 to provide information on the hydraulic characteristics of hydrostratigraphic units (HSUs) and the chemistry of local groundwater. Unlike the other WPM-OV wells in this drilling program, Well ER-18-2 is constructed with a single completion interval. Consequently, the testing program for this well was more limited.

This document presents the data collected during well development and hydraulic testing for Well ER-18-2 and the analytic results of groundwater samples taken during this testing.

The objectives of the development and testing program were:

1. Increase the hydraulic efficiency of the well.
2. Restore the natural groundwater quality.
3. Determine the hydraulic parameters of the formations penetrated.
4. Collect groundwater characterization samples to evaluate composite chemistry (wellhead sample).

Well ER-18-2 was the third of the WPM-OV wells to be developed and tested. Activities began February 7, 2000, and were completed in mid-April 2000. Testing activities included a constant-rate pumping test, monitoring of water quality parameters, and sampling of the composite discharge.

A.1.1 Well ER-18-2 Specifications

The drilling and completion specifications for Well ER-18-2 were obtained from a draft of the *Completion Report for Well ER-18-2* (Townsend, 2002). This report also provided the lithologic and stratigraphic interpretation for this well.

A.1.2 Development and Testing Plan

Well development consisted of pumping water from the well to clean out sediment and drilling-introduced fluid in order to restore the natural productivity and the natural water quality of the formation(s) in the completion interval. The well was pumped at as high a rate as possible and surged to the extent possible to promote the removal of lodged and trapped sediment. Both hydraulic response and water quality during development were assessed to evaluate the status of development.

The testing program was structured to provide the most complete assessment of the hydrology and groundwater quality of the formation(s) accessed by the well completion. The elements of the testing can be found in *Well Development and Hydraulic Testing Plan for Western Pahute Mesa - Oasis Valley Wells*, Rev. 0, November 1999 (WDHTP) (IT, 1999d).

Testing activities for this well included: (1) a constant-rate pumping test to determine hydraulic parameters for the formation the well is completed in, and (2) a groundwater characterization sample of water produced during pumping after development. The testing program for this well was more limited than for other wells in this program because: (1) the single interval completion did not provide discrete access to multiple zones or formations, (2) the completion configuration did not provide continuous access to the formation in the completion interval, and (3) the pump had to be located in the 5 1/2-inch (in.) casing precluding access to the completion interval with logging and sampling tools during pumping.

A.1.3 Schedule

The generic schedule developed for the WPM-OV WDHTP is listed below:

1. Installation of well development and hydraulic testing equipment (estimated 2 days).
2. Well development (estimated 7 days).
3. Water level recovery (estimated 5 days).
4. Constant-rate pumping test and wellhead composite sampling (estimated 10 days).
5. Water level recovery (estimated 5 days).
6. Water level measurement (estimated 1 day).

Several elements of this generic schedule do not apply to this well because of the reduced complexity of the completion, as previously explained. The history of the testing program at Well ER-18-2 is shown in Table A.1-1. Some additional time was required during the development phase for lowering the pump to accommodate the excessive drawdown that occurred during pumping.

Table A.1-1
General Schedule of Work Performed at ER-18-2

Activity	Start	Finish
Site mobilization	2/7/2000	2/14/2000
Install access line and pump string	2/8/2000	2/14/2000
Check pump functionality	2/15/2000	2/15/2000
Initial pumping and well development	2/15/2000	2/16/2000
Pump shutdown for modifications	2/17/2000	2/23/2000
Lower pump and check pump functionality	2/23/2000	2/24/2000
Develop well and conduct step-drawdown testing	2/24/2000	3/1/2000
Shutdown pump and monitor for recovery and pretest	3/1/2000	3/13/2000
Constant-rate test	3/13/2000	3/21/2000
Groundwater characterization sampling	3/21/2000	3/21/2000
Pump shutdown/monitor recovery	3/21/2000	4/11/2000
Demobilize from site	3/21/2000	4/11/2000

A.1.4 Governing Documents

Several documents govern the field activities presented in this document. The document describing the overall plan is the WDHTP (IT, 1999d). The implementation of the testing plan is covered in *Field Instructions for Western Pahute Mesa - Oasis Valley Well Development and Hydraulic Testing Operations*, Rev. 0, December 1999 (IT, 1999b), as modified by Technical Change No. 1, dated December 22, 1999. This document calls out a variety of Detailed Operating Procedures (DOPs) (IT, 1999a) and Standard Quality Practices (SQPs) (IT, 2000), specifying how certain activities are to be conducted. The work was carried out under the *Site-Specific Health and Safety Plan for Development, Testing, and Sampling of Clean Wells, 1999* (IT, 1999c). Specifications for the handling and analyses of groundwater samples are listed in the *Underground Test Area Quality Assurance Project Plan*, Rev. 2 (DOE/NV, 1998).

A.1.5 Document Organization

This data report is organized in the following manner:

- Section A.1.0: Introduction
- Section A.2.0: Summary of Development and Testing. This chapter presents mostly raw data in the form of charts and graphs. Methodologies for data collection are described, as well as any problems that were encountered. Data is presented under the following topics: water level measurements, interval-specific head measurements, pump installation, well development, flow logging during pumping, constant-rate pumping

test, water quality monitoring, groundwater sampling, thermal-flow logging and ChemTool logging.

- Section A.3.0: Data Reduction and Review. This chapter further refines and reduces the data to present specific results that are derived from the program objectives. Information is presented on vertical gradients and borehole circulation, intervals of inflow into the well, the state of well development, reducing the data from the constant-rate test, changes in water quality parameters, and representativeness of groundwater samples.

- Section A.4.0: Environmental Compliance. This chapter records the results of the tritium and lead monitoring, fluid disposition, and waste management.

- Section A.5.0: References.

- Attachment 1: Manufacturer Pump Specifications.

- Attachment 2: Water Quality Monitoring - Grab Sample Results. This appendix shows the field laboratory results for temperature, electrical conductivity (EC), pH, dissolved oxygen (DO), turbidity and bromide in relation to date/time and gallons pumped.

- Attachment 3: Water Quality Analyses - Composite Characterization Sample and Discrete Samples.

- Attachment 4: Fluid Management Plan Waiver for WPM-OV Wells.

- Attachment 5: Electronic Data Files Readme.txt This attachment contains the readme file text included with the electronic data files to explain the raw data files included on the accompanying compact disc (CD).

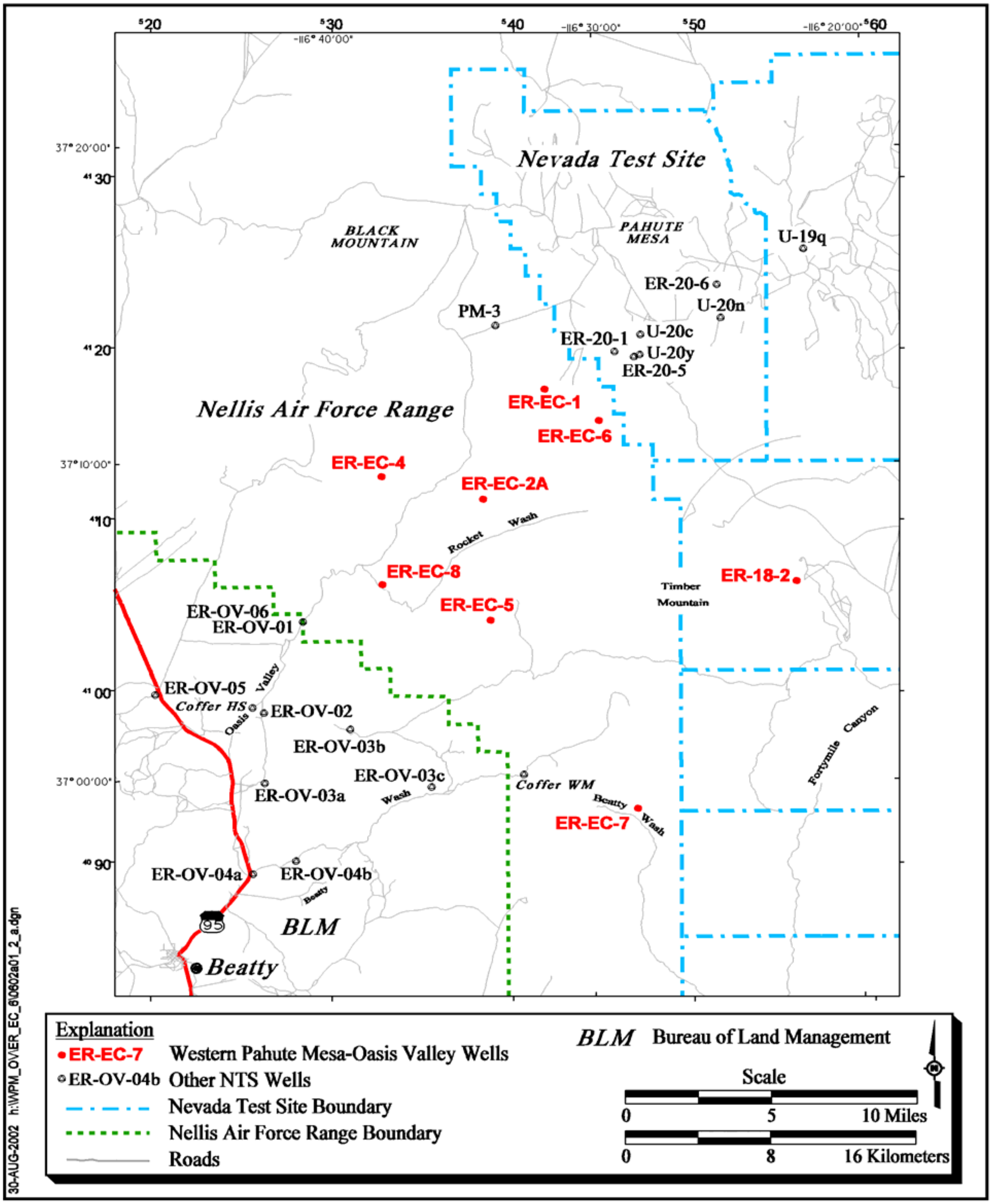


Figure A.1-1
Area Location Map

A.2.0 Summary of Development and Testing

This section presents details of the well development and testing activities, associated data collection activities, and summaries and depictions of the unprocessed data collected. The detailed history of Well ER-18-2 development and testing is shown in Table A.2-1.

A.2.1 Water Level Measurement Equipment

Following is a general description of the equipment used by IT Corporation, Las Vegas Office (ITLV) for measurements and monitoring during development and testing. Other equipment used for specific parts of the program are described in the appropriate section.

Depth-to-water measurements were made with a metric Solinst e-tape equipped with either a conductivity sensor or a float switch. The pressure transducers (PXDs) were Design Analysis Associates Model H-310, which are vented. The vent line is housed in an integral cable of sufficient length to allow installation of the PXD to its maximum working depth below the water surface. The cable was crossed over to a wireline above the water surface. The PXDs employ a silicon strain gauge element and downhole electronics to process the voltage and temperature measurements. Data is output to a Campbell Scientific CR10X datalogger located on the surface using SDI 12 protocol. The rated accuracy of the PXDs are 0.02 percent full scale (FS). Barometric pressure was measured with a Vaisala Model PTA 427A barometer housed with the datalogger. All equipment was in calibration.

A.2.1.1 Data Presentation

Most of the data were loaded into Excel® spreadsheets for processing and are presented with graphs directly from the spreadsheets. Due to the nature of the data and how the data were recorded in the datalogger program, certain conventions were used in presenting the data. Following are explanations of these conventions to aid in understanding the data presentations:

- The time scale for all monitoring is in Julian Days, as recorded by the datalogger. Julian Days are consecutively numbered days starting with January 1 for any year. This format maintains the correspondence of the presentation with the actual data, and presents time as a convenient continuous length scale for analytical purposes.

- The PXD data are presented as the pressure recorded by the datalogger, so that it corresponds to the raw data in the data files. These data can be

Table A.2-1
Detailed History of Development and Testing Activities

Date	Activities
8/16/1999	ITLV installs 0-15 psig PXD for predevelopment water level monitoring.
9/24/1999	ITLV removes PXD.
2/7/2000	Begin site mobilization for development and testing; drill rig moved on site.
2/8/2000	Install access line to a depth of 1,437.3 ft bgs. ESP contractor prepares pump for installation.
2/9/2000	Pump is assembled and wired. The pump and one joint of the 2 7/8-in. pump string are hung in the well.
2/10/2000	Pump is landed at 1,426.9 ft bgs; intake is located at 1,407 ft bgs.
2/14/2000	Pump is wired to transformer/VSD. Data collection equipment is installed.
2/15/2000	Drill rig moved off site. ITLV measures water level, and installs 0-50 psig PXD. Pump started at 60 hz, producing 29 gpm. Reduce rate to 23 gpm at 57.0 hz. PXD lowered twice as drawdown approaches PXD set depth.
2/16/2000	Pumping at 21 gpm. Pump failure starting at 23:00. VSD powered down and pumping discontinued.
2/17/2000	ESP pump hand on-site. Delay time increased in VSD. Decide to lower pump into 5.5-in. casing for cooling purposes.
2/20/2000	PXD removed and well head disassembled.
2/22/2000	Drilling rig moved back on site.
2/23/2000	Pump lowered four joints, totaling 76.8 ft, placing the motor within the 5.625-in. od casing. Pump now landed at 1,503.7 ft bgs, intake at 1,483.8 ft bgs. ITLV measures water level, which has not fully recovered. ITLV sets 0-50 psig PXD.
2/24/2000	Start pump at 56 hz; 24 gpm. ITLV lowers PXD to keep it below the pumping water level - the PXD doesn't have sufficient range for the total drawdown. The pumping rate is adjusted several times for testing, and set to 19 gpm for the night.
2/25/2000	Pump is shut down and restarted several times while monitoring drawdown. Drawdown exceeds 160 ft at 15 gpm.
2/26/2000	Pumping resumed at approximately 15 gpm during the day, but discontinued at night.
2/27-3/10/2000	Pumping resumed and adjusted to approximately 10 gpm. Rate declines slowly to approximately 6 gpm (from magnetic flowmeter) at a constant frequency setting of 51.6 hz.
3/1/2000	Pump shut off: DRI installs check valve. Check valve becomes stuck at depth of about 94 ft. Monitor water level recovery.
3/8/2000	ITLV removes 0-50 psig PXD and installs 0-75 psig PXD. Continue to monitor water level recovery.
3/13/2000	Start constant-rate test at 10 gpm. VSD immediately shuts pump down. VSD settings modified and pump restarted.
3/14-21/2000	Continue constant-rate test. Check valve restricts flow erratically, causing fluctuations in output and noise in drawdown. PXD is periodically lowered to accommodate increasing drawdown.
3/21/2000	ITLV/DRI/LLNL collects groundwater characterization sample. Shut down pump at 16:00 to end constant-rate test.
3/21-4/11/2000	Monitor water level recovery. Demobilize equipment from site except for water level monitoring equipment.

BN - Bechtel Nevada
DRI - Desert Research Institute
ITLV - IT Corporation, Las Vegas
LLNL - Lawrence Livermore National Laboratory
VSD - Variable speed drive
psig - Pounds per square inch gauge
ESP - Electrical Submersible Pump Systems
ft - Foot (feet)
hz - Cycles per second (hertz)
gpm - Gallons per minute
A - Amps
bgs - Below ground surface
in. - Inch(es)
PXD - Pressure transducer
od - Outside diameter

processed to various forms of head, with or without barometric correction. The required additional data to process the data into any required form are included in this report. Note that the data files contain a column in which the raw pressure measurement has been processed to a head measurement in terms of feet of water column above the PXD. The conversion was based on an approximate standard density for water, and was for field use in monitoring downhole conditions. In Section A.3.1, a well-specific value for the water density is derived and used for the processing of the drawdown response into head.

- Groundwater pressure measurements are reported as pounds per square inch gauge (psig) since the PXDs used for groundwater pressure monitoring were vented and not absolute. Pressure differences are reported as pounds per square inch (psi). Atmospheric pressure (i.e., barometric pressure) is reported as millibars (mbar); this is an absolute measurement.

- On graphs showing both PXD data and barometric data, the pressure scales for psi and mbar have been matched to show the changes in pressure proportionately. One psi is approximately equal to 69 mbar. For presentation convenience, the scales are not matched exactly, but are close enough so that the relative magnitude of the pressure changes is apparent. Complete electronic data files are included on an accompanying CD which allows the user to evaluate details of barometric changes and aquifer response, as desired.

- The data on water density in this report are presented in terms of the derived conversion factor for pressure in psi converted to vertical height of water column in feet. This is actually the inverse of weight density expressed in mixed units (feet-square inches/pound or feet/pounds per square inch). This is a convenient form for use in calculations. Later in the text, the derived densities are discussed in terms of specific gravity.

- Note that various derived values for parameters presented in this report may differ from values previously reported in morning reports. These differences are the result of improved calculations. Changes in measured parameter values are the result of corrections based on checking and confirming values from multiple sources.

- The production rates given in the text, shown in figures, and recorded in the data files are the flowmeter readings. During well development, 1 to 3 gpm was diverted to the Hydrolab® before production rate measurement by the flowmeter. The specific flow to the Hydrolab® at any particular time is not known exactly.

A.2.2 Predevelopment Water Level Monitoring

Following completion of Well ER-18-2, the water level in this well was monitored with a PXD and datalogger for a period of approximately five weeks to establish the equilibrium composite head for this well. Figure A.2-1 shows the results of this monitoring. An electronic copy of this data record can be found on the CD as file ER-18-2 Water-Level Monitoring.xls.

A.2.3 Depth-to-Water Measurements

A series of depth-to-water measurements were made in Well ER-18-2 as part of the various testing activities. Table A.2-2 presents all of the equilibrium, composite water-level measurements made during the testing program. Measurements representing nonequilibrium or noncomposite water levels are presented in the appropriate section for the testing activity involved.

Table A.2-2
Equilibrium, Composite Depth-to-Water Measurements

Date	Time	Depth-to-Water bgs		Barometric Pressure (mbar)
		Feet	Meters	
7/16/1999	14:15	1,212.9	369.69	---
8/16/1999	11:10	1,212.81	369.66	---
9/24/1999	17:31	1,212.56	369.59	---
2/15/2000	13:05	1,212.47	369.56	836.6

bgs - Below ground surface
mbar - Millibars

A.2.4 Zone-Specific Head Measurements

Well ER-18-2 was constructed with only one completion interval; consequently, there were no interval-specific head measurements.

A.2.5 Pump Installed for Development and Testing

Well ER-18-2 was known to have low productivity from the large amount of drawdown and slow water level recovery during drilling. Consequently, a low-rate permanent sampling pump (rated at 30 gallons per minute [gpm]) was installed and used for development and testing. During the development and testing program, it was found that this pump had to be operated near its minimum rate to minimize drawdown. Regardless, the pump had to be subsequently lowered into the 5 1/2-in. fiberglass casing in order to increase cooling on the motor and to accommodate the drawdown. With the pump relocated in the 5 1/2-in. casing, there was insufficient room to install an access line past the pump for running tools below the pump. This precluded performing activities such as flow logging while pumping and downhole discrete sampling.

A.2.5.1 Pump Installation

The permanent sampling pump was installed in Well ER-18-2 by Bechtel Nevada (BN) with the assistance of the Electrical Submersible Pump (ESP) Systems representative. A 2 3/8-in. access line was landed at 1,437.30 feet (ft) below ground surface (bgs). The pump assembly was hung on a 2 7/8-in. outside diameter (od) stainless-steel tubing. The total length of the pump assembly, including crossover, is 27.08 ft. The bottom of the pump assembly was initially landed at 1,426.94 ft bgs with the intake at 1,407.01 ft bgs. The pump was subsequently lowered an additional four joints totaling 76.79 ft, placing the bottom of the pump at 1,503.73 ft and the intake at 1,483.80 ft bgs. With the top of the 5.5-in. casing at approximately 1,475 ft bgs, this put the entire pump assembly within the 5.5-in. casing. Table A.2-3 summarizes the details of the pump assembly components. Specifications for this pump can be found in Attachment 1.

Figure A.2-2 depicts the final wellhead configuration. The stickup of the access line above ground surface is 3.86 ft.

Table A.2-3
Testing and Dedicated Sampling Pump

Pump Component	Type/Model	Serial Number	Length (feet)	Other Information
ESP Pump	TD 800	2D8I15041	6.57	52 Stage
ESP Protector	TR3-STD	3B8I07986	5.10	- - -
ESP Motor	TR3-UT/13 THD	1B8I06467	14.34	30 hp, 740 V, 30 A

It was planned to install a model "R" seating nipple just above the pump in the production tubing to allow installation of a wireline-set check valve for the constant-rate test. However, the seating nipple was not installed in this well because the check valve would not fit into the permanent stainless-steel production tubing string. Consequently, a check valve could not be installed. However, when the pump was lowered, the additional four joints of tubing used were 2 7/8-in. Hydril, which would accommodate the check valve. Due to some confusion about this matter, a check valve was placed into the well prior to the constant-rate pumping test. This check valve dropped through the Hydril tubing, but stopped at the top of the stainless-steel tubing. The check valve was left in the tubing string during the constant-rate test, but it was not functional as a check valve.

Power to the pump is controlled with a Centrilift variable speed drive (VSD). To maintain a constant production rate for testing, the transmitter of the Foxboro flowmeter was connected to the VSD in a feedback loop to supply the VSD with continuous flow rate information. The VSD automatically adjusts the frequency of the power supplied to the pump to maintain a constant production rate. The flowmeter record shows that this worked very well and a constant production rate could be maintained as drawdown progressed.

A.2.5.2 Pump Performance

Selected records of pump performance are shown in Table A.2-4. Note that pumping in this well resulted in large drawdowns that increased at an approximately linear rate as pumping continued. The drawdowns associated with the different pumping rates are not stabilized values; the values are provided to simply illustrate the magnitude of drawdown that occurred. The record of drawdown response with time should be consulted to get a sense of the relative performance. Also, note that the production rate declines with increasing drawdown for a given VSD setting (cycles per second [hz]) because the total dynamic head (TDH) increase was substantial. These production rates are in line with performance projections supplied by the manufacturer for this pump at similar pumping parameters.

The static water level in this well was approximately 1,212.6 ft bgs. With the pump initially landed at 1,426.94, there was about 194 ft of water above the pump intake. However, the pump should not be operated with the water level drawn down to the intake because the pump requires a certain minimum pressure at the

Table A.2-4
Pump Performance

Date -- Time	VSD Setting (hz)	Production Rate[a] (gpm)	Approximate Drawdown (ft)
2/15/2000 -- 21:30	57	22.9	141.4
2/16/2000 -- 02:00	57	22.0	170.0
2/16/2000 -- 06:00	57	20.9	181.4
2/16/2000 -- 22:30	56	18.22	179.0
2/24/2000 -- 12:34	56.0	23.12	97.5
2/24/2000 -- 17:00	55.3	19.24	152.2
2/25/2000 -- 14:00	53.6	15.36	126.3
2/25/2000 -- 17:15	54.1	15.42	161.4
2/26/2000 -- 18:00	54.5	15.36	170.7
2/27/2000 -- 10:35	51.4	10.94	90.8
2/27/2000 -- 17:20	51.6	9.24	115.6
2/28/2000 -- 15:00	51.6	6.9	119.43
2/29/2000 -- 15:15	51.6	6.5	122.73
3/13/2000 -- 14:00	50.2	12.1	37.11
3/14/2000 -- 12:30	52.3	10.0	86.65
3/16/2000 -- 14:00	51.9	10.85	130.2
3/21/2000 -- 12:15	52.9	10.50	189.1

[a]Recorded from magnetic flowmeter, does not include diversion stream through the Hydrolab®, which was only used during the development phase.

Significant figures recorded as reported from field documents.

hz - Hertz, cycles per second
gpm - Gallons per minute
ft - Foot (feet)

intake for proper operation. Consequently, the amount that the water level could be drawn down to is somewhat less. Initially, at a production rate of 20-22 gpm, the drawdown was approximately 180 ft after 12 hours. The testing plan required continuous pumping for 10 days, so the pumping rate was reduced to a minimum to reduce the drawdown. However, at the reduced pumping rate, the velocity of water flow around the motor was lower than the requirement for motor cooling.

After this large drawdown was observed, the pump was lowered from the 7.625-in. casing into the 5.5-in. casing to provide more depth for drawdown and to improve cooling of the pump motor at lower pumping rates. The smaller diameter casing increased the velocity of water flow past the motor, meeting specification at the reduced pumping rate. Pumping operation was expected to proceed at the minimum rate that the pump could sustain during the constant-rate test (approximately 10 gpm for 10 days), without exceeding a specified maximum drawdown. The intent was to limit the maximum drawdown to the range of the available PXD with the greatest range, which was 0-75 psig. This range could accommodate a maximum drawdown of about 170 ft. As it turned out, this was exceeded, and the PXD had to be lowered in the middle of the test.

A.2.6 Development

There were two objectives for well development, the physical improvement of the condition of the well completion and restoration of the natural water quality. The early development activities were primarily designed to improve the physical condition of the well completion. This involved removing drilling fluid and loose sediment left from drilling and well construction to maximize the hydraulic efficiency of the well screen, gravel pack, and the borehole walls. These improvements promote efficient and effective operation of the well and accurate measurement of the hydrologic properties. The development phase of these operations were primarily intended to accomplish hydraulic development in preparation for hydraulic testing.

Restoration of the natural water quality includes removal of non-native fluids introduced by the drilling and construction activities and reversal of any chemical changes that have occurred in the formation due to the presence of those fluids. This objective of development addresses the representativeness of water quality parameter measurements and chemical analyses of samples taken from the well. Restoration is mostly a function of the total volume of water produced. An evaluation of the status of development at the time of sampling is presented in Section A.3.5.

The history of the development phase for Well ER-18-2 is shown in Table A.2-1. The generic plan allowed seven days for this phase, but additional time was required in order to lower the pump and to adjust the schedule to fit into the overall work scheme for UGTA field activities.

A.2.6.1 Methodology and Evaluation

The basic methodology for hydraulic development was to pump the well at the highest possible rates, and periodically surge the well by stopping the pump to allow backflow of the water in the pump column. The parameters of the pumping operations, production rates, and drawdown responses were recorded continuously by a datalogger from the production flowmeter and a downhole PXD. Barometric pressure at the ground surface was also recorded in conjunction with PXD records.

Monitoring during development included hydraulic performance data and a variety of general water quality parameters intended to evaluate both the effectiveness of the development activities and the status of development. These parameters included drawdown associated with different production rates to evaluate improvement in well efficiency, visual observation of sediment production and turbidity to evaluate removal of sediment, water quality parameters (temperature, pH, EC, turbidity, DO), and the bromide (Br^-) concentration to evaluate restoration of natural water quality. With regard to the Br^- concentration, the drilling fluid used during drilling was “tagged” with lithium bromide to have an initial concentration from 10 milligrams per liter (mg/L) to over 50 mg/L. The concentration was increased as water production increased to keep the concentration in the produced water at measurable levels. This methodology served to provide a measure of water production during drilling through reference to the dilution of the tracer, and later provided a measure of development for evaluating the removal of residual drilling fluids from the formation.

A.2.6.2 Hydraulic Development Activities

A PXD was installed in the access tube of the well to monitor the hydraulic response of the well during pumping. The PXD range must be sufficient to accommodate the change in pressure corresponding to the amount of drawdown produced by pumping at the maximum rate. It is also advantageous to use a PXD with the minimum range necessary to maximize accuracy. As discussed in Section A.2.5.2, the amount of drawdown in Well ER-18-2 was unexpectedly large and restricted the maximum pumping rate. The 0-50 psig PXD initially installed was found to have inadequate range and was replaced with a 0-75 psig PXD for the constant-rate test. This PXD range was the greatest available; however, the PXD had to be repositioned during the test because the drawdown exceeded this range.

Information on the initial 0-50 psig PXD installation calibration is presented in Table A.2-5 to provide data on the composite density of the water. The other PXD calibrations that were done during the development and testing program are inaccurate because they were done while the well was recovering to static from previous pumping.

Table A.2-5
PXD Installation Prior to Well Development

Design Analysis H-310 PXD SN 2269, 0-50 psig					
Installation Date: 2/15/2000					
Calibration Data (Installation): 2/15/2000					
Static water level depth 1,212.47 ft bgs					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC[a] (ft)	985.00	1,035.00	1,055.00	1,075.00	1,095.00
PXD psig	--	11.584	20.146	28.691	37.237
Delta depth (ft): Cal5 - Cal2					60.00
Delta psi: Cal5 - Cal2					25.653
Density ft of water column/psi: delta depth/delta psi (ft/psi)					2.339
Equivalent ft water: PXD psig (at Cal 5) x density of water (ft/psi)					87.09
Calculated PXD installation depth: static water level + equiv. ft water					1,299.56

[a]Length of wireline below top of casing: does not include the length of the PXD integral cable.

ft - Foot (feet)
bgs - Below ground surface
PXD - Pressure transducer
psi - Pounds per square inch
psig - Pounds per square inch gauge

The method of installing these PXDs does not provide a direct measurement of the total depth at which the PXD was located. The uncertainty in the total measured depth is due to uncertainty in the hanging length of the PXD vent cable, which is difficult to measure accurately, and cable stretch in the wireline. Therefore, the installation depth is calculated from the depth-to-water and calibration measurements made during installation or removal, whichever is more appropriate. The pressure reading of the PXD at the installation depth is multiplied by the water density conversion factor to give the depth below the static water level, which is then added to the measured depth-to-water level. The water density conversion factor is determined from the calibration measurements.

The well was pumped on an irregular schedule over a total period of 15 days for development purposes. This period was longer than planned because the pump had to be lowered and there were scheduling conflicts, as described in Section A.2.5. During that time, development consisted of pumping at rates as great as possible, periodically stopping the pump to surge the well with the backflow from the production tubing. Step drawdown protocol was generally not used because the range of pumping rates that could be used was too restrictive to effectively assess well and pump performance. Water quality was monitored using both field laboratory grab sample testing and with an in-line Hydrolab® cell with instrumentation recorded by a datalogger.

A.2.6.2.1 Pumping Rates and Hydraulic Response

Figure A.2-3 shows the datalogger record of the pumping rate and hydraulic response during the development phase. Figure A.2-4 shows the datalogger record of the hydraulic response and barometric pressure. An electronic file of these data can be found on the attached CD with the file name 18-2Aqtest_Dev.xls. The data record for Julian Days 46 through 48 shows the initial testing of the pump to determine the operating range of the pump (see Table A.2-4) and resultant drawdown. The pump was inactive for Julian Days 49 to 55. The flowmeter and discharge lines were dismantled between Julian Days 51 to 55. The graph in Figure A.2-3 shows a pumping rate of 6 gpm for these days, but this is an artifact of having disconnected the flowmeter from the datalogger. The pump was lowered on Julian Day 54, requiring that the PXD be removed and reset. Pumping was resumed and run at various rates from Julian Day 55 through 61.

Drawdown during pumping continually increased and did not approach equilibration. The barometric record shows that the barometric pressure was proportionately constant relative to the PXD pressure. The drawdown stress that could be applied to the well completion for development was limited by the depth the pump. The magnitude of drawdown repeatedly imposed during development was substantial, but the production rate from the formation was very low. Pumping was periodically stopped to surge the well. The depth to which the pump was finally lowered was projected to accommodate the drawdown over the course of a 10-day pumping period at a production rate of approximately 10 gpm.

Several factors should be kept in mind when scrutinizing the pumping and drawdown record from the development phase. First, the well was operated without a check valve. Consequently, a water column above the pump was not maintained in the production tubing after the pump was stopped. When the pump was restarted, sufficient water had to be pumped to fill the tubing and surface hose before production would register at the flowmeter. This produces a lag time of approximately 4 minutes between the start of a drawdown response and the start of the flowmeter readings. Also note the brief surge that registered with the flowmeter just after the pump was started. This is probably a slug of residual water that had been left in a low spot of the surface hose and was pushed through the flowmeter by air compressed ahead of the rising water column.

Second, because there was little head on top of the pump at startup, the initial pumping rate was much higher than the rate when the final, stable TDH was reached. The pumping rate decreased as the TDH increased until the discharge system was filled and TDH stabilized. This phenomenon is illustrated in Figure A.2-5. Dividing the volume of the discharge system by the time lag for flowmeter readings to start gives a production rate much greater than the VSD setting would produce under stable pumping conditions. As a result of this situation, the initial drawdown rate was much greater until the stable pumping rate was reached. Since the large amount of drawdown resulted in low head on the pump intake, there may have been some cavitation at the pump intake affecting performance and creating turbulence, which is reflected in noisy data.

A.2.6.2.2 Surging and Step-Drawdown Protocol

Figure A.2-3 and Figure A.2-4 show each instance when the pump was stopped. Since the range of possible pumping rates was severely restricted, the step-drawdown protocol was not used with this well.

Stopping the pump produced a surging effect in the well which can be seen very clearly in Figure A.2-6. This figure shows a representative instance of surging expanded to illustrate the detail. When the pump is stopped, the water in the production casing backflows through the pump into the well, raising the water level in the well. This is referred to as the ‘U-tube’ effect. The water level in the well casing temporarily rises above the instantaneous head in the formation around the completion because the rate of backflow down the casing is faster than the rate the water is injected into the formation under the instantaneous head differential. This action produces a reverse head differential which ‘surges’ the well. The reverse flow appears in the apparent recovery of the well as a fast initial recovery rate and then results in a rise above the equilibrium water level. Following this is a decline to the equilibrium head. The surge rapidly dissipates, merging into the actual recovery curve.

A.2.6.2.3 Other Observations

During development, visual observations were made of the water discharge, primarily whenever the pump was started, to monitor the amount of sediment produced. Logbook entries indicated that there was initial reddish brown turbidity in the water for one minute or less each time the pump was started, after which the water cleared.

A.2.7 Flow Logging During Pumping

Downhole flow logging during pumping was not conducted for this well.

A.2.8 Constant-Rate Test

A constant-rate pumping test was conducted following well development to collect hydraulic response data for determination of aquifer parameters. Prior to the test, the water level in the well was monitored to observe recovery to ambient head from development pumping and to establish baseline pretest conditions. The well was allowed to recover for 13 days between March 1 and March 13, 2000. Pumping for this test commenced on March 13, 2000, and continued for eight days until March 21, 2000. The water level was calculated from PXD measurements on March 13 before the start of pumping at 1,216.27 ft bgs, which indicated that it still had about 3.4-3.7 ft to go to reach static. Due to schedule and cost limitations the test was initiated at this point since full recovery was expected to take much longer. The test was terminated early because of excessive drawdown in the well; however, the major testing objectives were met. Pumping during the constant-rate test continued the development process to restore natural water quality for sampling purposes. Following the pumping period, head recovery was monitored for 21days until April 11, 2000. Again, water level recovery did not reach equilibrium before termination of monitoring, but was approximately 1.7-2.0 ft lower than the expected static water level.

A.2.8.1 Methodology

A continuous datalogger record was captured for barometric pressure and head pressure on the PXD in the well, extending from pretest monitoring through the recovery monitoring. During pumping, the discharge rate of produced water was also recorded continuously. The production rate of the pump was controlled using a feedback loop from the discharge flowmeter to ensure a consistent rate. In addition, water quality was monitored during the constant-rate test with field analyses of grab samples taken daily.

A pumping rate of 10 gpm was chosen for the test. As mentioned in Section A.2.6.2.2, this rate was estimated to be near the maximum rate the well would be able to sustain for the test duration without excessive drawdown. It was recognized that the PXD range of 0-75 psig would not accommodate the expected total drawdown, but this was the largest PXD pressure range available. Since the pump could not be run at a substantially lower rate, it was decided to adjust the PXD depth periodically as necessary to capture the entire drawdown response.

The PXD was installed on March 8, 2000, originally reported in the morning reports at a calculated depth of 1,363.94 ft bgs based on the calibration performed at the time. However, at the time of installation, the rising water level was approximately 11 feet from the static water level and the calculations used a nominal density for water. The PXD depth was recalculated after removal when the water level was tagged at 1,214.62 ft bgs, which was only 2 feet from static. Based on the calibrations and calculations at removal, the PXD installation depth was 1,372.43 ft bgs. This is the most accurate calculated value because the water level was closer to static and a well-specific density for water was used. The calculations for this PXD installation are shown in Table A.2-6.

Table A.2-6
PXD Installation for Constant-Rate Test

Design Analysis H-310 PXD SN 2270, 0-75 psig					
Installation Date: 3/08/2000					
Calibration Data (Removal): 4/11/2000					
Static Water level depth 1,214.62 ft bgs[a]					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC[b] (ft)	960.00	1,010.00	1,045.00	1,080.00	1,115.00
PXD psig	---	22.195	36.84	51.507	66.326
Delta depth (ft): Cal5 - Cal2					105.00
Delta psi: Cal5 - Cal2					44.131
Density ft of water column/psi: delta depth/delta psi (in ft/psi)					2.382
Equivalent ft water: PXD psig (at Cal5) x density of water (ft/psi)					157.81
Calculated PXD installation depth: static water level + equiv. ft water					1,372.43

[a]Water level at the time of removal; ambient static is about 1,212.6 ft bgs
[b]Length of wireline below top of casing (does not include the length of the PXD integral cable)

ft - Foot (feet)
PXD - Pressure transducer
psi - Pounds per square inch
psig - Pounds per square inch gauge
bgs - Below ground surface

A.2.8.2 Hydraulic Data Collection

Figure A.2-7 shows the datalogger record for the constant-rate test pumping period in terms of the pumping rate and the hydraulic response to pumping. Figure A.2-8 shows the head record for both the pumping period and the recovery period, as well as the barometric pressure record. These graphs illustrate the datasets and major features of the respective activities. Note that these graphs were made with only half the data (every other data point) due to limitations for data handling in the graphing program. Pumping started on March 13, 2000 (73.58384 Julian days), and was terminated on March 21, 2000 (81.66741 Julian days). The average pumping rate was 10.19 gpm. The data file is 18-2Aqtest_HT.xls on the accompanying CD. The pumping rate record is noisy, with variations of +\- 10 gpm from the 10 gpm average. This was probably due to intermittent restriction of flow by the loose check valve in the upper production casing. This phenomenon can be seen in Figure A.2-7. On the other hand, only a small amount of noise was evident in the drawdown PXD record. Note that the barometric record has been scaled proportionate to the PXD record so that fluctuations are consistent. The barometric record shows that the barometric pressure was proportionately constant relative to the PXD pressure changes.

A.2.9 Water Quality Monitoring

Water quality monitoring of the well discharge was conducted during pumping to provide information on water chemistry and to indicate when natural groundwater conditions predominate in the pumping discharge. Certain parameters such as Br^- ion concentration, pH, EC, turbidity, and DO were expected to decline as development progressed indicating natural groundwater quality as opposed to water affected by drilling and completion activities. Also, parameter values should stabilize after prolonged pumping and development as natural groundwater permeates the well environment. Rebound of parameter values at the beginning of each cycle of pumping was expected to decline toward the values observed toward the end of the previous cycle as development progressed.

The standard parameters that were monitored during development and testing of Well ER-18-2 include: pH, EC, temperature, turbidity, DO, and Br^- ion. In addition, lead and tritium were sampled in compliance with the schedule in the Fluid Management Plan (including waivers) (DOE/NV, 1999). In-line monitoring data was collected continuously for all the standard parameters except bromide. Grab samples were obtained every two hours when possible and analyzed for all the water quality parameters.

Pumping was initiated on February 15, 2000, at 17:57 for well development. In-line monitoring began February 24, 2000, at about 14:00 with the operation of a Hydrolab® H20 Multiprobe. The Hydrolab® fed directly to the datalogger where data could be continuously accessed via a portable laptop computer. Grab sample monitoring was initiated on February 15, 2000, at 18:25, as the field laboratory was fully operational during functionality testing of the pump.

A.2.9.1 Grab Sample Monitoring

Grab samples were obtained from a sample port located on the wellhead assembly. For the development phase, grab samples were collected and analyzed approximately every two hours, mostly during daylight hours, beginning on February 15 and ending on March 1, 2000, at 8:00. The pump was not on between February 17 and February 24. For the constant rate pumping test, two or three grab samples were obtained daily beginning on March 13 and ending on March 21, 2000.

Grab samples were analyzed using equipment and methodology contained in the DOP ITLV-UGTA-312, “Water Quality Monitoring”; DOP ITLV-UGTA-301, “Fluid Sample Collection”; and DOP ITLV-UGTA-101, “Monitoring and Documenting Well Site Activities.” All instruments were calibrated according to DOP ITLV-UGTA-312 at the beginning of each 12-hour shift, and a calibration check was completed at the end of each shift. The following instruments were used to analyze grab samples:

- YSI 58 (DO)
- YSI 3500 Multimeter (pH, EC, and temperature)
- HF Scientific DRT-15C Turbimeter (turbidity)

- Orion 290A (bromide)
- HACH DR100 Colorimeter Kit (lead)

The complete results of grab sample monitoring have been compiled and are presented in Attachment 2. The results have been related to the pumping rate, the total discharge, and the phase of development or testing. Additionally, two graphs have been made showing water quality parameters versus total discharge in gallons. Figure A.2-9 shows EC, pH, and DO. Figure A.2-10 shows turbidity and Br^- concentrations. The temperature of the grab samples averaged 45.9 degrees Celsius (°C) varying between 39.8 and 49.0°C; the results are not depicted. Temperature differences can often fluctuate depending on ambient air temperature and the speed with which the temperature of the wellhead sample is measured. Figure A.2-9 shows that pH, EC, and DO remained fairly constant throughout the monitoring: EC between 1,350 and 1,550; pH between 7.4 and 7.7; and DO mostly between 0.3 and 0.5. Where fluctuations did occur, they can be attributed to pump shutdowns/startups. This can be seen in the beginning of the constant-rate test in Figure A.2-9.

In Figure A.2-10, the turbidity chart shows a steep decline and a leveling off between 1.0 and 2.0 nephelometric turbidity units (NTUs). Again, peaks can be seen at pump shutoffs/startups. The bromide concentration fluctuated erratically between 0.1 and 0.7 mg/L. Interestingly, the Br^- peaks appeared to coincide with the turbidity peaks. There were no long-term trends in any of the parameters which indicate any continuing progress in well development. The bromide concentrations in the produced water suggest persistence of drilling fluids in the formation at a low level. The results of lead and tritium monitoring is presented in Section A.4.0, Environmental Compliance.

A.2.9.2 In-Line Monitoring

In-line monitoring was conducted using a Hydrolab® H2O Multiprobe. The Campbell Scientific datalogger recorded data at various sampling intervals ranging from 5 seconds to 5 minutes. These intervals varied depending on changes in pressure and head. The parameters temperature, EC, pH, turbidity, and DO were recorded continuously when the pump was running between February 24 at 13:55 and March 1, 2000, at 08:35. In-line data were recorded every two hours on a "Water Quality Data Form" for comparison with grab sample results. The Hydrolab® was calibrated and maintenance was performed at the beginning of operations and every three to four days thereafter according to DOP ITLV-UGTA-312. The Hydrolab® was taken off-line during the constant-rate test because it diverts from 1 to 3 gpm away from the flowmeter. With the discharge rate set at 10 gpm for the constant-rate test, the Hydrolab® could conceivably divert a substantial portion of the flow which could cause unsteadiness in the flow rate.

The Hydrolab® in-line data are depicted in two figures. Figure A.2-11 shows a graph of the EC and pH during development, and Figure A.2-12 shows DO and turbidity. In Figure A.2-11, pH leveled off at about 7.6, which correlates well with the grab sample data. The EC shows more fluctuations, but within a narrow range of 1,200 to 1,300 micromhos per centimeter (μmhos/cm). This is not far from the grab sample range of 1,350 to 1,550 µmhos/cm. The spikes in the first half of the graph coincide with pump shutoffs/startups. Temperature averaged 46.9°C on the Hydrolab® data, varying between 37 and 50°C, and correlating closely with the 45.9°C average from the grab samples. In Figure A.2-12, the DO graph shows a leveling off with values ranging between 0.75 and 0.85 mg/L. This level is considerably higher than the grab sample range of 0.3 to 0.5 mg/L. In addition, the turbidity data does not correlate well with the grab sample data. The graph of turbidity in Figure A.2-12 shows a leveling off around 10 NTUs compared to 1 to 2 NTUs in the grab sample data. Turbidity and DO are highly influenced by entrained air, turbulence, and the configuration of the Hydrolab®. The in-line data have been saved and are contained in the Excel® file 18-2AqTestHydrolab.xls on the accompanying CD.

A.2.10 Groundwater Sample Collection

Only one type of groundwater sample was collected for characterization of the groundwater in Well ER-18-2, a composite wellhead sample.

A.2.10.1 Downhole Discrete Sampling

The purpose of discrete sampling is to target a particular depth interval for sampling under either static or pumping conditions. Discrete sampling is optimally performed after the well has been determined to meet the following criteria: (1) the maximum possible development has occurred for the interval in which the samples will be collected and (2) a pumping rate can be maintained that will ensure a representative sample of the interval. Since Well ER-18-2 has only one completion interval, the primary objective for discrete sampling does not apply. In addition, the completion interval of almost 900 ft is only accessed through three slotted joints separated by blank joints spanning about 170 ft. Since the inflow through those screen joints could not be specifically attributed to the formation opposite the screen joints, there was no value to discrete sampling in evaluating any water quality difference across the completion interval.

A.2.10.2 Groundwater Composite Sample

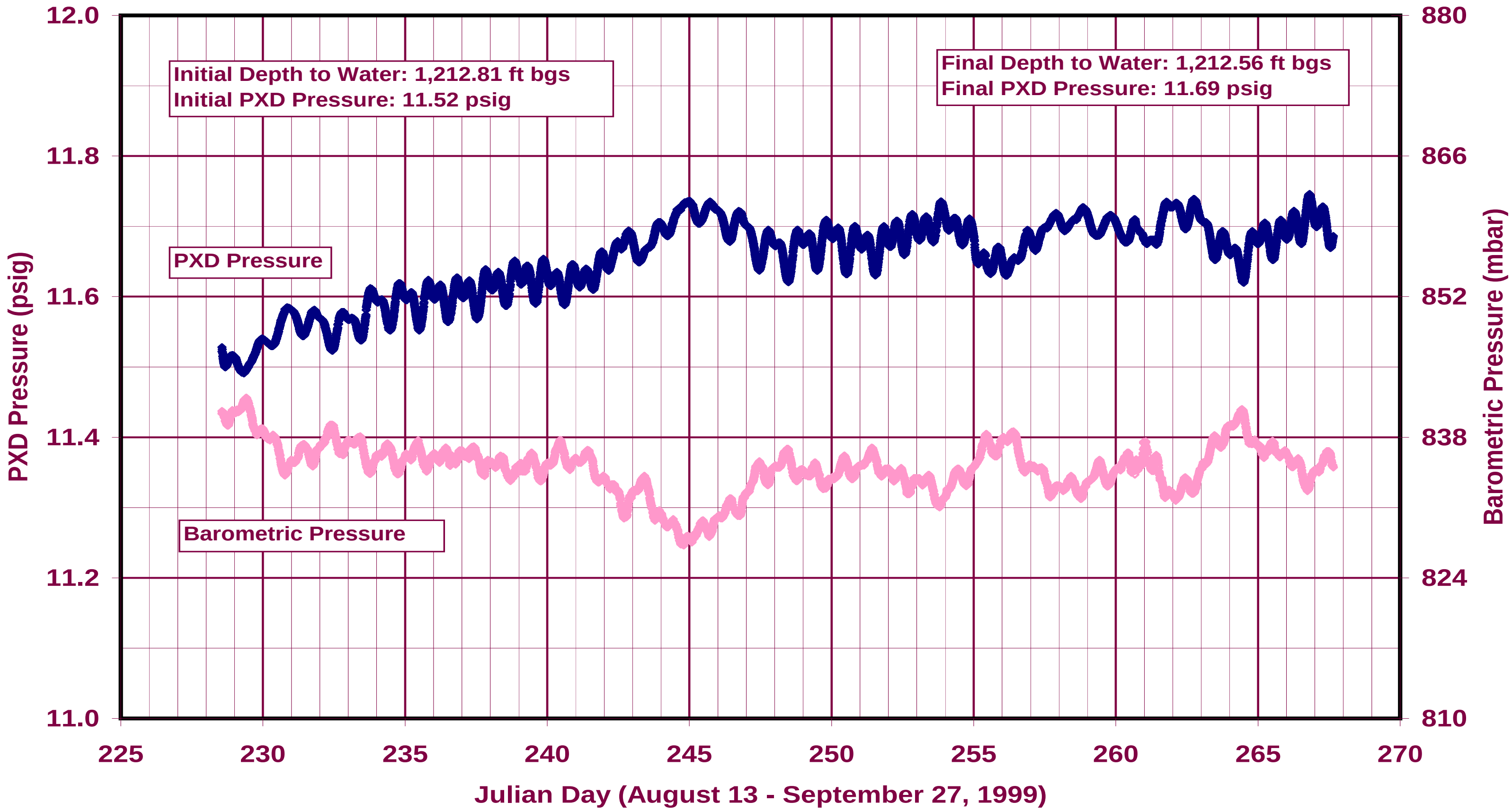
The purpose of this sample is to obtain a composite of as much of the well as possible. The composite groundwater characterization sample was collected at the end of the constant rate pumping test from the sampling port at the wellhead. Since this sample is meant to represent a composite of the whole well, there are two criteria for the sample to be the most representative: (1) the sample should be obtained after pumping for the longest possible time and (2) the pumping rate should be as great as possible in order for the water production to include as much of the completion as possible.

On March 21, 2000, beginning at 10:45, a composite characterization sample was collected from the wellhead sampling port directly into sample bottles. A field duplicate sample was obtained concurrently. A constant production rate of 10 gpm was maintained during the sampling event, the same rate used during the constant-rate test. At the time of sampling, approximately 223,000 gallons of groundwater had been pumped from the well during development and testing activities as recorded by the magnetic flowmeter. The samples were processed according to the following procedures: DOP ITLV-UGTA-302, "Fluid Sample Collection"; SQP ITLV-0402, "Chain of Custody"; and SQP ITLV-0403, "Sample Handling, Packaging, and Shipping." Samples were immediately stored with ice and transported to a secure refrigerated storage. Samples were collected for Paragon, Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), and Desert Research Institute (DRI).

The final, validated results of the March 21, 2000, composite sample have been tabulated and are presented in Attachment 3.

A.2.11 Thermal Flow Log and ChemTool Log

Thermal flow logging is usually conducted at the very end of the development and testing program to determine flow in the well under ambient, static conditions. This logging was not conducted at ER-18-2 because the well has only one short screened interval which would not reflect any natural circulation in the completion interval accurately. In addition, there was no access because the pump was set within the 5.5-in. casing.



PXD - Pressure transducer
psig - Pounds per square inch gauge
ft bgs - Feet below ground surface

Figure A.2-1
Predevelopment Water Level Monitoring

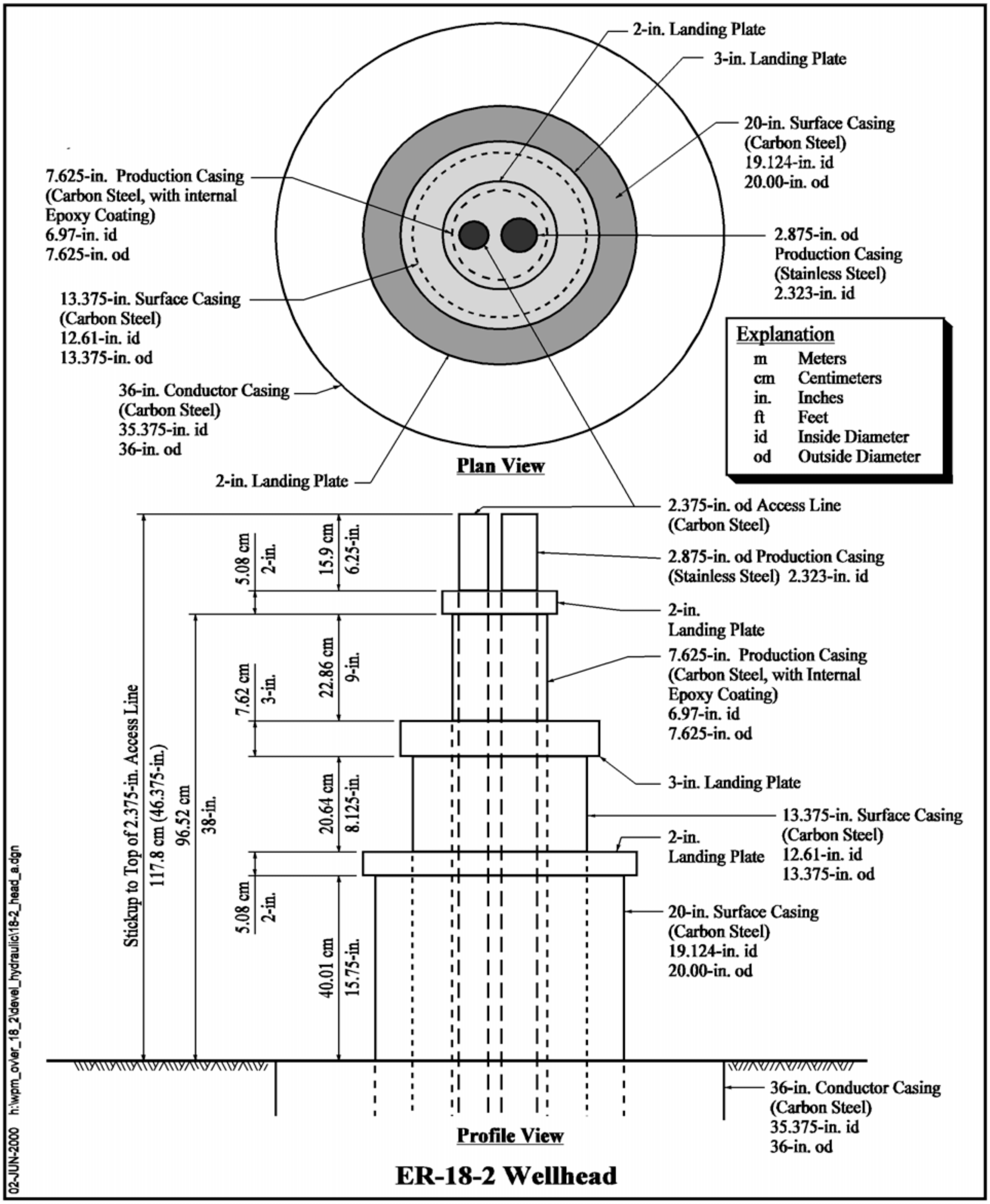
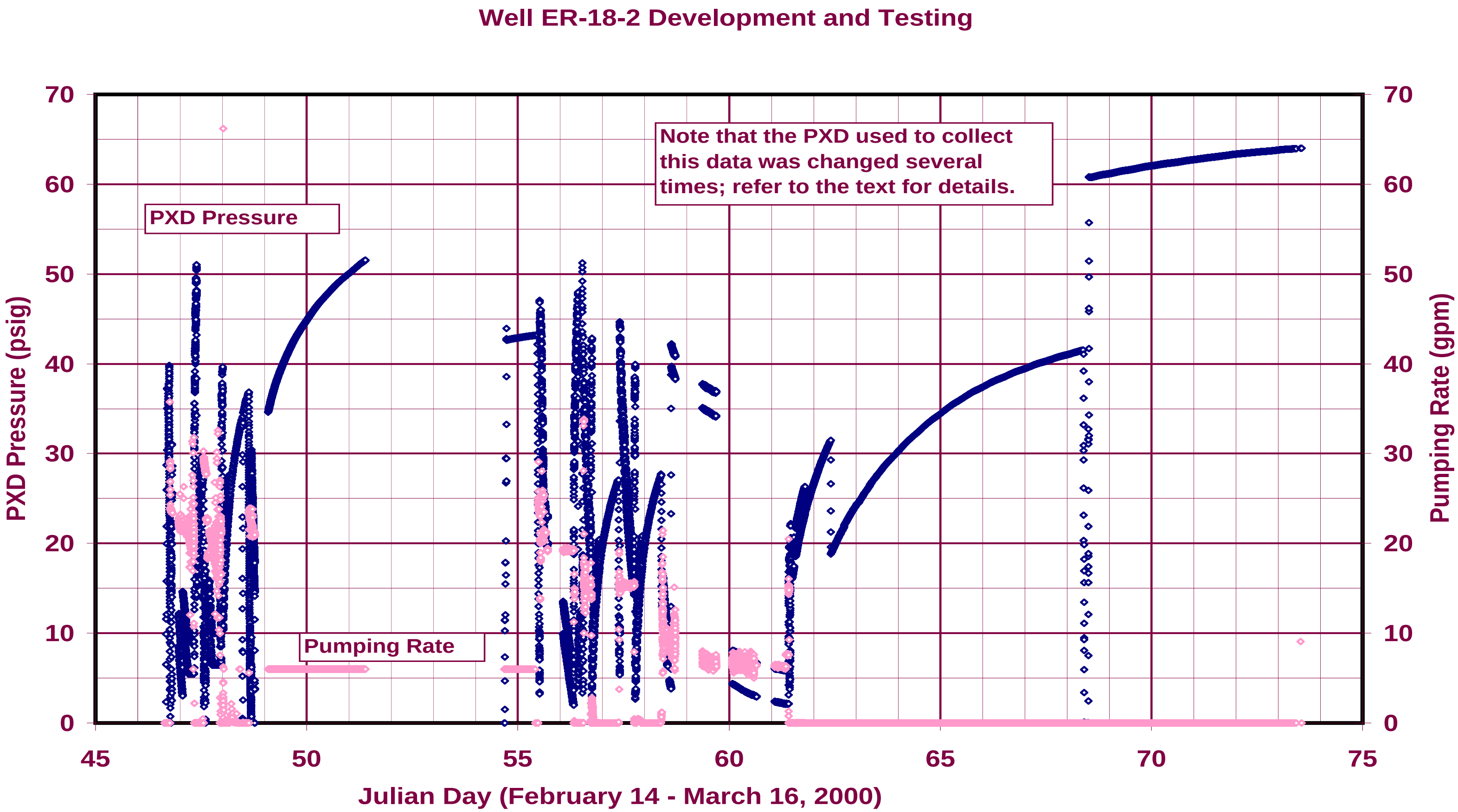
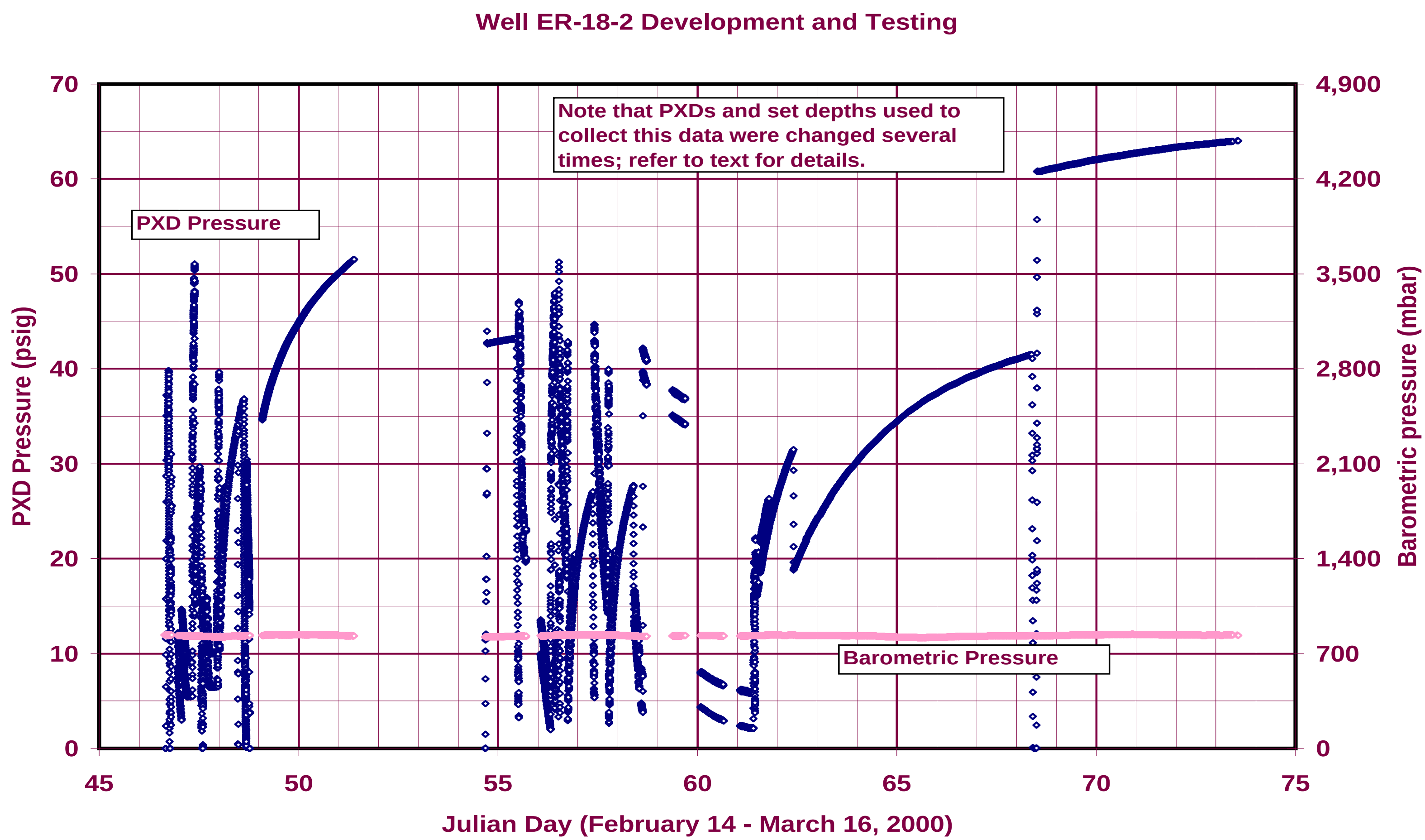


Figure A.2-2
Wellhead Completion Diagram After Sampling Pump Installation



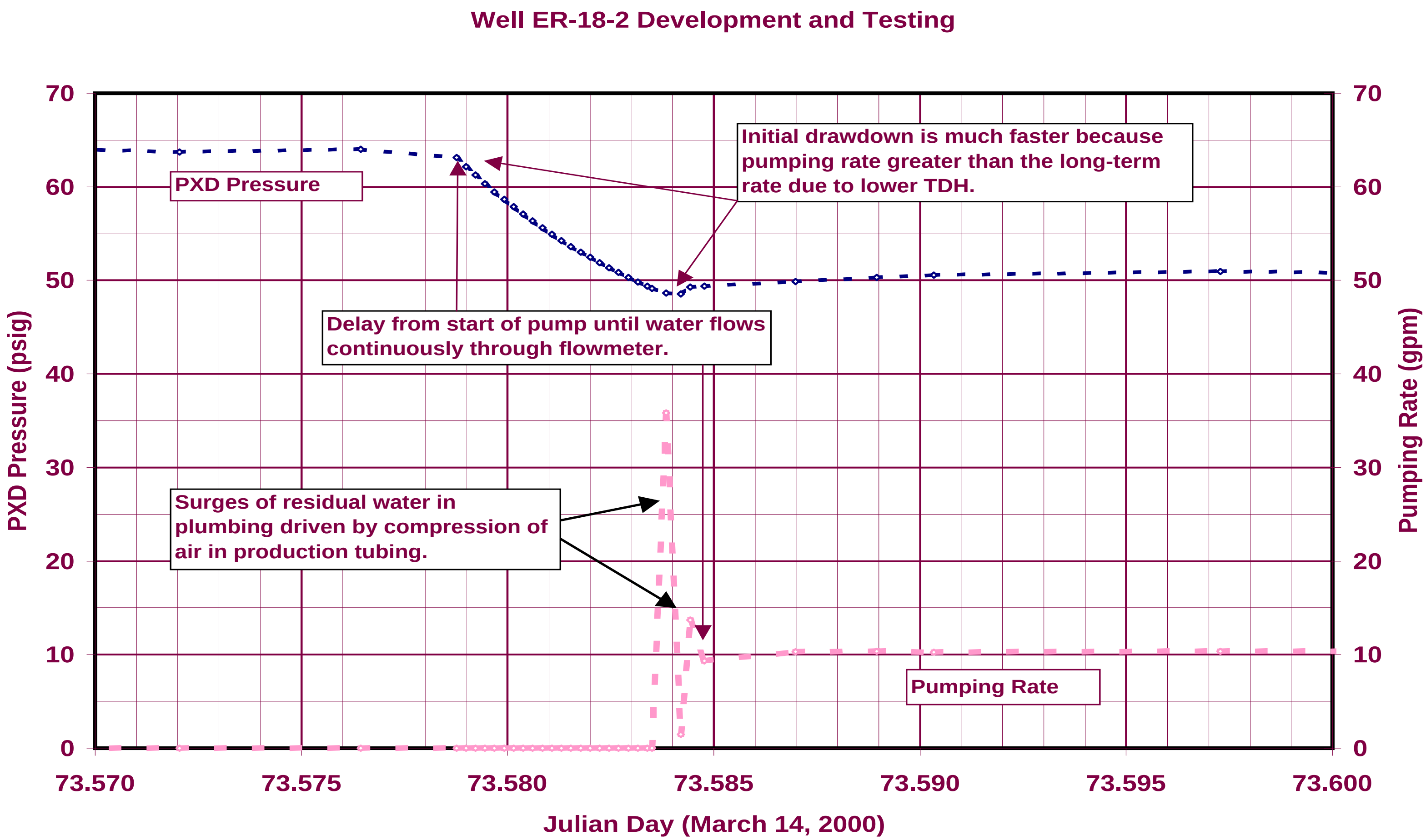
PXD - Pressure transducer
psig - Pounds per square inch gauge
gpm - Gallons per minute
MAG_GPM - pumping discharge rate from magnetic flowmeter

Figure A.2-3
Pumping Rate and Hydraulic Response During Development



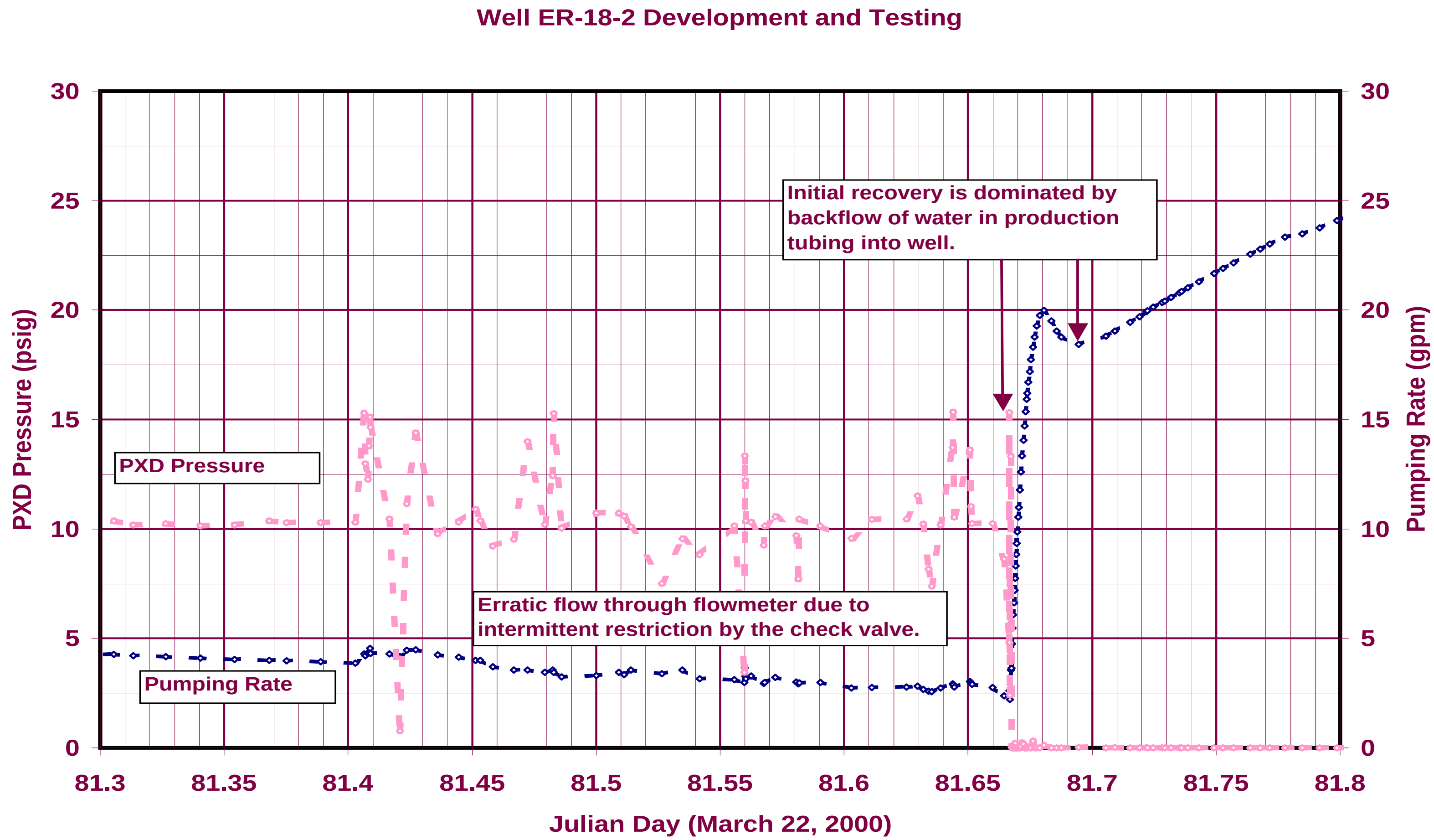
PXD - Pressure transducer
psig - Pounds per square inch gauge
mbar - Millibars

Figure A.2-4
Hydraulic Response and Barometric Pressure During Development



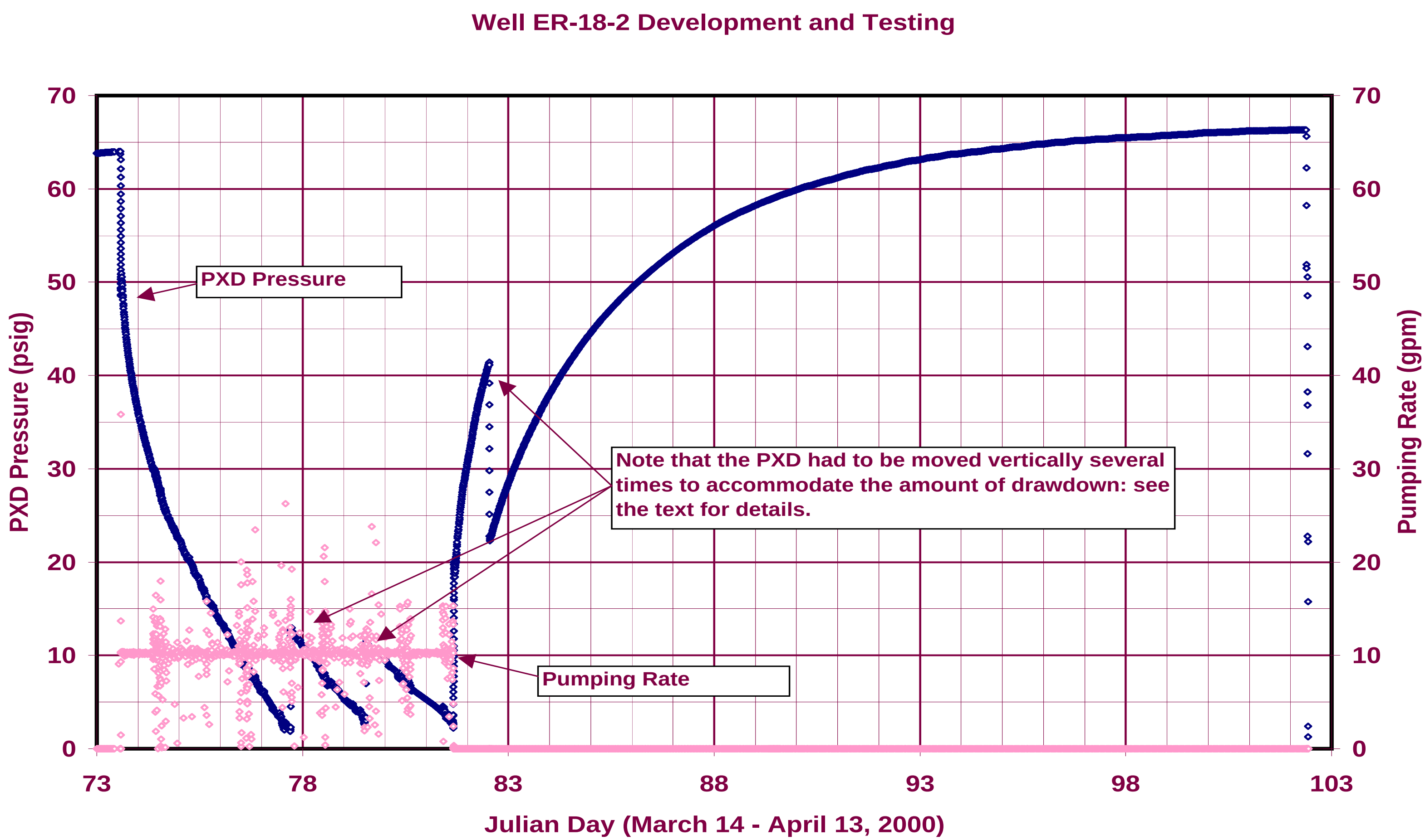
PXD - Pressure transducer
psig - Pounds per square inch gauge
gpm - Gallons per minute
TDH - Total dynamic head

Figure A.2-5
Detail of Startup Effects



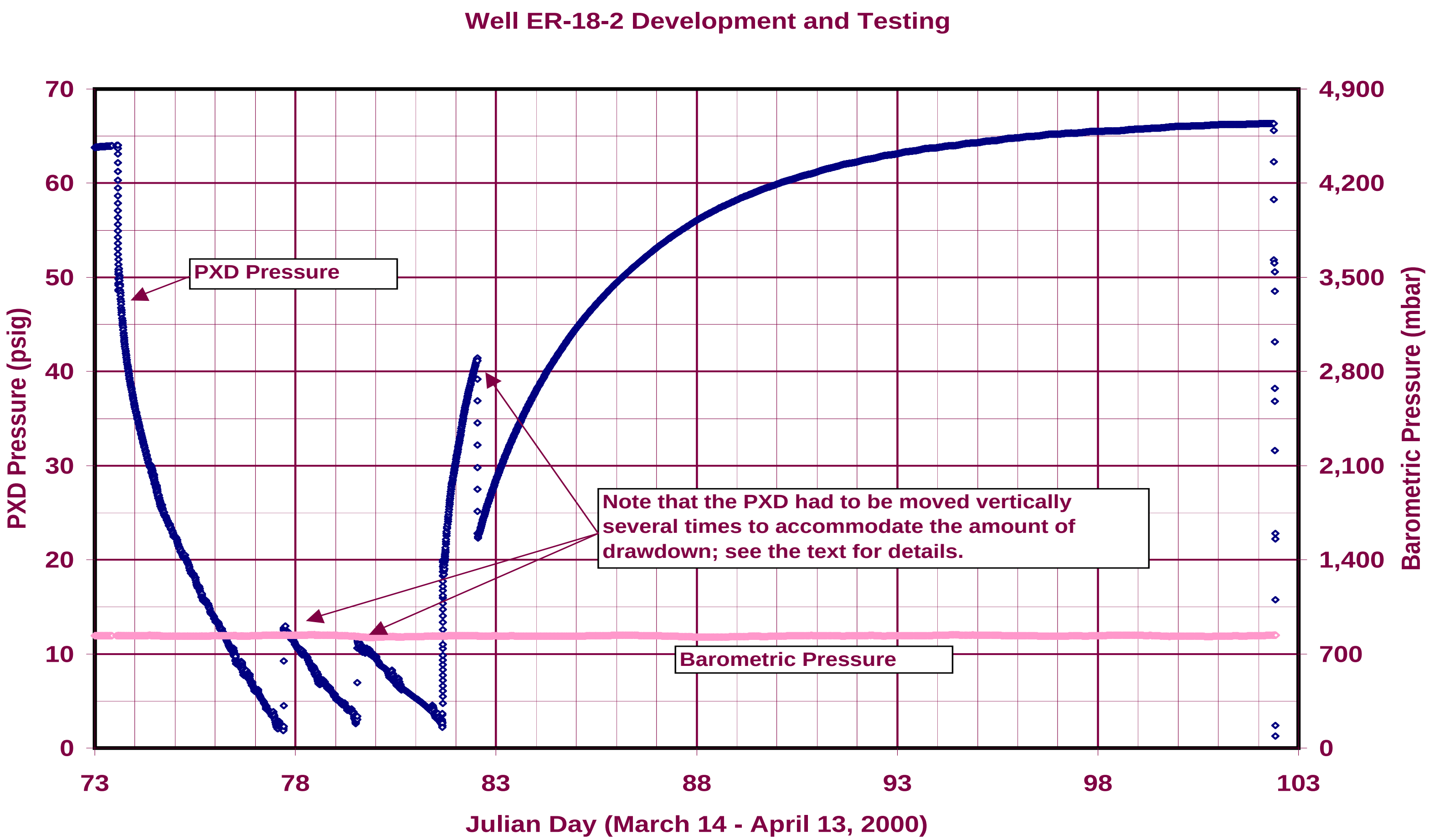
PXD - Pressure transducer
psig - Pounds per square inch gauge
gpm - Gallons per minute

Figure A.2-6
Detail of Stopping Effects and Surging



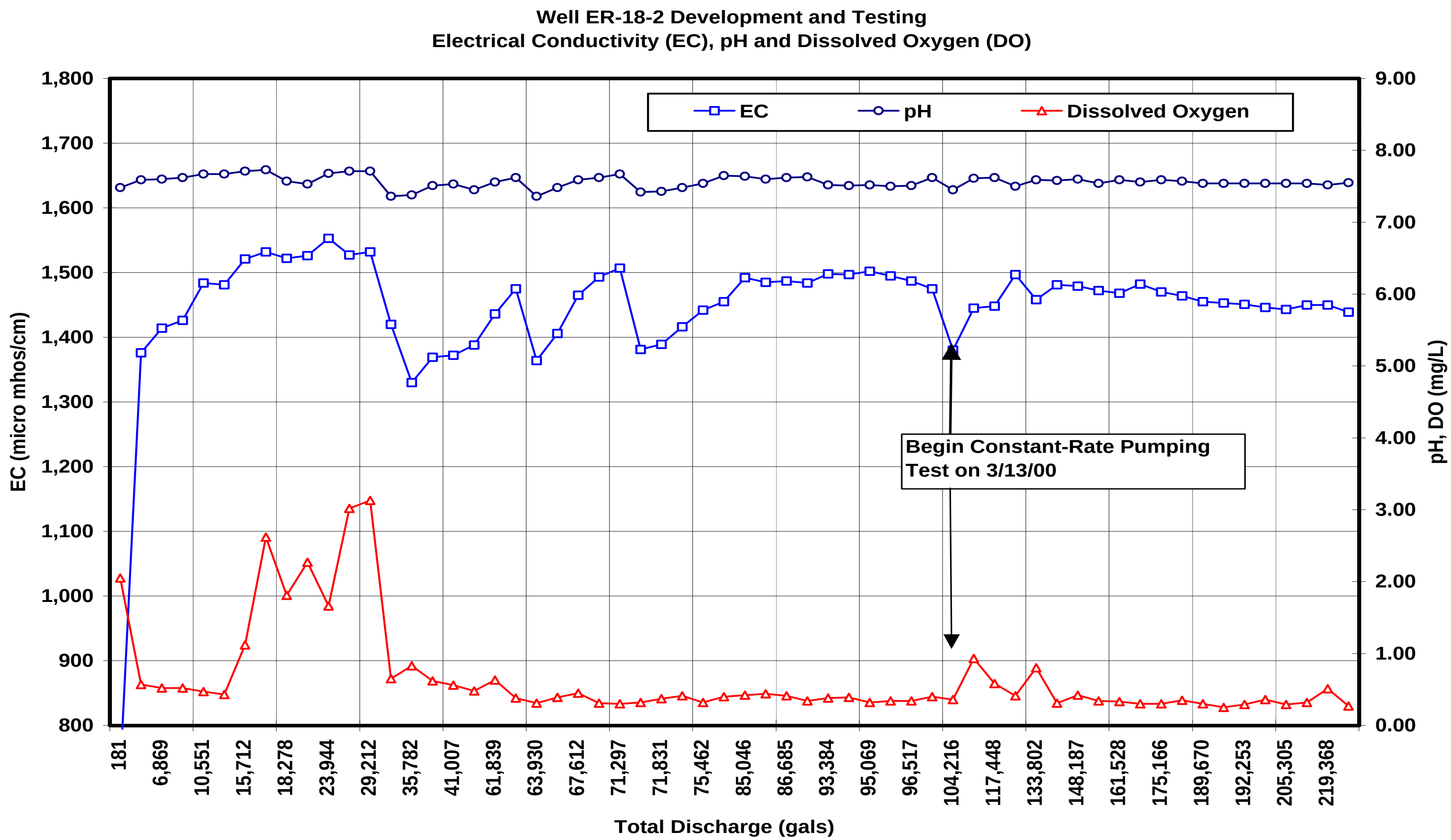
PXD - Pressure transducer
psig - Pounds per square inch gauge
gpm - Gallons per minute

Figure A.2-7
Pumping Rate and Hydraulic Response During Constant-Rate Test



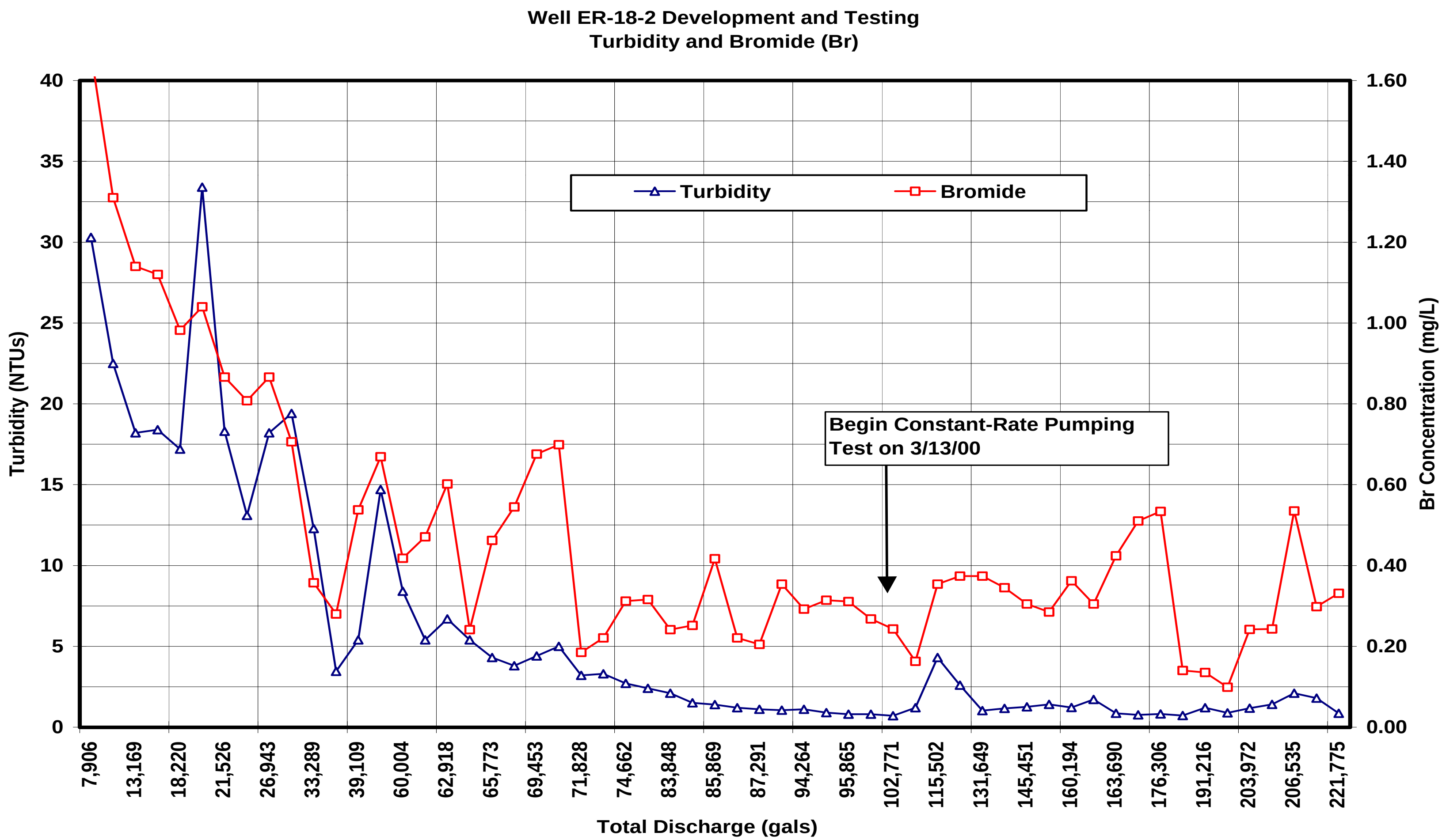
PXD - Pressure transducer
psig - Pounds per square inch gauge
mbar - Millibars

Figure A.2-8
Hydraulic Response and Barometric Pressure During Constant-Rate Test



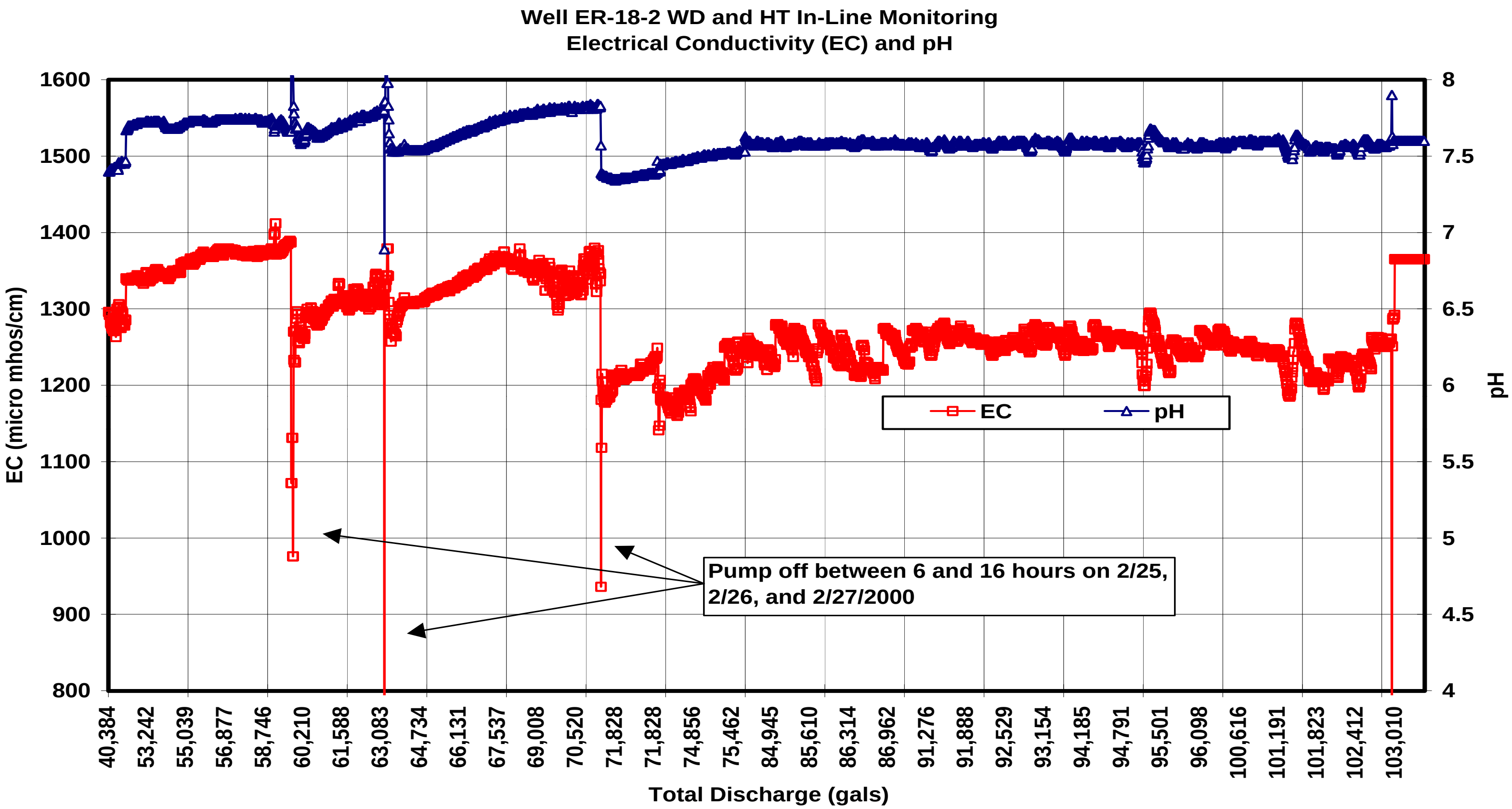
mg/L - Milligrams per liter
gals - Gallons
cm - Centimeter

Figure A.2-9
Grab Sample Monitoring for EC, pH, and DO



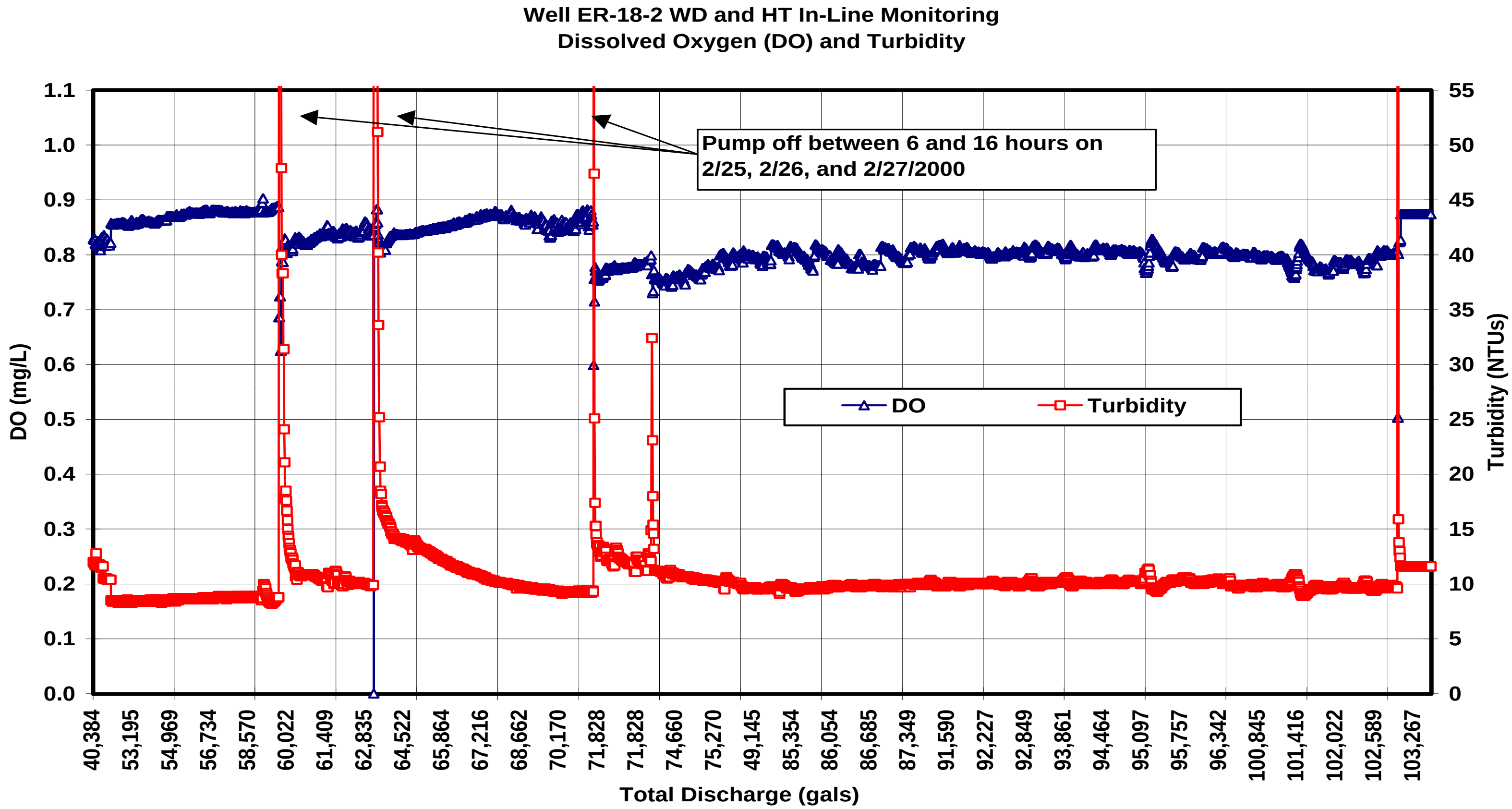
NTUs - Nephelometric turbidity unit
mg/L - Milligrams per liter

Figure A.2-10
Grab Sample Monitoring for Bromide and Turbidity



cm - Centimeters
gals - Gallons
WD and HT - Well development and hydraulic testing

Figure A.2-11
In-Line Monitoring for EC and pH



WD and HT - Well development and hydraulic testing
mg/L - Milligrams per liter
NTUs - Nephelometric turbidity units
gals - Gallons

Figure A.2-12
In-Line Monitoring for DO and Turbidity

A.3.0 Data Reduction and Review

This section presents basic reduction and processing of data collected during the Well ER-18-2 development and testing program. Data review and preliminary examination of the results are offered, clarifications of details are provided, and points of interest are noted. Any data interpretations in this section are preliminary and subject to change in future data analysis tasks.

A.3.1 Composite Water Density

The composite density of the water in the well is computed by dividing the change in depth of the PXD by the change in PXD pressure over the change in depth measured for calibration during installation or removal of the PXD. Determining the composite density from the actual pressure of the water column is required to determine the well-specific water density.

The calculated composite density conversion factor is 2.338 ft of water column/psi (0.988 in terms of specific gravity corrected for temperature). This value was derived from the PXD removal calibration measurements made for the predevelopment monitoring, as shown in Table A.3-1, which is included in the file ER-18-2 Water-Level Monitoring.xls on the CD. This record was selected as the most representative of the equilibrium condition of the well. This value is almost identical to the result from the initial PXD installation for this monitoring dataset as well as the initial PXD installation prior to the start of development. During the PXD installation/removal done for the constant-rate test the water level was moving still equilibrating; therefore, the data is not appropriate for determining density. The specific gravity values are based on calculations relative to values for standard temperature corrected weight density of water (Roberson and Crowe, 1975). This value appears reasonable.

A.3.2 Well Development

Well development actions did not appear to have a substantial effect on improving the hydraulic efficiency of the well. Very little sediment was produced and there was very little apparent improvement in specific capacity (drawdown divided by production rate) of the well during development.

A.3.3 Constant-Rate Test

The drawdown and recovery data from the constant rate pumping test have been processed to remove the offsets resulting from changes in the PXD depth during the record and to adjust for the influences of barometric pressure changes.

Table A.3-1
PXD Installation for Predevelopment Monitoring

Design Analysis H-310 PXD SN 2264, 0-15 psig					
Install Date: 8/16/1999					
Calibration Data (Removal): 9/24/1999					
Static water level depth 1,212.56 ft bgs					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC[a] (ft)	1,115.54	1,122.10	1,128.66	1,135.23	1,141.79
PXD psig	0.4618	3.2694	6.0978	8.8974	11.691
Delta depth (ft): Cal5 - Cal1					26.25
Delta psi: Cal5 - Cal1					11.229
Density ft of water column/psi: delta depth/delta psi (in ft/psi)					2.338
Equivalent ft water: PXD psig (at Cal 5) x density of water (ft/psi)					27.33
Calculated PXD installation depth: static water level + equiv. ft water					1,239.89

[a]Length of wireline below top of casing; does not include the length of the PXD integral cable.

ft - Foot (feet)
bgs - Below ground surface
PXD - Pressure transducer
psi - Pounds per square inch
psig - Pounds per square inch gauge

A.3.3.1 Barometric Efficiency

Barometric efficiency is a measure of the proportional response of the head (water level) in the well to a change in barometric pressure; when barometric pressure rises, the head will be depressed by some fractional amount. The proportional response of the well to barometric changes was determined from the predevelopment monitoring record. This was the best record where there was a substantial, short-term barometric excursion with a corresponding, well-defined response. A short-term, transient response was used to avoid the influence of other trends in the static water level of the well. Figure A.3-1 shows the segment of monitoring which was used to calculate the barometric efficiency. Table A.3-2 shows the parameter values that were used in the calculation. These values were extracted from the data file (ER-18-2 Water-Level Monitoring.xls on the CD). Efficiency was computed as the ratio of the maximum change in PXD pressure from the trend to the maximum change in barometric pressure from the trend during the excursion. The trend value for each parameter was computed as the average of the beginning and end values of the excursion since the excursion was almost symmetrical. Barometric efficiency was then used to apply a correction for the barometric pressure variation that occurred during the constant-rate test and recovery period.

Table A.3-2
Calculation of Barometric Efficiency

Barometric Excursion	Time Julian Days	PXD Pressure (psi)	Barometric Pressure (mbar)
Beginning	241.1736	11.615	835.5
Peak	245.3056	11.705	828.83
End	249.3750	11.659	835.04
PXD excursion psi: Peak psi - Trend[a] psi			0.068
Barometric excursion mbar: Peak mbar - Trend[a] mbar			-6.44
Barometric efficiency psi/mbar: PXD excursion psi/Barometric excursion mbar			-0.01056
Barometric efficiency %			-72.8

[a]Trend value computed as the average of the beginning and end values

psi - Pounds per square inch
mbar - Millibars
PXD - Pressure transducer

A.3.3.2 Drawdown Record

Figure A.3-2 shows the resultant record for the pumping period. The raw data record contained more data than the spreadsheet was able to graph at one time, so the record was reduced by eliminating every other data point. Because the data record is so dense, this is not noticeable. Offsets in the PXD psi record due to the relocation of the PXD were removed. The record following each relocation was shifted by the difference between before and after values, after the lines of record during the shift were removed.

The pressure drawdown record was processed as a change in pressure from the pressure at the beginning of pumping. Barometric changes were similarly processed. The PXD psi data points were then adjusted by -0.01056 psi/mbar (barometric efficiency) for the corresponding barometric change (-72.8 percent of the barometric change from the initial barometric pressure at the start of the drawdown data). The correction for barometric variation did not have a great effect because the drawdown was proportionally large compared to barometric variations during the test. The correction did remove some minor inflections in the drawdown curve, resulting in a very consistent response.

The pressure drawdown record was then converted to equivalent change in groundwater head using a conversion value for pressure to water head, as discussed in Section A.3.1. This information is presented in Table A.3-1. The water level measured during removal of the PXD after recording the test was used to locate the record vertically. This was the best measurement available because the water level was moving slowly at this point. Finally, the drawdown record in terms of depth was converted to head by subtraction from the surface reference elevation. This method of processing avoids the uncertainty associated with determining the elevation of the PXD, and ensures that the processed record corresponds to all water level measurements.

A.3.3.3 Recovery Record

Figure A.3-2 shows the recovery period after correction for barometric variation. The same comments on processing and presentation for the drawdown record (Section A.3.3.2) apply to the recovery record. The well was allowed to recover for 21 days, but still had not completely recovered when the PXD was removed. The last depth-to-water measurement was taken on April 11, 2000, at 1,214.62 ft bgs. The equilibrium static water level for this well is approximately 1,212.6 - 1,212.9 ft bgs.

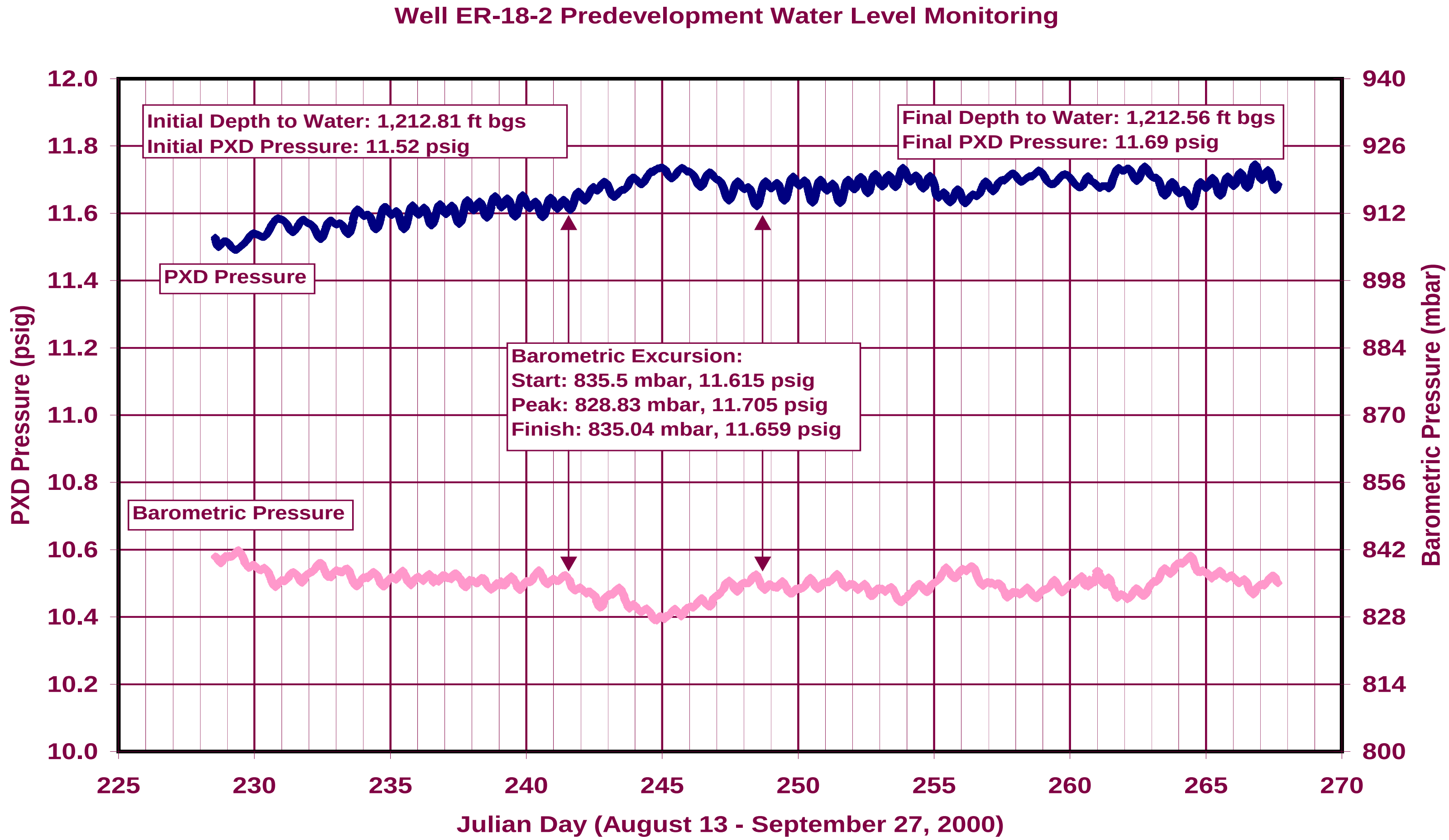
A.3.4 Water Quality

The grab sample and in-line monitoring results comprise all of the information on water quality parameters. A ChemTool log was not run during development and testing, although a log was run at the time the well was drilled, prior to well completion. Most of the parameters stabilized or appeared to be slightly declining. The only exception was the Br^- concentration which was erratic, but was generally below 0.6 mg/L.

A.3.5 Representativeness of Hydraulic Data and Water Samples

The water quality, development, hydraulic testing, and composite sampling data must be considered applicable to the entire single completion interval since there is no discrete-depth data. This is a simple assumption, but there is little basis for more specific conclusions.

The only data available on downhole flow conditions is from the precompletion thermal flow log that was run at the time the well was drilled. This log indicated that natural flow inside the well was downward, suggesting a downward vertical gradient. The highest velocity (1.2 gpm) was around 1,900 ft bgs at approximately the location of the top of the uppermost joint of slotted casing. Since no flow logging was performed on Well ER-18-2 during pumping, there is no specific information on where flow is entering the slotted screen joints. However, the well completion consisted of three joints of slotted casing separated by single joints of blank casing located in the bottom one-third of the 900-ft open interval, see Figure A.2-2. This arrangement does not provide for continuous access to the formation throughout the open interval, so any depth discrete data collected could have been misleading.



PXD - Pressure transducer
psig - Pounds per square inch gauge
ft bgs - Feet below ground surface
mbar - Millibars

Figure A.3-1
Determination of Barometric Efficiency

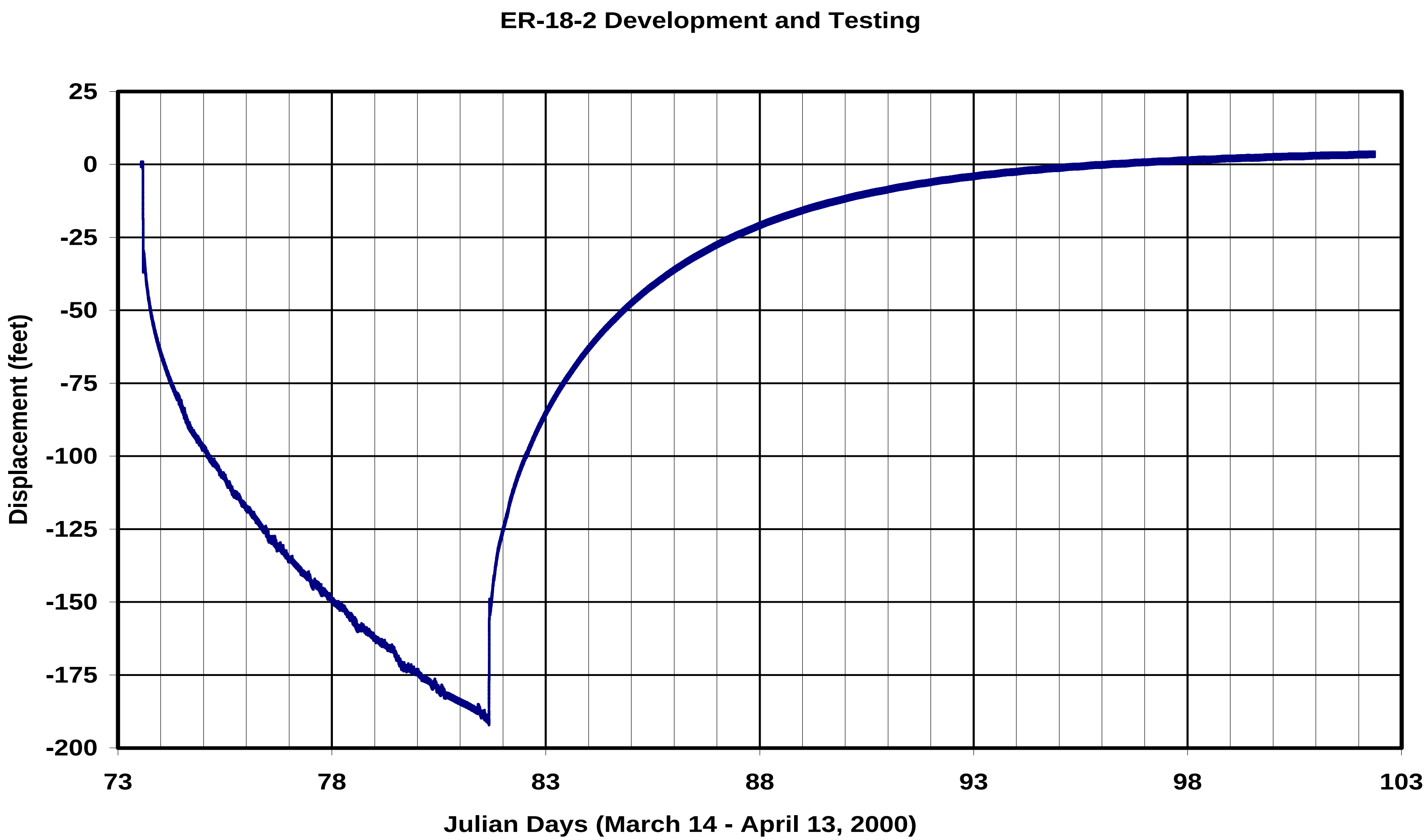


Figure A.3-2
Constant-Rate Pumping Test with Barometric Correction

A.4.0 Environmental Compliance

A.4.1 Fluid Management

All fluids produced during well development and hydraulic testing activities were managed according to the *Fluid Management Plan for the Underground Test Area Subproject* (FMP) (DOE/NV, 1999) and associated state-approved waivers. In accordance with the FMP and the waivers, the fluids produced during drilling were monitored and tested for tritium and lead daily. Several samples of water were collected from the sumps and analyzed at a certified laboratory for total and dissolved metals, gross alpha/beta, and tritium. Based on this process knowledge, the DOE/NV requested a waiver for the disposal of fluids produced during well development/hydraulic testing for Wells ER-EC-1, ER-EC-4, ER-EC-5, ER-EC-6, ER-EC-7, ER-EC-8, and ER-18-2. The NNSA/NV's proposal was to conduct activities at these well sites under far-field conditions with a reduced frequency of on-site monitoring. In October 1999, the Nevada Division of Environmental Protection (NDEP) granted NNSA/NV a waiver to discharge fluids directly to the ground surface during well development, testing, and sampling at the above wells (NDEP, 1999). The waiver (provided in Attachment 4) was granted under the mandate that the following conditions were satisfied:

- The only fluids allowed to be discharged to the surface are waters from the wells.
- Fluids will be allowed to be discharged to the ground surface without prior notification to NDEP.
- Waters that are heavily laden with sediments need to be discharged to the unlined, noncontaminated basins to allow the sediments to settle out before being discharged to the land surface.
- One tritium and one lead sample from the fluid discharge will be collected every 24 hours for analysis.
- Additional sampling and testing for lead must be conducted at 1 hour and then within 8 to 12 hours after the initial pumping begins at each location. If the field-testing results indicate nondetects for lead (less then 50 micrograms per liter [µg/L]), then the sampling may be conducted every 24 hours. If the field testing indicates detectable quantities less then 75 µg/L (5 times the *Nevada Drinking Water Standards* [NDWS]), then

sampling must occur every 12 hours until two consecutive nondetects occur. Sampling and testing may then resume on the 24-hour schedule.

- NDEP must be notified within 24 hours if any of the limits in the FMP are exceeded.

A.4.1.1 Water Production and Disposition

At Well ER-18-2, all fluids from the well development and testing were discharged into unlined Sump #1. Sump #1 serves as an infiltration basin and has an overflow pipe approximately 8.4 ft from the bottom. No discharge of fluids to ground surface via the overflow pipe occurred during well development and testing.

A total of approximately 223,000 gallons of groundwater were pumped from Well ER-18-2 during well development, hydraulic testing, and sampling activities. Table A.4-1 contains the Fluid Disposition Reporting Form for the testing program.

A.4.1.2 Lead and Tritium Monitoring

Lead and tritium samples were collected daily according to the FMP and waivers. Lead analysis was conducted on site in the field laboratory using a HACH DR 100 Colorimeter according to DOP ITLV-UGTA-310, "Field Screening for Lead in Well Effluent." A tritium sample was collected daily at the sample port of the wellhead. The sample was kept in a locked storage until transported to the Bechtel Nevada (BN) Site Monitoring Service at the Control Point in Area 6. The sample was analyzed using a liquid scintillation counter.

The NDWS were not exceeded at any time. The highest lead result was 1.5 µg/L and highest tritium activity was 1,245.04 picocuries per liter (pCi/L). The complete results of lead and tritium monitoring are presented in Table A.4-2.

A.4.1.3 Fluid Management Plan Sampling

A fluid management sample was collected from the active unlined sump at the end of well development and testing activities to confirm on-site monitoring of well effluent. The sample was collected on March 21, 2000. The FMP parameters of total and dissolved metals, gross alpha and beta, and tritium were requested for analysis. The laboratory results are presented in Table A.4-3 and compared to the NDWS.

A.4.2 Waste Management

Wastes generated during well development and testing activities were managed in accordance with the *Underground Test Area Subproject Waste Management Plan, Revision 1* (DOE/NV, 1996); the *Waste Management Field Instructions for the Underground Test Area Subproject* (IT, 1997); SQP ITLV-0501, "Control of Hazardous Materials"; and SQP ITLV-0513, "Spill Management." The following

Table A.4-1
Fluid Disposition Reporting Form

Site Identification: ER-18-2
Site Location: Nevada Test Site, Area 18
Site Coordinates: N 4,106,591; E 555,642 (UTM, NAD 83 meters)
Well Classification: ER
IT Project No: 776706.020804; 799416.00020180

Report Date: June 12, 2000
DOE/NV Subproject Manager: Bob Bangerter
IT Project Manager: Janet Wille
IT Site Representative: Jeff Wurtz
IT Environmental Specialist: Patty Gallo

Well Construction Activity	Activity Duration		#Ops. Days[a]	Well Depth (m)	Import Fluid (m^3)	Sump #1 Volumes (m^3)		Sump #2 Volumes[c] (m^3)		Volume of Infiltration Area (m^3)[d]	Other[e] (m^3)	Fluid Quality Objectives Met?
	From	To				Solids[b]	Liquids	Solids	Liquids	Liquids		
Phase I: Vadose-Zone Drilling	5/3/99 17:00	5/9/99 06:00	5.5	370	558	199	433	N/A	N/A	433	NA	YES
Phase I: Saturated-Zone Drilling	5/9/99 06:00	5/14/99 07:05	5	762	434	150	267	N/A	N/A	267	NA	YES
Phase II: Initial Well Development	2/15/00 17:23	3/01/00 9:50	9	762	NA	NA	388.7	NA	NA	137.8	NA	YES
Phase II: Aquifer Testing	3/13/00 13:50	3/21/00 18:00	9	762	NA	NA	456.1	NA	NA	0	NA	YES
Phase II: Final Development	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cumulative Production Totals to Date:			28.5	762	992	349	1,544.8	0	0	837.8	NA	

[a]Operational days refer to the number of days that fluids were produced during at least part (>3 hours) of one shift.
[b]Solids volume estimates include additional volume attributed to rock bulking factor (*1.5).
[c]Optional fluid management devices not installed for this well site.
[d]Ground surface discharge and infiltration within the unlined sump.
[e]Other refers to fluid conveyance to other fluid management locations or facilities away from the well site, such as vacuum trucktransport to another well site.
NA = Not Applicable; m = Meters; m^3 = Cubic meters; AIP = Analysis In Process
Total Facility Capacities: Sump #1 (Unlined w/ discharge pipe) = 810 m^3 Sump #2 (Unlined) = 1185 m^3

Infiltration Area (assuming negligible infiltration) = NA m^3

Approximate Remaining Facility Capacity as of 4/11/00 Sump #1 = 103 m^3 (12.7 %) Sump #2 = 1,185 m^3 (100 %)
Current Average Tritium = 0 pCi/ℓ
Notes:

IT Authorizing Signature/Date: Janet Wille 6-16-00

Table A.4-2
Results of Tritium and Lead Monitoring at ER-18-2

Sampling Date	Sample Number	Lead Results[1]	Tritium Results[2]	
		μg/L	dpm[a]	pCi/L[a]
2/15/2000	ER-18-2-021500-1	<1.0	- - -	672.7
2/162000	ER-18-2-021600-1	<2.0	0.0	0.0
2/172000	ER-18-2-021700-1	0.5	0.0	0.0
2/242000	ER-18-2-022400-1	<1.0	0.0	0.0
2/252000	ER-18-2-022500-1	1.0	0.0	0.0
2/26/2000	ER-18-2-022600-1	1.5	0.0	0.0
2/27/2000	ER-18-2-022700-1	<1.0	0.0	0.0
2/282000	ER-18-2-022800-1	<1.0	N/A[b]	N/A[b]
2/29/2000	ER-18-2-022900-1	<1.0	0.0	0.0
3/012000	ER-18-2-030100-1	<1.0	13.82	1,245.04[c]
3/132000	ER-18-2-031300-1	<2.0	0.0	0.0
3/14/2000	ER-18-2-031400-1	1.0	0.0	0.0
3/152000	ER-18-2-031500-1	<2.0	0.0	0.0
3/162000	ER-18-2-031600-1	<1.0	0.0	0.0
3/172000	ER-18-2-031700-1	<1.0	- - -	893.8[d]
3/18/2000	ER-18-2-031800-1	<1.0	0.0	0.0
3/19/2000	ER-18-2-031900-1	<1.0	0.0	0.0
3/20/2000	ER-18-2-032000-1	1.0	0.0	0.0
3/212000	ER-18-2-032100-1	<1.0	- - -	1,200.3
Nevada Drinking Water Standards:		15.0	- - -	20,000

[1]Lower detection limit 2 ppb.
[2]Lower detection limit 500 to 1,000 pCi/L, depending upon calibration.

[a]Analysis provided by Bechtel Nevada Site Monitoring Service at the Control Point in Area 6
[b]Results not reported by BN; analytical results evidently lost
[c]pCi/L derived from the following conversion equation: dpm/5mL * 1,000 mL/L * 0.45045 pCi/dpm = pCi/L
[d]Sample vial damaged during analysis

N/A - Not analyzed
dpm - Disintegrations per minute
mL = Milliliter
L - Liter
pCi - Picocuries

Table A.4-3
Preliminary Analytical Results of Sump Fluid Management Plan Sample at Well ER-18-2

Analyte	CRDL	Laboratory	NDWS	Results of Sump Composite Sample # 8-2-032100-4F
Metals (mg/L)				
				Total | Dissolved
Arsenic	0.01	Paragon	0.05	0.039 | 0.04
Barium	0.2	Paragon	2.0	B 0.036 | B 0.033
Cadmium	0.005	Paragon	0.005	U 0.005 | U 0.005
Chromium	0.01	Paragon	0.1	B 0.0014 | B 0.0015
Lead	0.003	Paragon	0.015	U 0.003 | U 0.003
Selenium	0.005	Paragon	0.05	U 0.005 | U 0.005
Silver	0.01	Paragon	0.1	U 0.01 | U 0.01
Mercury	0.0002	Paragon	0.002	B 0.000057 | B 0.000058
Analyte	**MDC**	**Laboratory**		**Result | Error**
Radiological Indicator Parameters-Level I (pCi/L)				
Tritium	280	Paragon	20,000	U 30 | +/- 170
Gross Alpha	3.6	Paragon	15	35.7 | +/- 6.1
Gross Beta	4.4	Paragon	50	6.8 | +/- 2.9

U = Result not detected at the given minimum detectable limit or activity
B = Result less than the Practical Quantitation Limit but greater than or equal to the Instrument Detection Limit
CRDL = Contract-Required Detection Limit per Table 5-1, UGTA QAPP (DOE/NV, 1998)
MDC = Minimum Detectable Concentration, sample-specific
NDWS = Nevada Drinking Water Standards
mg/L = Milligrams per liter
pCi/L = Picocuries per liter

exceptions were added in the *Field Instructions for WPM-OV Well Development and Hydraulic Testing Operations* (IT, 1999b) because chemical and/or radiological contamination was not expected:

- Decontamination rinsate from laboratory and on-site equipment decontamination operations shall be disposed of with fluids in the on-site infiltration basin.

- All disposable sampling equipment and personal protective equipment shall be disposed of as sanitary waste and may be placed directly in on-site receptacles.

As a result of well development and testing activities, only one type of waste was generated in addition to normal sanitary waste and decontamination water:

- Hydrocarbon: One drum of hydrocarbon waste was produced containing oily/diesel-stained absorbent pads/debris and used pump oil.

Hazardous waste, such as combustion by-products, were not produced at this site because bridge plugs were not set in this well. All waste, hydrocarbon and hazardous, were disposed of by BN Waste Management after well development operations at the NTS were completed.

A.5.0 References

DOE/NV, see U.S. Department of Energy, Nevada Operations Office.

IT, see IT Corporation.

IT Corporation. 1997. *Waste Management Field Instructions for the Underground Test Area Subproject*. Las Vegas, NV.

IT Corporation. 1999a. *Detailed Operating Procedures Underground Test Area Operable Unit*. Las Vegas, NV.

IT Corporation. 1999b. *Field Instructions for Western Pahute Mesa - Oasis Valley Well Development and Hydraulic Testing Operations,* Rev. 0, December. Las Vegas, NV.

IT Corporation. 1999c. *Site-Specific Health and Safety Plan for Development, Testing and Sampling of Clean Wells*. Las Vegas, NV.

IT Corporation. 1999d. *Well Development and Hydraulic Testing Plan for Western Pahute Mesa - Oasis Valley Wells,* Rev. 0. Las Vegas, NV.

IT Corporation. 2000. *ITLV Standard Quality Practices Manual,* Vol. 1 and 2. Las Vegas, NV.

NDEP, see Nevada Division of Environmental Protection.

Nevada Division of Environmental Protection. 1999. Letter from P. Liebendorfer (NDEP) to R. Wycoff (DOE/NV) granting a waiver from the FMP for WPM-OV wells and stipulating conditions for discharging fluids, 19 October. Carson City, NV.

Roberson, J.A., and C.T. Crowe. 1975. *Engineering Fluid Mechanics*. Boston, MA: Houghton Mifflin Company.

Townsend, M., Bechtel Nevada. 2002. Communication regarding completion and geology of Well ER-18-2. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1996. *Underground Test Area Subproject Waste Management Plan,* Rev. 1. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1998. *Underground Test Area Quality Assurance Project Plan*, Rev. 2. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1999. *Attachment 1 - Fluid Management Plan for the Underground Test Area Subproject* in "Underground Test Area Subproject Waste Management Plan," Rev. 1. Las Vegas, NV.

Attachment 1

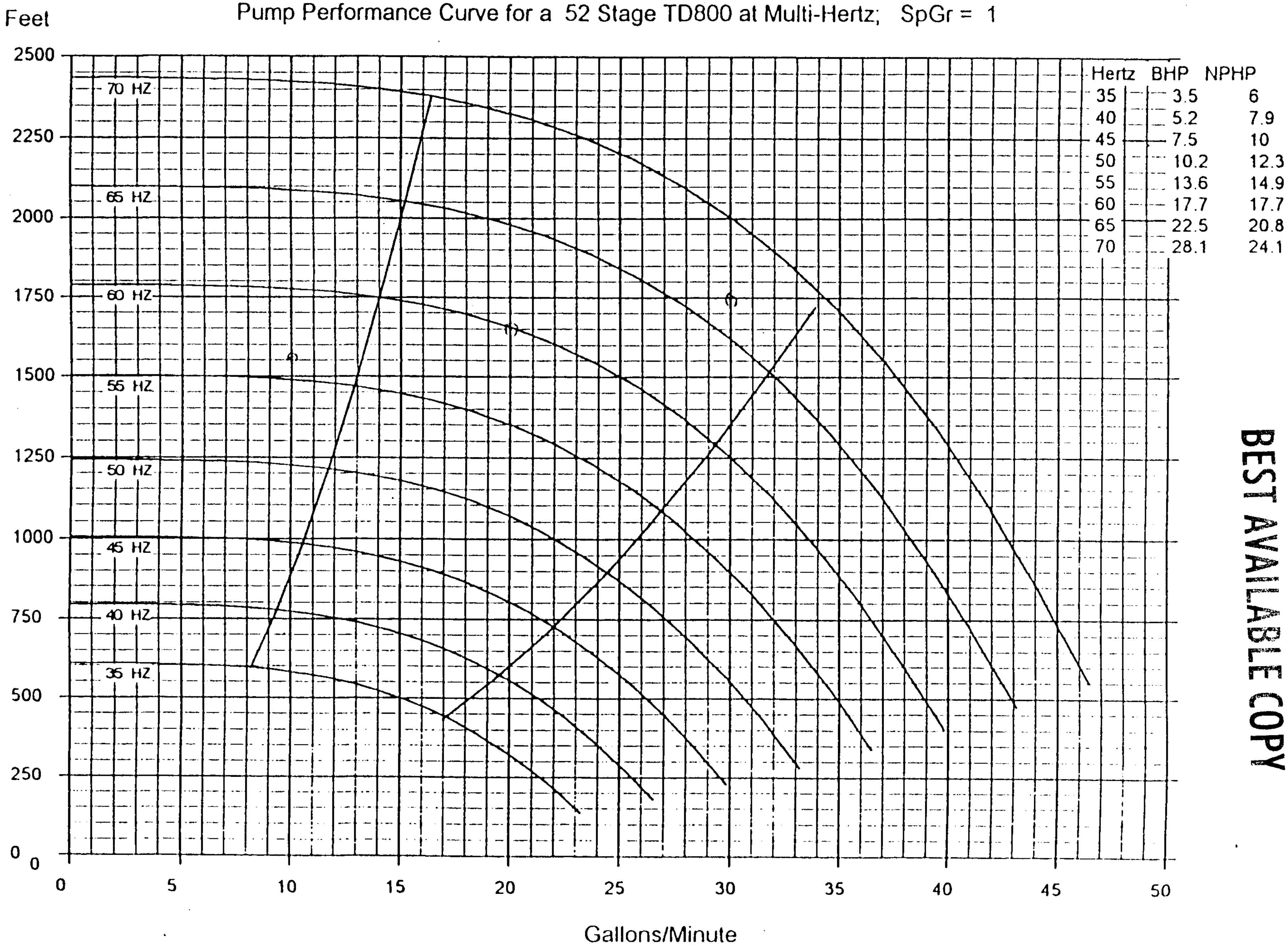
Manufacturer Pump Specifications

Dedicated Sampling Pump

Plot Program by Electric Submersible Pumps,Inc

4.00 ESP Pumps

Pump Performance Curve for a 52 Stage TD800 at Multi-Hertz; SpGr = 1



Att-3

Attachment 1

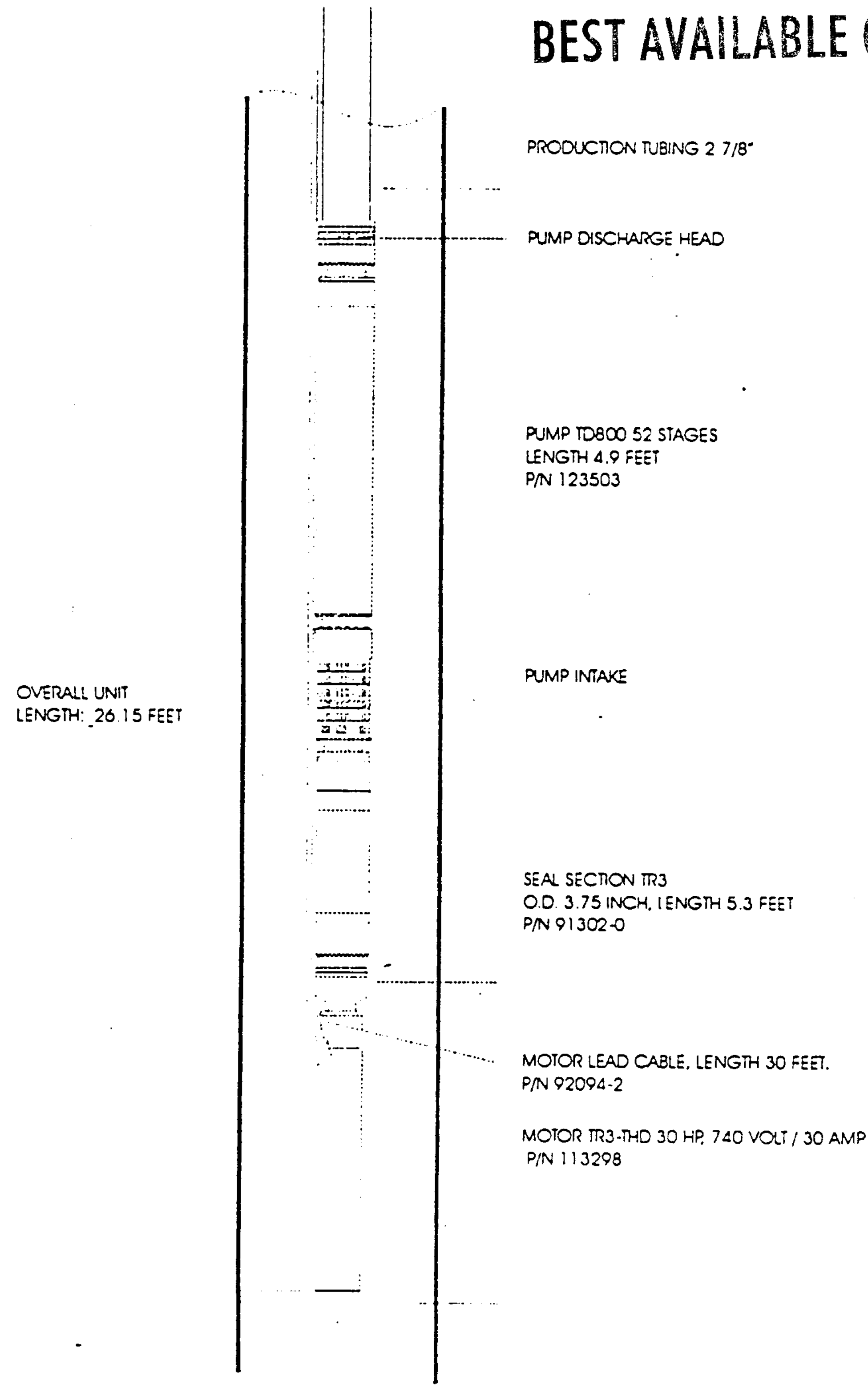
BEST AVAILABLE COPY

ESP

Bechtel Nevada
Las Vegas Nevada
Item Number 0002

WOOD GROUP

BEST AVAILABLE COPY



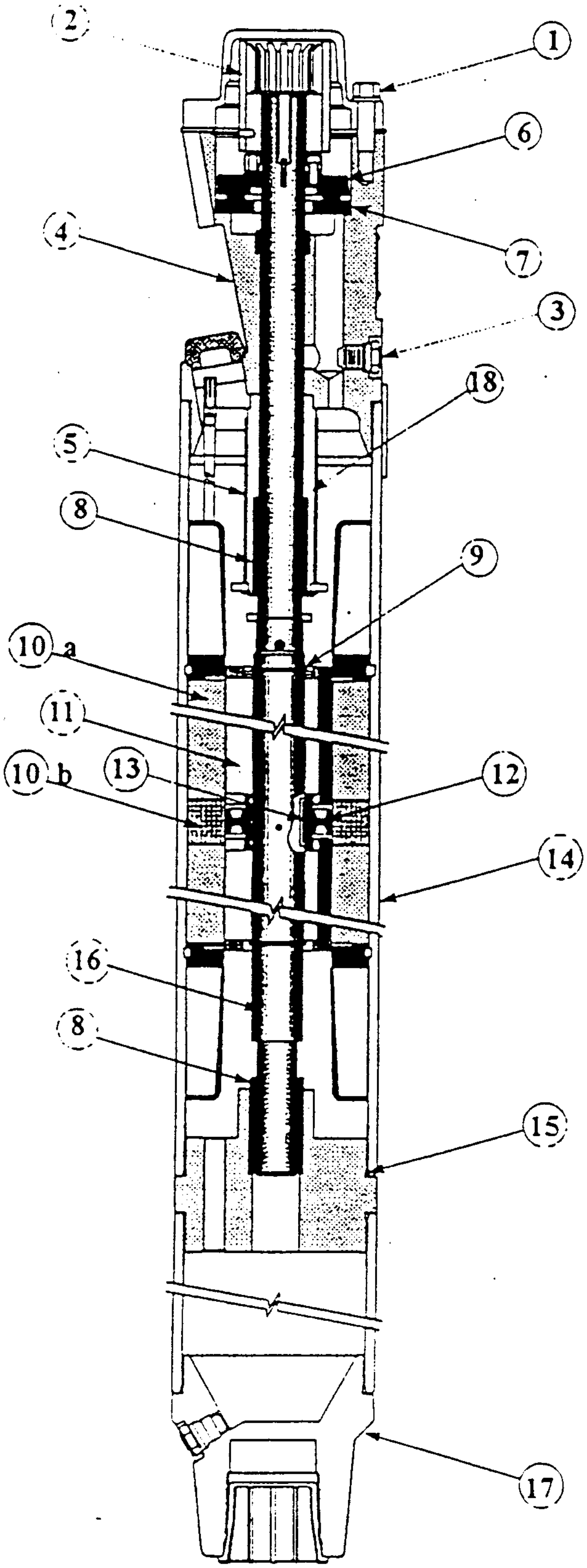
NOT TO SCALE

ESP

BEST AVAILABLE COPY

WOOD GROUP

MOTOR, SINGLE 30HP, 740 V 30A



PARTS LIST

ITEM	DESCRIPTION / MATERIAL
1	Unit Bolts Monel K500, UNS N05500
2	Coupling Steel 1042, ASTM 576
3	Vent Plugs Monel K500
4	Head Steel 1042, ASTM 576
5	Lead Guard Synthane
6	Thrust Runner Steel, C1117
7	Thrust Bearing Bronze, SAE 660 MP-481
8	Bushings Bronze 660
9	Snap Rings Beryllium Copper
10	Stator Laminations a)Steel b)Bronze,Silicon
11	Rotor Laminations Steel
12	Rotor Bearing Nitralloy
13	Rotor BearingSleeve Bronze 660
14	Stator Housing Steel 1026, ASTM A513
15	"O" Rings Viton
16	Shaft Steel 4130, ASTM A513, ASTM A519, UNS G41300
17	Base Steel 1042, ASTM 576
18	Guide Tube Steel 1020, ASTM A513,A519, UNS G10200

O.D. - 3.75 INCH
LENGTH - 13.3FEET
WEIGHT -495 LBS

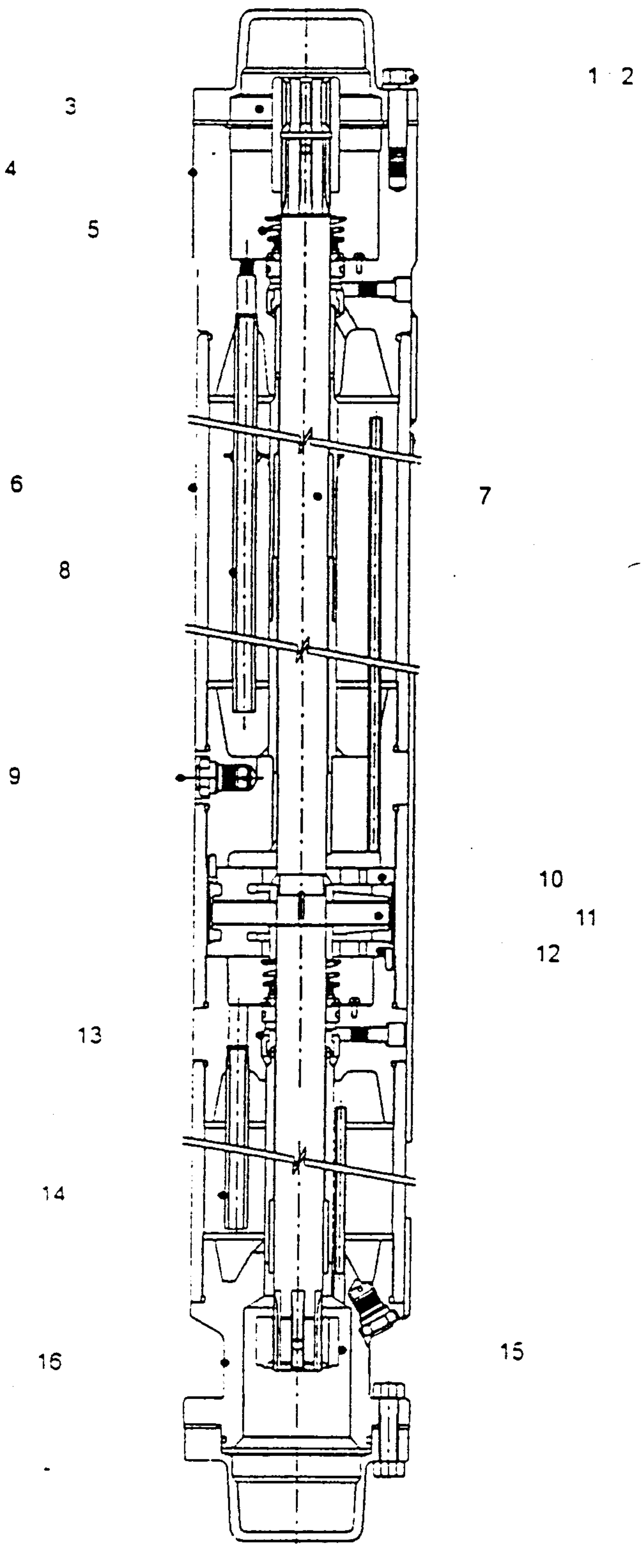
materials\mtr,tr-sgl.cdr

QUALITY RUNS DEEP AT ESP

New Release 15 May 1997

BEST AVAILABLE COPY

Standard Seal



PARTS LIST

WOOD GROUP

ITEM	DESCRIPTION
1	Screw, Hex Head - Monel
2	Washer, Lock - Monel
3	Coupling - Monel
4	Head, Seal
5	Seal, Mechanical
6	Housing
7	Shaft
8	Breather Tube
9	Valve, Drain/Fill
10	Bearing, Up-Thrust
11	Runner, Thrust
12	Bearing, Down-Thrust
13	Water Shedder
14	Breather Tube
15	Coupling Adapter
16	Base

TYPE TR3
3.75 O.D.
5.3 FT.
Shaft Dia. 1"
Shaft Nitronic 50
Weight 125 lbs.

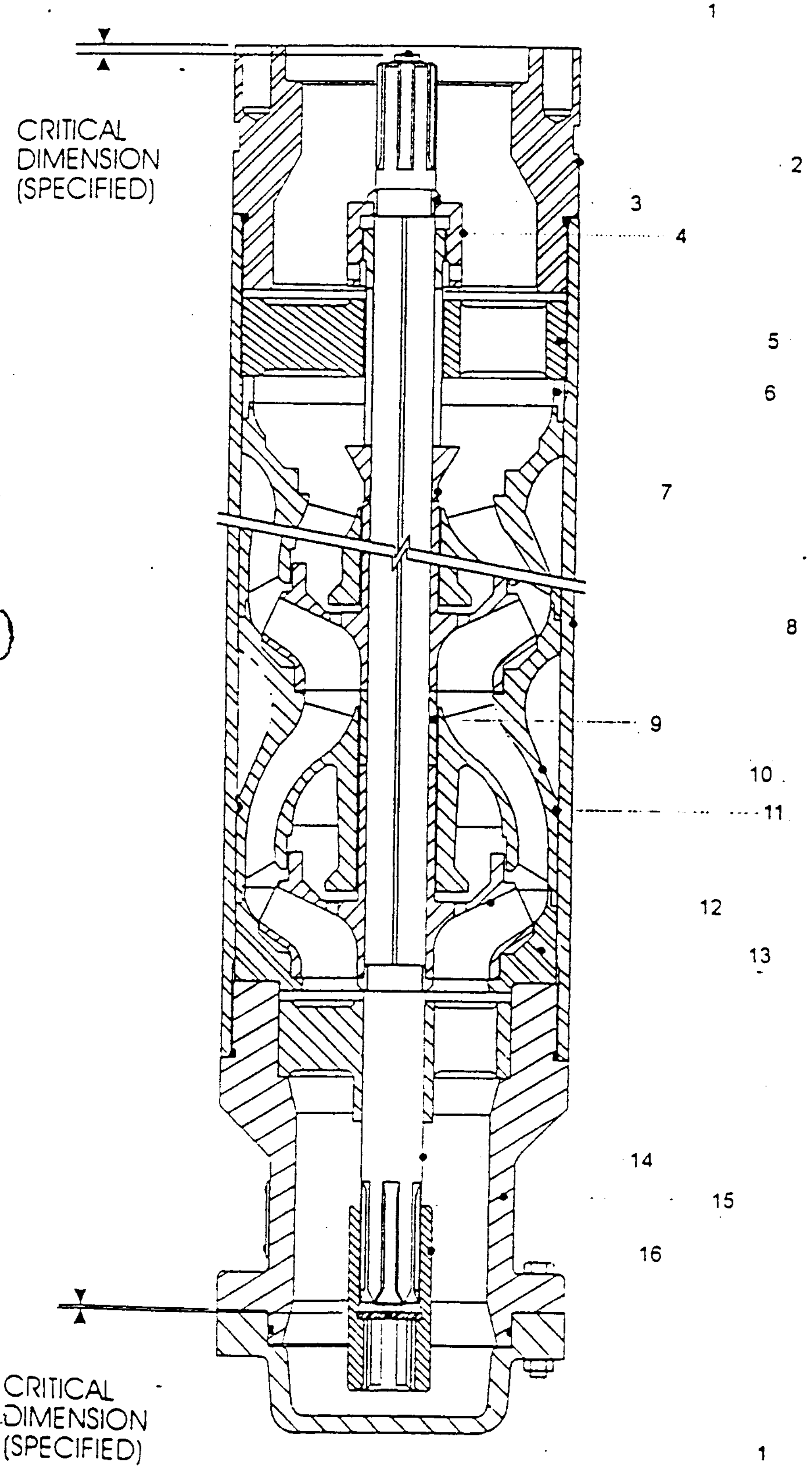
tr-std.cdr

ESP

Standard Pump (Floater Stage Design)

BEST AVAILABLE COPY

WOOD GROUP



PARTS LIST

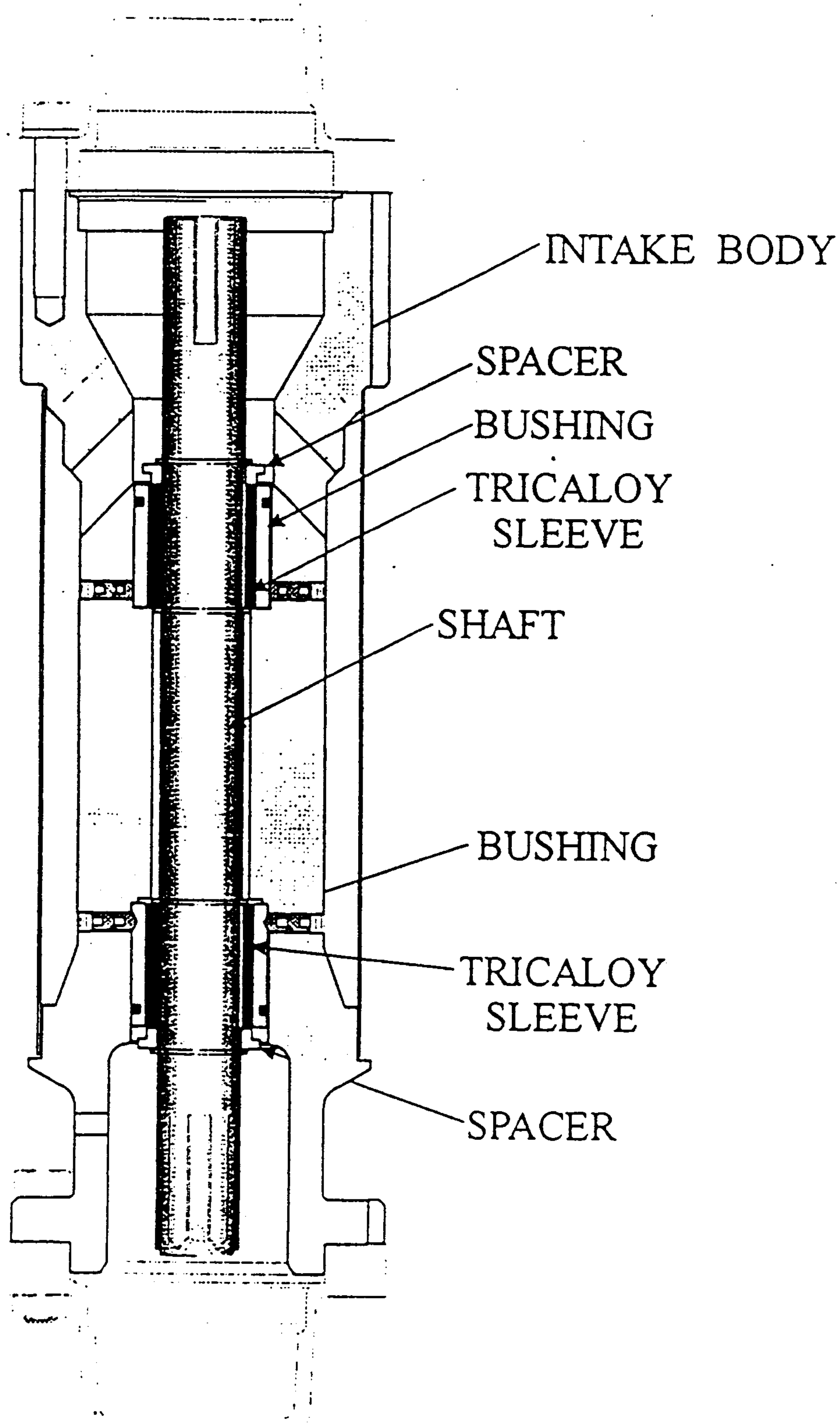
ITEM	DESCRIPTION
1	Adj. Nuts & Shims
2	Head, TDM
3	Two Piece Ring
4	Compression Nut, Sleeve & Set Screw
5	Compression Bearing
6	Compression Tube
7	Fluid Director
8	Housing
9	Spacer - Impeller
10	Diffuser
11	O'Ring, Diffuser
12	Impeller
13	Lower Diffuser
14	Shaft
15	Base, TDM S/A
16	Coupling

TD800
51STAGE
3.87O.D.
4.9 FT
2 3/8 8RD DISCHARGE
BOLT ON INTAKE

Attachment 1 cdr

3.87 INTAKE

BEST AVAILABLE COPY

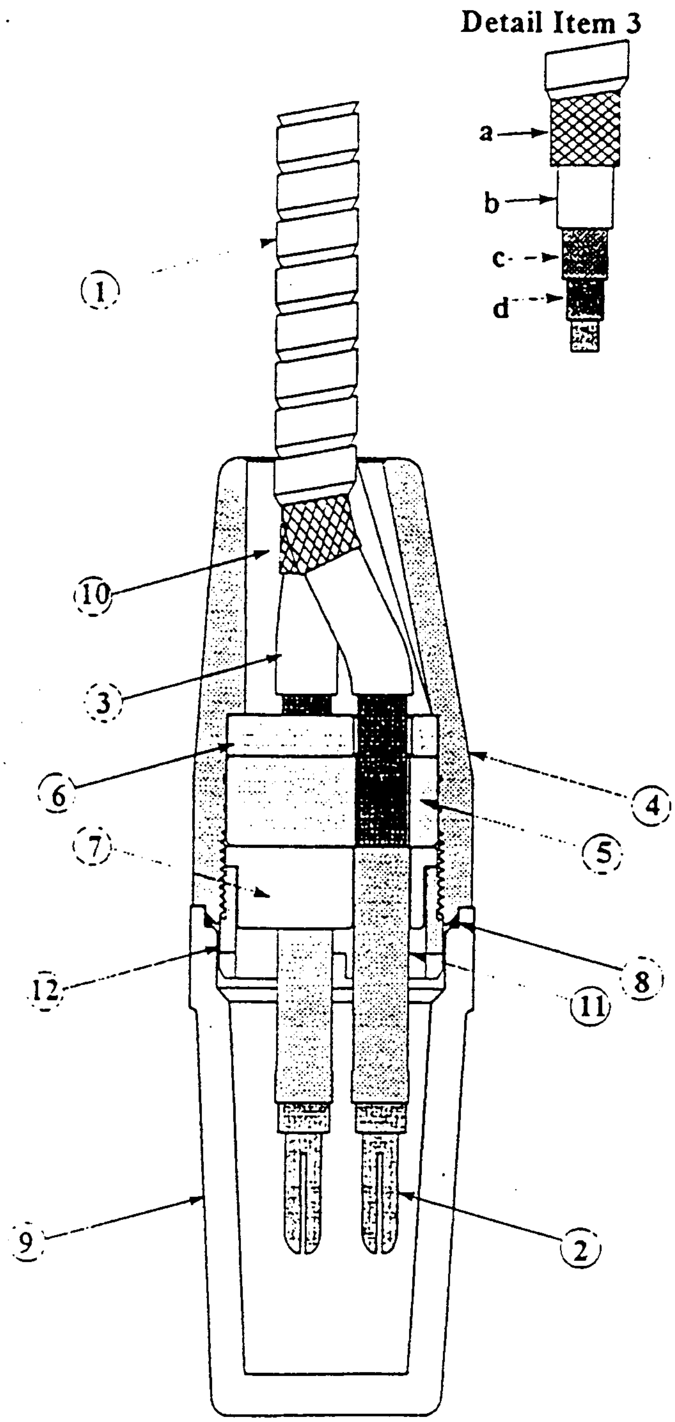


ESP

BEST AVAILABLE COPY

WOOD GROUP

MLC, Tr3 KEOTB GALV.



PARTS LIST

ITEM	DESCRIPTION / MATERIAL
1	Cable, Flat KEOTB Cable w/ Galv Armor
2	Terminal Beryllium Copper MP1012
3	Insulated Conductor a) Nylon Braid b) Lead Sheath c) EPDM Insulation d) Kapton Tape
4	Pothead Casting Ni-Resist
5	Insulation Block High Dielectric Hypalon
6	Wall, Upper Epoxy Glass G10-11, MP1017-1018
7	Wall, Lower Aluminum 2014
8	O-Ring HSN 75 Duro
9	Shipping Cap Ni-Resist
10	Filler Epoxy, Thermoset
11	Tubing, Shrink Teflon FEP
12	Nut, Compression Steel 1042 ASTM 576

materials\mlc.tr5-kelb-4kv.cdr

QUALITY RUNS DEEP AT ESP

New Release 27 May 1997

Attachment 2

Water Quality Monitoring - Grab Sample Results for Well ER-18-2

Table ATT.2-1
Water Quality Monitoring - Grab Sample Results for Well ER-18-2
(Page 1 of 4)

Date	Time hr:min.	Temperature °C	EC μmhos/cm	pH SU	DO mg/L	Turbidity NTUs	Bromide mg/L	Pumping Rate gpm	Total Discharge gallons	Comments/Phase of Development or Testing
2/15/2000	18:25	44.9	729	7.48	2.05	12.2	4.61	29.0	181	Begin development 2/15/00, 17:57
2/15/2000	21:00	46.8	1,376	7.59	0.57	43.5	- - -	23.4	440	Water has a burnt cooking oil odor
2/15/2000	22:00	47.4	1,414	7.60	0.52	39.5	- - -	22.5	6,869	
2/16/2000	0:00	46.6	1,426	7.62	0.52	30.3	1.67	22.1	7,906	
2/16/2000	2:00	48.0	1,484	7.67	0.47	22.5	1.31	25.1	10,551	
2/16/2000	4:00	48.2	1,481	7.67	0.43	18.2	1.14	21.2	13,169	
2/16/2000	6:00	47.8	1,521	7.71	1.12	18.4	1.12	23.8	15,712	
2/16/2000	8:00	42.4	1,532	7.73	2.62	17.2	0.98	22.8	18,220	Pump off between 8:30 and 13:27
2/16/2000	13:27	31.8	1,522	7.57	1.81	33.4	1.04	30.3	18,278	
2/16/2000	15:30	44.9	1,526	7.53	2.27	18.3	0.87	22.9	21,526	
2/16/2000	17:30	41.0	1,553	7.68	1.66	13.1	0.81	20.4	23,944	
2/16/2000	20:00	48.2	1,527	7.71	3.02	18.2	0.87	18.8	26,943	DO probe serviced
2/16/2000	22:00	47.6	1,532	7.71	3.13	19.4	0.71	15.4	29,212	Pump failed; shut down at 23:00
2/17/2000	17:12	43.6	1,420	7.36	0.65	12.3	0.36	21.7	33,289	Pump on from 15:11 to 18:42
2/24/2000	11:50	42.5	1,330	7.38	0.83	3.5	0.28	29.1	35,782	BN rig lowers pump 77 ft into 5.5-in. casing for cooling purposes
2/24/2000	14:15	48.1	1,369	7.51	0.62	5.4	0.54	25.2	39,109	Start pump at 11:15 at 24 gpm
2/24/2000	16:00	47.6	1,372	7.53	0.56	14.7	0.67	21.2	41,007	Pumping rate varied between 25 and 20 gpm
2/25/2000	14:00	44.3	1,388	7.45	0.48	8.4	0.42	15.2	60,004	Pump off between 7:43 and 13:15
2/25/2000	16:00	47.0	1,436	7.56	0.63	5.4	0.47	15.3	61,839	

Table ATT.2-1
Water Quality Monitoring - Grab Sample Results for Well ER-18-2
(Page 2 of 4)

Date	Time hr:min.	Temperature °C	EC µmhos/cm	pH SU	DO mg/L	Turbidity NTUs	Bromide mg/L	Pumping Rate gpm	Total Discharge gallons	Comments/Phase of Development or Testing
2/25/2000	17:10	48.2	1,475	7.62	0.38	6.7	0.60	15.2	62,918	Shut off pump at 17:30
2/26/2000	10:00	44.2	1,364	7.36	0.31	5.4	0.24	15.1	63,930	Pump restarted at 9:10
2/26/2000	12:00	47.2	1,406	7.48	0.39	4.3	0.46	15.3	65,773	
2/26/2000	14:00	48.0	1,465	7.59	0.45	3.8	0.55	15.3	67,612	
2/26/2000	16:00	49.0	1,493	7.62	0.31	4.4	0.68	15.3	69,453	
2/26/2000	18:00	49.0	1,507	7.67	0.30	5.0	0.70	15.3	71,297	Shut off pump at 18:15
2/27/2000	11:00	43.0	1,381	7.42	0.32	3.2	0.19	8.8	71,828	Pump restarted at 9:35
2/27/2000	13:00	45.3	1,389	7.43	0.37	3.3	0.22	9.5	71,831	
2/27/2000	15:00	46.4	1,416	7.48	0.41	2.7	0.31	9.1	74,662	
2/27/2000	17:00	45.3	1,442	7.54	0.32	2.4	0.32	7.5	75,462	
2/28/2000	8:45	47.3	1,455	7.65	0.40	2.1	0.24	7.9	83,848	Total discharge extrapolated; meter reading was incorrect
2/28/2000	11:00	45.8	1,492	7.64	0.42	1.5	0.25	7.0	85,046	
2/28/2000	13:00	45.6	1,485	7.60	0.44	1.4	0.42	6.7	85,869	
2/28/2000	15:00	46.0	1,487	7.62	0.41	1.2	0.22	6.5	86,685	
2/28/2000	16:30	46.1	1,484	7.63	0.34	1.1	0.21	6.6	87,291	
2/29/2000	8:00	46.2	1,498	7.52	0.38	1.1	0.35	6.0	93,384	
2/29/2000	10:00	45.9	1,497	7.51	0.39	1.1	0.29	6.9	94,264	
2/29/2000	12:00	45.5	1,502	7.52	0.32	0.9	0.31	7.3	95,069	
2/29/2000	14:00	45.8	1,495	7.50	0.34	0.8	0.31	6.9	95,865	
2/29/2000	16:00	45.4	1,487	7.51	0.34	0.8	0.27	6.4	96,517	

Table ATT.2-1
Water Quality Monitoring - Grab Sample Results for Well ER-18-2
(Page 3 of 4)

Date	Time hr:min.	Temperature °C	EC µmhos/cm	pH SU	DO mg/L	Turbidity NTUs	Bromide mg/L	Pumping Rate gpm	Total Discharge gallons	Comments/Phase of Development or Testing
3/1/2000	8:00	45.1	1,475	7.62	0.40	0.7	0.24	6.3	102,771	Pump shut off at 10:00; DRI attempts to install check valve, which becomes stuck; DRI large vehicles unable to reach site
3/13/2000	14:35	39.8	1,380	7.45	0.36	1.2	0.16	10.3	104,216	Begin Constant Rate test at 13:50 at 10 gpm
3/14/2000	9:00	45.6	1,445	7.61	0.93	4.3	0.35	10.5	115,502	
3/14/2000	12:10	45.7	1,448	7.62	0.58	2.6	0.37	9.8	117,448	
3/15/2000	11:20	43.0	1,497	7.50	0.41	1.0	0.37	10.8	131,649	
3/15/2000	14:50	42.4	1,458	7.59	0.80	1.2	0.35	10.3	133,802	
3/16/2000	9:45	48.5	1,481	7.58	0.31	1.3	0.31	10.1	145,451	
3/16/2000	14:15	47.5	1,479	7.60	0.42	1.4	0.29	10.1	148,187	
3/17/2000	9:50	48.1	1,472	7.54	0.34	1.2	0.36	10.2	160,194	
3/17/2000	12:00	46.7	1,468	7.59	0.33	1.7	0.31	10.2	161,528	
3/17/2000	15:30	46.4	1,482	7.56	0.30	0.9	0.42	10.3	163,690	
3/18/2000	10:10	48.0	1,470	7.59	0.30	0.8	0.51	10.6	175,166	
3/18/2000	12:00	47.0	1,464	7.57	0.35	0.8	0.53	10.6	176,306	
3/19/2000	9:40	48.4	1,455	7.54	0.30	0.7	0.14	8.1	189,670	
3/19/2000	12:10	48.6	1,453	7.54	0.25	1.2	0.14	6.0	191,216	
3/19/2000	13:50	48.4	1,451	7.54	0.29	0.9	0.10	10.4	192,253	
3/20/2000	8:50	46.2	1,446	7.54	0.36	1.2	0.24	11.5	203,972	
3/20/2000	11:00	46.6	1,443	7.54	0.29	1.4	0.24	10.4	205,305	
3/20/2000	13:00	46.3	1,450	7.54	0.32	2.1	0.54	10.3	206,535	

Table ATT.2-1
Water Quality Monitoring - Grab Sample Results for Well ER-18-2
(Page 4 of 4)

Date	Time hr:min.	Temperature °C	EC µmhos/cm	pH SU	DO mg/L	Turbidity NTUs	Bromide mg/L	Pumping Rate gpm	Total Discharge gallons	Comments/Phase of Development or Testing
3/21/2000	9:51	47.3	1,450	7.52	0.51	1.8	0.30	10.4	219,368	Collect GW samples 10:45 to 14:40
3/21/2000	13:45	46.6	1,439	7.55	0.27	0.9	0.33	10.6	221,775	Pump shut off at 16:00
3/21/2000	16:00	- - -	- - -	- - -	- - -	- - -	- - -	- - -	223,181	

°C - Degrees Celsius
EC - Electrical Conductivity
DRI - Desert Research Institute
hr:min - Hour: minute
mg/L - Milligrams per liter
DO - Dissolved oxygen
GW - Groundwater
NTUs - Nephelometric turbidity units
gpm - Gallons per minute
µmhos/cm - Micromhos per centimeter
SU - Standard Units
in. - Inch

Attachment 3

Water Quality Analyses, Composite Characterization Sample and Discrete Samples

Table ATT.3-1
Analytical Results of Groundwater Characterization Samples at Well ER-18-2
(Page 1 of 3)

Analyte	Laboratory Detection Limit[a]	Laboratory	Results of Wellhead Composite Sample #18-2-032100-1	
Metals (mg/L)				
			Total	Dissolved
Aluminum	0.2	Paragon	U 0.097	U 0.084
Arsenic	0.01	Paragon	0.044	0.04
Barium	0.1	Paragon	B 0.015	B 0.015
Cadmium	0.005	Paragon	UJ 0.005	UJ 0.005
Calcium	1	Paragon	5.4	5.6
Chromium	0.01	Paragon	U 0.01	B 0.00065
Iron	0.1	Paragon	U 0.099	U 0.081
Lead	0.003	Paragon	U 0.003	U 0.003
Lithium	0.01	Paragon	0.26	0.26
Magnesium	1	Paragon	UJ 0.054	UJ 0.051
Manganese	0.01	Paragon	0.023	0.023
Potassium	1	Paragon	3.7	3.7
Selenium	0.005	Paragon	U 0.005	U 0.005
Silicon	0.05	Paragon	19	19
Silver	0.01	Paragon	U 0.01	U 0.01
Sodium	1	Paragon	340	350
Strontium	0.01	Paragon	0.21	0.21
Uranium	0.2	Paragon	U 0.2	U 0.2
Mercury	0.0002	Paragon	B 0.00011	U 0.000077
Trace Elements (mg/L)				
Trace Elements	Sample-Specific	UNLV-HRC	N/A	
Inorganics (mg/L) - unless otherwise noted				
Chloride	0.2	Paragon	13	
Fluoride	0.5	Paragon	13	
Bromide	0.2	Paragon	J 0.12	
Sulfate	1	Paragon	55	
pH (pH units)	0.1	Paragon	J 7.9	

Table ATT.3-1
Analytical Results of Groundwater Characterization Samples at Well ER-18-2
(Page 2 of 3)

Analyte	Laboratory Detection Limit[a]	Laboratory	Results of Wellhead Composite Sample #18-2-032100-1
Total Dissolved Solids	20	Paragon	J 910
Electrical Conductivity (micromhos/cm)	1	Paragon	1400
Carbonate as CaCO3	100	Paragon	U 100
Bicarbonate as CaCO3	100	Paragon	730
Dissolved Inorganic Carbon (mg/L as HCO3-)	Not Provided	LLNL	871
Organics (mg/L)			
Total Organic Carbon	1	Paragon	1.3
Redox Parameters (mg/L)			
Total Sulfide	5	Paragon	UJ 5
Age and Migration Parameters (pCi/L) - unless otherwise noted			
Carbon-13/12 (per mil)	Not Provided	DRI	+ 0.5 +/- 0.2
C-14, Inorganic (pmc)	Not Provided	LLNL	1.6
C-14, Inorganic age (years)*	Not Provided	LLNL	34,081
Chlorine-36	Not Provided	LLNL	1.33E-04
Cl-36/Cl (ratio)	Not Provided	LLNL	3.02E-13
He-4 (atoms/mL)	Not Provided	LLNL	1.70E+14
He-3/4, measured value (ratio)	Not Provided	LLNL	4.01E-06
He-3/4, relative to air (ratio)	Not Provided	LLNL	2.9
Oxygen-18/16 (per mil)	Not Provided	DRI	-14.6 +/- 0.2
Strontium-87/86 (ratio)	Not Provided	LLNL	0.708606 +/- 0.00003
Uranium-234/238 (ratio)	Not Provided	LLNL	0.000695
H-2/1 (per mil)	Not Provided	DRI	-109 +/- 1.0
Colloids	Not Provided	LANL	See Table ATT.3-2
Radiological Indicator Parameters-Level I (pCi/L)			
Gamma Spectroscopy	Sample-Specific	Paragon	All nuclides reported with a 'U'
Tritium	290	Paragon	U 110 +/- 170
Gross Alpha	2.9	Paragon	J 51.8 +/- 8.1
Gross Beta	4.5	Paragon	U 2.4 +/- 2.7
Carbon-14	320	Paragon	U 310 +/- 200

Table ATT.3-1
Analytical Results of Groundwater Characterization Samples at Well ER-18-2
(Page 3 of 3)

Analyte	Laboratory Detection Limit[a]	Laboratory	Results of Wellhead Composite Sample #18-2-032100-1
Radiological Indicator Parameters-Level II (pCi/L)			
Strontium-90	0.28	Paragon	U 0.33 +/- 0.19
Plutonium-238	0.05	Paragon	U -0.004 +/- 0.016
Plutonium-239	0.033	Paragon	U -0.002 +/- 0.016
Iodine-129	1.1	Paragon	U -0.04 +/- 0.66
Technetium-99	3.7	Paragon	U 4.5 +/- 2.4

U = Result not detected at the given minimum detectable limit or activity.
J = The result is an estimated value.
B = The result is less than the contract-required detection limit, but greater than the instrument detection limit.
N/A = Not applicable for that sample
mg/L = Milligrams per liter µg/L = Micrograms per liter pCi/L = Picocuries per liter
micromhos/cm = Micromhos per centimeter
pmc = Percent modern carbon

*The carbon-14 age presented is not corrected for reactions along the flow path.

[a]If there is only one value present, that value is the detection limit for each analysis (or there was only one analysis).

Table ATT.3-2
Colloid Analyses for Well ER-18-2

Analyte	Laboratory	Results of Wellhead Composite Sample #18-2-032100-1
Colloid Particle Size Range (in nanometer)		Colloid Concentration (particles/mL)
50 - 60	LANL	1.107E+07
60 - 70	LANL	9.692E+06
70 - 80	LANL	7.244E+06
80 - 90	LANL	4.671E+06
90 - 100	LANL	2.948E+06
100 - 110	LANL	3.572E+06
110 - 120	LANL	2.298E+06
120 - 130	LANL	1.324E+06
130 - 140	LANL	9.242E+05
140 - 150	LANL	8.992E+05
150 - 160	LANL	4.496E+05
160 - 170	LANL	4.496E+05
170 - 180	LANL	3.996E+05
180 - 190	LANL	4.496E+05
190 - 200	LANL	3.498E+05
200 - 220	LANL	3.996E+05
220 - 240	LANL	1.540E+05
240 - 260	LANL	5.740E+04
260 - 280	LANL	4.480E+04
280 - 300	LANL	2.560E+04
300 - 400	LANL	6.340E+04
400 - 500	LANL	1.500E+04
500 - 600	LANL	1.740E+04
600 - 800	LANL	2.920E+04
800 - 1000	LANL	4.800E+03
>1000	LANL	1.680E+04
Total Concentration, Particle Size Range, 50-1000 nm	LANL	4.76E+07

Attachment 4

Fluid Management Plan Waiver for WPM-OV Wells

STATE OF NEVADA
KENNY C. GUINN
Governor

PETER G. MORROS, Director
ALLEN BIAGGI, *Administrator*
(775) 687-4670
TDD 687-4678

Administration
Water Pollution Control
Facsimile 687-5856

Mining Regulation and Reclamation
Facsimile 684-5259

Waste Management
Corrective Actions
Federal Facilities

Air Quality
Water Quality Planning
Facsimile 687-6396

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

DIVISION OF ENVIRONMENTAL PROTECTION

333 W. Nye Lane, Room 138
Carson City, Nevada 89706-0851

October 19, 1999

Ms. Runore C. Wycoff, Director
Environmental Restoration Division
U.S. Department of Energy
Nevada Operations Office
P.O. Box 98593-8518
Las Vegas, Nevada 89193-8518

RE: U.S. Department of Energy's "Request For A Waiver From the Fluid Management Plan For Well Development At Wells ER-EC-1, ER-EC-4, ER-EC-5, ER-EC-6, ER-EC-7, ER-EC-8, and ER-18-2" (Oct. 5, 1999)

Dear Ms. Wycoff:

The Nevada Division of Environmental Protection (NDEP) has reviewed the U.S. Department of Energy's (DOE) request for a waiver to discharge fluids directly to the ground surface during the development, testing, and sampling of wells Wells ER-EC-1, ER-EC-4, ER-EC-5, ER-EC-6, ER-EC-7, ER-EC-8, and ER-18-2. NDEP hereby approves the requested waiver with the following conditions:

> Condition 1 - The only fluids allowed to be discharged to the surface are waters from the wells.
>
> Condition 2 - Any waters that are heavily laden with sediments need to be discharged to the unlined, non-contaminated basins in order to allow the sediments to settle out before being discharged to the land surface.
>
> Condition 3 - Additional sampling and testing for lead must be conducted at 1 hour and then within 8 to 12 hours after the initial pumping begins at each location. If the field testing results indicate non-detects for lead, then the sampling may be conducted every 24 hours. If the field testing indicates detectable quantities (if less then 5 times the

Runore C. Wycoff, Director
October 19, 1999
Page 2

SDWA standard) then sampling must occur every 12 hours until 2 consecutive nondetects occur. Sampling and testing may then resume on the 24 hour schedule.

Condition 4 - NDEP shall be notified within 24 hours should any of the limits set forth in the Fluid Management Plan be exceeded.

If you have questions regarding this matter please contact me at (775) 687-4670 (ext. 3039), or Clem Goewert at (702) 486-2865.

Sincerely,

Paul J. Liebendorfer, PE
Chief
Bureau of Federal Facilities

CC/SJ/CG/js

cc: L.F. Roos, IT, Las Vegas, NV
Patti Hall, DOE/ERD
Ken Hoar, DOE/ESHD
S.A. Hejazi, DOE/NV, Las Vegas, NV
Michael McKinnon, NDEP/LV

ERD (R)
ERD (RF)
EM (RF)
MGR (RF)

FILE CODE #

ERD Bangerter 10/4/99
ERD Wycoff 10/5/99
ERD Arlene 10/5/99

OCT 05 1999

Paul J. Liebendorfer, P.E., Chief
Department of Conservation and Natural Resources
Division of Environmental Protection
333 W. Nye Lane, Room 138
Carson City, NV 89706-0851

REQUEST FOR A FLUID MANAGEMENT PLAN WAIVER FOR WELL DEVELOPMENT AT WELLS: ER-EC-1, ER-EC-4, ER-EC-5, ER-EC-6, ER-EC-7, ER-EC-8, AND ER-18-2

The DOE Nevada Operations Office (DOE/NV) has completed drilling and well construction activities at seven wells as part of the Underground Test Area (UGTA) Pahute Mesa/Oasis Valley drilling program. Subsequent investigation activities planned for these wells include well development, hydraulic testing, and groundwater sampling. These activities will result in the production of substantial volumes of groundwater, which are subject to the conditions in the UGTA Fluid Management Plan (FMP) (July 1999). DOE/NV is requesting a waiver from the UGTA FMP (July 1999) to allow fluids produced during these activities to be discharged directly to the ground surface.

Enclosed for your information are the results for fluid management samples collected from the sumps and characterization samples collected by bailer from the boreholes upon completion of drilling activities. The enclosed data, coupled with the distance of the well locations from the nearest underground test, supports the premise that radiological and/or chemical contamination will not be encountered during subsequent investigation activities. Therefore, DOE/NV proposes to conduct activities at these well sites under far field conditions with a reduced frequency of on-site monitoring. The proposal includes the following elements:

- The on-site monitoring program will consist of collecting one tritium and one lead sample from the fluid discharge every 24 hours for analysis.
- Fluids will be allowed to discharge to ground surface without prior notification to the Nevada Division of Environmental Protection.
- All other conditions for far field wells, in the FMP, will be in effect.

This proposed strategy would be applicable only to well development, testing, and sampling activities at these well sites. These activities are scheduled to begin on October 18, 1999.

Paul J. Liebendorfer -2-

If you have any questions, please contact Robert M. Bangerter, of my staff, at (702) 295-7340.

Original Signed By:

Runore C. Wycoff

Runore C. Wycoff, Director
Environmental Restoration Division

ERD:RMB

cc w/encl:
M. D. McKinnon, NDEP, Las Vegas, NV

cc w/o encl:
S. R. Jaunarajs, NDEP, Carson City, NV
C. M. Case, NDEP, Carson City, NV
C. J. Goewert, NDEP, Las Vegas, NV
L. F. Roos, IT, Las Vegas, NV
K. A. Hoar, ESHD, DOE/NV, Las Vegas, NV
S. A. Hejazi, OCC, DOE/NV, Las Vegas, NV
P. L. Hall, EM, DOE/NV, Las Vegas, NV

Attachment 5

Electronic Data Files Readme.txt

ER-18-2 Data Report:

This README file identifies the included data files.

Included with this report are 3 files containing data that were collected electronically during the development and testing program for Well ER-18-2. The .xls data files were originally collected in ASCII format by datalogger, and the data have been imported into Microsoft EXCEL 97 with minimal changes. Files 1 and 2 contain two sheets, a RAW DATA sheet and a PROCESSED DATA sheet. The PROCESSED DATA sheet references the Raw Data sheet and performs basic processing on the data. Please consult the data report for more information on the data.

The files are:

1) 18-2AqTest_Dev.xls
Complete monitoring record of development.

2) 18-2Aqtest_HT.xls
Complete monitoring record of testing.

3) 18-2 Water-Level Monitoring.xls
Pre-development monitoring record.

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