GROUND WATER AND SURFACE WATER MEASUREMENTS

AT THE BARING SPRING SITE

LINCOLN COUNTY, WASHINGTON

John Covert

December, 1995

OFTR 95-18

SHORELANDS AND WATER RESOURCES PROGRAM

OPEN FILE TECHNICAL REPORT

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

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This Open-File Technical Report presents the results of a hydrologic investigation by the Water Resources Program, Department of Ecology. It is intended as a working document and has received internal review. This report may be circulated to other Agencies and the Public, but it is not a formal Ecology Publication.

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ABSTRACT

Static ground-water levels, and spring stage have been measured at the Baring Spring site adjacent to Sinking Creek in Lincoln County, Washington, over a number of years. This long-term monitoring program has provided sufficient data for an analysis of the pumping effects of irrigation wells on the surface and subsurface hydrology in the area.

Water-level measurements indicate that the water levels in both the Priest Rapids and Roza Members of the Wanapum Basalt fluctuate in accordance with the pumping of irrigation wells (irrigation cycles). Discharge at the Baring Spring also fluctuates with the irrigation cycles. This clearly demonstrates hydraulic continuity between the ground water and surface water at the site. Continuous records indicate that stage fluctuations in the spring lag three to four days behind the response observed in the basaltic aquifers.

ACKNOWLEDGMENTS

Many thanks to the following Department of Ecology staff for their dedicated and careful assistance in this project:

Gene Drury for his numerous trips to the site to monitor water levels in the observation wells and the spring.

Linton Wildrick and Jim Lyerla for their thought-provoking discussions about the interrelationships between surface water and ground water in the shallow basalts of eastern Washington.

Linton Wildrick for his manuscript review.

INTRODUCTION

Ground water pumped from the Miocene Columbia River Basalt Group (CRBG) in eastern Washington is the main source of water for crop irrigation in several counties including Lincoln County, Washington. Since the late 1960s, synoptic measurements conducted during the spring of each year have demonstrated significant declines in ground-water levels in some agricultural areas of Lincoln County (Wildrick, 1982 and 1991). More recently, spring-fed, perennial and intermittent streams and lakes have experienced reduced flows and levels that have been attributed to declining water levels in basaltic aquifers (Wildrick, 1982 and 1991). Sinking Creek, in northern Lincoln County, has been experiencing reduced flows for several decades (Wildrick, 1991).

In 1991, two observation boreholes were drilled within 50 feet of Baring Spring, owned by John Rosman, along Sinking Creek (T25N/R34E-08N01s). Two piezometers were installed (one in each of two basaltic aquifers) in the "Rosman" observation well (Unique Well ID AAE572; Barnett, 1992), and one piezometer was installed in the shallow, observation well (Unique Well ID: AAE573) to monitor the alluvial aquifer which discharges to Baring Spring. In 1980, the United States Geological Survey (USGS) installed a stilling well and staff gage in the Baring Spring. This report provides a compilation and interpretation of the ground-water levels and spring stages at the site (both intermittent and continuous records) during the period May 1991 to December 1993.

Purpose of the study

This study is part of Ecology's continuing efforts to identify the causes for the drying up of Sinking Creek and to understand the relationship of the pumping of irrigation wells to streamflow and lake declines in the Columbia Plateau region. Numerous water level measurements have been collected at the Baring Spring site from the two observation wells and the spring itself since 1991.

Location of the study area

The study area is located in northern Lincoln County, Washington, near the northern edge of the Columbia Plateau physiographic province, and a few miles south of the towns of Wilbur and Creston (Figure 1).

The two observation wells were drilled within 50 feet of the Baring Spring, or "Rosman Spring" as called by local residents (Figure 2). The surrounding land is range, hay, and wheat fields. The spring is located on the northern edge of a shallow coulee which contains Sinking Creek and its floodplain. The Priest Rapids Member of the Wanapum Basalt outcrops roughly 50 feet north of the site (Barnett, 1992). Surface elevation at the site is approximately 2210 feet above mean sea level (from the USGS Creston Butte 7.5 minute quadrangle) (Figure 2).

Previous studies

Barnett (1992) discusses the drilling and piezometer installation of the observation wells. As-built specifications from his report are reproduced in Appendix A. Detailed lithologic logs and geophysical logs can be found in Barnett (ibid.).

Wildrick (1991) summarizes the relationships between stratigraphy and aquifer occurrence in the Sinking Creek area, and provides a thorough review of previous investigations (both regional and local in scope).

Baring Spring Area

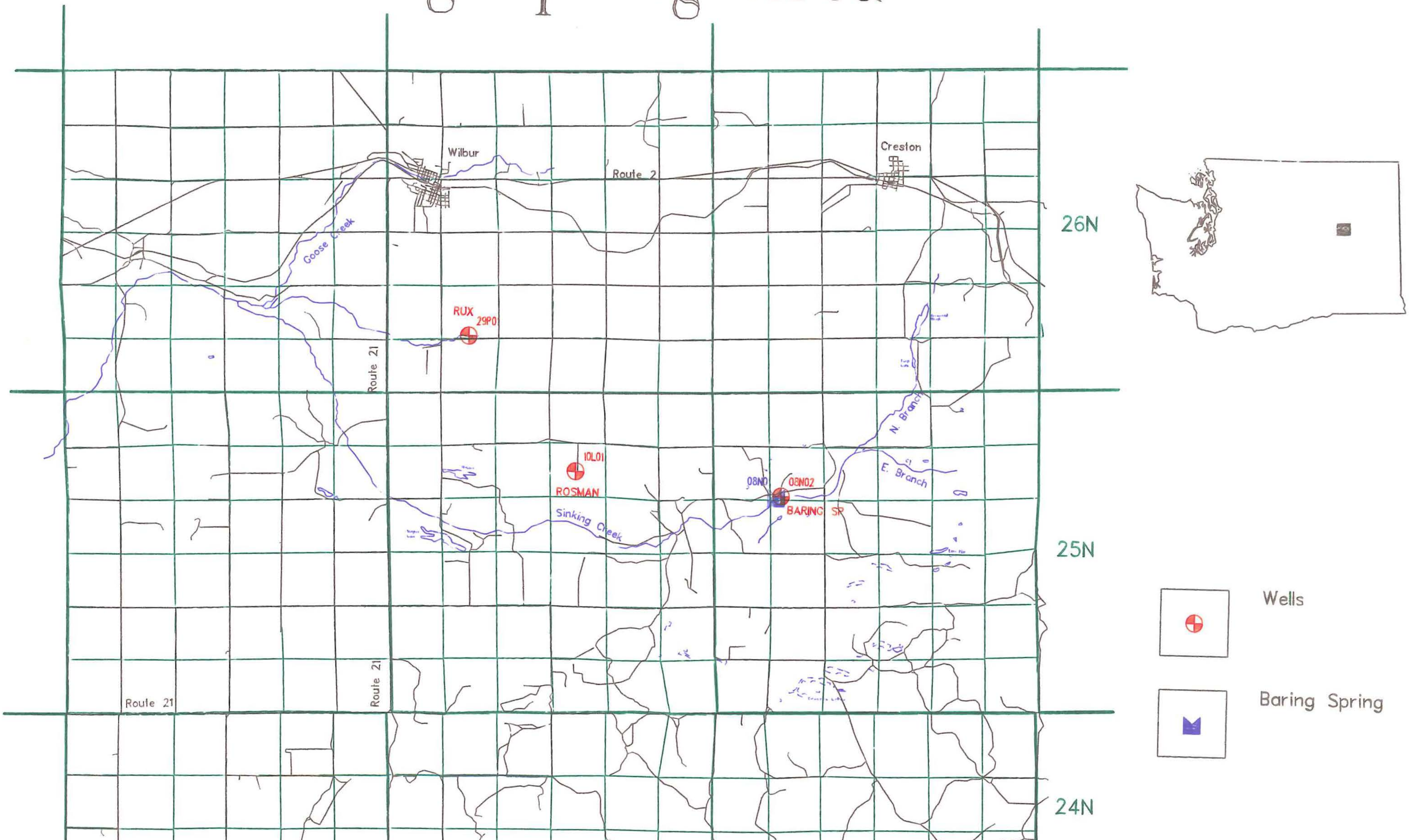
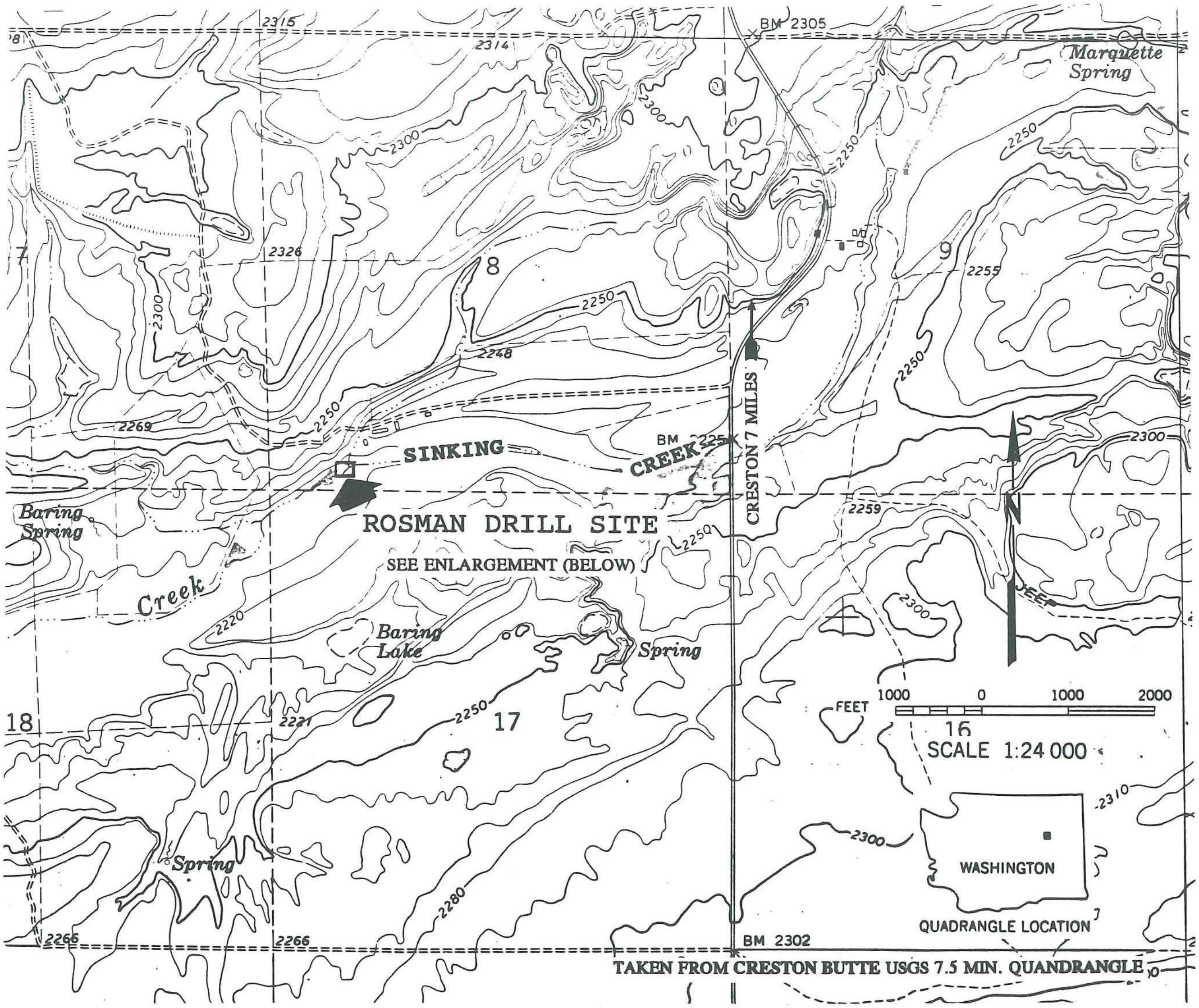


Figure 1



DETAIL OF AREA ENCLOSED ABOVE

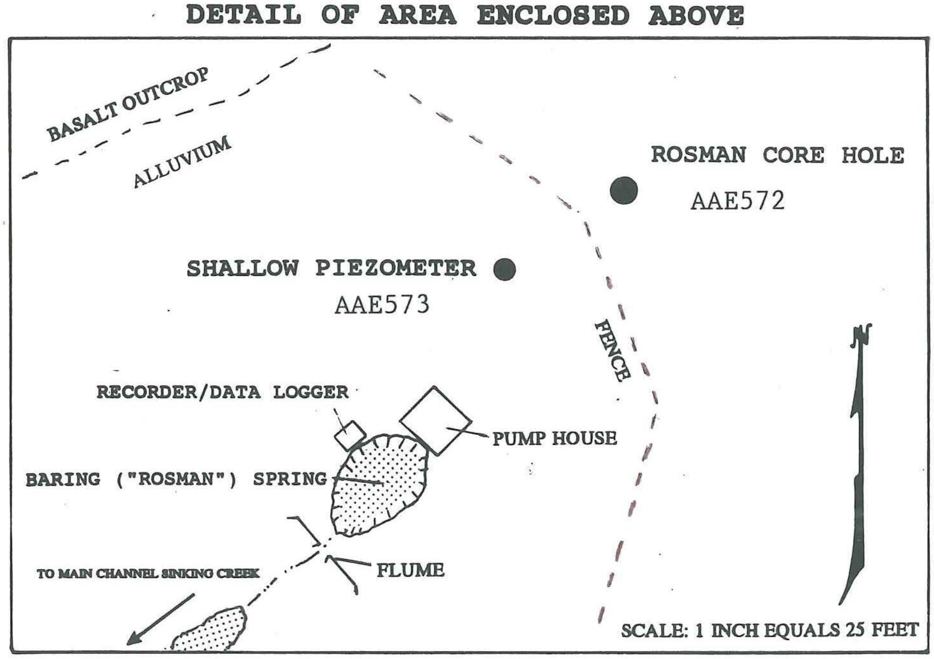


Figure 2

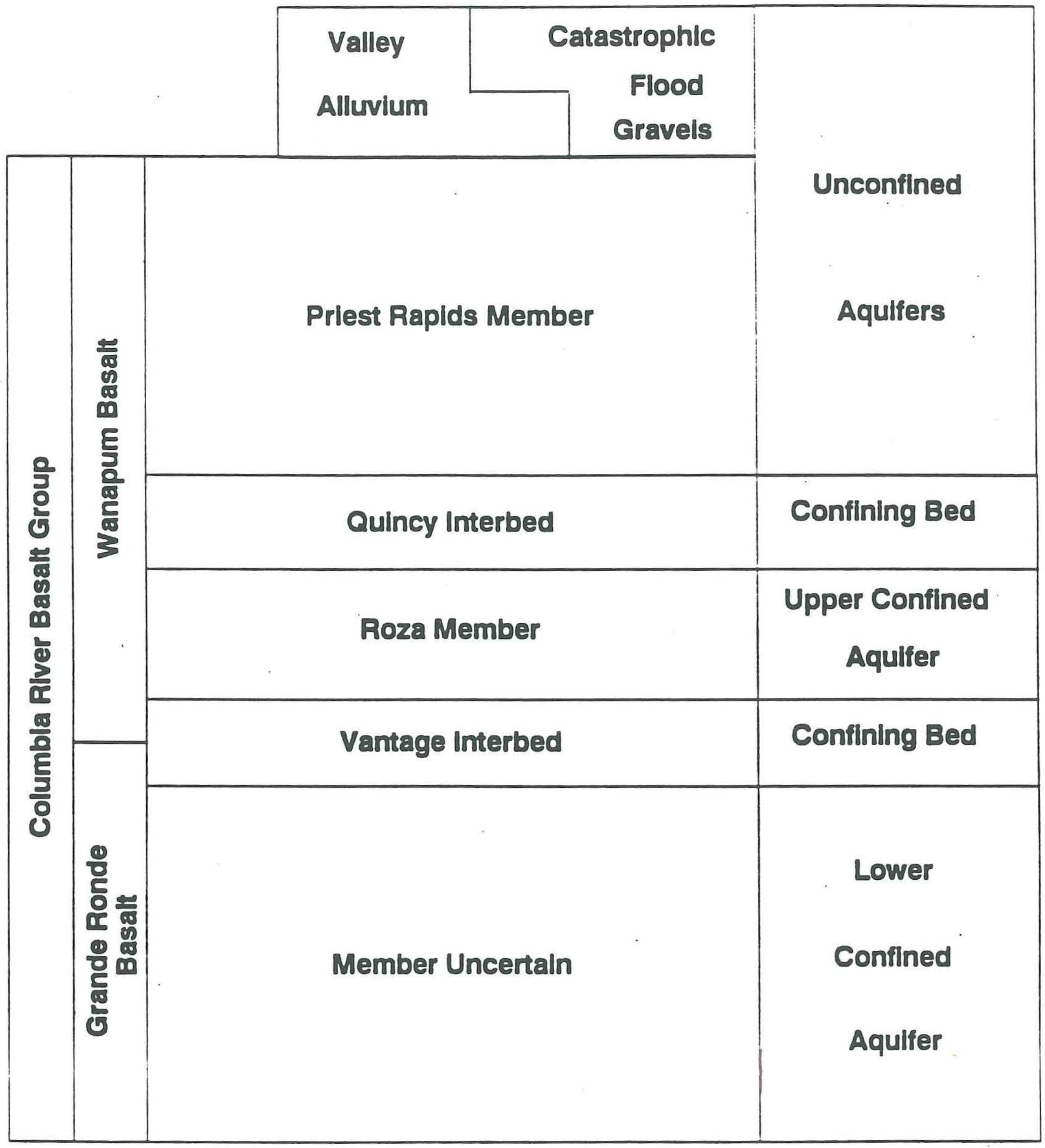


Figure 3. Hydrostratigraphy for the Sinking Creek Area
(modified after Wood, 1987b)

HYDROSTRATIGRAPHY AND WELL CONSTRUCTION

The study site lies near the northern boundary of the lava flows of the Columbia River Basalt Group (CRBG). Figure 3 illustrates the general stratigraphy of the area. Barnett (1992) summarizes the stratigraphy encountered during drilling of the two observation wells. The deeper borehole, AAE572 (Total Depth 325') is located 50 feet northeast of Baring Spring and was drilled by the diamond-bit coring method. It penetrates 10 feet of Quaternary alluvium, 174 feet of Priest Rapids Member Basalt, 141 feet of the Roza Member Basalt, 0.5 feet of Vantage Member Claystone Interbed, and the top 9.5 feet of the Grande Ronde Basalt. Core samples indicate that the Quincy Interbed is absent.

The shallow borehole, AAE573, is located 16.5 feet southwest of the deeper borehole (Figure 2) and was drilled by the continuous-flight augering method. It penetrates 9.5 feet of Quaternary alluvium, the lower 5 feet of which is coarse gravel and sand, and comprises an unconfined aquifer.

Two piezometers (1-inch diameter, schedule 80 PVC tubing) were installed in observation well AAE572. A piezometer was screened and sand-packed from 285.0 feet to 315.0 feet below land surface in the Roza Member. This piezometer is referenced as T25N/R34E-08N02 and is referred to as "Roza" on several of the figures in this report.

A second piezometer was screened and sand-packed from 157.0 feet to 177.0 feet below land surface in the Priest Rapids Member basalt (Appendix A). This piezometer is referenced as T25N/R34E-08N03 and is referred to as "Priest Rapids" on several of the figures in this report. Within the borehole, both screened zones were isolated above and below with bentonite plugs.

One piezometer (1-inch diameter, schedule 80 PVC tubing) was installed in observation well AAE573. It was screened and sand-packed from 4.5 to 9.5 feet below land surface (Appendix A). This piezometer is referenced as T25N/R34E-08N04 and is referred to as "Alluvium" on several of the figures in this report.

DATA COLLECTION

Water level monitoring equipment installed at the site

Static water levels were measured in the three piezometers and stage at the spring on a regular basis by Washington State Department of Ecology (WDOE) personnel throughout the duration of the study. Measurements were taken using a steel tape calibrated to 0.01 of a foot. Continuous recorders were installed in the deeper observation well (AAE572) and the stilling well at the spring for a portion of the study (1993). In June 1993, pressure transducers were installed in borehole AAE572 (a 10-psi transducer (Druck Model PDCR 830) in the piezometer screened in the Roza Member Basalt and a 5-psi transducer (Druck Model PDCR 830) in the piezometer screened in the Priest Rapids Member Basalt). Both transducers were connected to an electronic datalogger (Unidata "Macro Data Logger", Model 7000) by 100 foot cables which were shielded and vented. This device was programmed to measure the water level every 15 seconds and then average and store the results every eight hours. In 1991, a shaft encoder (Unidata Model 6509) and float was installed in the stilling well at the spring. Initially, the spring stage was read from an LED screen built into the shaft encoder. In May 1993, a data logger (Unidata Portable Data Logger Model 6003B) was attached to the shaft encoder. This device was programmed to take readings every 5 seconds and then average and store the results every eight hours (on the same schedule as the Macro Data Logger). The shaft encoder, Macro Data Logger, and Portable Data Logger were all securely stored in the field box installed at the stilling well (see Plate 1). Data from both loggers was downloaded regularly to a portable microcomputer. Using Unidata's software (Starlog), the data was output in spreadsheet format to allow manipulation and analysis. Additional measurements by steel tape were also taken to allow verification of the electronic measurements.

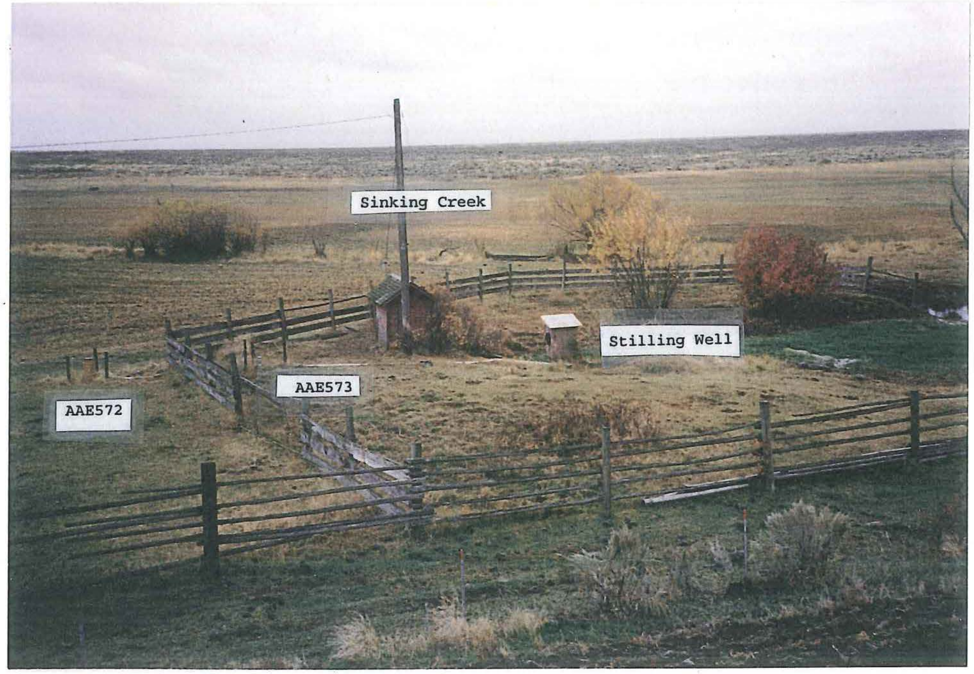


Plate 1a. The Baring Spring Site. The photo was taken from the basalt outcrop (see Figure 2 and Plate 1b), looking southeast across the coulee. Sinking Creek passes south of the spring and is outlined by the line of bushes running through the field.

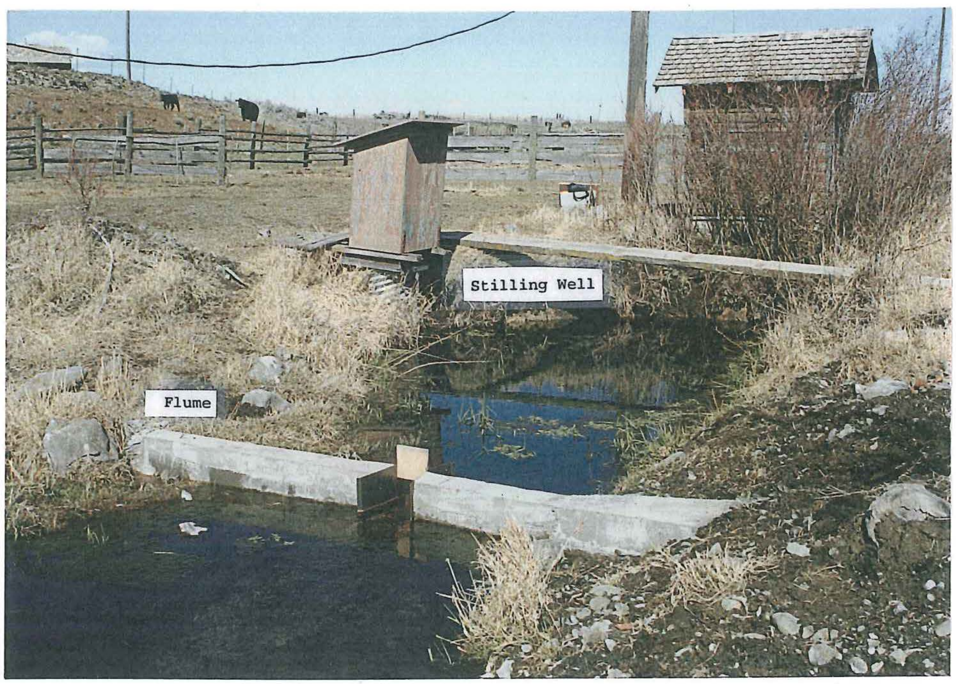


Plate 1b. Close-up of Baring Spring. Basalt outcrop can be seen along the top left edge of the picture. Continous monitoring equipment was stored within the enclosure attached to the top of the stilling well.

RESULTS

Figure 4 is a hydrograph of the intermittently measured static water levels and spring stages at the site during the study. The left Y axis indicates the depth to water below a common measurement point (DTW Below MP) for the two piezometers screened in the Priest Rapids and Roza aquifers. The right Y axis depicts the depth to water below a common measurement point for the water level in the alluvial aquifer (well AAE573) and the stage of Baring Spring (stilling well). Note the difference in scales between the two Y axes.

The water levels monitored in the three piezometers represent the heads in three distinct aquifers. A downward, ground-water-flow potential exists between the three aquifers with the Priest Rapids head intermediate between the shallower unconfined head and the deeper Roza head.

The difference in heads between the three aquifers varies depending on whether irrigation wells in the vicinity are being pumped. During the winter months and into spring, the water levels rise in all aquifers. During this period, the difference in heads averages approximately eight feet between the unconfined and Priest Rapids aquifers, and approximately seven feet between the Priest Rapids and Roza aquifers. During the irrigation season, the differences in heads between the aquifers increases. The average difference between the unconfined and Priest Rapids aquifers increases to roughly seventeen feet, and the difference between the Priest Rapids and Roza aquifers increases to thirteen feet.

Wildrick (1991) discusses the effects that pumping of ground water from basalt aquifers has on both spring discharge and static-water level measurements in observation wells. That study detected pumping effects in observations of the stage in Baring Spring prior to the drilling of the adjacent boreholes.

Recent measurements confirm the previous analysis by Wildrick. Fluctuations of the water levels in both basalt aquifers at the site clearly demonstrate the effects of irrigation pumping in the vicinity (Figure 4). In May of 1992 and 1993 (soon after the irrigation season begins), water levels begin a steady decline which lasts for about two months. In mid-summer, water levels recover for a period of about one month, coinciding with the cessation of pumping during wheat harvest in the area. Then in August, the water levels start declining again, coinciding with pre-irrigation for next year's wheat crop. This decline continues until the wells cease pumping in late September or early October, and then the water levels begin their annual recovery during the winter months. Water levels continued to rise during the winter and early spring for all three winters depicted. No other processes could account for these fluctuations, particularly the mid-summer rise when there is too little rainfall to provide ground-water recharge.

Water Levels In Baring Spring and Three Nearby Piezometers

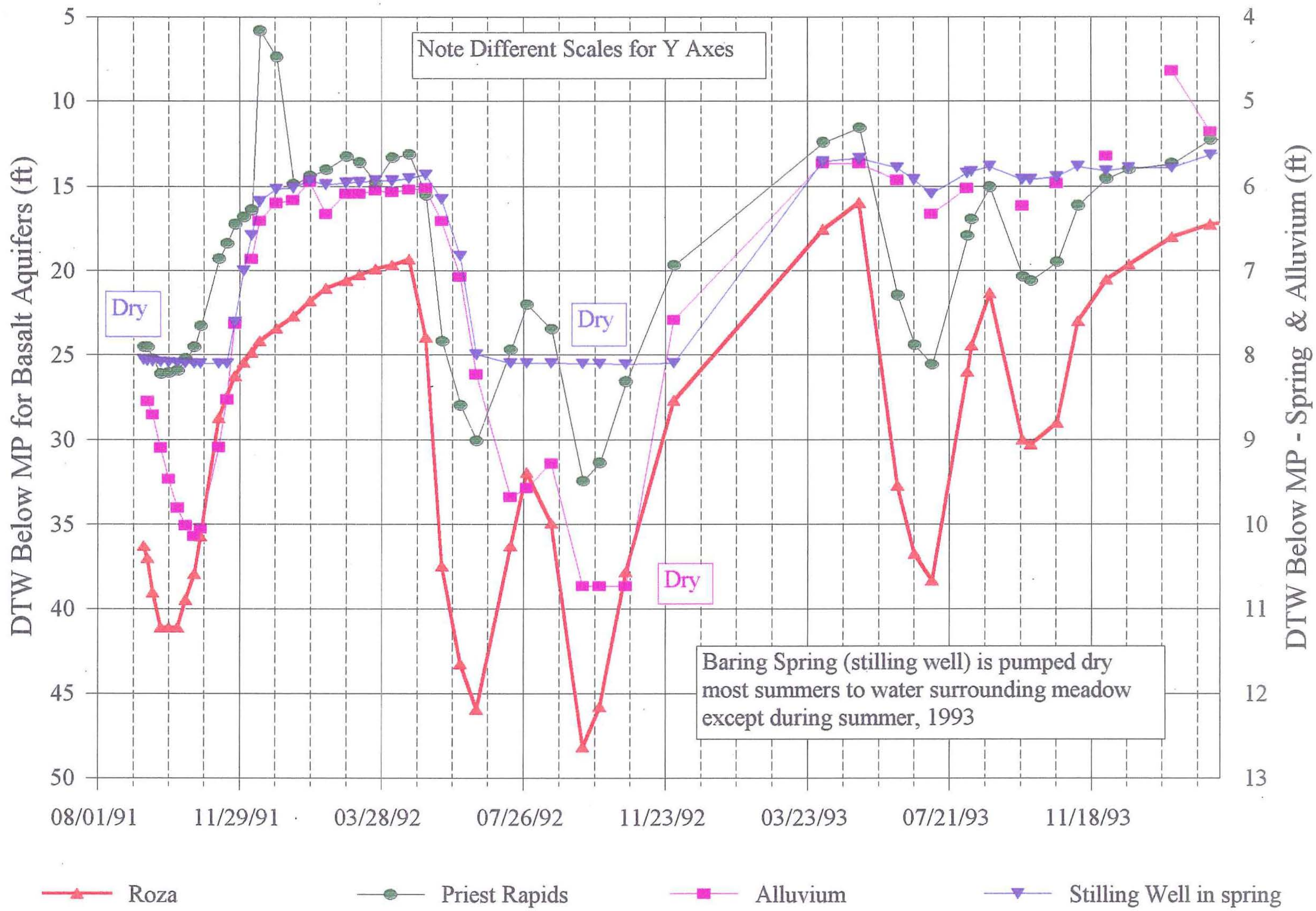


Figure 4

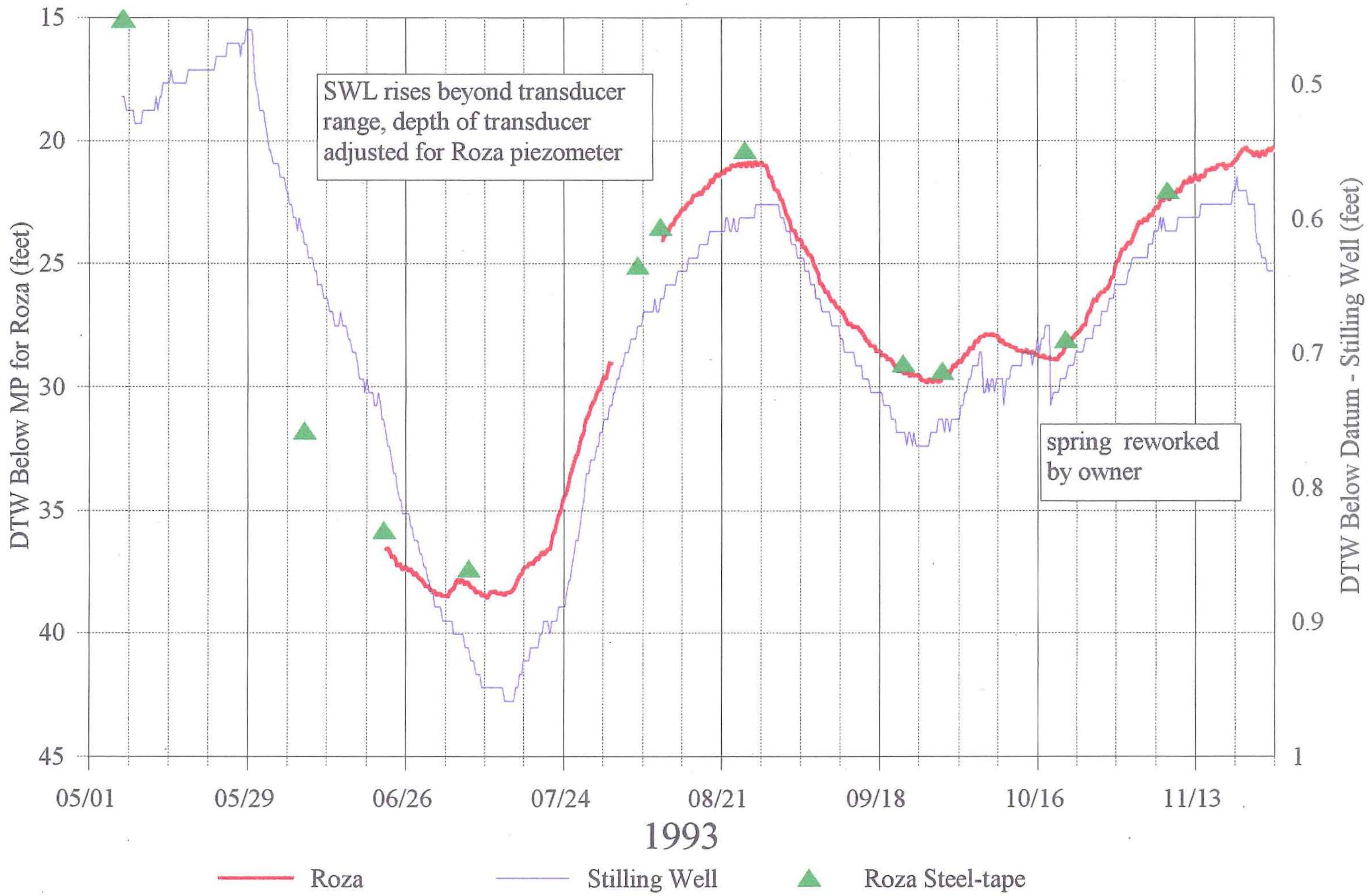
During most irrigation seasons, the Baring Spring is pumped by the owner to water the surrounding meadow. This removes the total flow of the spring and lowers the stage so much that the stilling well is dewatered and the float rests on the mud (Figure 4). During 1992, the alluvial piezometer went dry during the latter part of the summer (Figure 4).

During the summer of 1993, the owner of the spring did not use the spring water to irrigate his meadow. This allowed the spring to flow during the "irrigation/harvest/pre-irrigation" pumping cycle, and the data for the spring stage was not masked by direct pumping from the spring. The continuous-record data collected during the summer of 1993 clearly demonstrates the "harvest rebound" in water levels for the basalt aquifer and an increase in the spring discharge (Figure 5). Eleven miscellaneous measurements (made with a steel tape) are also plotted for the Roza piezometer. They demonstrate that the transducer in the Roza aquifer was responding accurately. During the fall of 1993, the owner dug out the old pump and installed a new submersible pump in the side of the spring; this construction activity disrupted the stage measurements collected at the stilling well.

Figure 6 presents a detailed view of a three week interval from 8/16/93 - 9/6/1993. This time period was chosen because it coincides with the start of the "pre-irrigation" cycle of water use in the Sinking Creek area. The curve representing the static water level in the Roza piezometer began to decline on 8/28/93. Approximately three days later, the stage in the spring started to decline in response to the same pumping stresses that caused the potentiometric surface in the Roza aquifer to decline. Note the different scales: the confined aquifer dropped four feet in 8 days; while the spring stage dropped 0.07' in the same time period.

Baring Roza Piezometer & Spring

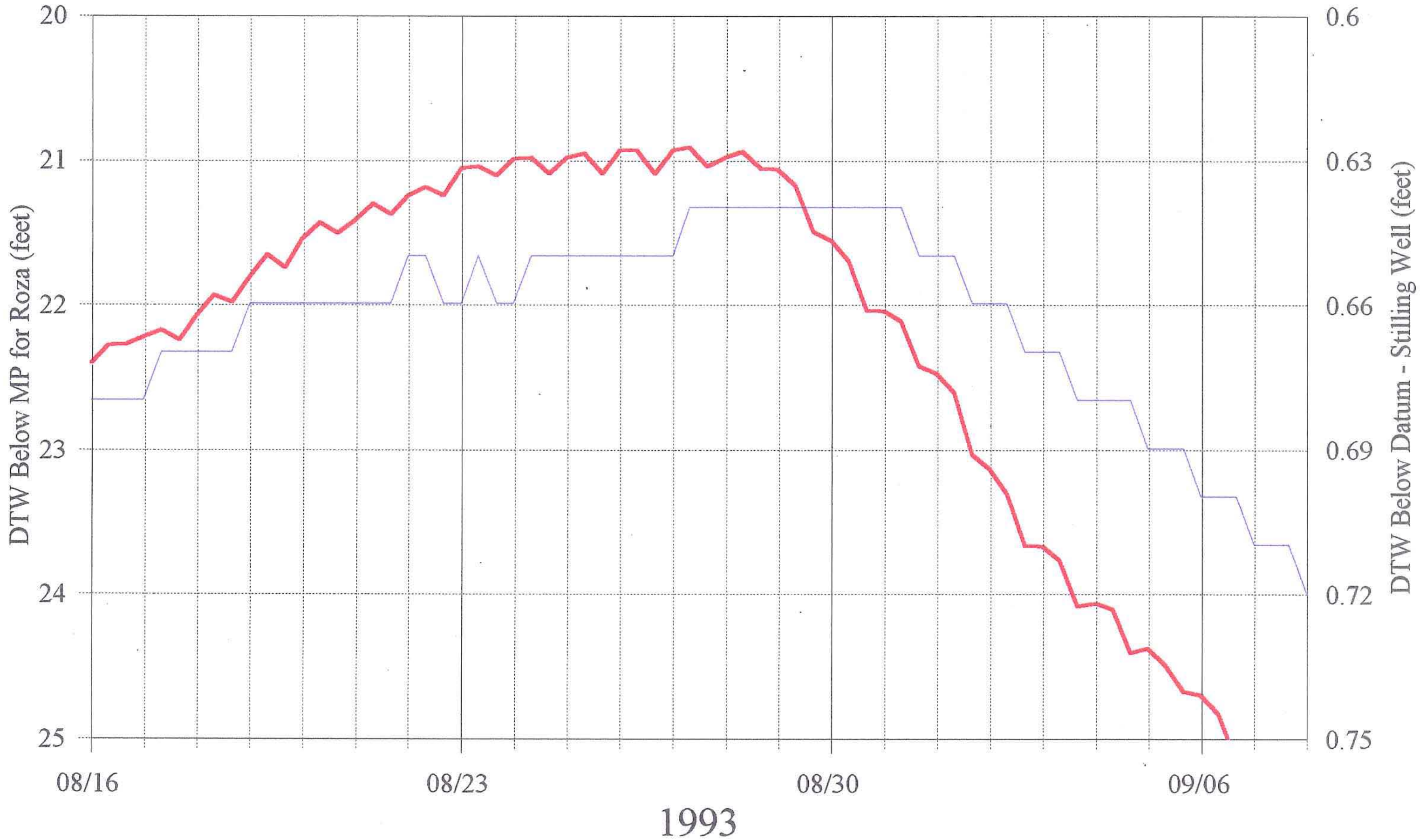
25N/34E-08N



10-psi transducer in Roza piezometer, shaft encoder on Stilling well - 8 hr continous readings. Miscellaneous steel tape measurements to verify accuracy of data for Roza SWL.

Figure 5

Baring Roza Piezometer & Spring
25N/34E-08N



10-psi transducer in Roza piezometer, shaft encoder on stilling well in Spring - 8 hr continous readings.
NOTE: Spring started dropping 3 - 4 days after Roza started dropping

Figure 6

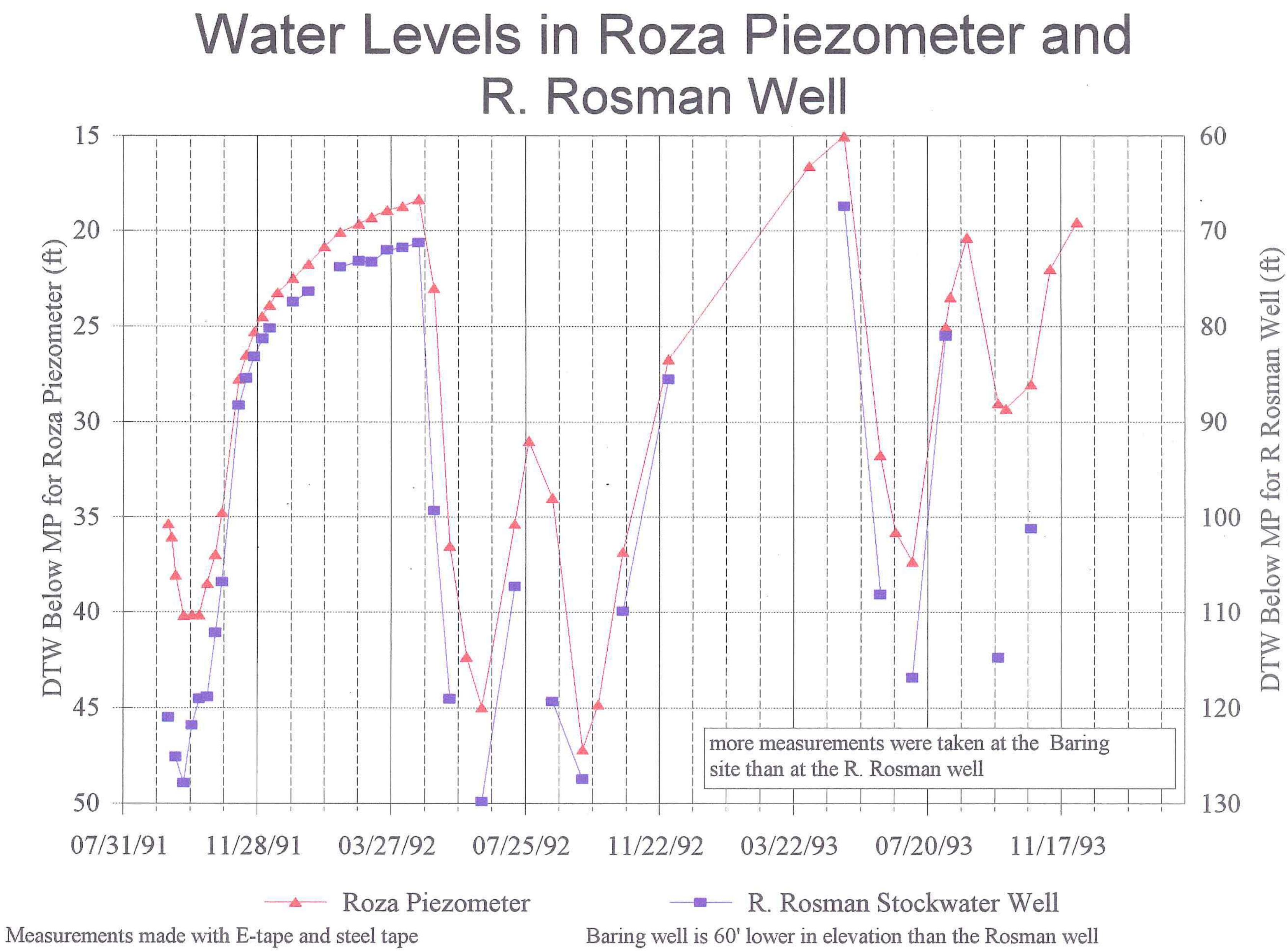

Water Levels in Roza Piezometer and R. Rosman Well
DTW Below MP for Roza Piezometer (ft)
DTW Below MP for R Rosman Well (ft)
15
20
25
30
35
40
45
50
60
70
80
90
100
110
120
130
07/31/91
11/28/91
03/27/92
07/25/92
11/22/92
03/22/93
07/20/93
11/17/93
more measurements were taken at the Baring site than at the R. Rosman well
Roza Piezometer
R. Rosman Stockwater Well
Measurements made with E-tape and steel tape
Baring well is 60' lower in elevation than the Rosman well

Figure 7

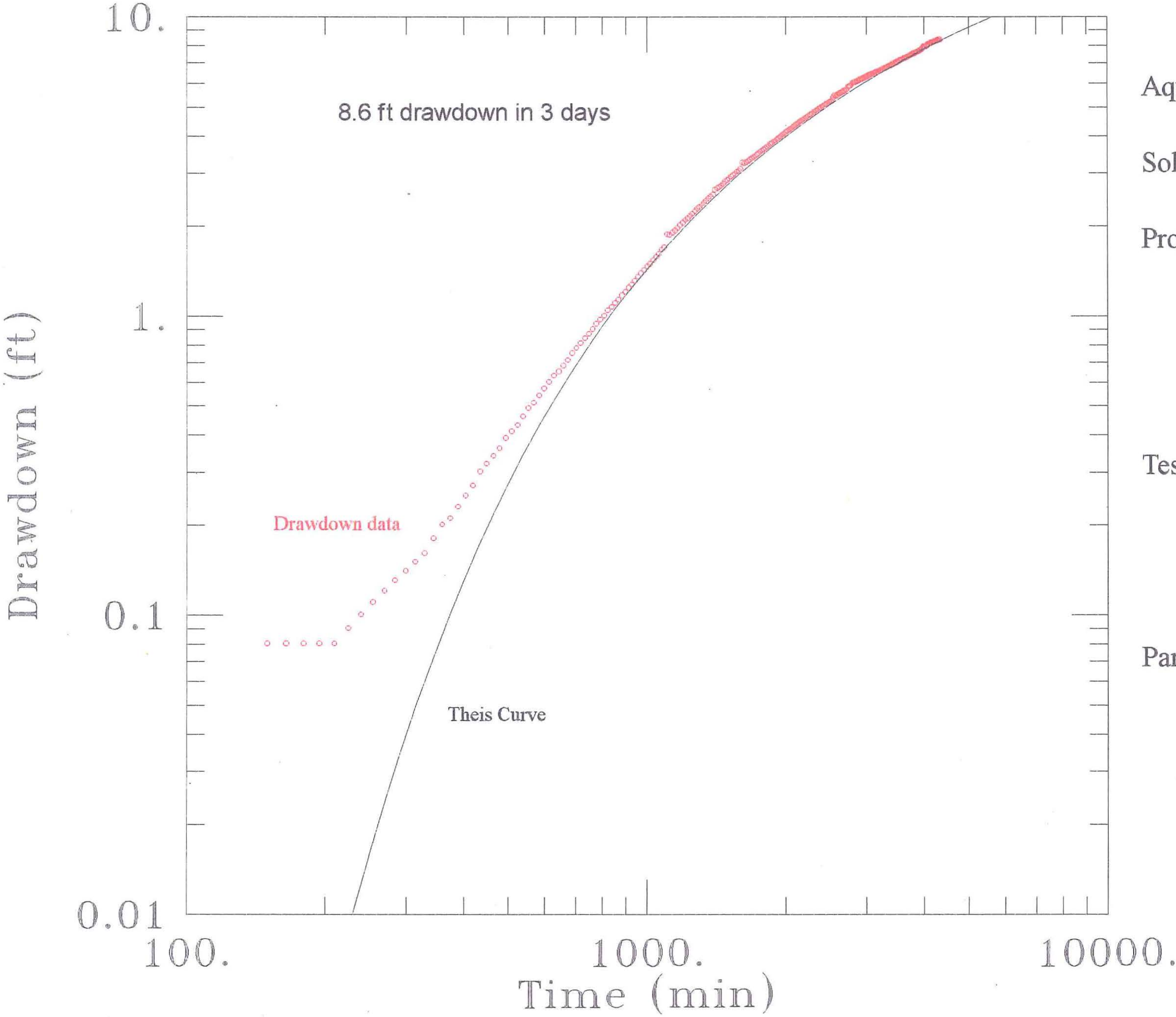
Correlation of responses observed at the Baring site to responses in other wells

The hydrographs for the Baring observation well (AAE572) are typical for the basalt aquifers throughout the Sinking Creek area. Numerous wells experience the same cycle of water-level decline (drawdown) during the irrigation season while wells are pumping, followed by water-level recovery after pumping ceases. For example, the hydrograph for the Baring Roza piezometer corresponds closely with that in a 260' deep, stockwater well owned by Robert Rosman (25N/33E-10L01; Figure 1). Both wells show the same response to pumping by nearby irrigation wells (Figure 7).

The basalt flows of the Priest Rapids Member crop out along Sinking Creek and at nearby tributary springs (Wildrick, 1991). This aquifer provides stock and domestic supplies to shallow wells in the area but cannot provide sufficient water supply for irrigation of more than a few acres (Wildrick, ibid). The larger irrigation wells (with pumping rates varying from a few hundred gallons per minute (gpm) to more than 3000 gpm) are completed in the Roza Member aquifer and/or the deeper Grande Ronde Basalt aquifer. The Grande Ronde aquifer was not encountered at the Baring observation well which only penetrated the top 9.5 feet of the Grande Ronde Basalt (Barnett, 1992).

In April, 1991, the WDOE conducted a 72-hour aquifer test on a 288-foot deep irrigation well owned by Butch Rux (26N/33E-29P01, Figure 1). This high-volume well (pumped at over 2500 gpm during the test) produces from the Roza Member aquifer. During the aquifer test, the Robert Rosman stockwater well (25N/33E-10L01) was used as an observation well. This observation well experienced 8.6 feet of drawdown during the 72 hour aquifer test (Figure 8). Applying a Theis Curve solution to the data yields a transmissivity estimate of 4,700 ft2/day (35,000 gal/day/ft). Numerous wells pump from the same aquifer as the Rux well. At least three irrigation wells (used as observation wells during the test) experienced drawdowns during the Rux test (unpublished data, WDOE). The Rux aquifer test demonstrates the long-distance propagation of pumping effects within the regional basalt aquifer in the Sinking Creek area (over 8 feet of drawdown at a distance of more than three miles in a 72 hour test with no other irrigation wells contributing to the decline in the potentiometric surface). Since both the Rosman stockwater well and the Baring site Roza piezometer well show similar responses to pumping stresses (Figure 7), it follows that the water level in the Baring Spring Roza piezometer also would have responded had this observation borehole been constructed prior to the Rux aquifer test. An observation well located approximately one mile east of the Roza piezometer well (almost 7.5 miles from the Rux well) experienced more than 1.7 feet of drawdown during the Rux aquifer test (InSitu Well 16-3, 25N/34E-16D3; unpublished data, WDOE).

R. Rosman Well Response to Rux Aquifer Test



Aquifer Model:
Confined
Solution Method:
Theis
Project Data:
test date: 4/15/91 - 4/18/91
test well: Rux Well
obs. well: R Rosman

Test Data:
Q = 341 cubic ft/min
r = 17,000 ft
b = 1 ft

Parameter Estimates:
T = 35,450 gal/day/ft
S = 5.18E-05

Figure 8

CONCLUSIONS

The corresponding fluctuations of pumping schedules, water-levels in piezometers, and discharge from the Baring Spring (Figures 4 and 5) indicate hydraulic continuity between ground water and surface water at the Baring site. Changes in the ground-water levels are followed by changes in the surface-water stage (Figure 6). Fluctuations in the water levels in the piezometers follow the same pattern observed at other wells in the area (Figure 7). These changes can be related to pumping of the regional Roza aquifer (Figure 8).

REFERENCES

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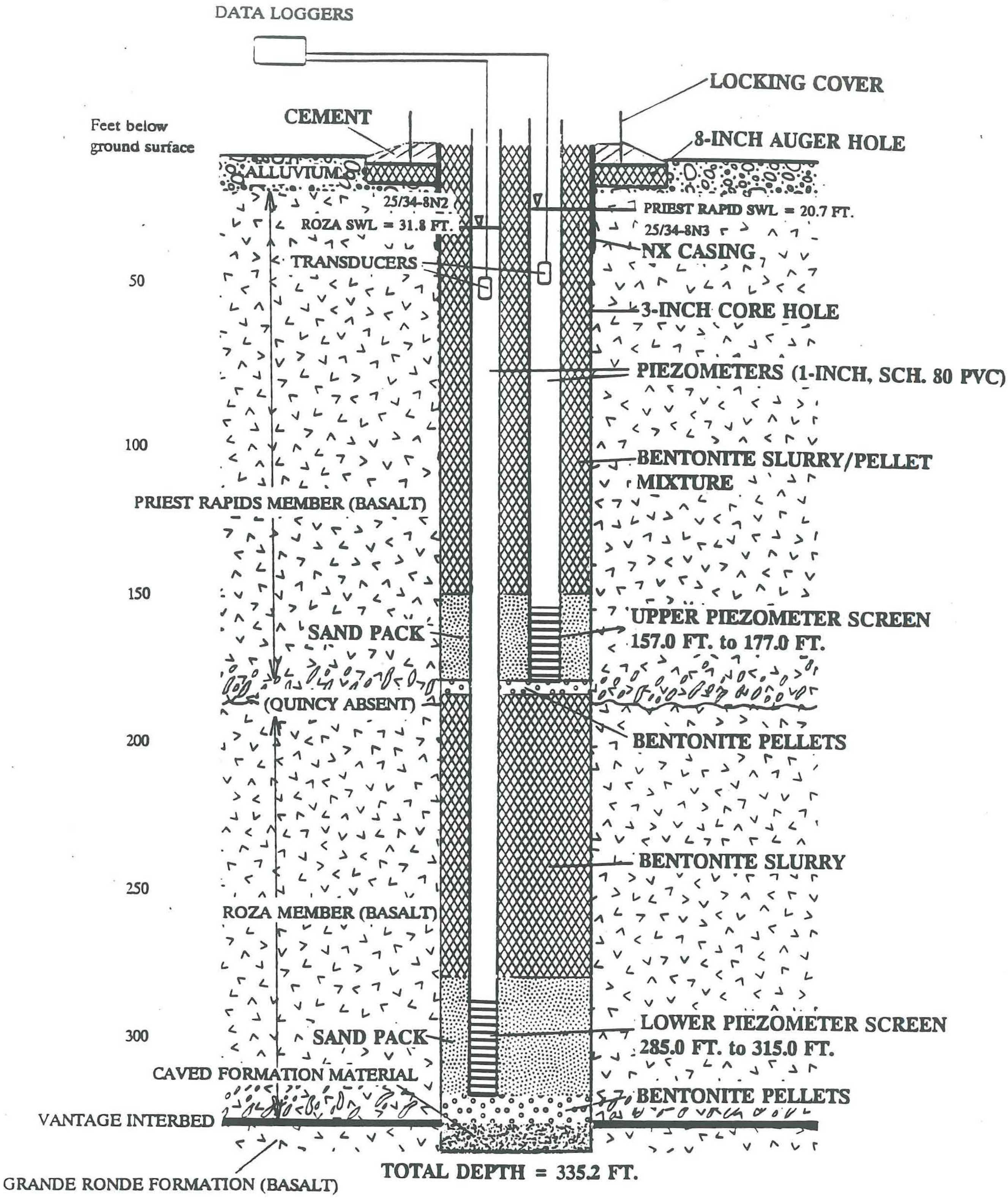
APPENDIX A

(from Barnett, 1992)

ROSMAN CORE HOLE

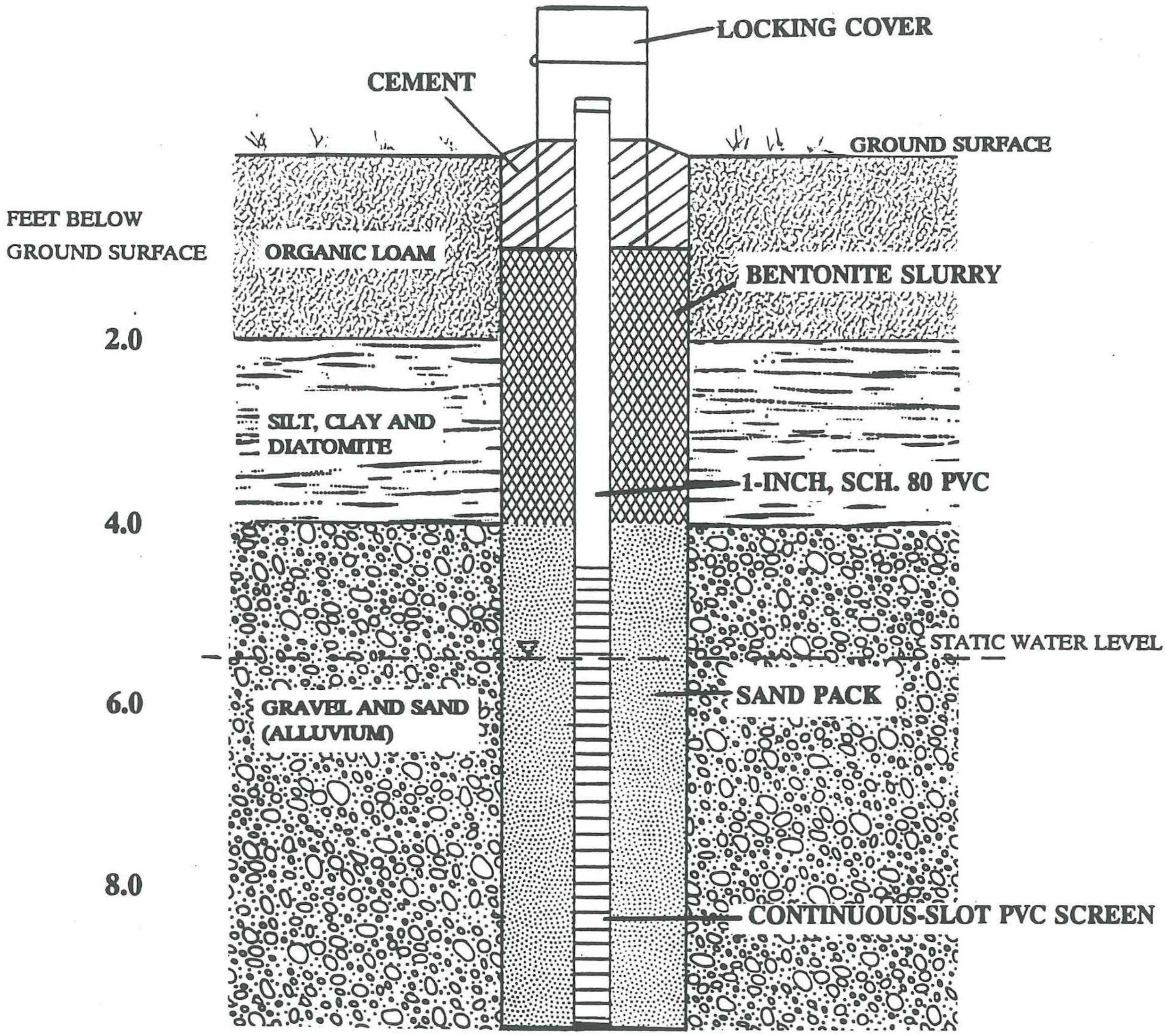
SURFACE ELEVATION = 2210 FT. MSL



One inch equals 50 feet vertically (horizontal not to scale)

ROSMAN SHALLOW PIEZOMETER

25/34-8N4



TOTAL DEPTH = 9.5 FT.

One inch equals 2 feet vertically (horizontal not to scale)