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Idaho Department of Water Resources

Open-File Report

EFFECTS OF EXCHANGE WELLS
ON THE TETON RIVER
IN THE REXBURG - TETON AREA,
MADISON AND FREMONT COUNTIES, IDAHO

EFFECTS OF EXCHANGE WELLS ON THE TETON RIVER IN THE REXBURG - TETON AREA, MADISON AND FREMONT COUNTIES, IDAHO

by
Steven J. Baker

Idaho Department of Water Resources
Boise, Idaho

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INTRODUCTION

Purpose and Objectives

Water users in the Rexburg-Teton area have recently expressed concern over new applications for exchange wells adjacent to Teton River. Their concerns include problems regarding water administration along with the potential effects of exchange wells on the shallow ground water and river. This report focuses on the latter.

In order to perform a comprehensive study of the effects of exchange wells on the hydrologic system, all exchange wells in the lower Teton River basin were included in the analysis. Fourteen exchange wells were identified in the area. This includes the four currently protested applications (three expansions of existing rights and one proposed new use).

The report is organized in the following format. The local hydrogeology is presented first in order to provide a description of the principal factors that control the movement of the ground water in the area and its relationship to the Teton River. This is followed by an evaluation of the potential effect of each exchange well on the Teton River.

Description of Study Area

The study area occupies about 50 square miles centered around the communities of Rexburg and Teton (see Figure 1). A broad alluvial plain occurs throughout most of the area. The plain slopes gently to the southwest and ranges in elevation from 4850 to 4950 feet (ft) above Mean Sea Level (MSL). Uplands, locally known as the Rexburg Bench, lie along the southeast and east borders (Haskett, 1972). Elevations on the bench are about 5200 ft above MSL. The area is drained by the Teton River which emerges from a narrow canyon that is carved into the Rexburg Bench immediately upstream from the study area. After a short distance on the alluvial plain, the Teton River splits into two branches that are known as the North and South Forks. Both of these forks empty into the Henry's Fork, a few miles outside the study area.

Acknowledgements

The author would like to thank Tim Luke, a hydrologist-in-training with the department, for his assistance in compiling data for this study. Field work performed by Dennis Dunn, a senior water resource agent for the Eastern Regional Office, was also greatly appreciated.

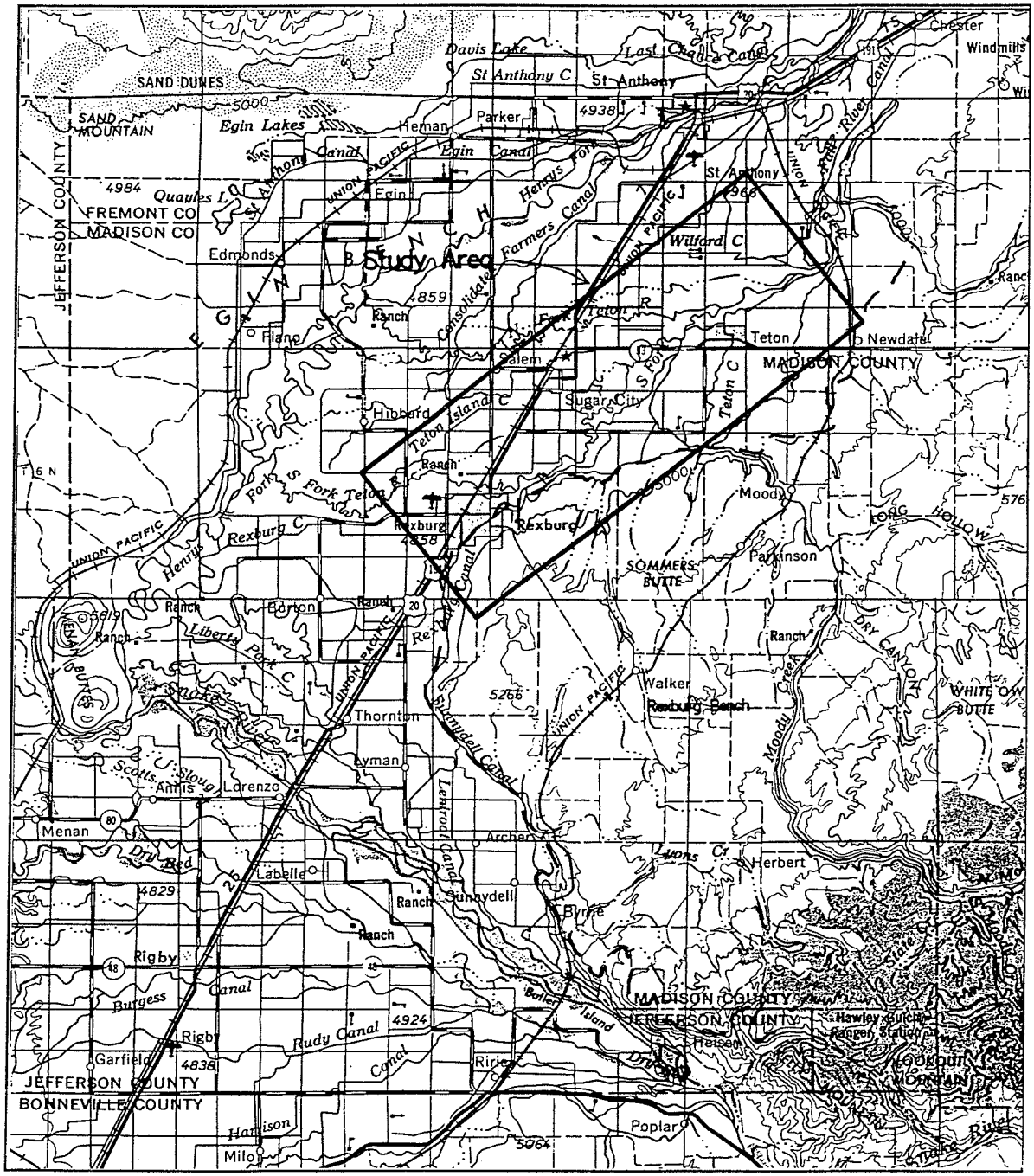

Figure 1. Location of study area

Well-numbering system

The well-numbering system used in this report is identical to the system that is used by the U.S. Geological Survey (USGS) in Idaho. The system indicates the location of wells within the official rectangular subdivision of the public lands, with reference to the Boise base line and meridian. The first two segments of the number designate the township and range. The third segment gives the section number, followed by three letters and a number, which indicate the ¼ section (160-acre tract), ¼-¼ section (40-acre tract), ¼-¼-¼ section (10 acre tract), and serial number of the well within the tract. Quarter sections are lettered A, B, C, and D in counterclockwise order from the northeast of each section. Within quarter sections, 40-acre and 10-acre tracts are lettered in the same manner. For instance, well 12S-22E-16CCC1 corresponds to the legal location SW¼, SW¼, SW¼, Section 16, Township 12 South, Range 22 East, and was the first well inventoried in that tract (see Figure 2).

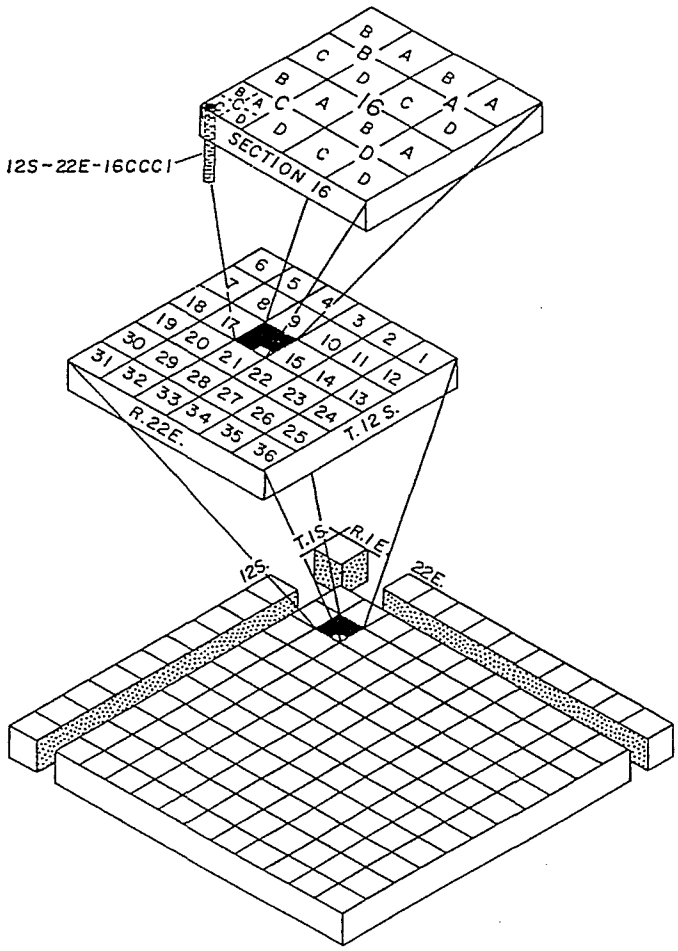

Figure 2. Well-numbering system

HYDROGEOLOGIC REGIME

Two aquifers exist in the study area. From previous studies along with Well Driller's Reports, a general understanding of the local geology of the aquifers was acquired. Utilizing water-level data obtained by Wytzes (1980) and the USGS, the approximate distribution of hydraulic head for both aquifers in the area was defined. Pertinent information about the wells that are referred to in this report are included in Table 1. Their locations are shown on Figures 4 and 6. A description of the aquifers and their relationship to the river follows.

Shallow Aquifer

The shallow aquifer is predominantly confined to the Quaternary alluvium which overlies the basalt and silicic volcanics in the area. It is composed of sand and gravel with lesser amounts of silt and clay layers (Ham, 1968). The alluvial deposits are thin on Rexburg Bench and progressively thicken towards the west and southwest away from it. Based on lithologic data from Well Driller's Reports, the elevation of the base of the alluvium was constructed and is shown in Figure 3. Due to the stratified nature of the alluvium, its ability to transmit water vertically and horizontally differ substantially. As a result, the downward percolation of ground water through these materials is impeded, creating the shallow aquifer in the area.

Recharge to the aquifer occurs primarily through infiltration from the Teton River and the network of canals in the area. Natural discharge from the aquifer occurs as springs and seepage faces along the eastern bank of the Henry's Fork west of the study area (Wytzes, 1980). Natural discharge also occurs as vertical leakage to the underlying deep aquifer. Artificial discharge occurs through pumpage from wells.

Based on water-level measurements taken in August 1977, a water-table map of the shallow aquifer was created and is shown in Figure 4. As can be seen, the configuration of the water table is strongly influenced by the effects of recharge from the Teton River system. The direction of ground-water movement is from northeast to southwest and parallels the flow in the South Fork of the Teton River. The predominant ridge in the water table immediately southeast of Sugar City is indicative of the effects of leakage from unconsumed irrigation water. The steeper gradient north of Teton may be related to a lower transmissivity of the aquifer in this area due to a thinning of the alluvium. The slope of the water table in the study area ranges from 3 to 32 ft per mile.

Table 1. Records of selected wells

Elevation of LSD: or land surface datum estimated from USGS topographic maps and field surveys.

Aquifer type: S - Shallow; D - Deep.

Use of water: H - Domestic; I - Irrigation; U - Unused.

Depth to water: measured by USGS in feet below land surface.

Well number	Elevation of LSD (ft)	Aquifer type	Use of water	Well depth (ft)	Depth to well opening (ft)	Depth to water (ft)	Date measured
05N-40E-01CCD1[1]	5305	D	--	716	104-716	440.3	03/21/77
06N-39E-13ABA1[2]	4864	S	U	30	28-30	6.8	08/04/77
23AAC1[1]	4844	S	U	25	18-23	6.4	08/02/77
23AAC2[2]	4844	D	U	465	257-449	28.6	05/05/77
06N-40E-09ADA1[1]	4895	S	--	≈62	--	8.6	08/03/77
09BBB2[2]	4887	S	U	25	23-25	7.9	08/01/77
13AAB1[2]	4925	S	H	80	--	46.4	08/03/77
31BBC1[2]	4855	S	H	50	--	19.1	08/03/77
07N-40E-19ADD2[1]	4856	D	U	355		32.1	04/27/77
23CCB1[1]	4923	S	--	50	48-50	44.8	08/03/77
35BCC1[2]	4915	S	--	--	--	35.8	08/03/77
07N-41E-18BBB1[2]	4959	D	H	165	--	123.0	05/09/77
18BBD1[2]	4958	S	H	--	--	10.9	08/03/77
30AAA1[1]	4948	D	--	--	--	92.4	04/05/77

[1] - Data obtained from Wytzes (1980); [2] - Data obtained from USGS

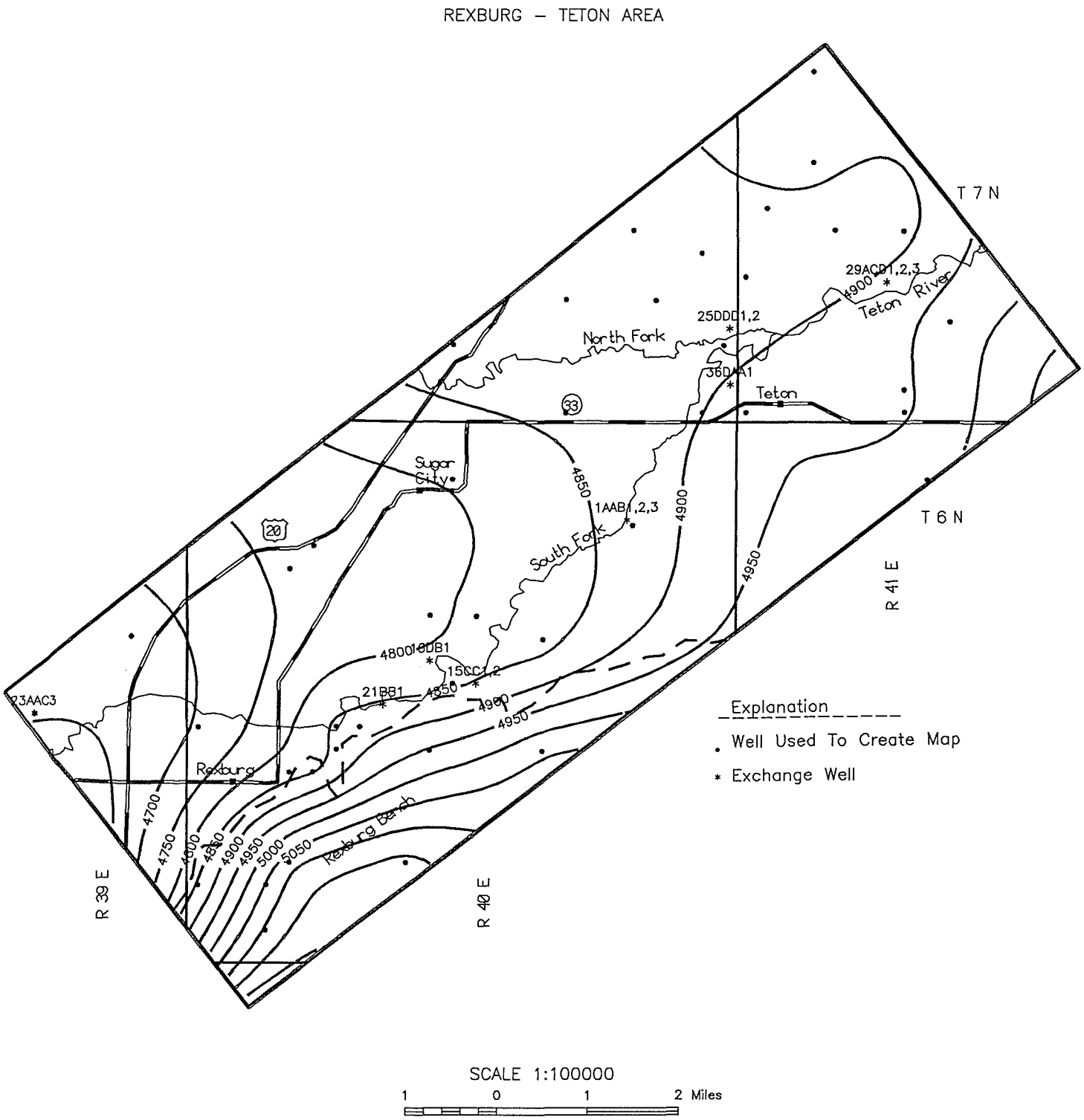

Figure 3. ELEVATION OF BASE OF QUATERNARY ALLUVIUM

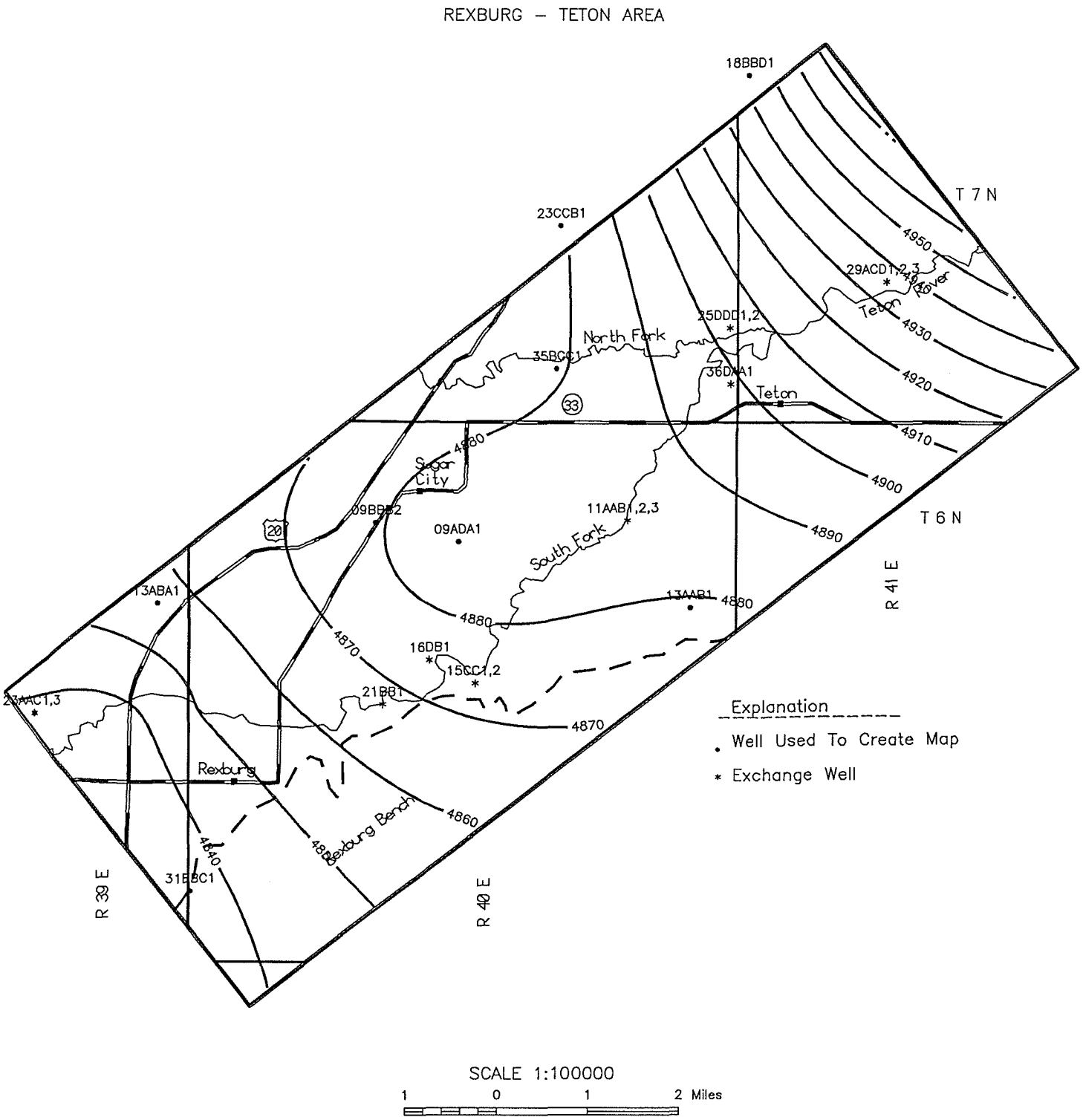

Figure 4. WATER–TABLE MAP OF SHALLOW AQUIFER, AUGUST 1977

Seasonal and long-term fluctuations in the shallow water table are shown on the hydrograph of well 06N-39E-13ABA1 included in Figure 5. Water levels are at their highest in mid-summer and lowest in mid-spring. Magnitudes of seasonal fluctuations are about 10 to 12 ft. Long-term changes in water levels for the period of record appear to be non-existent. This implies that the balance between recharge and discharge in the shallow aquifer has remained relatively unchanged during the past 15 years.

Deep Aquifer

The deep aquifer is contained within the basalt of the Snake River Group and silicic volcanics. The silicic volcanics underlie the area at depth and are near the surface in the Rexburg Bench. They are composed of massive rhyolitic lava flows and welded ash flows interbedded with basalts and ash (Stearns, et al., 1938). The water-bearing properties of these rocks are highly variable. West of Rexburg Bench, basalts of the Snake River Group immediately overlie the silicic volcanics. This unit consists of a succession of thin basaltic lava flows whose aggregate thickness gradually increases towards the west. The main water-bearing zones in the basalt occur at the contacts between flows, where open spaces and rubbly zones at the top of one flow were not completely filled by succeeding flows (Stearns, et al., 1938).

Recharge to the aquifer occurs through deep percolation of precipitation where the rocks are near the surface at the Rexburg Bench and area to the east and from leakage from the overlying shallow aquifer. Natural discharge from the aquifer occurs as ground-water underflow leaving the area to the west. This underflow merges with flow in the Snake River Plain aquifer system which ultimately discharges as springs to the Snake River below Milner Dam. Artificial discharge in the study area occurs through pumpage from wells.

Based on water-level measurements taken in spring 1977, the elevation of the potentiometric surface of the deep aquifer was constructed for the area and is shown on Figure 6. As can be seen, the direction of ground-water movement is from east to west. The slope of the potentiometric surface in the study area ranges from 6 to 9 ft per mile. Although this surface was created with only five wells, it roughly compares with previous maps of the deep aquifer in the area (Crosthwaite, et al., 1970; Wytzes, 1980). Any potential error in the elevation of the potentiometric surface included in this map will have little effect on the results from this study because of the significant head differences that exist between the shallow and deep aquifers in the area.

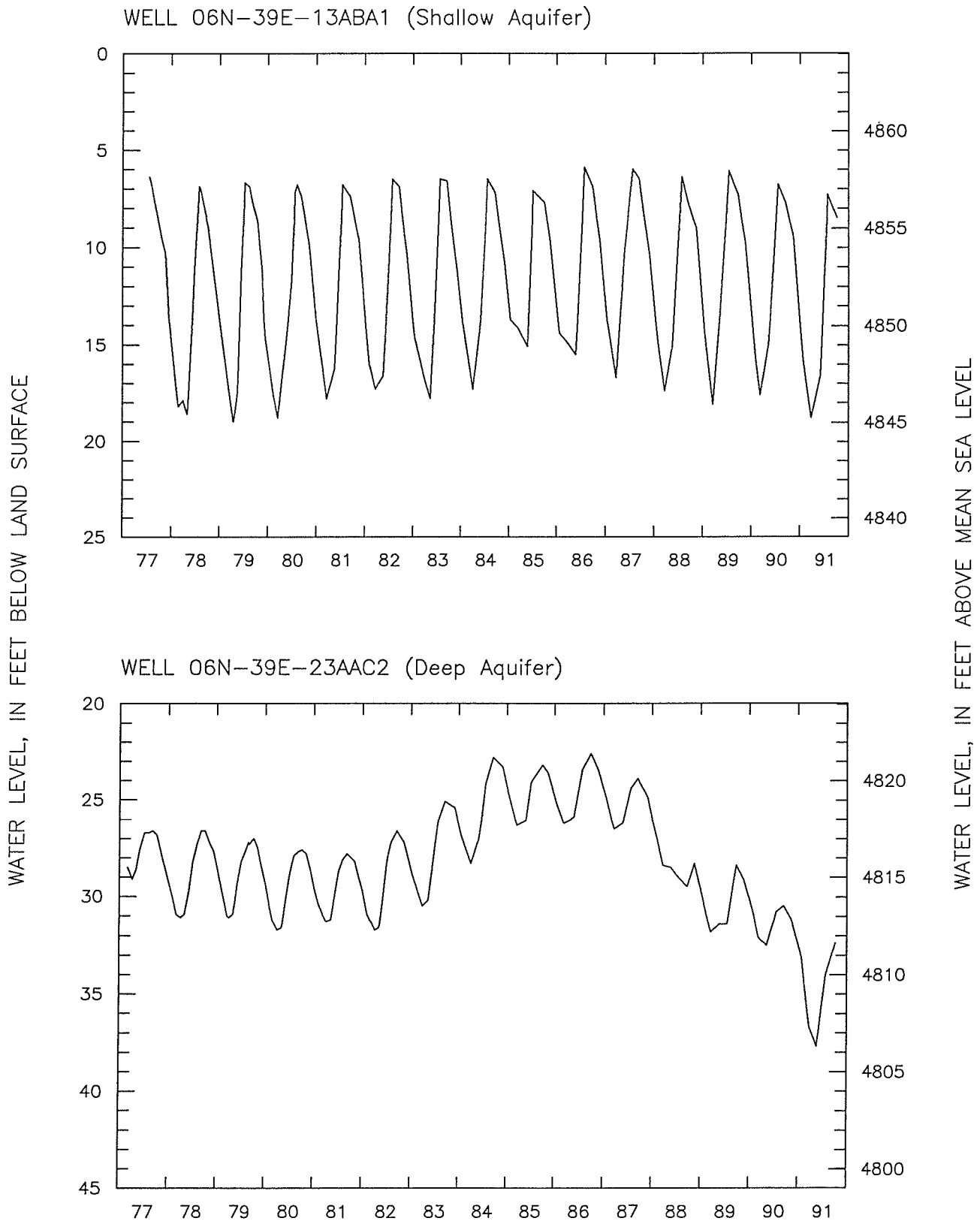

Figure 5. HYDROGRAPHS OF WELLS 06N-39E-13ABA1 AND 06N-39E-23AAC2

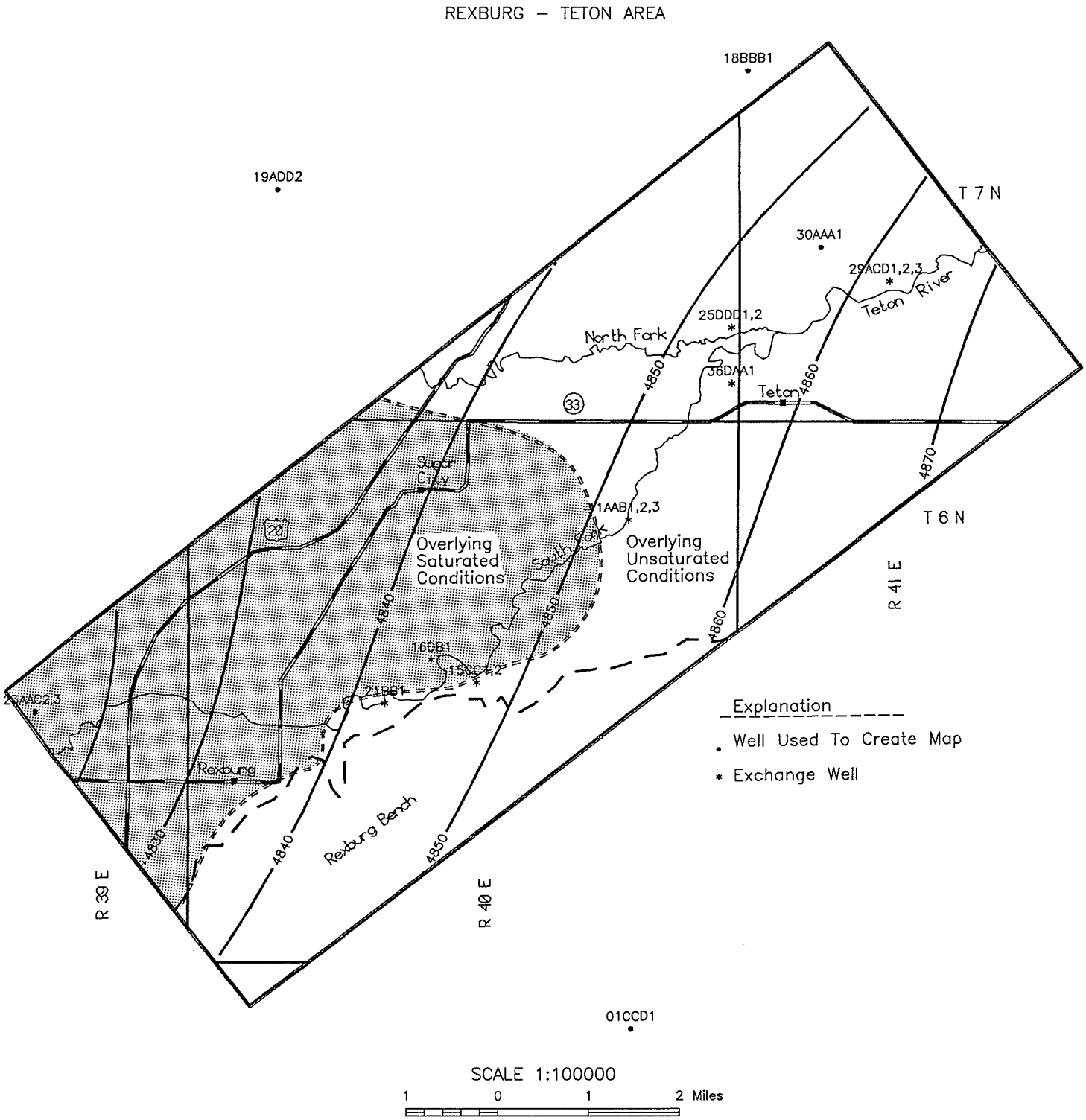

Figure 6. POTENTIOMETRIC SURFACE MAP OF DEEP AQUIFER, MARCH–MAY 1977

Seasonal and long-term fluctuations of the potentiometric surface are illustated by the hydrograph of well 06N-39E-23AAC2 included in Figure 5. Water levels are at their highest in early fall and lowest in mid-spring. Magnitudes of seasonal fluctuations are generally about 3 to 5 ft. Long-term changes in water levels for the period of record appear to follow annual variations in regional water supply. Increased pumpage due to low stream flows probably have accentuated the declines observed during the current drought period of 1987-91.

Relationship Between Teton River and Shallow Aquifer

The relationship of the ground water and surface water in Rexburg-Teton area is complex. Throughout most of the study area, the Teton River and its forks are losing to the ground water. However, near Rexburg, it appears that the ground water is tributary to the river based on the bending of the water-table contours up-gradient near the river in this area.

To assist in illustrating the relationship between the Teton River and shallow aquifer, a hydrogeologic profile along the river was created and is shown on Figure 7. Based on the elevation of the river and the August 1977 water table, it appears that the shallow aquifer is both hydraulically connected and disconnected from the river in the study area. The point at which the 4880 ft water table contour intersects the river approximately delineates the transition point between these two zones (shown on Figure 7). Up-gradient from this point, the river remains above the elevation of the water table, whereas, down-gradient from it the river and water table are at approximately the same elevation. This implies that a well pumping from the shallow aquifer above the transition point and adjacent to the river would not directly cause greater losses from the Teton River due to its use. However, over time (probably within an irrigation season) the well would alter the local gradients and ultimately increase losses from the river where it is hydraulically connected to the ground water.

Relationship Between Shallow and Deep Aquifers

The relationship between the shallow and deep aquifers is undoubtedly complex. The shallow aquifer has been referred to be perched by several authors (Crosthwaite, et al., 1967; Ham, 1968). By definition, this implies that an unsaturated zone exists between the shallow and deep aquifers. Haskett, et al., (1977) describe the shallow aquifer as semi-perched and partially hydraulically separated from the deep aquifer. Whereas, Wytzes (1980) modeled the two aquifers as if they were completely saturated throughout. Leakage calculated from his model was based on head differences between the two aquifers.

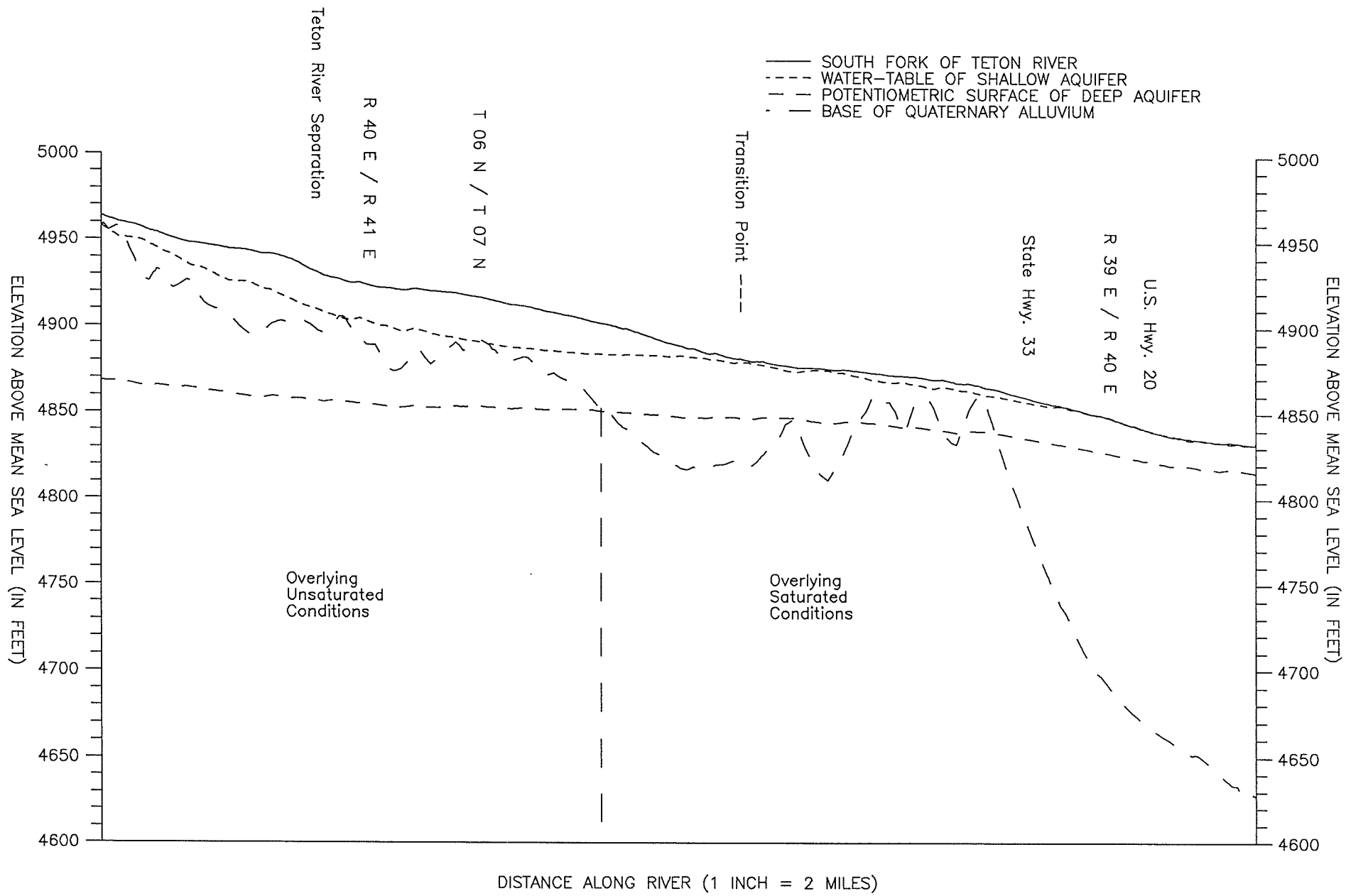

Figure 7. HYDROGEOLOGIC PROFILE ALONG SOUTH FORK OF TETON RIVER

From available data, it appears that both unsaturated and saturated conditions exist in the study area. In areas where head in the deep aquifer is below the base of the Quaternary alluvium, it is implied that unsaturated conditions exist between the two aquifers. This is because the shallow aquifer is thought to predominantly occur in the alluvium based on Well Driller's Reports. Saturated conditions are thought to occur throughout both aquifers in areas where the alluvium is thick and the head in the deep aquifer lies within the it. The approximate areas where unsaturated and saturated conditions overlie the deep aquifer in the study area are shown on both the potentiometric surface map (Figure 6) and the profile (Figure 7).

The difference between unsaturated and saturated conditions is important when assessing the effects of pumping ground water from the deep aquifer on the shallow aquifer. If saturated conditions exist, then any stress on the deep aquifer will cause greater head difference between the two aquifers, and as result, will increase the amount of downward leakage from the shallow to the deep aquifer. However, due to the low vertical hydraulic conductivities of the impeding layers separating the two aquifers (evident by the large head difference between them), the amount of increased leakage would probably be small. According to Ham (1967), results from two aquifer tests conducted a few miles to west of the study area near the Henry's Fork in which the deep aquifer was pumped, indicated no measurable effects on the shallow aquifer. However, changes in river stage during the tests may have obscured any observable effects on the shallow aquifer. In addition, the short length of the tests (48-hours) may have not been long enough to allow the effects of pumping the deep aquifer to propagate through the impeding layers to the shallow aquifer.

Where unsaturated conditions prevail, any stress on the deep aquifer would not cause downward leakage to increase locally. Effects on the shallow aquifer could, however, be experienced over time because saturated conditions exist nearby. As pumping of the deep aquifer continued in this area the interface between saturated and unsaturated conditions would gradually move down-gradient. Leakage would increase immediately down-gradient from the interface where saturated conditions exist until reaching a constant at the interface. Undoubtedly, the long-term effects on the shallow aquifer from pumping the deep aquifer in this area would be considerably less than where saturated conditions exist throughout.

EVALUATION OF EXCHANGE WELLS

Based on the local hydrogeology and well completion, each exchange well was evaluated for its potential impact on the Teton River. Four hydrogeologic settings / well completion scenarios were identified in the study area. From least to greatest potential impact on the river they include:

1) a well located where overlying unsaturated conditions exist and is completed solely in the deep aquifer;
2) a well located where overlying saturated conditions exist and is completed solely in the deep aquifer;
3) a well located where the river and ground water are hydraulically disconnected and is completed partially or solely in the shallow aquifer;
4) a well located where the river and ground water are hydraulically connected and is completed partially or solely in the shallow aquifer.

The location of the exchange well was used to determine which hydrogeologic setting(s) that it occurred in. The items pertaining to well completion that were used in the analysis include depth to water, depth to base of alluvium, and depth to well opening intervals. Based on this information, each exchange well was put into one of the four scenarios of potential impact on the Teton River. A listing of the exchange wells including the data used in the analysis along with the results are shown in Table 2.

On October 7, 1991, IDWR measured depth to water in 11 of the 13 existing exchange wells. Water levels for the two remaining exchange wells were obtained from other sources. These data were compared with estimated values from the shallow and deep aquifer maps (shown on Figures 4 and 6) to assist in determining which aquifer(s) each exchange well was completed in. Because of the significant difference in hydraulic head between the shallow and deep aquifers (greater than 50 ft in some areas), depth to water is an excellent indicator to determine which aquifer an exchange well is completed in.

Depth to base of alluvium and well opening intervals were acquired from the Well Driller's Report, if one was available. These data were compared with an estimated value from the base of the Quaternary alluvium map (Figure 3) and used to help determine whether a given exchange well was open solely to the deep aquifer. Even though, the shallow aquifer is not exclusively confined to the alluvium, this comparison provided a general indicator of the amount of vertical separation in a well between the approximate base of the shallow aquifer and the first well opening.

Table 2. Well completion parameters for exchange wells

Elevation of LSD: or land surface datum estimated from USGS topographic maps.

Depth to water: measured by IDWR on 10/7/91 and estimated from shallow and deep aquifer maps (Figures 4 and 6).

Base of alluvium: reported by Well Driller and estimated from base of alluvium map (Figure 3).

Potential impact on river: based on hydrogeologic setting and well completion; 1-least to 4-greatest.

Well number	Well owner	Date of well completion	Elevation of LSD (ft)	Depth to water (ft)			Base of alluvium (ft)		Well opening (ft)	Potential impact on river
				IDWR	Estimated shallow[1]	Estimated deep[2]	Well Driller's	Estimated		
06N-39E-23AAC3	USBR	08/25/69	4844	32.4[3]	8	32	186	186	245-438	2
06N-40E-11AAB1	Hoopes Bros.	--	4908	31.5	25	60	--	39	--	?3
11AAB2	Echo Ranch	--	4908	30.4	25	60	--	39	--	?3
11AAB3	Brent Ricks	03/11/84	4908	30.1	25	60	--	39	?-358	?3
15CC1	Darrel Ard	08/06/77	4890	56.9	18	47	80	35	158-238 245-258	2
15CC2	Hink Inc.	06/12/82	4890	57.2	18	47	187	35	206-305	2
16DB1	Ray Brown	11/20/77	4880	40[4]	8	40	40	67	82-88	4
21BB1[5]	Arnold	--	4873	--	8	35	--	20	--	2 or 4
07N-40E-25DDD1	DeMarr Bott	05/25/77	4929	73.5	28	80	78	52	84-148	1
25DDD2	Clint Hoopes	07/08/77	4929	73.4	28	80	78	52	82-100 120-160	1
36DAA1	Canyon Creek	--	4930	≈34[6]	34	79	--	24	--	3
07N-41E-29ACD1	Bob Parkinson	04/20/77	4953	98.1	19	95	56	43	136-180	1
29ACD2	Schwendiman	06/03/78	4953	97.1	19	95	55	43	55-75 90-180	1
29ACD3	Schwendiman	03/24/80	4953	99.2	19	95	51	43	138-181	1

[1] - Adjusted to 10/91 conditions (+1.7) using well 06N-39E-13ABA1; [2] - Adjusted to 10/91 conditions (+3.8) using well 06N-39E-23AAC2;
[3] - Based on well 06N-39E-23AAC2; [4] - Reported by Well Driller; [5] - Proposed exchange well; [6] - Cascading water, unable to obtain accurate measurement.

Five existing exchange wells fall into scenarios 3 or 4 suggesting that their use may be impacting flows in the Teton River during the irrigation season. Exchange wells 06N-40E-11AAB1,2,3 appear to be completed in both aquifers according to the water level. However, when measuring depth to water in these wells, cascading water was not observed which would have suggested they were open to the shallow aquifer. Well Driller's Reports are apparently not available for these wells. Based on its shallow well completion and reported complaints by shallow domestic well owners in the area, it appears that exchange well 06N-40E-16DB1 is partially completed in the shallow aquifer. The water level reported by the Well Driller does not indicate this. Based on cascading water observed in exchange well 07N-40E-36DAA1, it seems fairly certain that this well is partially completed in the shallow aquifer. A Well Driller's Report could not be found for it.

Further investigation of these exchange wells is warranted. This may be as simple as finding Well Driller's Reports for the ones that are not currently available to a more involved process of pulling pumps and lowering flow meters and geophysical logging tools into them. If, after a more detailed review of well completion, a well is still found to fall into one of these two scenarios, then the well should rehabilitated to seal it off from the shallow aquifer or be plugged and abandoned.

During the completion of proposed exchange well 06N-40E-21BB1, necessary steps should be taken in order to ensure the shallow aquifer is adequately sealed off and the well is solely open to the deep aquifer. In order to minimize its potential impact on the Teton River, a more suitable location for this well would be up-gradient in the area where unsaturated conditions overlie the deep aquifer (scenario 1).

The eight exchange wells that are solely completed in the deep aquifer should have a minimal impact on the shallow aquifer and Teton River. The five wells that are located in the area where unsaturated conditions overlie the deep aquifer will have even less impact. This is the preferred area where future exchange wells should be located.

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