Book 13

TECHNICAL COMPLETION REPORT

WATER MANAGEMENT AND GROUNDWATER

in the

HENRY'S FORK - UPPER SNAKE RIVER BASIN OF IDAHO

by

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ABSTRACT

A water resource study of the Lower Henry's Fork area and the Upper Snake River Basin in Idaho was undertaken to evaluate the hydrological relationships between the perched and regional groundwater tables, river reach-gain and irrigation water management. Data on irrigation system diversions and return flow, cropping patterns and water use, and river flows were used to evaluate a basin water budget for the area. For the 1975 water year the net recharge from the study area to the Snake Plain regional aquifer is estimated to be 509,000 acre feet or approximately 8 percent of the total input to the aquifer.

Manipulation of the perched water table to effect sub-irrigation in sandy soils on some areas of the basin requires canal diversions in excess of 11 acre feet per acre and causes rises in the water table of 2-40 feet over the season. A groundwater model of the perched system is being developed and will be integrated with the current model of the Snake River Fan aquifer to the south of the Henry's Fork.

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INTRODUCTION

The Henry's Fork of the Snake River, sometimes referred to as the North Fork, is one of the major tributaries to the Snake River. Its importance to the agriculture and economy of the basin through which it flows is indicated by the fact that over 125,000 acres are irrigated by waters from its main stream and tributaries. Its importance to the water resources of Idaho is not insignificant as the Henry's Fork Basin aquifer serves as a major source of inflow to the vast Snake Plain aquifer. Past estimates of this inflow have been on the order of 10% of the groundwater budget of the large aquifer. (de Sonneville, 1974)

I can therefore be seen that a greater and more accurate knowledge of the relationships between the hydrologic components of this region is an enhancement to the planning efforts of the U. S. Corps of Engineers and other agencies involved with the management of Idaho's most important natural resource. Successful utilization of some of the state's river operation models as well as the digital model of the Snake Plain Aquifer depend significantly upon a quantitative knowledge of the water resources of the Henry's Fork Basin. Actual data to support these efforts have been lacking in the past, and the reliability of the estimates that have been made are deemed questionable by some.

It has thus been the purpose of this study to attempt to collect new data and evaluate existing data in order to gain a more accurate understanding of the hydrology of this region and its effects on the Snake Plain Aquifer in particular.

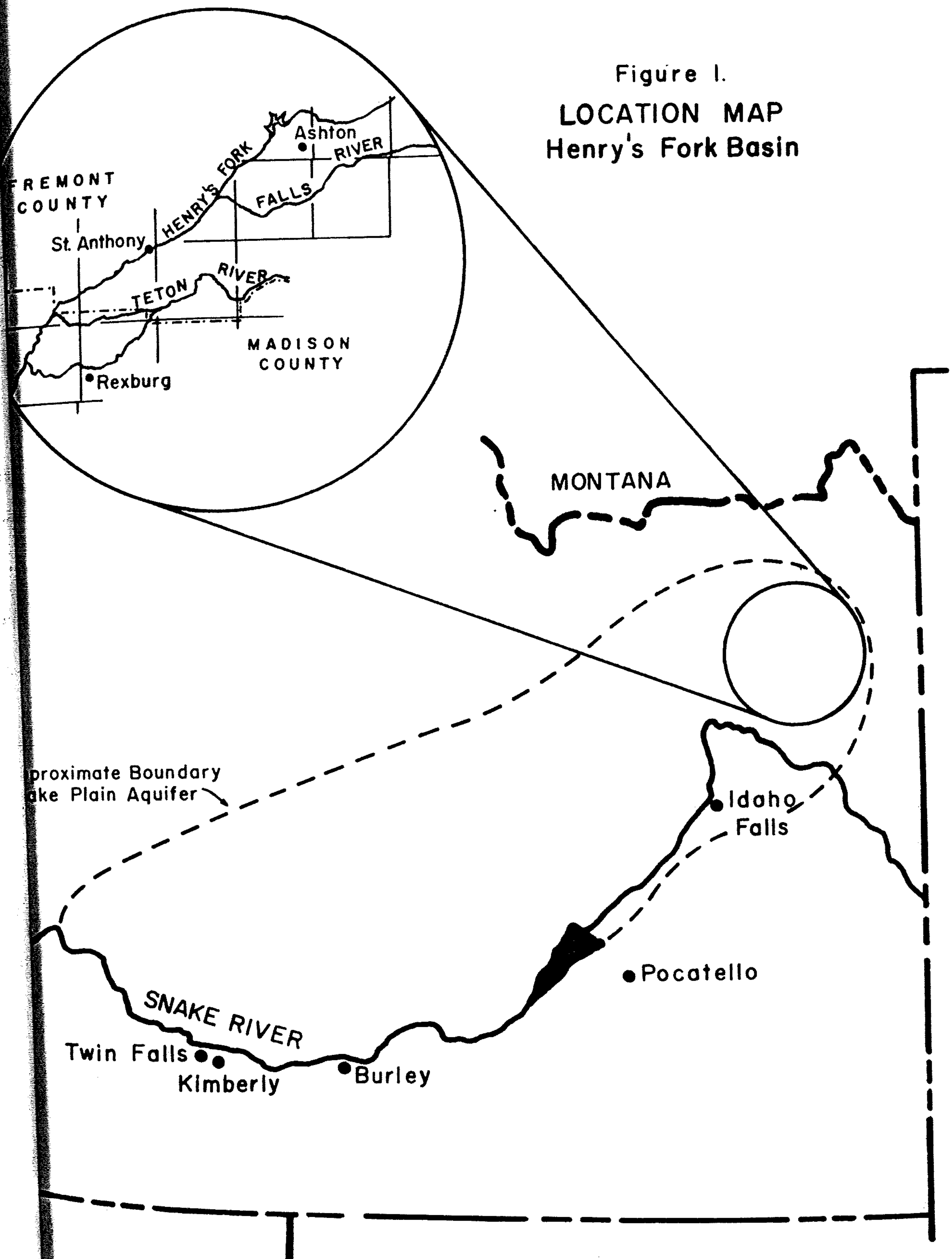
The investimation was undertaken in cooperation with the U.S. Army Corps of Engineers who funded the University study and with the Idaho Department of Water Resources under a continuing program for improving the Snake Plain Aquifer groundwater model.

PROJECT AREA

The area of this study is located within Madison and Fremont Counties, Idaho; essentially it includes all lands in the two counties which are irrigated by waters from the Henry's Fork, Falls and Teton Rivers. The northeast boundary runs approximately along a line from the confluence of the Warm and Henry's Fork Rivers to the diversion point of the Yellowstone Canal from the Falls River. The southeast side of the area is bounded by an upland region, which includes the Rexburg Bench in the southern end. To the northwest the study area is bounded by other uplands, which include an area of shifting sand dunes and to the west by the Snake Plain, along a line running approximately NNE from the Menan Buttes. The entire area lies between approximately 111°15' and 111°55' west longitude and 43°48' and 44°10' north latitude.

Figure 1 shows the location of the study area which is in western Madison County and the southern part of Fremont County. Major geographic

Figure 1.
LOCATION MAP
Henry's Fork Basin



areas include the Egin Bench area on the west, the Henry's Fork, the Falls River and the lowlands east of the Henry's Fork including the lower reaches of the Teton River. Figure 2 shows the major streams and cities in the study area.

The major water use in the area is for irrigation, and most lands are served by the Fremont-Madison Irrigation District. Groundwater pumping for irrigation is prevalent in the southeast portion of the study area known as the Rexburg Bench.

The climate of the Henry's Fork Basin is characterized by moderately hot summers and cold winters. Over the year 1975 the temperature at St. Anthony (1WNW), which is fairly representative of the basin, ranged from a minimum of -25°F in January to a maximum of 91°F in July. The average temperature at this station for the same year was 39.7°F, which departed -3.0° from the normal temperature. Precipitation for the station was measured at 16.43 inches (417 mm) in 1975 which was 1.98 inches (50 mm) above normal. Each month of a normal year for this station sees at least one inch of precipitation excepting the months of July, August, September and October. This shows that precipitation over the year is relatively evenly distributed, although due to snow storage of moisture the actual runoff of this precipitation is not so evenly distributed. The average frost free growing season ranges from about 105 days in the lowlands to about 95 days in the bench lands of the basin, Crosthwaite et al (1970).

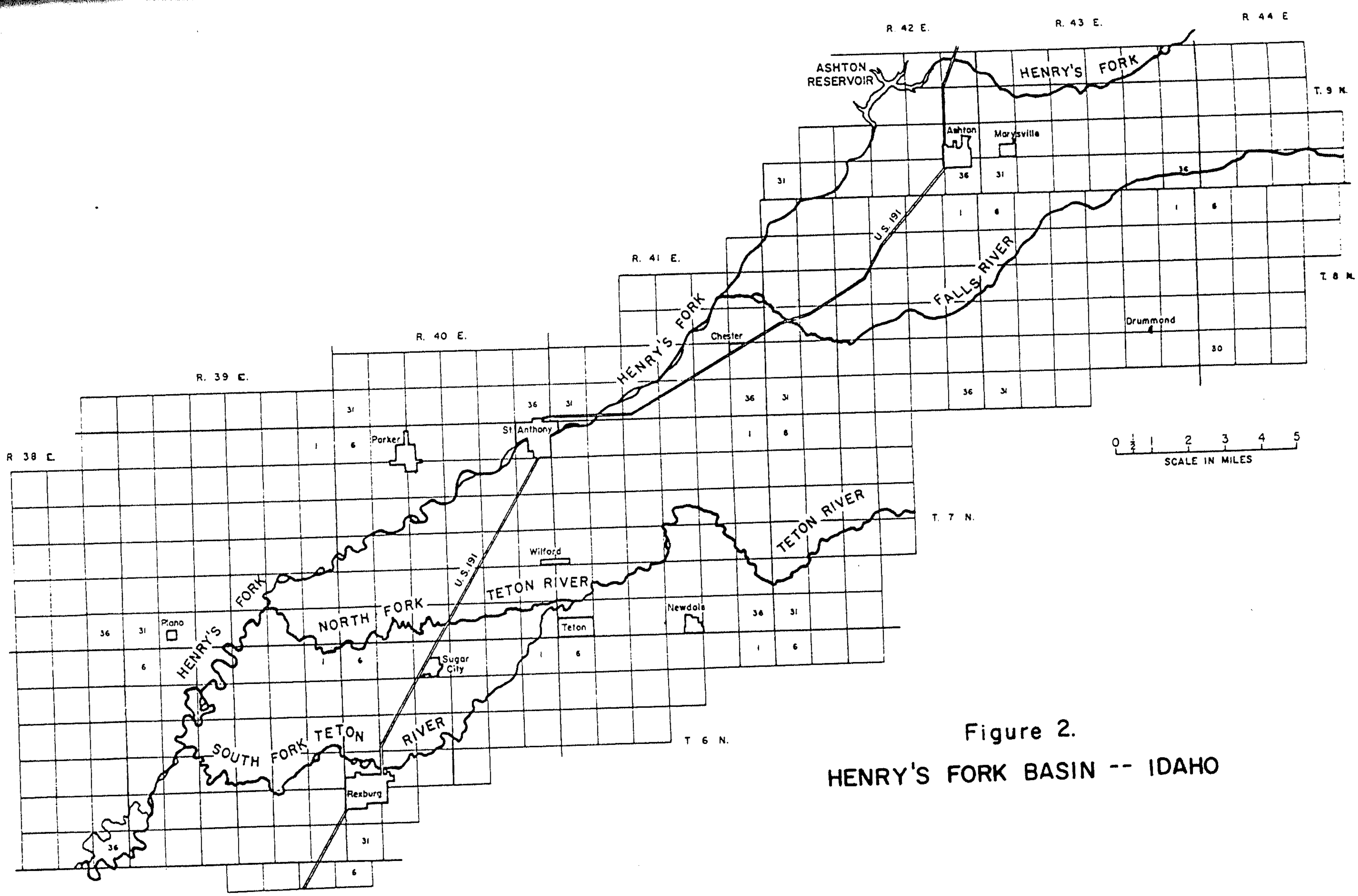


Figure 2.

HENRY'S FORK BASIN -- IDAHO

OBJECTIVES

The purpose of the study was to develop preliminary data and relationships for future use in developing a groundwater model of the area or extending the Snake Plain Aquifer model. Understanding of the reach-gain for the Henry's Fork and relationship between surface and groundwater return flows were also needed. The specific objectives were:

(1) To determine the relationships between river flow, irrigation diversions and return flows in the Henry's Fork tributary of the Snake River.

(2) To delineate areas of irrigation water use by irrigation districts and canal companies in the Henry's Fork Basin.

(3) To develop water budget data on the Henry's Fork for determination of groundwater recharge for input to the digital simulation model of the Snake Plain Aquifer.

(4) Determine and display groundwater movement in the Henry's Fork Basin.

CROP DISTRIBUTION

Data on crop acreages were obtained from the crop reports submitted to the U. S. Bureau of Reclamation by the Fremont-Madison Irrigation District. The 1974 report is used here because it is more detailed, perhaps because 1974 was a Department of Commerce Agricultural census year. The composite 1974 crop distribution of the major crops in the two counties based on a total irrigated acreage of 295,850 acres was determined to be:

grain	37.0%
hay	4.1% (includes irrigated pasture)
potatoes	32.4%
alfalfa	26.4%

IRRIGATED SERVICE AREAS

Service area maps compliled by the U. S. Bureau of Reclamation for studies on the Teton Basin project and updated by the Idaho Department of Water Resources show the irrigated areas of the various irrigation districts of the Henry's Fork Basin. Delineation of service areas for the various canals is difficult. The total number of irrigated acres for the basin, which was used in determining the total consumptive use, was 126,890. Some systems commingle water in canals and share common diversion and distribution works. Figure 3 shows the service areas for most canal systems in the study area. Some small systems were included with adjacent larger systems for convenience. Table 1 lists the irrigated acreage for each canal or district compiled from Idaho Department of Water Resources data and as published on the Water Master's report for District 01 (1974).

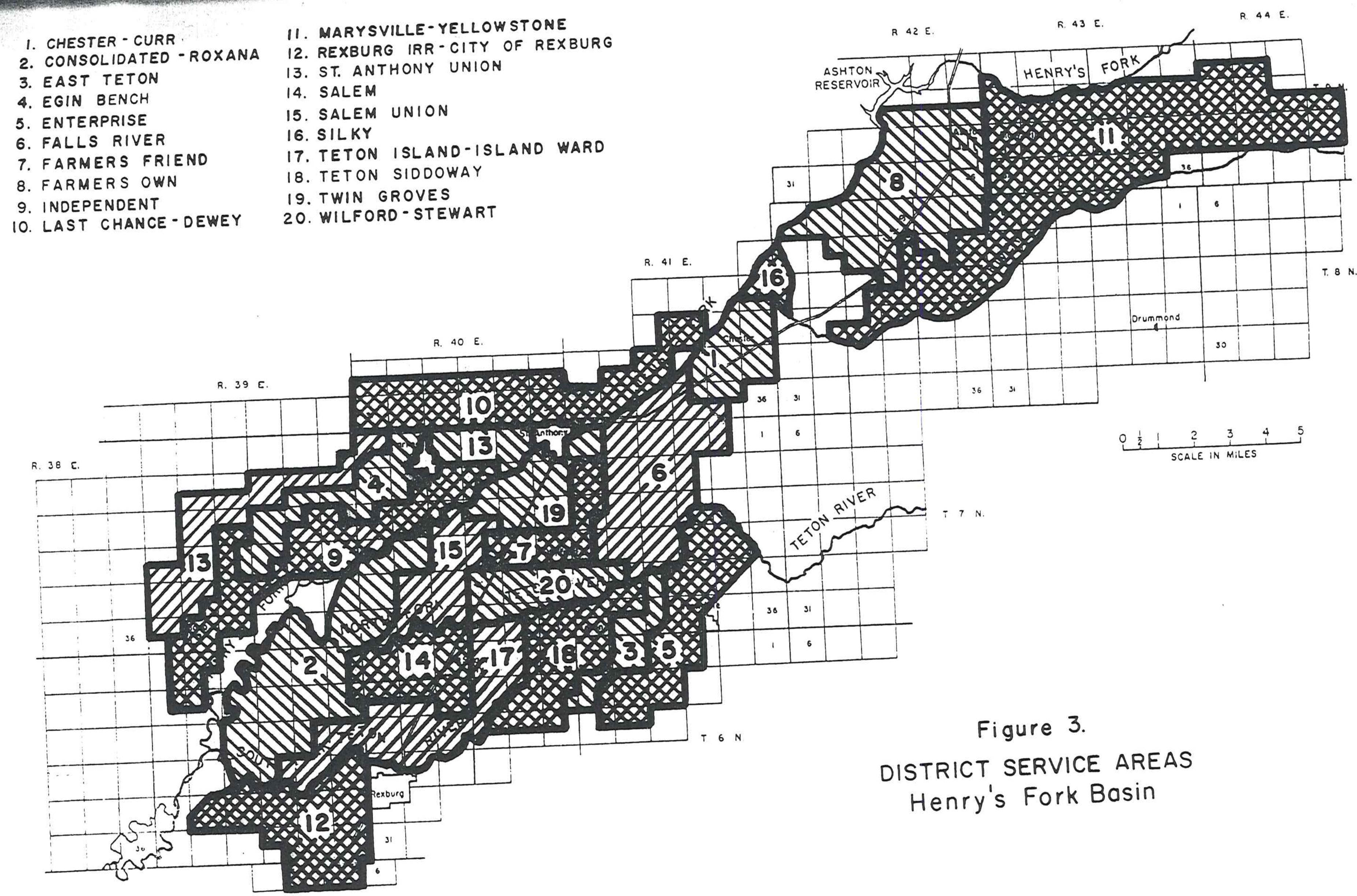


Figure 3.
DISTRICT SERVICE AREAS
Henry's Fork Basin

Table 1. Irrigated Acreage - Henry's Fork Basin, Idaho

IRRIGATION DISTRICT	IDWR DATA	WATERMASTER'S DATA
1. Marysville - Yellowstone	22,605	18,100
2. Farmer's Own	8,445	5,800
3. Enterprise	6,890	5,890
4. Falls River - Bell	8,152	9,110
5. Chester - Curr	3,187	2,700
6. Silky	681	1,080
7. Last Chance - Dewey	7,983	3,060
8. St. Anthony Union	7,235	12,000
9. Farmer's Friend	3,680	3,025
10. Twin Groves	2,742	2,500
11. Salem Union	4,700	5,500
12. Egin Bench	5,260	7,000
13. Independent	7,730	6,000
14. Consolidated - Roxana	9,660	6,880
15. Teton - Siddoway	4,165	2,500
16. Wilford - Stewart	3,235	2,778
17. Teton Island - Island Ward	6,980	13,700
18. Salem	4,415	--
19. East Teton	2,205	--
20. Rexburg Irr. - City of Rexburg	6,940	6,230
Basin Total	126,890	117,913*

* "Total Falls River, Henry's Fork and Lower Teton", p. 34, Watermaster's Report, 1974.

CONSUMPTIVE USE

Values of potential evapotranspiration for the Rigby area for 1970 completed by de Sonneville (1972) were considered to be representative of the Rexburg-St. Anthony area for 1975. These data were based upon climatological data at Idaho Falls. The only other station (in the proximity of the Henry's Fork Basin) where sufficient climatological data was available to make potential evapotranspiration estimates is at Ashton, Idaho. Since Ashton's elevation (5260 ft. msl) is higher than most of the basin, it was decided to utilize the 1970 Rigby (Idaho Falls) data instead. The total seasonal potential evapotranspiration from this data was 33.15 inches (842 mm).

Crop coefficients applicable to this area were obtained from the Agricultural Research Service report on evapotranspiration for Silver Creek, and adjusted according to the difference in starting dates and lengths of the growing season for Silver Creek and the Henry's Fork Basin.

Multiplying these adjusted crop coefficients by the calculated potential evapotranspiration yielded bimonthly values of crop consumptive use for each of the major crops. The total seasonal consumptive use for these crops was:

grain - 20.3 inches (515 mm)

hay - 24.8 inches (631 mm)

potatoes - 18.8 inches (476 mm)

alfalfa - 28.3 inches (719 mm)

Using the calculated consumptive use values for each crop and the crop distribution coefficients, a weighted value of bimonthly consumptive use for the entire basin was calculated, Table 2. The total seasonal crop consumptive use is 22.0 inches (559 mm). For the total irrigated acreage of 126,890 a (51352 ha), the total seasonal crop consumptive use for the basin was calculated to be 232,737 af (287 x $10^6 m^3$).

IRRIGATION PRACTICES

Water is conveyed to irrigated lands in the Henry's Fork area by means of unlined gravity ditches. Diversions from the Henry's Fork serve lands on the western side of the valley where subirrigation is practiced and on the eastern part of the valley. Ten diversions from Fall River serve lands in the Fall River Valley and on the eastern side of the Henry's Fork River. One canal diverts from the Fall River and irrigates land some 25 miles south across the Teton River. Lands under this canal system operated by the Enterprise Irrigation District are irrigated entirely by sprinkler. Diversions from the Teton River and the North and South Fork of the Teton River number about 18 and serve lands as far south as Rexburg.

TABLE 2. ESTIMATED EVAPOTRANSPIRATION

IRRIGATED LANDS - HENRY'S FORK BASIN

Date (Inclusive)	Potential Evapo- (1) transpiration (inches)	GRAIN Crop (2) Coeff.	GRAIN Actual E.T. (inches)	ALFALFA Crop (2) Coeff.	ALFALFA Actual E.T. (inches)	POTATOES Crop (2) Coeff.	POTATOES Actual (3) E.T. (inches)	PASTURE Crop (2) Coeff.	PASTURE Actual E.T. (inches)	WEIGHTED Actual E.T. inches	WEIGHTED Actual E.T. mm
MAY 1-15	1.73	0.26	0.45	0.71	1.23	0.50	0.86	0.75	1.30	0.82	21
MAY 16-31	3.10	0.31	0.96	0.96	2.98	0.21	0.65	0.75	2.32	1.45	37
JUNE 1-15	2.64	0.78	2.06	1.00	2.64	0.24	0.63	0.75	1.98	1.70	43
JUNE 16-30	3.74	1.02	3.81	0.86	3.22	0.32	1.20	0.75	2.80	2.76	70
JULY 1-15	4.48	1.03	4.61	0.60	2.69	0.50	2.24	0.75	3.36	3.28	83
JULY 16-31	3.97	0.89	3.53	0.96	3.81	0.70	2.78	0.75	2.98	3.33	85
AUG. 1-15	3.39	0.58	1.97	1.00	3.39	0.84	2.85	0.75	2.54	2.65	67
AUG. 16-31	3.01	0.24	0.72	1.00	3.01	0.90	2.71	0.75	2.26	2.03	52
SEPT. 1-15	3.31	0.20	0.66	0.61	2.02	0.82	2.71	0.75	2.48	1.76	45
SEPT. 16-30	2.14	0.22	0.47	0.88	1.88	0.50	1.07	0.75	1.60	1.08	27
OCT. 1-15	1.18	0.62	0.73	0.95	1.12	0.62	0.73	0.75	0.88	0.84	21
OCT. 16-31	0.46	0.68	0.31	0.68	0.31	0.68	0.31	0.68	0.31	0.31	8
SEASON TOTAL	33.15		20.28		28.32		18.76		24.84	22.01	559

(1) Based on Idaho Falls climatological data, 1970.
(from DeSonneville, 1972)

(2) Taken from Wright and Jensen, 1975, with adjustment for beginning and end of growing seasons.

(3) Weighted according to crop distribution for Henry's Fork Basin, 1974 (See Table 1).

Eleven diversions from the main stem of the Henry's Fork serve areas on the west and east sides of the river. Lands served by canal systems on the west side of Henry's Fork, locally referred to as the Egin Bench are subirrigated. Approximately 28,200 a (11,416 ha) are served by six canal systems. The perched water table underlying the area is manipulated by controlling applications from canals diverting upstream of St. Anthony.

Net irrigation applications on the Egin Bench, 11.74 acre foot per acre (3.58 m^3/m^2), were measured during the 1975 irrigation season, Figure 4. Surface return flows from districts serving these lands averages 6.1 percent of the diversion for the irrigation season.

Subirrigation is utilized because of the sandy soils and has evolved through the years as the most expedient method of irrigation. Small feeder ditches through level fields are used to apply sufficient water for manipulation of the perched water table. In addition, canals and laterals are checked and road borrow pits are maintained full of water.

IRRIGATION DISTRIBUTION SYSTEMS

Diversion and transmission facilities for irrigation water are not modern. River diversion structures generally consist of concrete or wooden checks with rectangular gates. Diversion dams consisting of temporary structures on gravel dikes are common.

Farm turnouts are generally wooden or concrete structures controlled either by the farmer or watermaster. Canals and laterals are earthen with few check structures. Distribution systems operated by the various irrigation companies sometimes cross each other or commingle with common

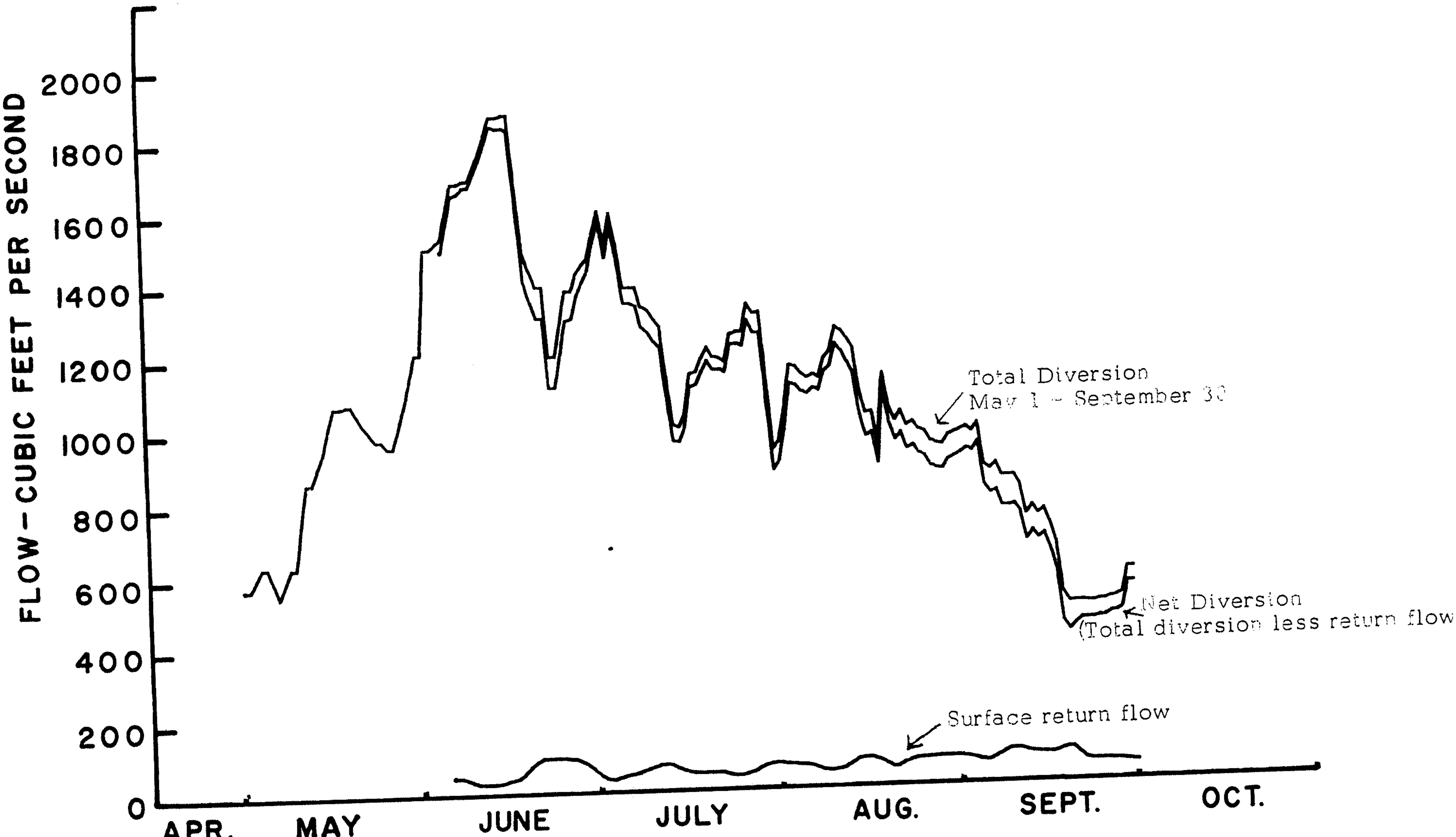


Fig. 4. Irrigation diversions and surface return flow, Egin Bench area, Henry's Fork Basin, Idaho -1[illegible].

pool and outlet structures.

The majority of the systems have surface return flow channels, however, most are generally small channels and may not flow continuously during the season. On several systems, particularly the Enterprise and East Teton Irrigation Districts, some surface return flows flow directly into an adjacent district main canal and serve as a significant portion of the project irrigation requirement.

Most systems are furnished water from the Fremont-Madison Irrigation District which has responsibility for control and delivery to individual canals from natural rights and upstream storage. Fremont-Madison Irrigation District has storage in Grassy Lake, Island Park and Henry's Lake Reservoirs.

Water is furnished to systems from April to October with those systems serving subirrigated tracts turning on the earliest and continuing until icing conditions occur at the headgates. In 1975 many canals started prior to May 1 and diverted until after October 30.

DATA COLLECTION

Surface Return Flows

A major input in the water budget and in any modeling effort of the aquifer in the Henry's Fork requires a seasonal distribution of river reach gain and losses. The total reach gain can be determined using river gaging stations data and recorded diversions. The surface return flow component of the reach gain can be measured and the groundwater component computed.

In 1975 surface return flows from irrigation systems on the Henry's Fork and Teton Rivers were measured. Discharge measuring devices including weirs and current meter rated sections with and without water stage recorders were installed at 25 stations. The flows were measured continuously or periodically depending on the fluctuations of the stream and seasonal distribution of flows at each station were determined. Figure 5 shows the coded location of the measuring points and Table 6 in Appendix A lists the canal name and pertinent data.

The seasonal distribution of surface return flow is also shown on Figure 4 for the Egin Bench area.

Irrigation Diversions

Diversions for irrigation from the Henry's Fork and Teton Rivers are recorded in the Water Distribution and Hydrometric Work, District No. 01 Snake River, Idaho (1975). These records are obtained by the Fremont-Madison Irrigation District or the U. S. Geological Survey and are reported daily for the May 1-September 30 water year. Additional measurements of early and late season flows have been obtained weekly since 1972.

Historical trends in diversion to canals served by the Falls River, Henry's Fork and Teton Rivers are shown on Figure 6. The total recorded

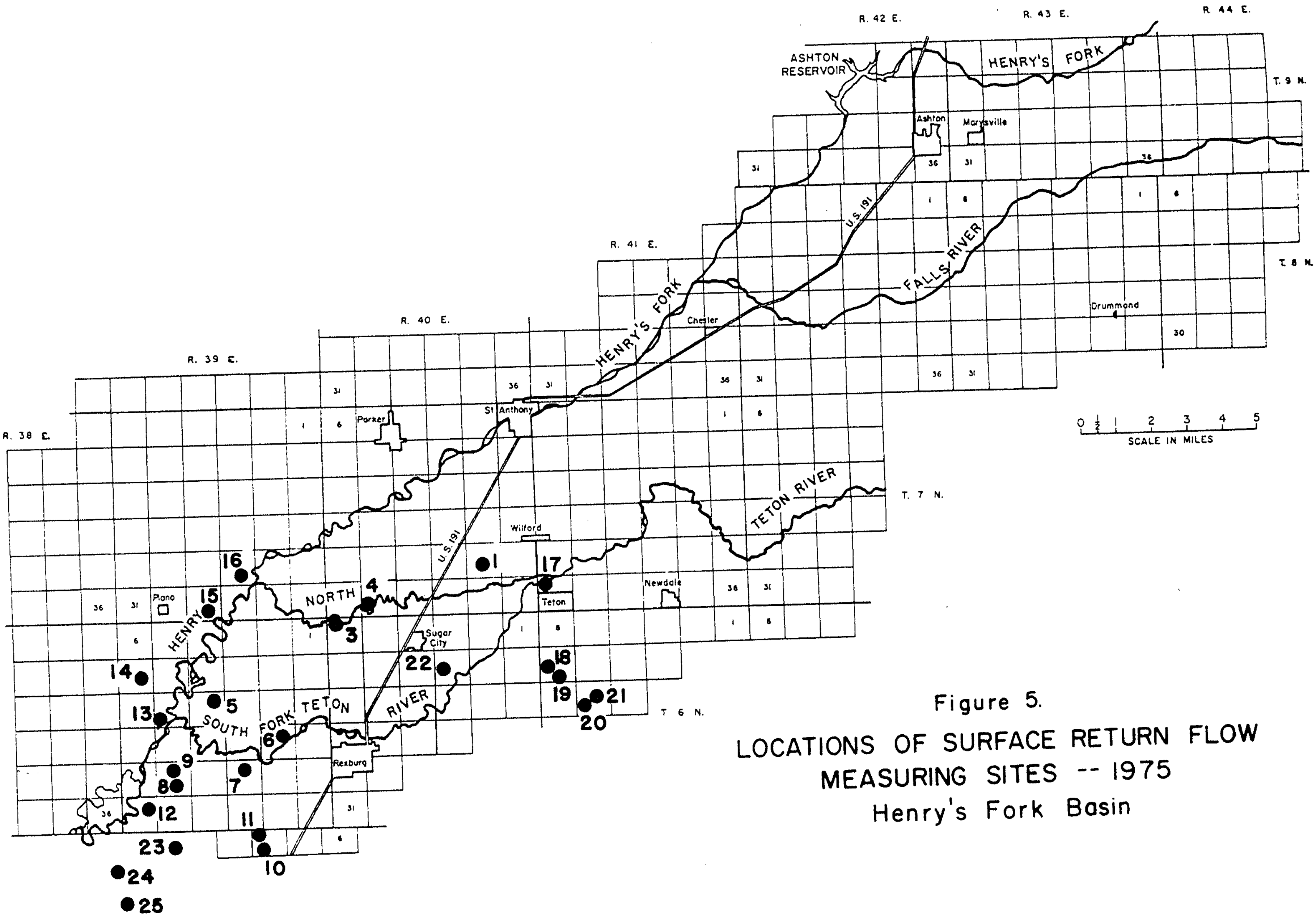


Figure 5.

LOCATIONS OF SURFACE RETURN FLOW MEASURING SITES -- 1975

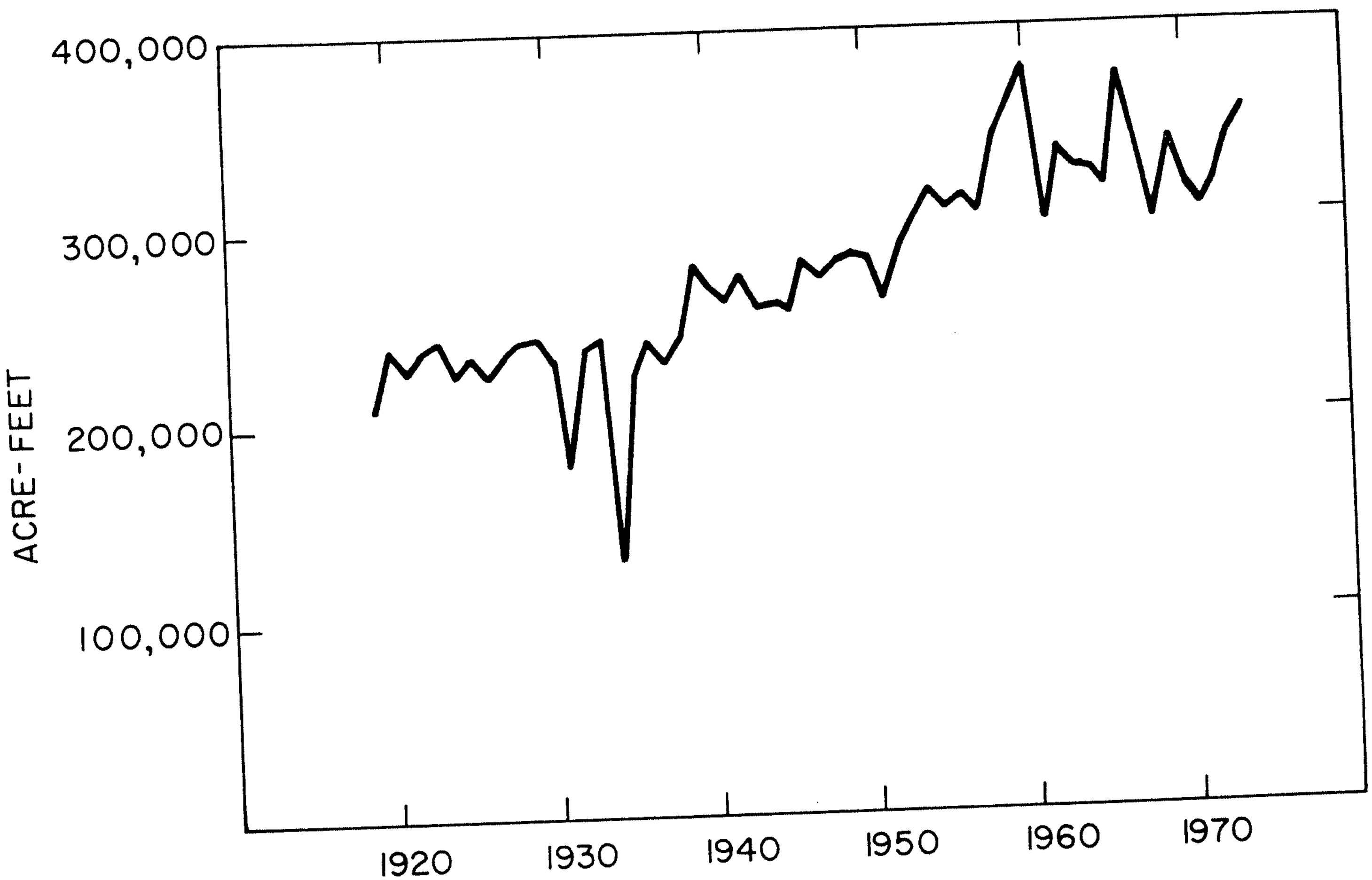
Henry's Fork Basin

Figure 6

IRRIGATION DIVERSIONS

HENRY'S FORK - ASHTON TO ST. ANTHONY

MAY 1 TO SEPT. 30



* Published in "Water Distribution and Hydrometric Work, District No. 01 Snake River, Idaho"

diversions from canals in the Henry's Fork area serving approximately 126,890 a (51352 ha) indicates a nearly continuous rise in total diversion since 1920. Irrigated acreage reportedly increased until 1937 and leveled off after that time, USBR (1946).

Geology

The rolling plains and lowlands in the Henry's Fork are generally underlain by alluvium and basaltic lava flows. The benchlands, which provide a transition zone between the lowlands and the broad plateaus and mountains to the north and east, are underlain by silicic volcanic rocks and occasional lava flows.

The alluvial deposits and basaltic lavas lie in a broad structural depression. In the central lowlands the alluvium are underlain by basalts, also. These are part of the Snake River Group of basalts and are part of a series of flows which in part constitute the Snake Plain Aquifer. They are found at depths of as much as 300 feet in the St. Anthony-Rexburg area, and are of unknown but great thickness. The basalts underlying the Rexburg Bench are of a different group, originating from several buttes southeast of the area and ranging from several hundred to a few feet thick. Between Ashton and St. Anthony, the basalts are veneered with alluvium. These deposits, consisting of clay, silt, gravel and sand, also occupy the upper strata of the central lowlands extending from St. Anthony south-westward to beyond the Snake River.

Well logs west of the Henry's Fork suggest that the alluvium in this area is mostly sand; in the remainder of the area, well logs show a predominance of gravel in the alluvial aquifer. Near the mouth of the Henry's Fork these deposits are nearly 350 feet thick.

Both these alluvial deposits and the basalts which lie beneath or are interfingered with them are characterized by relatively large coefficients of transmissivity; the Henry's Fork Basin Aquifer is thus a highly permeable one capable of transporting great quantities of water.

For a more complete discussion of the geology of this area, see Crosthwaite (1970).

Groundwater

The regional water table slopes generally westward toward the Mud Lake area. The Henry's Fork and Teton Rivers are perched above the regional water table. At St. Anthony, the river is perched approximately 100 to 150 feet above the regional water table but near the mouth of Henry's Fork, the water table is only a few feet below river level. Seasonal fluctuations vary over the area from 8-10 feet in the central area (St. Anthony-Rexburg) to 3-5 feet in the western part of the area and in the upland area which is underlain by silicic volcanic rocks. The regional water table response is apparently influenced strongly by the application of surface irrigation in areas underlain by the Snake River Basalts.

The Egin Bench and alluvial deposits of the central area east of the Henry's Fork are underlain by a perched water table. The perched water table extends west past the town of Plano, south to Menan Buttes at the confluence of the Henry's Fork and South Fork of the Snake River and merges into the perched water table of the Snake River Fan. Figure 7 shows the approximate limits of the perched water table (Crosthwaite et al, 1970). The Snake River Fan in the Rigby-Ririe area has been studied and a groundwater model completed for this alluvial aquifer (Brockway and de Sonneville 1971).

Major fluctuations of the perched water table are dependent on surface water applications and the characteristics of the alluvial material locally. Fluctuations in the Snake River Fan (Brockway, de Sonneville 1973) and the Henry's Fork perched water tables vary from 2-40 feet annually (Crosthwaite et al 1970).

Figure 8 is a hydropgraph of well 7N-40E 5dbc1 located north-northwest of the city of Parker. The seasonal fluctuations for the 1971-73 period represent typical responses of the perched water table to irrigation applications with the peak elevations being nearly equal in all years. The 1974 peak of the water table for this well was 2.84 feet below land surface which is similar to prior years. Other wells in the perched water table show similar responses, however, the amplitude of the rise varies locally.

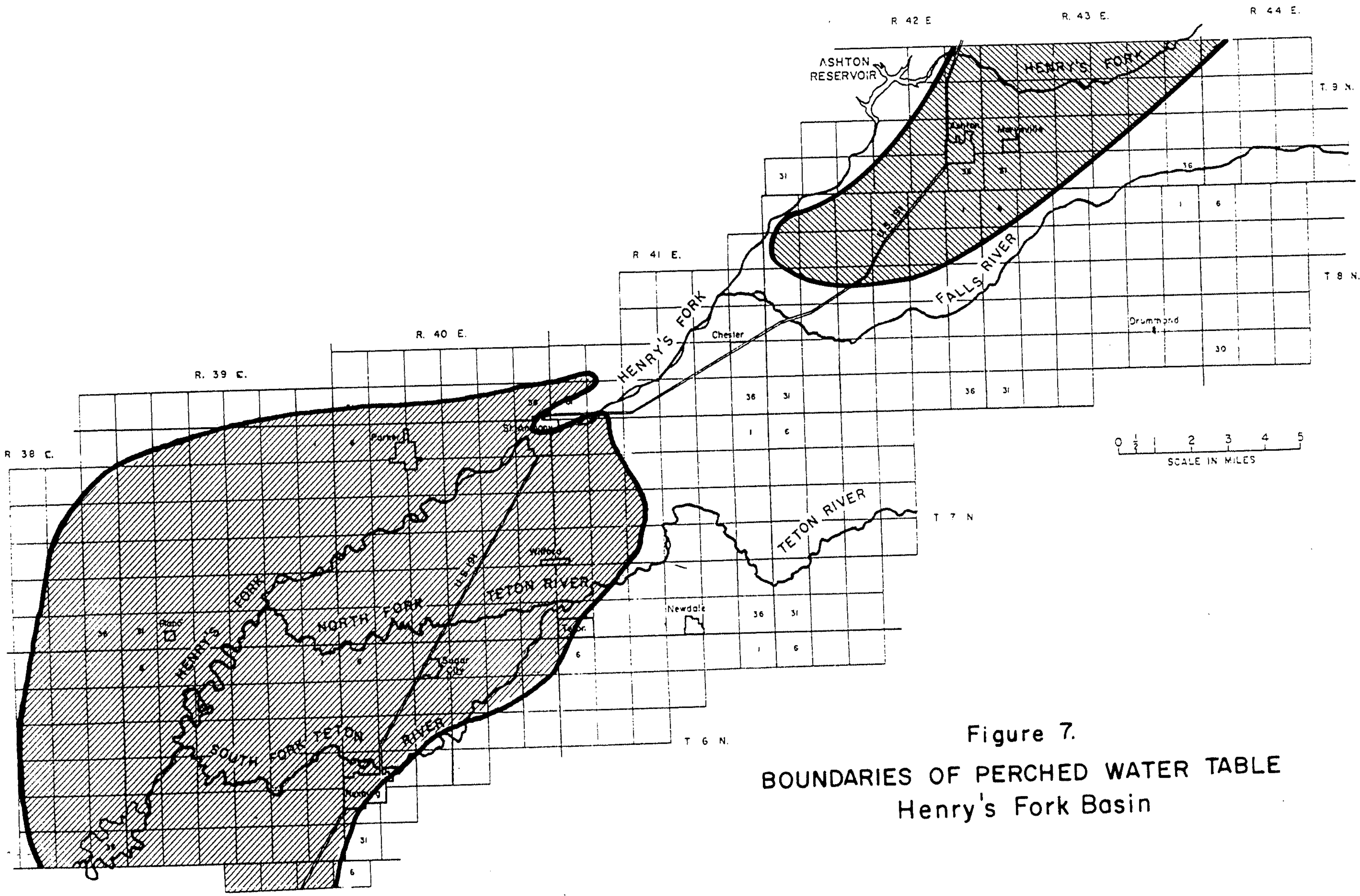
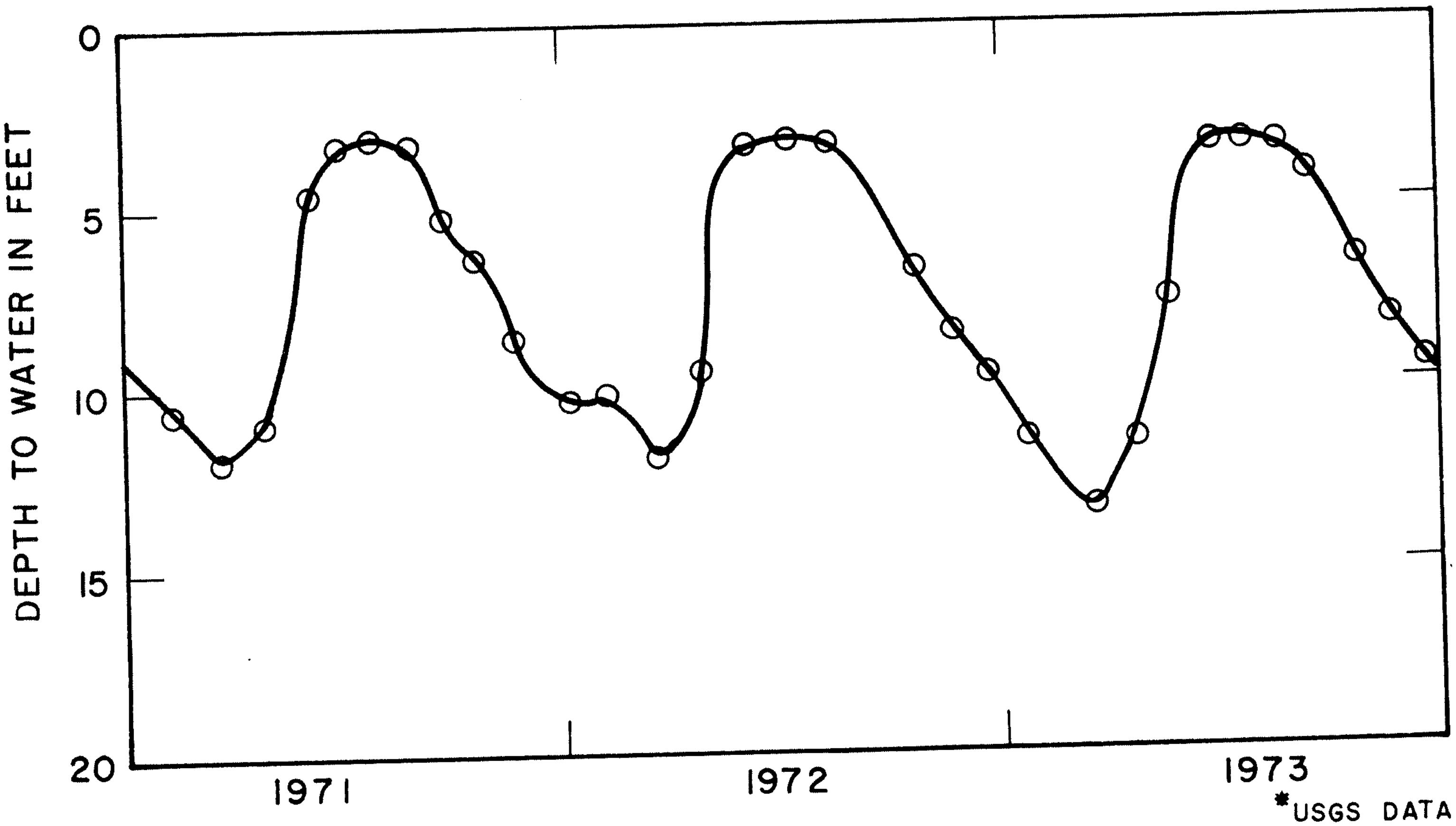


Figure 7.
BOUNDARIES OF PERCHED WATER TABLE
Henry's Fork Basin

Fig. 8 HYDROGRAPH OF WELL 7N-40E 5DBC1*
(APPROXIMATELY ONE MILE NNW OF PARKER, IDAHO)



A perched water table also is present in the area around Ashton as a result of irrigation applications from the Falls River. It is generally believed that a groundwater divide between the perched water table in the Ashton area and the St. Anthony area exists and that there is very little subsurface lateral movement between the two bodies (Whitehead 1977). There is, however, gain to the Henry's Fork near Ashton from the perched water table.

River Gains and Losses in the Henry's Fork Basin

An investigation of approximate gains/losses to the rivers of the Henry's Fork Basin was undertaken. A survey of records from the USGS and the Watermaster was made to determine which stream flows were already being observed. It was decided to include two reaches on the Falls River, six reaches on the Teton River, and four reaches on the Henry's Fork River for a mass discharge measurement. On September 25, 1975, personnel from the Idaho Water Resources Research Institute and the Idaho Department of Water Resources secured current meter flow measurements at various locations as needed in order to delineate each of the reaches. Twelve measurements in all were made using a Neyrpic cable-mounted flow meter. The results of this investigation are summarized in Table 3.

Table 3. River Gains and Losses - Henry's Fork and Tributaries, September, 1975

HENRY'S FORK	Inflow cfs	Outflow cfs
Reach H1:		
Henry's Fork at Fritz's Bridge (M)	1839	
Dewey Canal (W)		15
Falls River (13049500)	312	
Last Chance Canal (W)		68
Cross Cut Canal (W)		55
St. Anthony Union Canal (W)		162
Farmers Friend Canal (W)		36
Twin Groves Canal (W)		72
Salem Union Canal (W)		116
Henry's Fork at St. Anthony (13050500)		1540
	2151	2064 (loss=87)
Reach H2:		
Henry's Fork at St. Anthony (13050500)	1540	
Egin Canal (W)		117
St. Anthony Union Feeder Canal (W)		22
Independant Canal (W)		102
Consolidated Farmers Canal (W)		157
Henry's Fork SW of Parker (M)		1430
	1540	1828 (gain=288)
Reach H3:		
Henry's Fork SW of Parker (M)	1430	
North Fork of Teton River (M)	163	
Canal Waste #1015 (R)	10	
Canal Waste #1014 (R)	31	
South Fork of Teton River (M)	258	
Canal Waste #1013 (R)	4	
Henry's Fork near Rexburg (13056500)		1700
	1896	1700 (loss=196)

Notes: U.S.G.S. gage records indicated by gage number in parenthesis.
Watermaster records are indicated by (W).
Records obtained by direct flow metering are indicated by (M).
Records obtained by observation of rated sections are indicated by (R).
For locations of canal wastes, see Table 6, Appendix.

FALLS RIVER

	Inflow cfs	Outflow cfs
Reach F1:		
Falls R. at Squirrel (13047500)	612	
Farmers Own Canal (W)		41
Conant Creek (M)	74	
Falls R. at Hwy. 32 (M)		856
	686	897 (gain=211)
Reach F2:		
Falls R. at Hwy. 32 (M)	856	
Enterprise Canal (W)		70
Falls River Canal (W)		206
McBee Canal (W)		3
Chester Canal (W)		43
Silkey Canal (W)		6
Curr Canal (W)		43
Falls R. at Chester (13049500)		312
	856	683 (loss=173)

TETON RIVER

	Inflow	Outflow
Reach T1:		
Teton R. at Teton Dam (13054805)	510	
Canyon Creek Canal Waste	2	
Hog Hollow Creek	40	
Cross Cut Canal Waste	10	
Teton R. near St. Anthony (1305500)		634
	562	634 (gain=72)
Reach T2:		
Teton R. near St. Anthony (1305500)	634	
Siddoway Canal (W)		6
Wilford Canal (W)		77
Teton Irrigation Canal (W)		40
Good Luck Canal (W)		6
North Fork of Teton R. at Teton (M)		306
South Fork of Teton R. at Teton (M)		329
	634	764 (gain=130)

TETON RIVER (Cont.)

	Inflow cfs	Outflow cfs
Reach NT 1:		
North Fork at Teton (M)	306	
Pincock Byington Canal		7
Teton Island Feeder Canal (W)		230
Canal Waste #1001	44	
North Fork N. of Sugar City		113
	350	350 (no loss or gain)
Reach NT 2:		
North Fork N. of Sugar City (M)	113	
Roxana Canal (W)		19
Island Ward Canal (W)		11
North Fork near Barker Rd. (above confluence w/Henry's Fork)		163
	113	193 (gain=80)
Reach ST 1:		
South Fork at Teton (M)	329	
Pincock-Garner Canal (W)		10
Canal Waste #1017 (R)	69	
Woodmansee-Johnson Canal (W)		13
Rexburg City Canal		12
Moody Creek	44	
Canal Waste #1022 (W)	3	
Rexburg Canal (W)		171
South Fork near Rexburg (M)		10
	445	216 (loss=229)
Reach ST 2:		
South Fork near Rexburg (M)	10	
Canal Waste #1006 (R)	6	
South Fork above confluence w/Henry's Fork (M)		258
	16	258 (gain=242)

The significance of the values of gains or losses obtained by this investigation is somewhat questionable. This is essentially due to the lack of accuracy of the discharge measurements, especially on the Henry's Fork and Falls River reaches where the values of gains/losses were easily within or close to the estimated ± 7% accuracy of the current metering. Another potential source of error is the possible inaccuracy of the reported daily discharges of canals by the watermaster. It should be noted that some recorded daily values are estimates based on observations made at intervals of varying lengths which are usually longer than one day.

Perhaps the most useful conclusions that can be drawn from this investigation are those regarding the signs and not necessarily the magnitudes of the gains or losses. This may not be true for the two reaches on the Henry's Fork whose recorded losses were less than 100 cfs because of the magnitude of the expected error from the current metering on those reaches.

These results also tend to indicate that the losses and gains from these rivers do indeed play a major role in the groundwater system of the Henry's Fork Basin. During the measurement period in September 1975, the estimated net gain to the rivers in the basin or loss from the perched aquifer was 338 cfs (Table 3). In considering a possible groundwater model of this basin, the magnitudes of these gains and losses need to be known more accurately. It is suggested that several more mass measurements or preferably continuous measurements by means of rated sections be made. Current metering should be performed as accurately as possible, and at least two discharge measurements at each point should be made in order to decrease the statistical error. Also, it would be helpful to make actual observations of the flow measurement devices on any canals that are running rather than depend solely on the reported values of the watermaster.

For the purposes of a groundwater model, either continuous measurements or four or five mass measurements should be carried out per year to determine the seasonal distribution of the gains or losses. The largest losses occur during the spring runoff season, but accurate flow measurements are most difficult during this period.

BASIN WATER BUDGET

In order to evaluate the total contribution of the Henry's Fork-Teton area below Ashton to recharge of the regional groundwater table, a basin water budget for 1975 was completed. The values used in this budget are shown in Table 4.

Discharge of the Henry's Fork at Ashton, Falls River near Squirrel and Teton River at Teton Dam were considered to be the major inputs to the basin. Moody Creek, which is tributary to the South Fork of the Teton River, is ungaged; however, the flow was measured during the

TABLE 4. SURFACE WATER LOSSES IN THE HENRY'S FORK BASIN

WATER YEAR - 1975

Date (Inclusive)	Falls R. (1) near Squirrel Cr.	Teton R. (1) at Teton Dam (AF)	Henry's (1) Fork near Ashton (AF)	Moody Creek (AF)	Total Inflow (AF)	Precipitation (3) (AF)	Total IN (AF)	Henry's (1) Fork near Rexburg (AF)	Evapotranspiration (2)	Total Outflow (AF)	Basin Loss (+) or Gain (-)
OCTOBER 1974	37,710	31,000	108,300	140	177,150	22,200	199,350	155,780	14,000	169,780	29,570
NOVEMBER	35,730	31,130	92,220	360	159,440	6,800	166,240	155,510	10,000	165,510	730
DECEMBER	36,150	25,770	92,150	--	154,070	20,900	174,970	154,990	10,000	164,990	9,980
JANUARY 1975	32,830	22,210	97,360	--	152,400	22,500	174,900	140,040	10,000	150,040	24,860
FEBRUARY	26,190	19,790	72,470	--	118,450	19,800	138,250	121,890	10,000	131,890	6,360
MARCH	26,290	36,110	84,250	--	146,650	13,800	160,450	134,580	10,000	144,580	15,870
APRIL	24,490	33,230	102,030	--	159,750	24,100	183,850	149,640	10,000	159,640	24,210
MAY 1-15	18,340	28,040	62,960	4,770	114,110	7,000	121,110	90,470	9,800	100,270	20,840
MAY 16-31	55,790	72,480	122,360	3,360	254,190	11,200	265,390	184,800	16,800	201,600	63,790
JUNE 1-15	110,490	81,700	132,400	1,270	325,860	2,800	328,660	256,390	19,600	275,990	52,670
JUNE 16-30	85,380	88,500	83,750	500	258,130	16,800	274,930	197,500	32,200	229,700	45,230
JULY 1-15	104,640	104,170	68,210	90	277,110	--	277,110	182,400	37,800	220,200	56,910
JULY 16-31	41,060	59,900	70,690	100	171,750	8,400	180,150	97,770	39,200	136,970	43,180
AUGUST 1-15	23,660	29,790	72,630	--	126,080	1,400	127,480	58,410	30,800	89,210	38,270
AUGUST 16-31	24,790	24,230	69,610	--	118,630	1,400	120,030	58,470	23,800	82,270	37,760
SEPT. 1-15	18,700	16,940	50,890	--	86,530	--	86,530	46,080	21,000	67,080	19,450
SEPT. 16-30	18,080	15,190	46,970	--	80,240	1,400	81,640	49,350	12,600	61,950	19,690
TOTAL	720,320	720,180	1,429,450	10,590	2,880,540	180,500	3,061,040	2,234,070	317,600	2,551,670	509,370

(1) USGS gaging stations, from Watermaster's report, District #1 (Idaho), 1975.

(2) Based on 140,000 acres of cropped and non-cropped land. Winter evapotranspiration assumed to be 0.5 feet (see Crosthwaite, p. 15) (See Table 2 for calculations of seasonal crop water use.

(3) Based on precipitation at St. Anthony 1WNW, (Climatological Data, NOAA, U.S. Dept. of Commerce; Vol. 77, No. 10 - Vol. 78, No. 9) and 140,000 acres.

early summer of 1975 by Water Resources Research Institute personnel. Henry's Fork at Rexburg was considered to be the lower limit of the basin for water budget purposes.

Precipitation input was based on U.S. Weather Service records for St. Anthony 1WNW for 1975 and total input was considered effective over 140,000 acres (56,650 ha). Evapotranspiration was calculated for cropped and non-cropped areas assuming 140,000 effective acres. Wintertime evapotranspiration was estimated at 0.5 ft. for the non-growing season or about 70,000 acre feet distributed over the October 1 - May 15 period.

The total seasonal value of 509,370 acre feet basin loss or groundwater recharge agrees with previous estimates and is consistent with the value determined by Crosthwaite (1970) and currently being used for the Snake Plain Aquifer model (de Sonneville 1971).

Unpublished data by the U.S. Geological Survey indicates that the groundwater in the Ashton area discharges into the Henry's Fork and does not contribute to the perched water table below St. Anthony.

Table 5 is a compilation of groundwater recharge from irrigated areas in the basin. Based on recorded diversions of 970,900 acre feet and measured canal surface return flows, the net diversion is 868,440 acre feet or 6.84 af/a (based on 126,890 irrigated acres). The computed net irrigation requirement of 1.32 af/a results in a computed net recharge to the perched aquifer for the irrigation season of 5.52 af/a

TABLE 5. GROUNDWATER RECHARGE FROM IRRIGATED AREAS

GROSS CANAL DIVERSIONS (1)

Date (1975) (Inclusive)	Total Above Squirrel (cfs)	Total Squirrel to Chester (cfs)	Total Ashton to St. Anthony (5) (cfs)	Total St. Anthony to Rexburg (cfs)	Total Teton River (cfs)	Basin Total (cfs)	Basin Total (AF)	Canal Waste Flows (2) (AF)	Net Diversions (AF)	Gross Diversion Per Acre (3) AF/(acre)	Net Diversion Per Acre (3) AF/(acre)	Crop Water Use (4) (feet)	Precipitation at St. Anthony (1WNW) (feet)	Irrigation Requirement (feet)	Net Recharge (feet)	Net Recharge (AF)
MAY 1-15	--	381	6,696	6,440	1,472	14,989	29,730	--	29,730	0.23	0.23	0.07	0.05	0.02	0.21	26,650
MAY 16-31	--	1,088	9,856	11,208	3,514	25,666	50,910	270	50,640	0.41	0.41	0.11	0.08	0.03	0.38	48,220
JUNE 1-15	--	3,894	19,781	17,742	7,358	58,775	116,580	5,500	111,080	0.92	0.87	0.16	0.02	0.14	0.73	92,630
JUNE 16-30	630	6,469	19,035	14,340	16,818	57,292	113,640	15,010	98,630	0.89	0.78	0.27	0.12	0.15	0.63	79,940
JULY 1-15	2,563	9,733	18,469	13,502	21,404	65,671	130,260	11,790	118,470	1.03	0.93	0.31	0.00	0.31	0.62	78,670
JULY 16-31	3,700	8,921	16,943	12,373	19,556	61,493	121,970	12,360	109,610	0.96	0.86	0.28	0.06	0.22	0.64	81,210
AUG. 1-15	2,597	7,707	15,037	11,389	15,207	51,937	103,020	9,710	93,310	0.81	0.73	0.20	0.01	0.19	0.54	68,520
AUG. 16-31	2,025	7,870	13,239	9,974	14,283	47,391	94,000	13,590	80,410	0.74	0.63	0.13	0.01	0.12	0.51	64,710
SEPT. 1-15	1,363	6,826	10,959	8,702	11,078	38,928	77,210	10,800	66,410	0.61	0.53	0.12	0.00	0.12	0.41	52,030
SEPT. 16-30	1,378	6,383	7,829	6,402	9,824	31,816	63,110	9,950	53,160	0.50	0.42	0.08	0.01	0.07	0.35	44,410
OCT. 1-15	--	--	--	--	--	23,700*	47,000	7,110	39,840	0.37	0.31	0.07	0.04	0.03	0.28	35,530
OCT. 16-30	--	--	--	--	--	11,900*	23,600	6,370	17,150	0.19	0.14	0.02	0.10	-0.08	0.22	27,920
SEASON TOTAL							970,900	102,460	868,440	7.66	6.84	1.82	0.50	1.32	5.52	700,440

* estimated

(1) from Watermaster's Report, District #1 (Idaho), 1975

(2) from Water Resources Research Institute data

(3) based on 126,890 irrigated acres (from IDWR data)

(4) see Table 2 for calculations of crop water use

(5) does not include Crosscut Canal

or 700,440 acre feet. Comparing this value with the 509,370 acre feet total recharge to the regional water table, or to the perched water table under Mud Lake to the west, Table 4, the difference of 191,070 acre feet is considered subsurface return flow to the streams or reach-gain. The single measurement of the reach-gain on Sept. 25, 1975 of 338 cfs from Ashton to Rexburg on a yearly basis results in a total gain of 244,700 acre feet. This figure is in excess of the 191,070 acre feet computed from the water budget. It is not expected that the September value of reach-gain would be effective over the entire year and further investigation of river reach-gains in the basin is needed.

GROUNDWATER MODELING

The perched water table in the Henry's Fork-Teton River basin serves as a source for rather extensive subirrigation and domestic water supply and contributes substantially to the regional water table of the Snake Plain Aquifer. For this reason a knowledge of the response of the perched water table to varying inputs and an understanding of the magnitude of the various components of the water budget is a necessity for updating the Snake Plain Aquifer model.

A decision was made to model the perched water table as an extension of the Rigby Fan model since the water tables are apparently of similar configuration. A one mile square grid network utilizing the

U.S. public land survey will be used. Boundaries of the model were selected based on geologic sections and essentially follow the limits of the alluvial fill connecting with the northern boundary of the Snake River Fan model along the Snake River, Figure 9.

The model uses the updated input program developed for the Snake River Fan area and will utilize the calibrated aquifer coefficients developed for the Fan area (de Sonneville, 1971). Since the response of the Snake River Fan perched water table is very similar each year, no new water table data will be used in that area and unless 1977 irrigation diversions are radically different from the 1975 input, the current input set will be used.

Figure 10 shows the general configuration of the perched water table within the model boundaries.

Several return flow measuring stations on the Teton River and canal systems on the east bank of the Henry's Fork were destroyed in the June 1976 flood caused by the Teton Dam failure. Consequently, no data collection was pursued during the 1976 season. Groundwater and return flow monitoring will be conducted during the 1977 season to secure additional input for the model.

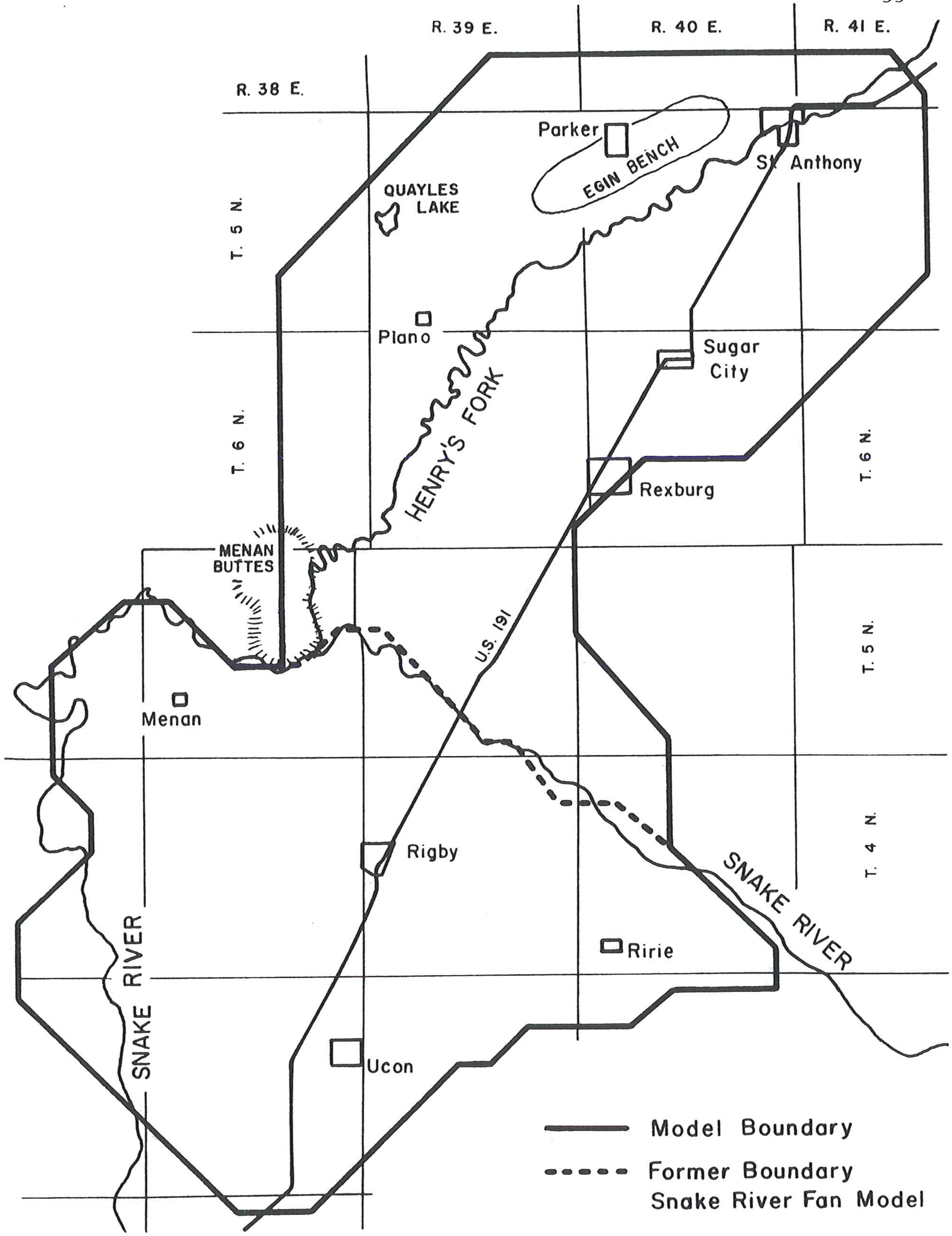


Fig. 9. Groundwater Model Boundaries - Henry's Fork Snake River Fan area - Idaho.

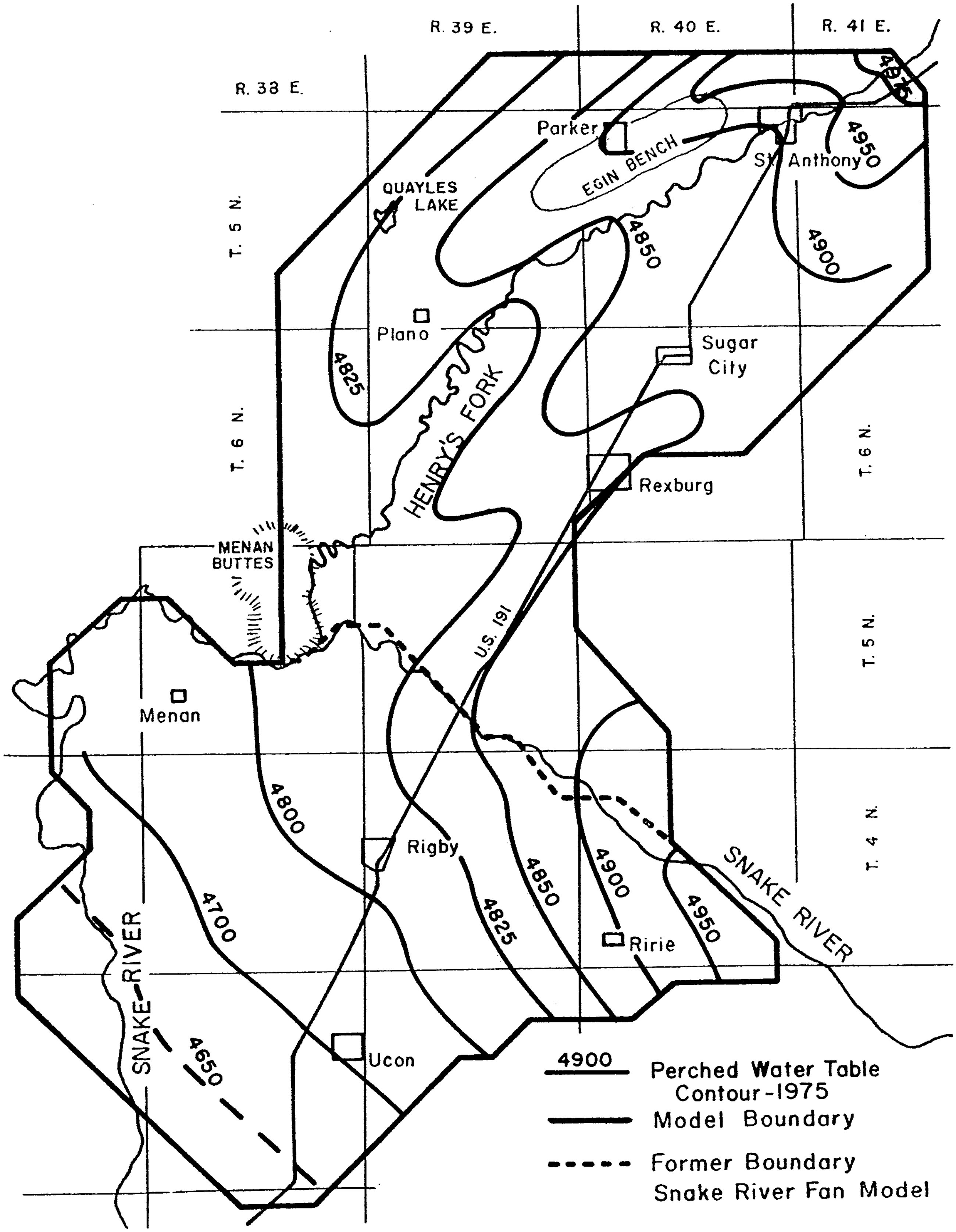


Fig. 10. Perched Water Table Contours - Henry's Fork
Snake River Fan area - Idaho 1975.

CONCLUSIONS AND RECOMMENDATIONS

The Henry's Fork - Teton River basin is a complex geohydrologic area. Knowledge of the relationship between the river systems, perched and regional groundwater tables and the irrigation water management practices is vital to planning efforts in the Snake River system. Subirrigation by manipulation of the perched water table is a long established practice on the Egin Bench area and other areas with high intake rate soils. The method is the most viable alternative to sprinkler irrigation but requires river diversions in excess of 11 acre ft/acre ($3.2\ m^3/m^2$). Surface return flows from subirrigated areas average approximately 6 percent over the season. However, groundwater return flow contributes substantially to the Henry's Fork from St. Anthony to Rexburg and to the Teton River from Teton Dam to the Henry's Fork confluence.

The 1975 basin water budget from Ashton to Rexburg indicates that the annual net groundwater loss from the basin or recharge to the regional aquifer is approximately of 509,000 acre feet (617 million cubic meters). Groundwater table contours of the perched water table indicate the subsurface flow is generally to the southwest, intermingling with flows in the Snake River Fan perched water table. In the area at the confluence of the Henry's Fork and the Snake River near Menan Buttes the regional water table and perched water table are nearly equal and will present some modeling problems.

One of the largest components of the water budget for the perched aquifer is the exchange between the rivers and the aquifer. An estimated net loss from the perched aquifer of 338 cfs in September 1975 indicates the magnitude of this component. However, the magnitude of the seasonal reach-gain for the various segments of the Henry's Fork and Teton Rivers will have to be more accurately determined. It is recommended that a major effort either by a series of current meter measurements or continuous measurements on rated river sections be undertaken.

Additional geological and geophysical investigations to define the geology and water table relationship in the vicinity of the Henry's Fork - Snake River confluence are needed. This determination would assist in modeling of the perched water table system as well as defining boundary conditions for the Snake Plain Aquifer model.

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APPENDIX

TABLE 6

Surface Return Flow Measuring Sites

Henry's Fork 1975

No.	Location and Description
1	Farmers Friend Canal Waste Junction of Farmers Friend and Pincock-Byington Canals. Three foot staff gage installed 6/4/75 on east side of canal upstream of structure. Current meter for rating from C.M.P. culvert crossing above structure. Sec. 26 17N R40E.
2	Roxanna Canal No significant return to Henry's Fork. Do not measure. Sec. 25 T7N R40E.
3	Consolidated Farmers Canal Spill to North Fork of Teton River. Calco meter gate on headwall of siphon under North Fork. NW1/4 Sec. 6 T6N R40E. Use free flow rating.
4	Salem Union Canal Spill to North Fork Sec. 32 T7N R40E. Rate channel about 100 yds. from confluence with North Fork. Staff gage installed 6/4/75.
5	Island Ward Canal Waste NE corner Sec 16 T6N R39E 5.8 ft. rectangular contracted weir if check boards are installed. 8" wide broad crested weir if no boards are installed. Install staff gage or stick weir.
6	Teton Island Canal Waste NE1/4 NE1/4 Sec. 23 T6N R39E 11 ft. rectangular suppressed weir (check structure) Approx. 300 yds. above confluence with South Fork of Teton River. Install staff gage if check boards are not used or stick weir.

No.	Location and Description
7	Rexburg Canal Spill to South Fork of Teton River. NW 1/4 NE 1/4 Sec. 27 T6N R39E. Near abandoned house and BM 4842 Culvert under road. Staff gage installed 6/4/75. Rate by current metering upstream in channel.
8	Rexburg Canal North Central Waste SE 1/4 SE1/4 Sec. 28 T6N R39E. Staff gage installed on 2x4 post at culvert inlet 6/4/75. Rate by current meter upstream of inlet.
9	Rexburg Canal North North Waste Center of Sec. 29 T6N R39E. Staff gage in upstream end of culvert used in 1974. Additional rating by current meter in upstream channel.
10	Rexburg Canal South South Waste NW1/4 NW1/4 Sec. 2 T5N R39E. On Kennedy Road Staff gage on outlet end of CMP culvert - 1974 Additional rating at culvert outlet.
11	Rexburg Canal South Central Waste NW1/4 NW1/4 Sec. 2 T5N R39E on Kennedy Road Staff gage on upstream end of culvert - 1974 Additional rating by current meter upstream of culvert inlet.
12	Texas Slough Canal Waste East side Sec. 31 T5N R39E Staff gage installed 6/4/75 on old check structure on right side of upstream concrete wall. Rate by current metering at check structure or at county road bridge upstream.
13	St. Anthony Union Canal Waste SW1/4 SW1/4 Sec. 17 T6N R39E on Plano Road Reinstalled 12 ft. rectangular constructed weir at check structure 6/5/75. Staff gage on weir bulkhead.

No.	Location and Description
14	St. Anthony Union Canal Spill - Overflow. SW1/4 SW1/4 Sec. 7 T6N R39E on Plano Road. Two 6 ft. overflow check bays. Use as retangular suppressed weirs. If check boards not changed install staff gage otherwise stick weir.
15	Egin Canal Wasteway SW1/4 SW1/4 Sec. 33 T7N R39E. Use farm road from county road on west side of section. Stilling well and recorder installed 1974. Additional rating by current meter upstream of pipe wasteway.
16	Egin Canal Spill - Overflow SW1/4 SW1/4 Sec. 27 T7N R39E. Recorder and staff gage installed in 1974 in outlet structure of pipe spill at bottom of hill. Spill from canal is over two 6 ft. wide check bags. Use bays as rectangular suppressed weirs to obtain discharge for rating outlet structure at recorder.
17	Teton Canal Spill - N W corner Teton City West side of Sec. 31 T7N R40E. Wooden bridge on Moody Road 3 ft. staff gage installed 6/4/75 on NE wing wall of upstream side of bridge. Current meter upstream side of bridge for rating.
18	Teton Canal Waste West side of Sec. 7 T7N R41E. 54 in. culvert under North South road 1 3/4 mile south of Teton City. 2 ft. staff gage installed 6/4/75 on inlet to culvert. Rate by current metering upstream of culvert.
19	East Teton Canal Waste South side of Sec. 7 T6N R41E. Rate by current metering. Spill into Moody Creek. Rated canal section.
20	Moody Creek at Archery Road West side Sec. 17 T6N R41E. Concrete bridge under North-South road. Staff gage installed in 1974 washed out between 5/22/75 and 6/4/75. New staff gage installed 6/4/75 on SE upstream wingwall. Rate by current metering upstream of bridge. Check for beaver activity below bridge.

No.	Location and Description
21	Enterprise Canal Waste Center Sec. 17 T6N R41E. Stilling well and recorder installed in 1974 for Upper Snake River Water Use Study. Recorder installed 6/4/75. Section is 8 ft. rectangular contracted weir Recorder No. 61-43041-66 ARS.
22	Teton Island Canal Spill West side Sec. 10 T6N R40E. 1/2 mile north of Moody Road. Southeast of Sugar C.M.P. under road. Installed staff gage 6/5/75 at downstream end of 6 ft. cmp. Rate by current metering downstream channel.
23	Texas Slough Sec. 5 T5N R39E. Wooden bridge on county road. Staff gage installed 6/5/75 on NW wingwall of bridge current meter from bridge with cable rig. May be susceptible to backwater from Henry's Fork.
24	Liberty Park Canal Waste NW1/4 NW1/4 Sec. 7 T5N R39E. Staff gage at inlet to culvert in farm yard. Gage on corner fence post. Rate with current meter upstream of culvert.
25	End of Bannock Jim and Spring Sloughs North side Sec. 18 T5N R39E. Culvert under road. Staff gage installed 6/5/74 in pond upstream of culvert. No apparent backwater effects. Current meter culvert outlet for rating.