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WATER RESOURCE MANAGEMENT IN THE UPPER SNAKE RIVER VALLEY[1]

By

J. A. Bondurant, C. E. Brockway & R. V. Worstell[2]

INTRODUCTION

In the irrigated areas of the western United States, numerous water management problems exist due, partially, to the historically uncoordinated development of multiple irrigation companies and districts. Some of the problems associated with these developments are multiple canals contributing high seepage losses, uncoordinated acquisition of adequate water supplies, and lack of effective methods, procedures and authorities for improving water deliveries and farm water management.

The Rigby, Idaho irrigated area served by the Great Feeder Canal and numerous smaller canal systems is a good example of this type of development. This irrigated area lies on an alluvial fan created by the Snake River where it emerges from the Teton mountains in eastern Idaho. The water table levels during the irrigation season in this alluvial fan have been rising, especially in recent years. Damage

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1/ Contribution from the Snake River Conservation Research Center, USDA, Agricultural Research Service; Idaho Agricultural Experiment Station cooperating.

2/ J. A. Bondurant, Agricultural Engineer; C. E. Brockway, Assistant Research Professor, Civil Engineering; and R. V. Worstell, Agricultural Engineer respectively, Kimberly, Idaho.

has occurred to residential and commercial property in the cities of Rigby and Ririe and to some cropped areas because of high water tables during the irrigation season. It was known that irrigation diversions to the area are high, but few data were available on the actual canal system operation and management, the transmission losses, the farm irrigation efficiencies, the overall seasonal water table variations, the surface return flow from the fan, or the transmissibility of the subsurface aquifiers.

River regulation through storage in Jackson Lake and Palisades Reservoir has stabilized the water supply and controlled floods so that re-evaluation of management practices is now feasible.

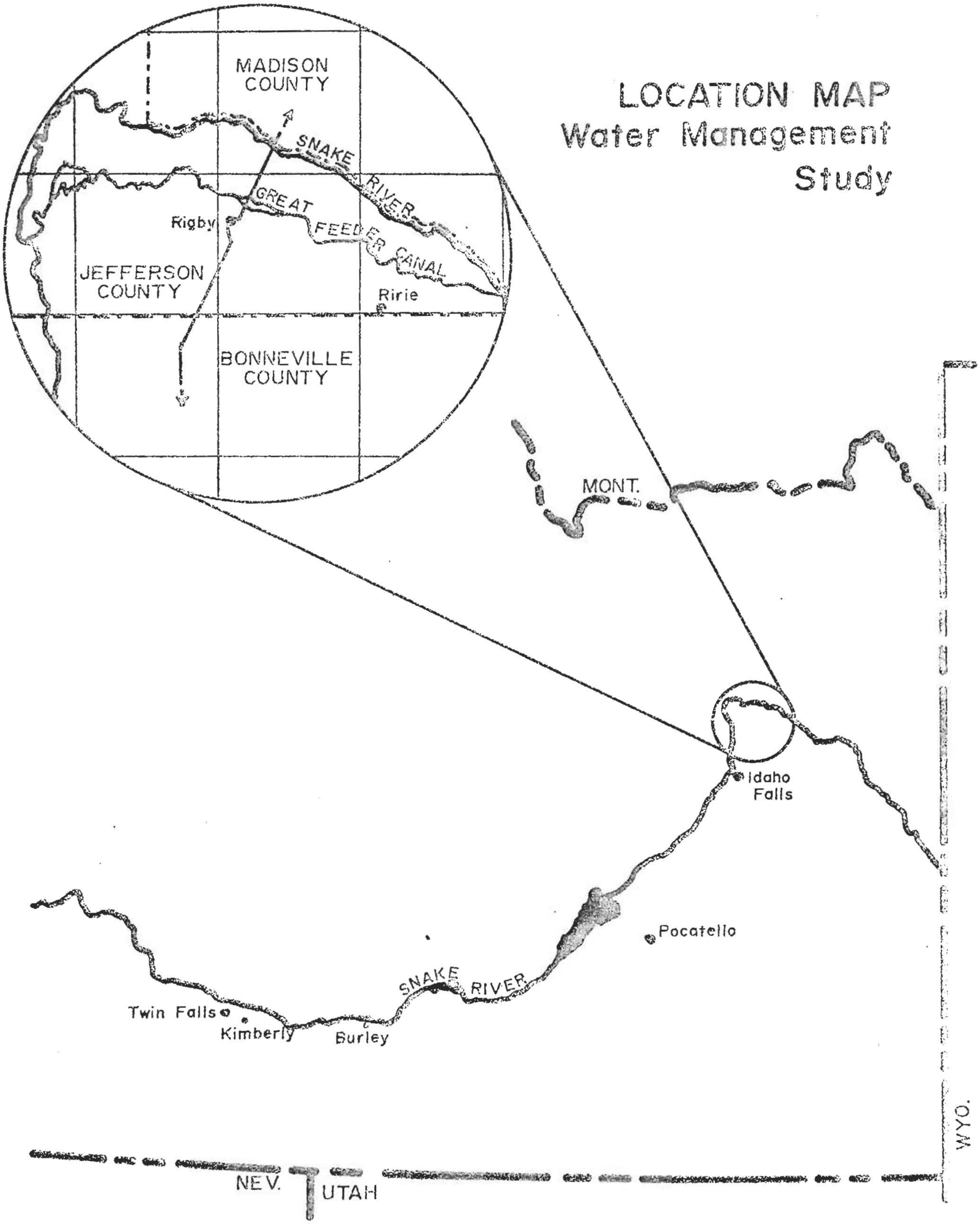
The Jefferson County Commissioners and the main water delivery organization, the Great Feeder Canal Company, contacted the Agricultural Research Service for advice on correcting the situation. Subsequently a study was initiated in cooperation with the University of Idaho, Water Resources Research Institute. The objectives of this study are to develop the technology for:

1. Analyzing regional water management problems.
2. Developing and evaluating alternate water management solutions based on the physical, economic, and sociological aspects of the area involved.
3. Systematic, rational methods of scheduling irrigation water deliveries to multiple canal companies and districts.

THE STUDY AREA

The water management study area as shown in Figure 1 is located in Jefferson and Bonneville counties in Townships 3, 4 and 5N and Ranges 37

FIGURE 1


LOCATION MAP
Water Management
Study
MADISON
COUNTY
SNAKE
RIVER
GREAT
FEEDER
CANAL
Rigby
JEFFERSON
COUNTY
Ririe
BONNEVILLE
COUNTY
MONT.
Idaho
Falls
Pocatello
SNAKE
RIVER
Twin Falls
Kimberly
Burley
WYO.
NEV.
UTAH

through 40 East of the Boise Meridian. The area selected for study comprises approximately 100,500 acres. The city of Rigby, Idaho lies in approximately the center of the study area and is the county seat of Jefferson County. Other communities in the area are Lewisville, in the western part of the area; Menan and Lorenzo in the northern part of the area; and the city of Ririe in the eastern part. This area is served by the irrigation system which was developed in the late 1800's by private and cooperative groups. A former channel of the Snake River runs east and west through the area and is used as a canal for the greater part of its length. This canal, referred to as the Great Feeder Canal, delivers water to some twenty smaller canals each operated by a separate and independent canal company or irrigation district. The lands served by canals under the Great Feeder system and other canals diverting directly out of the Snake River have some of the earliest water rights in the upper Snake River Basin. As a result of these early water rights, water for irrigation has generally not been in scarce supply. With the construction of Palisades dam and reservoir in 1954 by the U. S. Bureau of Reclamation, new storage rights purchased by the individual canal companies have firmed up the irrigation water supply so that a shortage of water is not likely to occur.

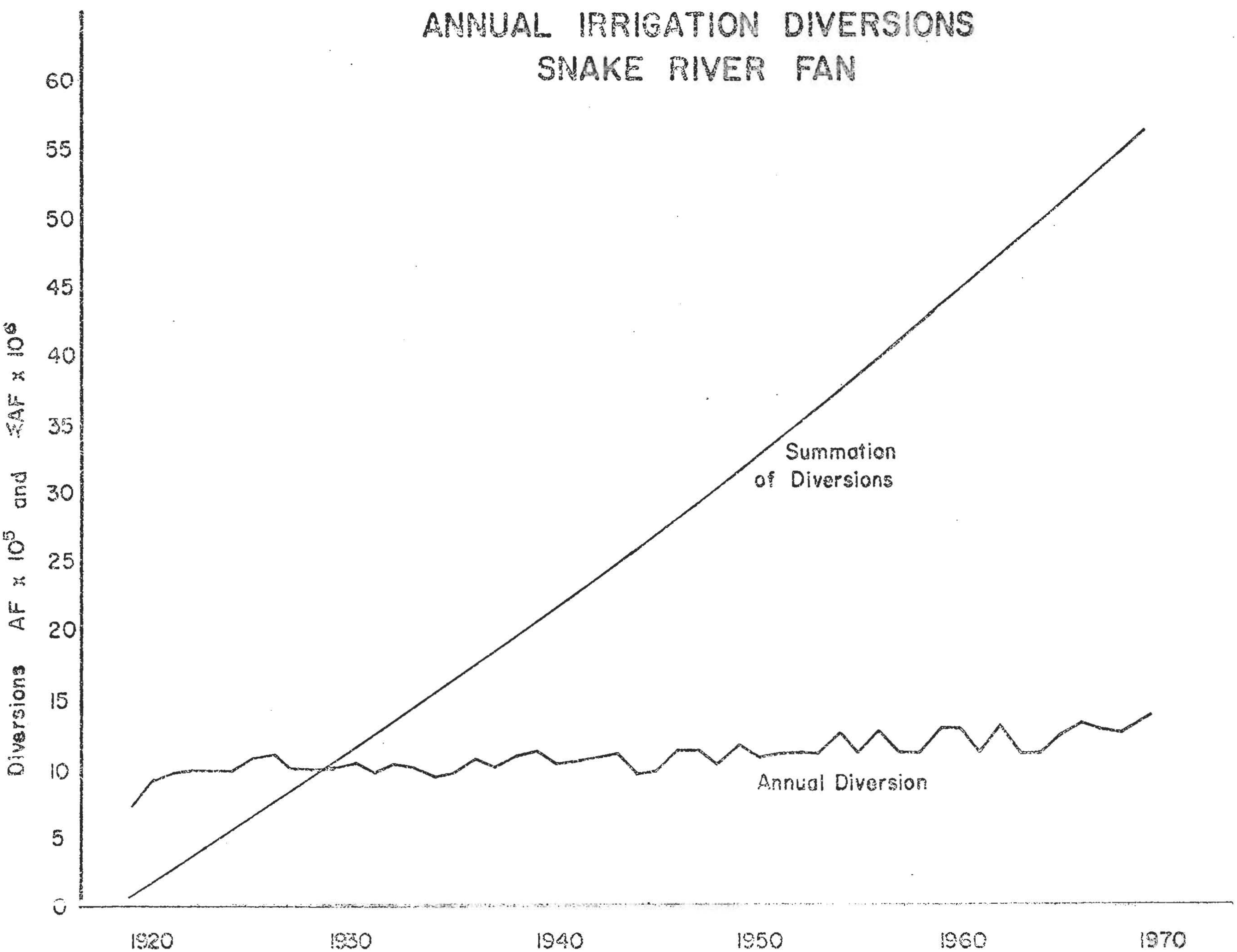
The soils in the area are generally quite coarse, varying in texture from east to west along the alluvial fan. The material from which the irrigation canals are excavated is generally rocky and quite permeable especially in the upper areas of the fan. Diversions from the individual canals to farm ditches are seldom measured; however on many of the farm turnouts there are or have been meter gates or other measuring devices. It appears that at this time these devices are not being used for water measurement.

Crops grown in the area are alfalfa, small grains, potatoes, and pasture. The size of the individual farms is lower than the average for the state and it is estimated that some 30% of the farm owners are part-time farmers and supplement their income with non-farm work. Border irrigation is practiced extensively and large inflow streams are used. The canals and laterals of the delivery systems are generally checked up as high as possible to allow for maximum farm diversions.

WATER SUPPLY

All of the irrigated lands in the study area are served from the Snake River with water rights dating as early as June 1880. The majority of the area is served by irrigation canals diverting from the Great Feeder Canal which serves as a by-pass for the Snake River main stream and generally runs continuously. Management of deliveries to the smaller independent canals is the responsibility of a cooperative group called the Great Feeder Board.

Historically diversions to the area are recorded in the reports of the watermaster for Water District 36 of the State of Idaho commencing in 1919 through the present. Some canals serve lands in the study area as well as land south of the area. Figure 2 shows the annual diversions for all canals for the period 1919 through 1970 and a mass curve of


ANNUAL IRRIGATION DIVERSIONS
SNAKE RIVER FAN
Diversions AF x 10^5 and ΣAF x 10^6
60
55
50
45
40
35
30
25
20
15
10
5
0
1920
1930
1940
1950
1960
1970
Summation of Diversions
Annual Diversion

accumulated discharges for the same period. The area irrigated under these canals, as indicated in the District 36 records, has not increased significantly over the period so that the trend of increase in total diversions is indicative of the trend in total diversion per acre. Several increases in slope of the mass curve can be seen after dry periods such as 1931-1935 and also after the Palisades reservoir became operational.

Total diversions per acre for the period 1 May to 30 September have increased over the period and were 10.2 af/acre in 1969. On some canals, diversions were made in October and November which are not recorded in District 36 records.

CLIMATE

The Rigby-Ririe area of Jefferson County lies in the climatological area known as the Upper Snake River Plains with moderately warm summers and rather severe winters. Temperatures average about 68° F in July and 17° F in January, and 0°F temperatures or lower generally occur for at least 16 days each year.

The growing season averages 123 days in duration and the growing degree days above 40°F average 3710 degrees days.

Precipitation averages 8.7 inches with 25% occurring in May and June and sunshine averages from 80 to 85% of possibility in July-September. Average windspeeds, generally from the south-southwest range from 10-15 miles per hour with high winds of 40-45 miles per hour occurring most often in April.

CROPS

Crop distribution throughout the study area is nearly uniform and U. S. Bureau of Reclamation reports for 1969 from irrigation districts comprising about 32,600 acres indicate the following distribution.

Mixed grains	31.2%
Alfalfa hay	27.6%
Irrigated pasture	7.3%
Potatoes	31.4%
Other	2.5%

IRRIGATION PRACTICES

Border irrigation is used extensively on grains, alfalfa and pasture. Large stream sizes are used and turnouts from the canals regulated, in most cases, by individual farmers. Large siphon tubes are used for border irrigation and overnight sets are not uncommon. Irrigation practices were evaluated in 1970 and 1971. Test results show that intake rates are very high. Border irrigation of grains resulted in 12 to 15 inches of water being applied to irrigate a 1300-foot run. Many fields are longer than this and streams used were as much as could be held in the border. Over-night irrigation with reduced stream size can result in almost twice this application while the soil profile generally will hold only 5 inches of water.

Furrow irrigation of potatoes was about 50% efficient for a 2-inch irrigation of 1000-foot furrows early in the season where the wheel compacted furrow was used. Use of noncompacted rows early in the season gave about 20% efficiency. Later in the season the vines fall into the rows and intake rates increase. Stream sizes used ranged from 10 to 80 gpm. Wheel compaction at the right soil moisture content can be very effective in reducing the intake rate of these soils. Nearly all fields could benefit from more leveling and the high intake rates measured indicate that this area would benefit from sprinkler irrigation.

The water master's records and spot field checking reveal that most canal companies in the study area are diverting at a rate greater than decreed rights. This occurs during about one-half of the irrigation season. Canal management by the watermasters is lax. On most canals, diversions are made at will by the farmers and canal check dams are operated by the farmer instead of the ditch rider. The prevailing attitude seems to be that the ditch rider's job is to keep the canal full regardless of what water rights exist. Although water right priorities are observed when the base stream flow diminishes, water is drawn from storage accounts and shortages have not appeared in recent years.

SYSTEM SIMULATION

In order to efficiently determine and evaluate the alternative solutions for relieving the high groundwater table, a method of predicting the response of the aquifer to varying degrees of change in the input and output is necessary. Analytical solutions to the basic flow equations are not applicable because of the complexity of the hydrogeologic system, varying boundary conditions and high degree of simplification needed to secure a solution. Analog models of the resistance-capacitance type would suffice. However, construction of an analog is costly and the size and flexibility required for this study would be difficult to achieve.

The availability of large digital computers and new finite difference techniques for solving the flow equations make a digital model most feasible. The General Electric time-share unit in Los Angeles is available through the terminal at the Snake River Research Center and access is available to the large IBM 360/75 system of the U. S. Atomic Energy Commission in Idaho Falls.

The model developed describes the response of the aquifer due to a wide range of conditions. It is general enough to be applied to other aquifers and areas and will accommodate non-homogenous and anisotropic aquifers. All boundary conditions normally encountered can be handled. Inputs to the modeled area include precipitation, canal seepage, irrigation application, river losses, or drainage well inputs. Outputs include crop evapotranspiration, pumped well discharges, natural spring discharges and aquifer leakage.

DATA COLLECTION

In order to properly calibrate the mathematical model, a large amount of field data was necessary. A continuous data collection program was begun in May 1970. Cooperating local residents have greatly assisted in the data collection program.

Geology

Available well logs from the Department of Water Administration and local residents indicate that the gravel aquifer is extensive over the fan. However, very few of the domestic wells for which logs are available are over 100 feet deep so that the depth of the gravels is not discernible over the entire fan. One exploratory well, one and one-half miles northwest of Rigby is 1008 feet deep and indicates a 300-foot depth of gravel underlain by 170 feet of clay above basalt. Basalt is encountered at shallow depths south of Ririe and fingers of basalt extend eastward from the Lewisville Knolls on the western edge of the area into the gravels.

To obtain more geologic information in the area, a cooperative geophysical study was undertaken in May 1971 with the U. S. Bureau of Reclamation. Electrical resistivity transects were run from east to west across the fan from the Lewisville Knolls east to the Snake River. Because of a lack of logged wells in the area, interpretation of the results was difficult. However, the study did point out some trends in the gravel depth and location of dry layers.

Ground Water Table Elevations

A network of some 40 wells was established in the area to monitor changes in the groundwater table throughout the year. Figure 6 shows the locations of wells and well points being measured in the network. Water stage recorders were installed on seven of the wells in order to detect fluctuations of shorter period than the normal weekly measurements. In the vicinity of Rigby, water

FIGURE 6

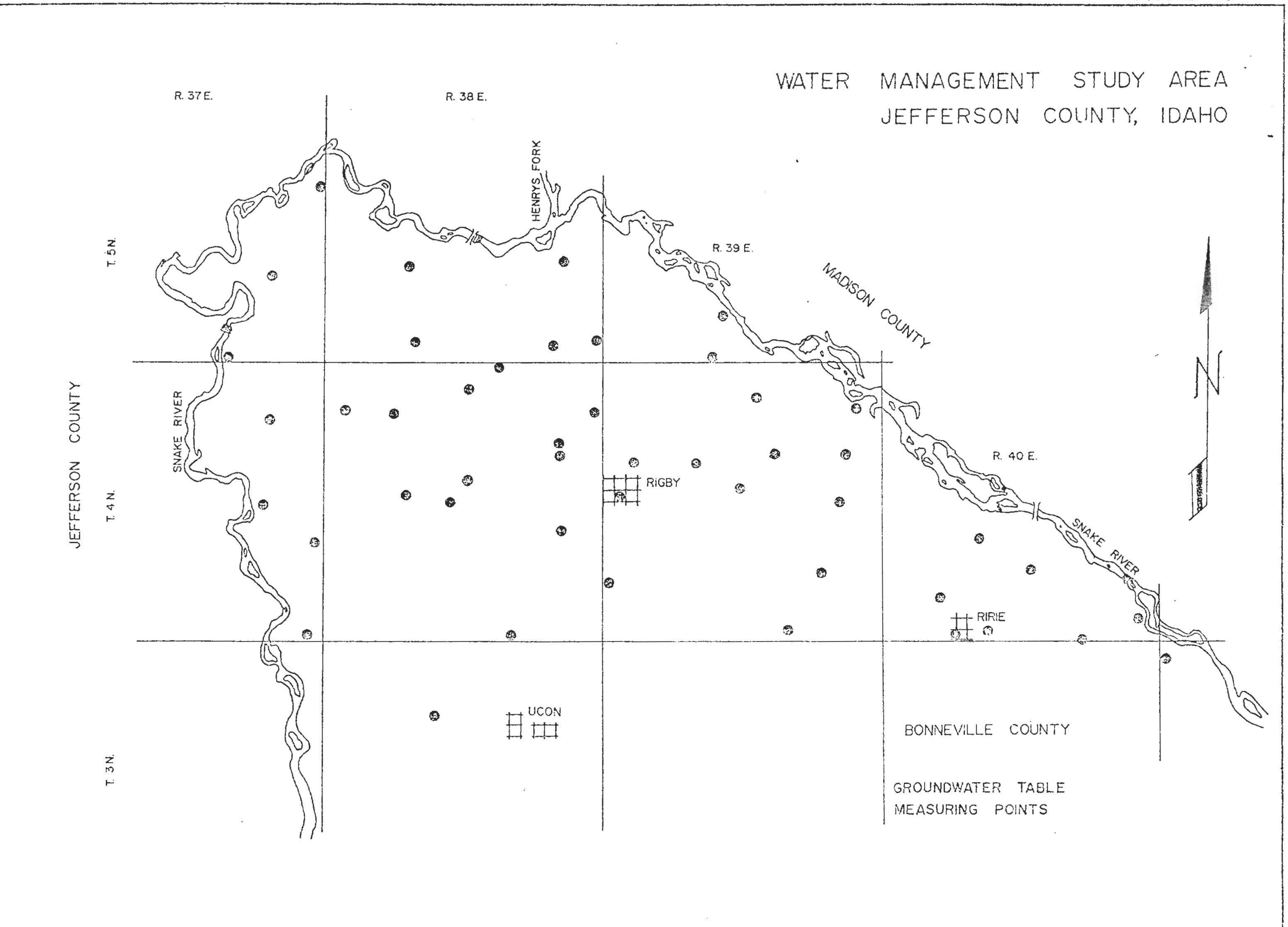

WATER MANAGEMENT STUDY AREA
JEFFERSON COUNTY, IDAHO
R. 37 E.
R. 38 E.
R. 39 E.
R. 40 E.
T. 5 N.
T. 4 N.
T. 3 N.
JEFFERSON COUNTY
HENRYS FORK
SNAKE RIVER
MADISON COUNTY
RIGBY
RIRIE
UCON
SNAKE RIVER
N
BONNEVILLE COUNTY
GROUNDWATER TABLE
MEASURING POINTS

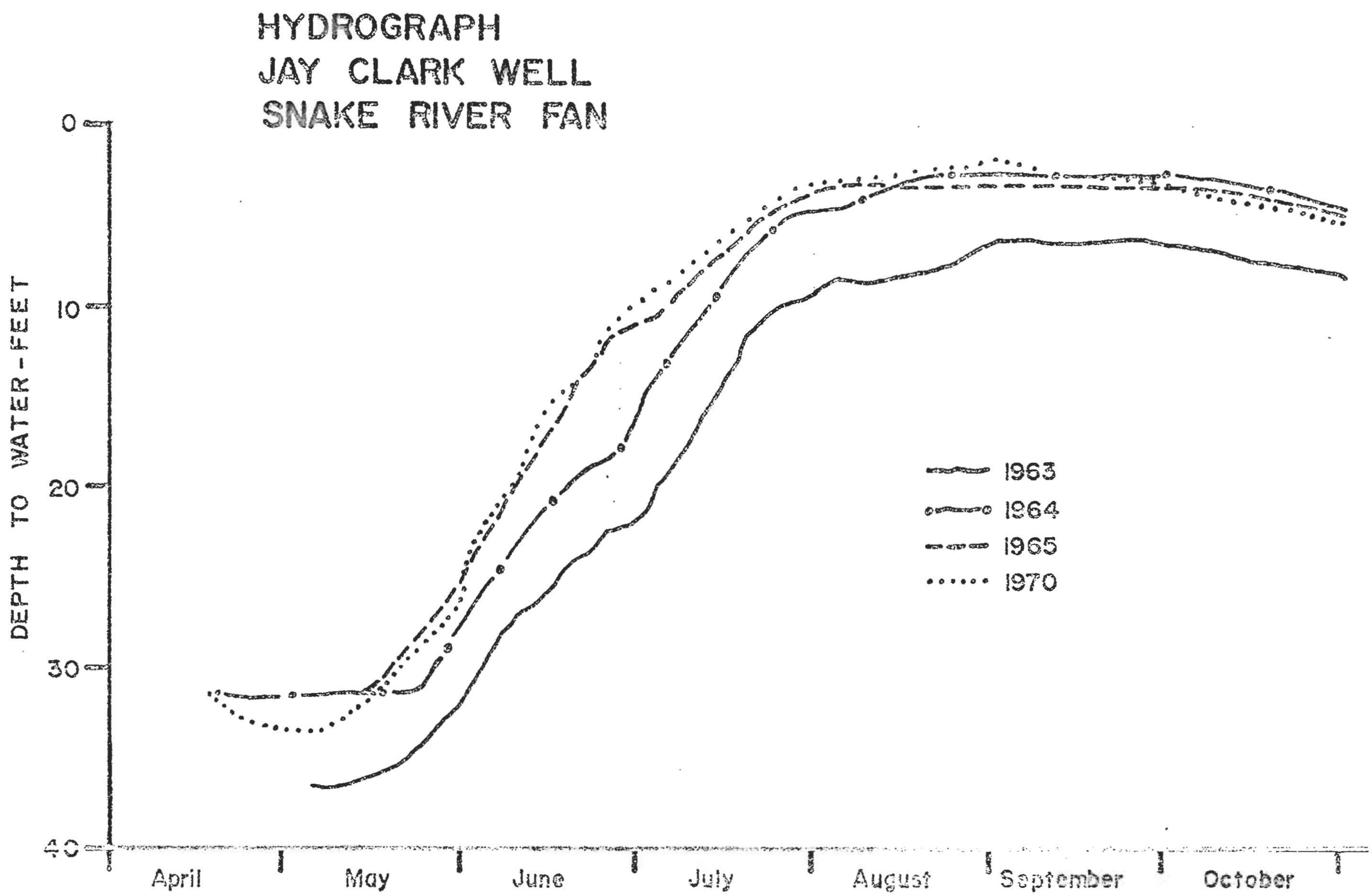
table rises of 30 feet or more have been recorded for the period from the beginning of the irrigation season until mid July. Figure 7 shows the hydrograph of the Clark well northwest of Rigby for several seasons beginning with 1963.

Water table contours for the area indicate a general east-west water flow with a rapid increase in water table depth on the west and southwest boundaries. Figure 8 shows the water table contours interpreted from well measurements made on July 15, 1970. The flow is generally from east to west with the flow under the Snake River south of the city of Roberts being at greater depths where the gravels of the fan apparently interfinger into basalts of the Snake Plain aquifer.

Maximum groundwater table elevations usually occur in the month of August and associated problems are prevalent during August and September. Figure 9 shows the depths to the water table on August 30, 1970 as computed from the groundwater contours. The area north and west of Rigby as indicated in the figure had depths to water of five feet or less during July, August and September of 1970. The area around the city of Ririe is a local groundwater mound and some reports of damage have been received from this area.

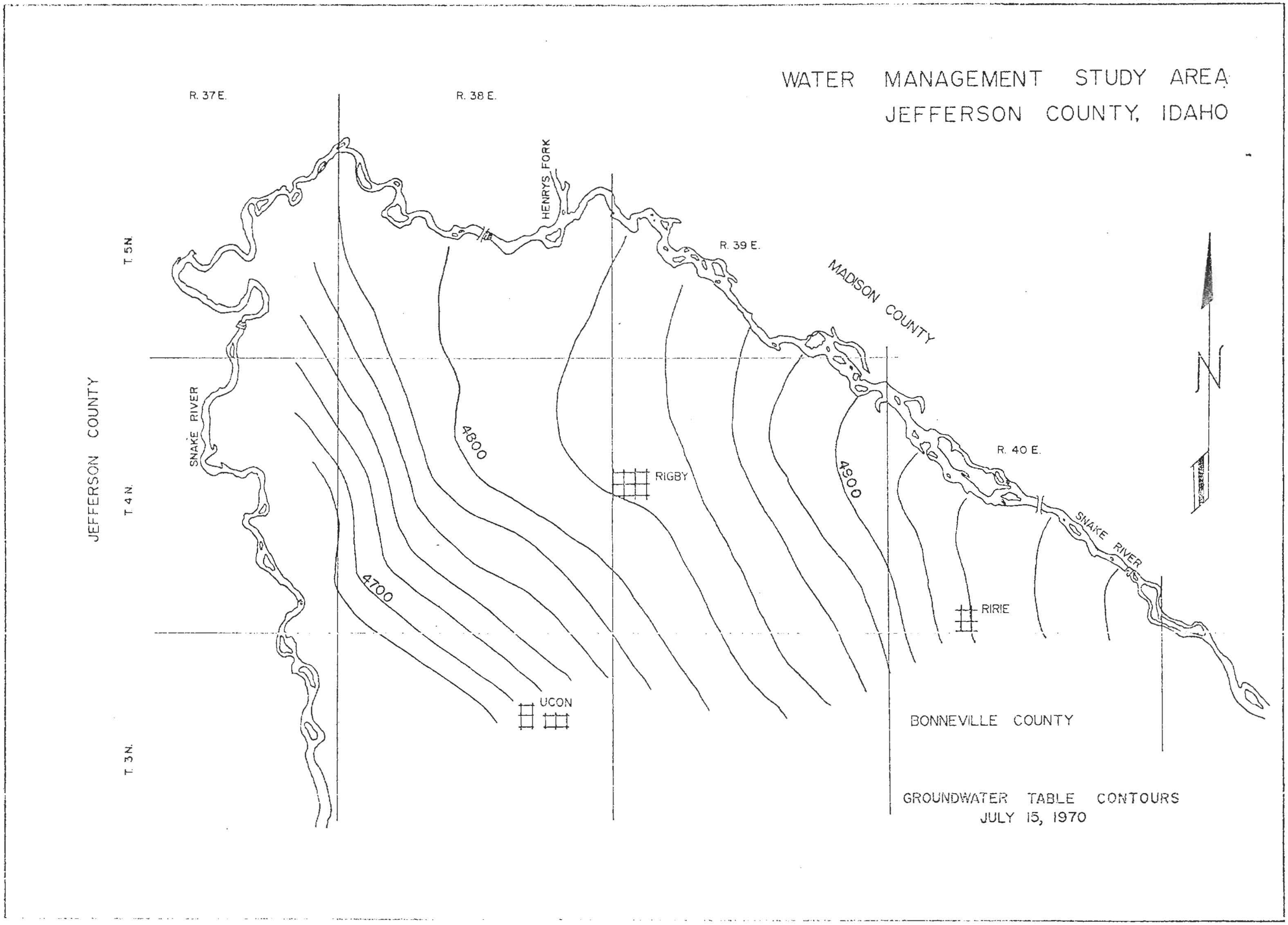
In August 1970 a questionnaire was sent to residents of Jefferson County requesting information on any damage or problems associated with the sub-water. A total of 700 questionnaires were mailed with the cooperation of the University of Idaho Extension Service. Seventy-eight affirmative returns were received which indicated problems such as water in basements, potato cellars, flooded fields or corrals. The locations of the affirmative returns closely correlated with the high water table areas as indicated in Figure 9. Estimates of damages for 1970 amounted to nearly $24,000.

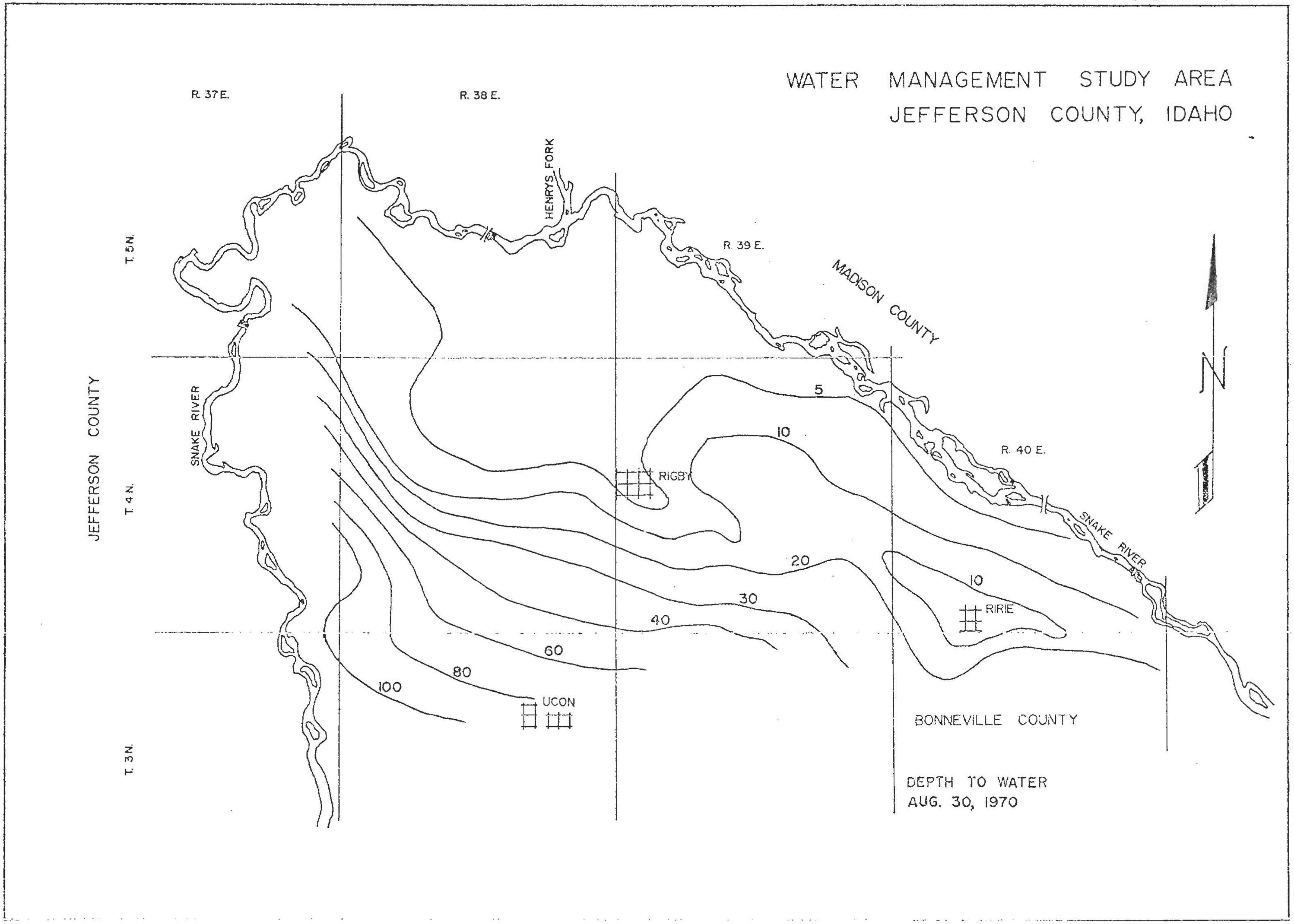
FIGURE 7



HYDROGRAPH
JAY CLARK WELL
SNAKE RIVER FAN
DEPTH TO WATER-FEET
0
10
20
30
40
April
May
June
July
August
September
October
1963
1964
1965
1970

FIGURE 8


WATER MANAGEMENT STUDY AREA
JEFFERSON COUNTY, IDAHO
R. 37 E.
R. 38 E.
R. 39 E.
R. 40 E.
T. 5 N.
T. 4 N.
T. 3 N.
HENRYS FORK
MADISON COUNTY
JEFFERSON COUNTY
SNAKE RIVER
4800
4700
4900
RIGBY
RIRIE
UCON
SNAKE RIVER
BONNEVILLE COUNTY
N
GROUNDWATER TABLE CONTOURS
JULY 15, 1970


WATER MANAGEMENT STUDY AREA
JEFFERSON COUNTY, IDAHO
R. 37 E.
R. 38 E.
R. 39 E.
R. 40 E.
T. 5 N.
T. 4 N.
T. 3 N.
HENRYS FORK
MADISON COUNTY
JEFFERSON COUNTY
SNAKE RIVER
SNAKE RIVER
RIGBY
RIRIE
UCON
BONNEVILLE COUNTY
N
5
10
10
20
30
40
60
80
100
DEPTH TO WATER
AUG. 30, 1970

Surface Water Diversions

Irrigation diversions for the major canals in the study area for the May 1 - September 30 period are recorded in the reports of Water District 36. These measurements, performed by District 36 and U.S. Geological Survey personnel, are obtained primarily by periodic current metering of the canals at selected rating sections and reporting of daily staff gage readings by watermasters. No standard water measuring devices are in use on the major canals. During the 1970 season measurements were extended by University and ARS personnel past the normal September 30 cutoff date through November 30 or until all canals had been shut down for the winter. Return flows to the Snake River at the Burgess Canal spill, Long Island Slough, and Great Feeder were measured throughout the season. Water transported out of the study area to the south was measured in the Anderson, Farmers Friend, and Harrison canals.

Figure 10 shows the recorded May - September diversions per acre from the Snake River for all canals on the Snake River fan. The acre feet per acre values were computed from discharges and acreages for each irrigation district as recorded in District 36 records. An increasing trend can be observed with the 1967-69 diversions approaching 10 acre feet per acre. The seasonal distribution of net diversions for 1970 is shown in Figure 11. The net diversion is calculated as the measured diversion at the canal headgates minus all surface wastes. An irrigated acreage of 82,250 acres in the study area was determined from 1966 aerial photographs and does not include roads, canal rights of way, farmsteads and undeveloped lands within the study area. Total diversions for May - November 1970 season were 1,507,000 acre feet of which 100,000 acre feet was measured as irrigation water transported out of

FIGURE 10

ANNUAL IRRIGATION DIVERSION PER IRRIGATED ACRE SNAKE RIVER FAN

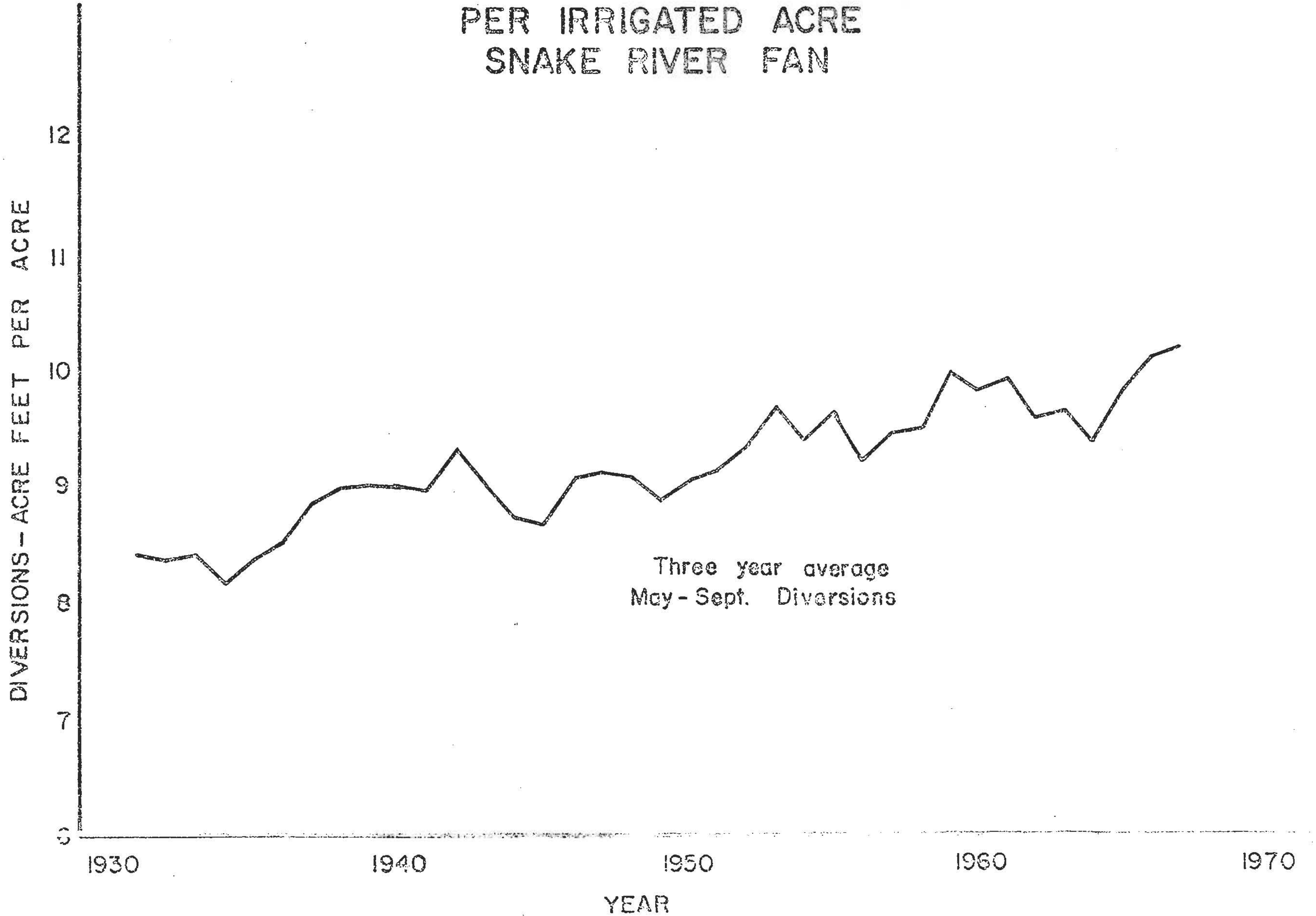
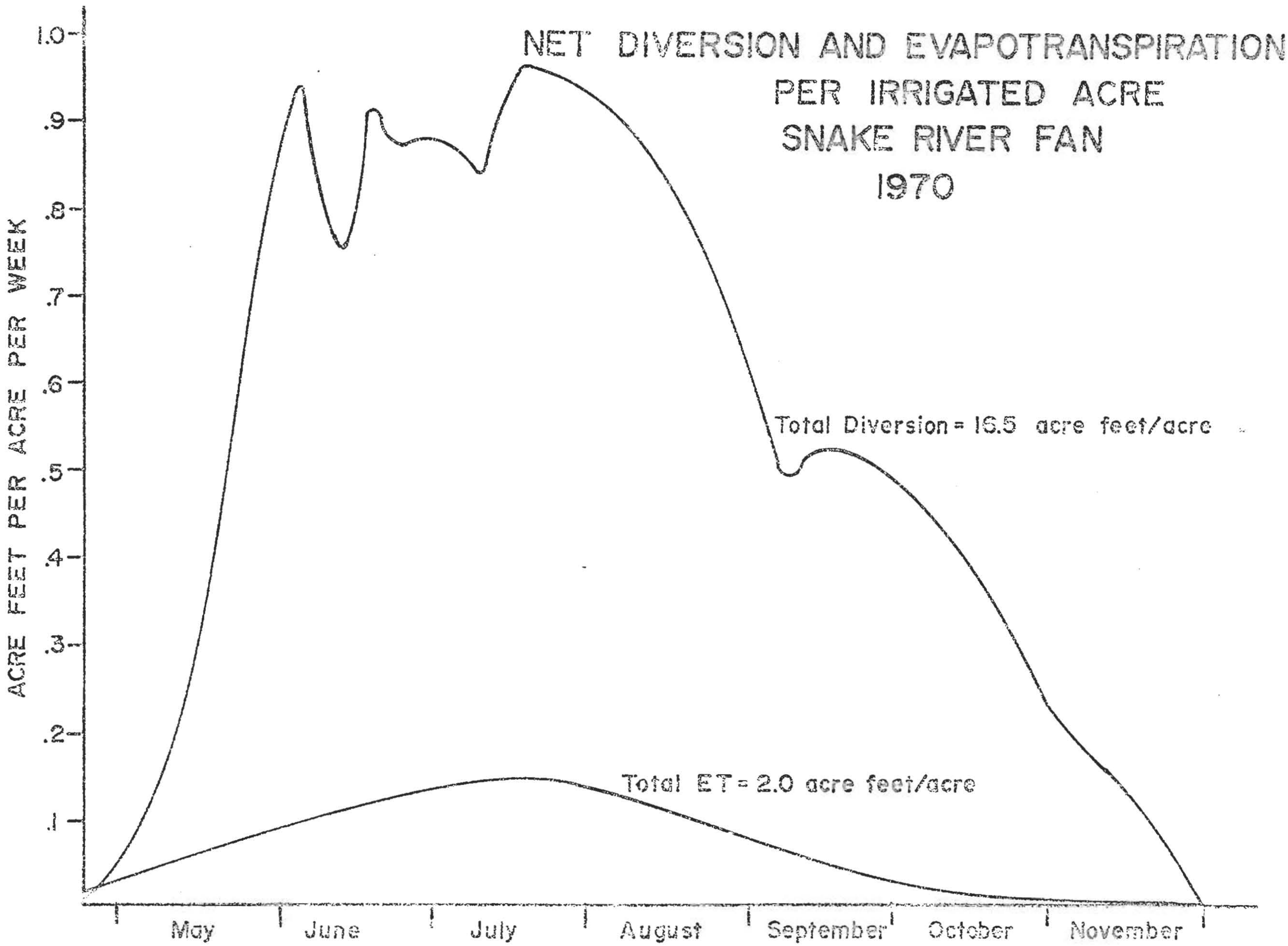


FIGURE 11


NET DIVERSION AND EVAPOTRANSPIRATION
PER IRRIGATED ACRE
SNAKE RIVER FAN
1970
Total Diversion = 16.5 acre feet/acre
Total ET = 2.0 acre feet/acre
ACRE FEET PER ACRE PER WEEK
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
May
June
July
August
September
October
November

the study area and 48,200 acre feet returned to the Snake River. The total net diversion for 1970 was 16.5 acre feet per irrigated acre of which 14% was diverted after September 30.

Canal Seepage Losses

The main canals of the systems have a total water surface area of 820 acres or slightly less than 1% of the irrigated area. Seepage tests were made in 20 locations in the late summer and fall of 1970 and in 16 locations in early spring of 1971. These tests were made by inflow-outflow measurement method in reaches with little or no diversion at the time of measurement. The accuracy of any one flow measurement is probably ±5 or 10% which can lead to much variability in seepage loss measurements but the average of many loss measurements will give values that are good estimates. The average of the 1970 tests was 3.55ft/day with a range from 0.2 ft/day to 11.5 ft/day. The average of the 16 tests made in early May, 1971 was 3.28 feet/day with a range of 0.67 to 12.07 ft/day.

The spring tests had an average value that was 8% less than the average found in late summer, but the reaches tested were not the same and the channel flow depths were 1½ to 2 feet lower in the spring.

The average loss of 3.43 ft/day for all of the tests would amount to a total loss of 2810 acre ft. per day (or 1405 cfs) if it were applicable to all the main canals in the system. Assuming a 150 day irrigation season this seepage rate would involve a loss of 428,500 acre feet per season or about 28 percent of the yearly diversion. Assuming a 200 day season, which more nearly approximates the actual operating procedure, canal seepage adds 570,000 acre feet to the aquifer.

Further seepage loss determinations will be made ~~in 1971~~ to improve on the accuracy of the estimates and to determine if some areas may have seepage losses that are consistently above or below the average.

Snake River Losses

Recognizing that losses in the Snake River as it flows over the fan can contribute to the groundwater table rise, an attempt was made to evaluate these losses. Stearns[3] in 1928 reported losses of from 20 cfs to 830 cfs or an average loss of 288 cfs or 3.3 percent of the flow from the measuring station at Heise to Lorenzo, a distance of about 13.8 miles. In 1970 current meter measurements were made at three times during the year during which the river was maintained at constant discharge at Palisades Dam. Discharge varied from 3340 cfs to 17,000 cfs and computed losses varied from 808 cfs to 208 cfs or an average of 408 cfs. Based on a loss of 408 cfs for a 200 day season, losses from the Snake River account for 41,600 acre feet of water added to the aquifer.

Evapotranspiration

Crop evapotranspiration for the 1970 season was calculated using the combination equation with crop coefficients based on the crop distribution for the 22,000 acres of the Burgess Canal system. Differences in crop distribution throughout the study area were not significant. Figure 11 shows the seasonal distribution of crop evapotranspiration for 1970. The total evapotranspiration for the season was 2.0 acre feet per acre or 161,900 acre feet for the study area.

DISCUSSION

From an engineering viewpoint, solution of water management problems in the Snake River fan area is a matter of collection and analysis of data. All available historical data (i.e., data which is in the public record) was collected. This comprised river flow records, canal diversions, water table elevations, well logs, crop yields, etc. Other data was collected as the project progressed — canal seepage losses. crop evapotranspiration, irrigation practice evaluations and surface water returns to the river. Analysis of these data tells how the water table problem originates and what alternative solutions may be suggested.

Evaluation of possible alternatives, particularly those contemplating canal lining, consolidation or change in irrigation management, awaits completion of calibrating the computer model. Having an aquifer as large as that underlying the eastern part of the fan has its drawbacks. There have been no deep wells and the depth of the aquifer is unknown as are also the transmissibility and vertical seepage rates.

The economics and social acceptability of proposed alternatives may be another story. Although modern machinery and farming techniques have been adopted, little change in irrigation practice has occurred even though drastic changes were recommended as long ago as 1909 by Bark (1). Some local opposition has been voiced to state and federal participation in the groundwater study.

Local people were used where it was possible to do so. The help proposed for alleviating the high groundwater tables is only to recommend alternative solutions. It will be the decision of the local people to implement which ever alternative looks most favorable to them.

After the area was surveyed and the historical data gathered, an initial analysis of water management problems was made and priorities were assigned to portions of the problem. Parts of the project have been "farmed out". Through cooperative work, the groundwater model, the conomic analysis and a complete study of a new irrigation distribution system are being developed as M.Sc. and Ph.D. problems by the University of Idaho students.

SUMMARY AND CONCLUSIONS

Results of two year's study show definitely that the Snake River fan irrigated area is in need of some system of water table control. Increasing inconvenience and financial loss to both urban and rural residents of the area is evident. Because of the number of factors affecting the water table such as contribution from the Snake River, canal seepage, irrigation application and others, the most feasible means of studying the system is by modeling. A digital model is more easily adapted to this study than analog or analytical models. The model developed utilizes a finite difference technique and is capable of handling any foreseeable aquifer boundary condition. Calibration of the model with inputs and aquifer response measured in 1970 and 1971 is being made.

Input and output data indicate the major contributions to the groundwater in the area. During the 1970 irrigating season losses from the Snake River from Heise to Lorenzo were approximately 41,600 acre feet. Diversions from the Snake River for irrigation were 1,507,000 acre feet of which 100,000 acre feet was transported out of the study area and 48,200 returned to the Snake River as surface waste. The net diversion per irrigated acre was 16.5 acre feet. Canal seepage accounted for 570,000 acre feet leaving a net irrigation application of 788,800 acre feet or 9.6 acre feet per acre. Crop use was computed to be 2.0 acre feet per acre.

The net diversion and irrigation application per season in the study area are somewhat greater than the state average, and farm water management could be improved. Distribution system management could also be improved with the objective of providing farm diversions in the amount of decreed rights only.

Any changes in water management which affect decreases in water application will affect the seasonal response of the water table. Changes in inputs such as this on the aquifer response will be analyzed with the model. In addition, some of the alternatives for water table control such as deep surface drain ditches, canal lining, canal consolidation, Snake River operation, and vertical drain wells will be investigated.

Implementation of any technically feasible alternatives could require financing by local residents and farmers. The economic feasibility of any corrective measures depends on the ability of the residents to finance the improvements. At present, the repayment capacity of the area is not known and a project is now underway to determine this potential.