CRITICAL FLOW FORECASTING FOR IRRIGATION REQUIREMENTS IN THE SEVIER RIVER BASIN, UTAH

By

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The need for specialized water supply forecasts on the Sevier River as outlined by Mr. Callister may be summarized as :

1. Dates that streamflow will fall to certain specified levels.
2. Volume and/or percent of primary rights for various periods.
3. Available storage water.

DATE OF CRITICAL LOW FLOWS

Mr. Callister has stated that full primary rights in some sections of the Sevier River are satisfied up to approximately the time that streamflow drops to certain values at specific gaging stations. These values represent the sum of the decreed rights within those sections and are of concern when river flow is on the recession limb of the hydrograph. Since the general form of the hydrograph is related to the volume of runoff during the high water period, the volume forecast may be used to estimate the date when specified flow values will occur.

The first such forecast point he mentioned is the gaging station at Hatch. Critical flow at this station is represented by approximately 100 cfs, below which full primary rights are not completely satisfied in Panguitch Valley. Figure 1 shows a plotting of the April 1st forecast of April-June runoff with the date that the river first falls below 100 cfs. The date when the critical value may be reached generally varies from the first of June to the end of the irrigation season in late September. In 1959, however, the flow never reached 100 cfs.

Since this stream ordinarily peaks in mid May, the revised May 1st forecast of the April-June runoff volume is used for the next estimate of the critical date. After the time of peak flow the forecast may be improved by using the amount (maximum mean daily peak) and date of the peak as additional parameters. Figure 2. For Circle Valley the critical flow at the Circleville gage is approximately 90 cfs. Since the record at this gage is relatively short, an estimate of the critical date is obtained from a plotting of the April-June volume at Hatch versus the time interval in days between the critical dates at the two stations. The critical flow at the Circleville gage has always been reached first.

Forecast relationships comparable to the above have been developed for Clear Creek at Sevier and Salina Creek near Salina. Critical flows on these streams are 5 cfs and 25 cfs, respectively.

VOLUME AND/OR PERCENT OF PRIMARY RIGHTS

The percent of primary water right that will be received in any given year is principally related to the volume of water in the river. Preparation of volume forecasts for basins such as the Sevier River, where streamflow is dependent upon current year snowmelt, groundwater carryover, return flow, low to intermediate elevation precipitation and soil moisture conditions, requires a thorough knowledge of the sources of water for the particular section being studied.

Each of the four river sections we are discussing derives its water from different combinations of the above factors. In Panguitch Valley the current year's snowmelt is the predominant factor. In Circle Valley water comes from early season high water, from return flow from the current season's irrigation in Panguitch Valley and a little from groundwater carryover. The principal source of water for Sevier Valley (Kingston to Vermillion Dam) is from high water flow of several tributaries and from return flow from irrigation within the valley itself. The lower section of the river below Vermillion Dam receives most of its water from groundwater carryover and from return flow from various sources.

In Panguitch Valley, the full demand for primary water is satisfied in about half of the years. Demand for the full primary right for the season (April-September) is not satisfied when the total April-September flow at Hatch is less than about 50,000 acre feet. Water users in this valley are not

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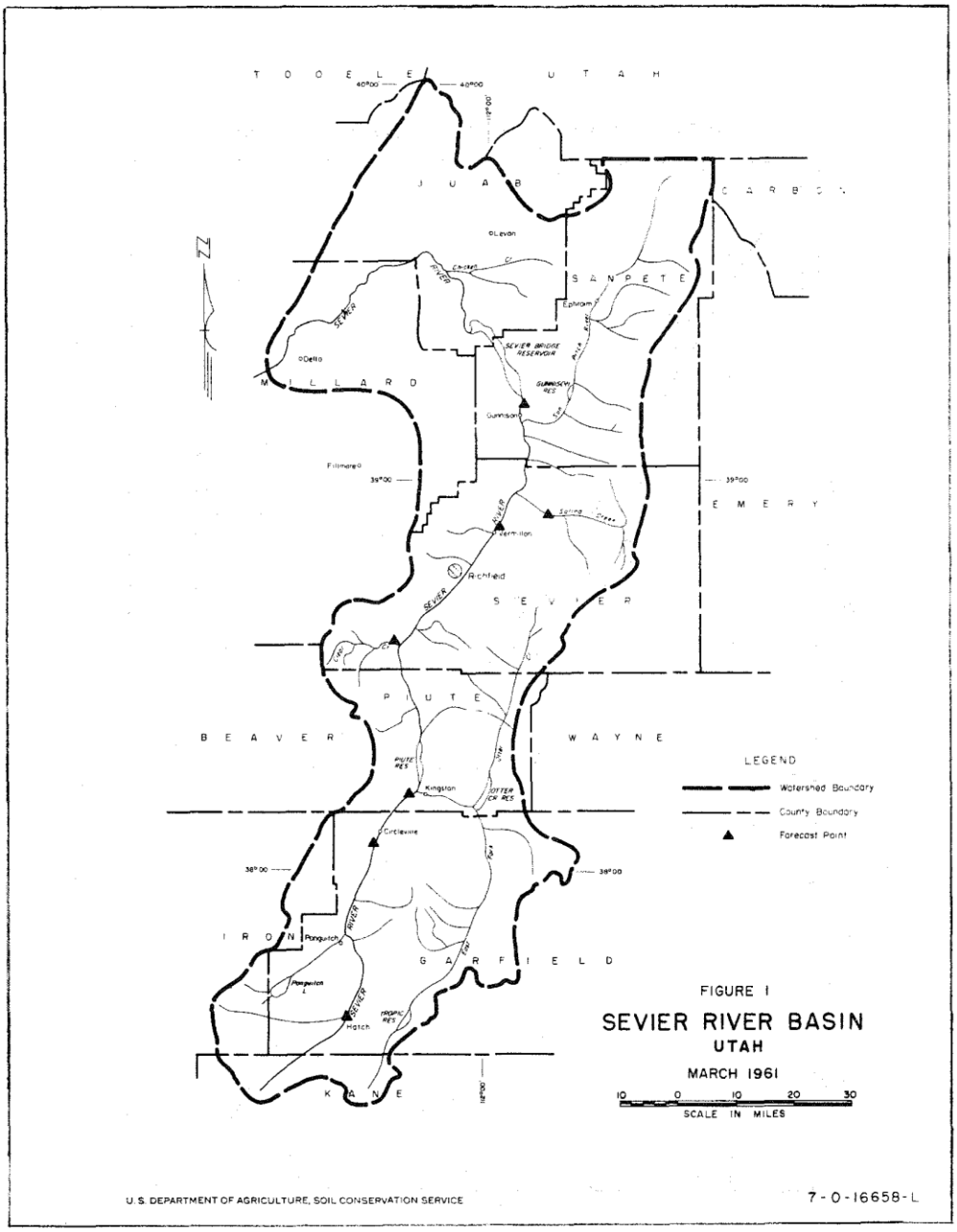

FIGURE 1

SEVIER RIVER BASIN
UTAH

MARCH 1961

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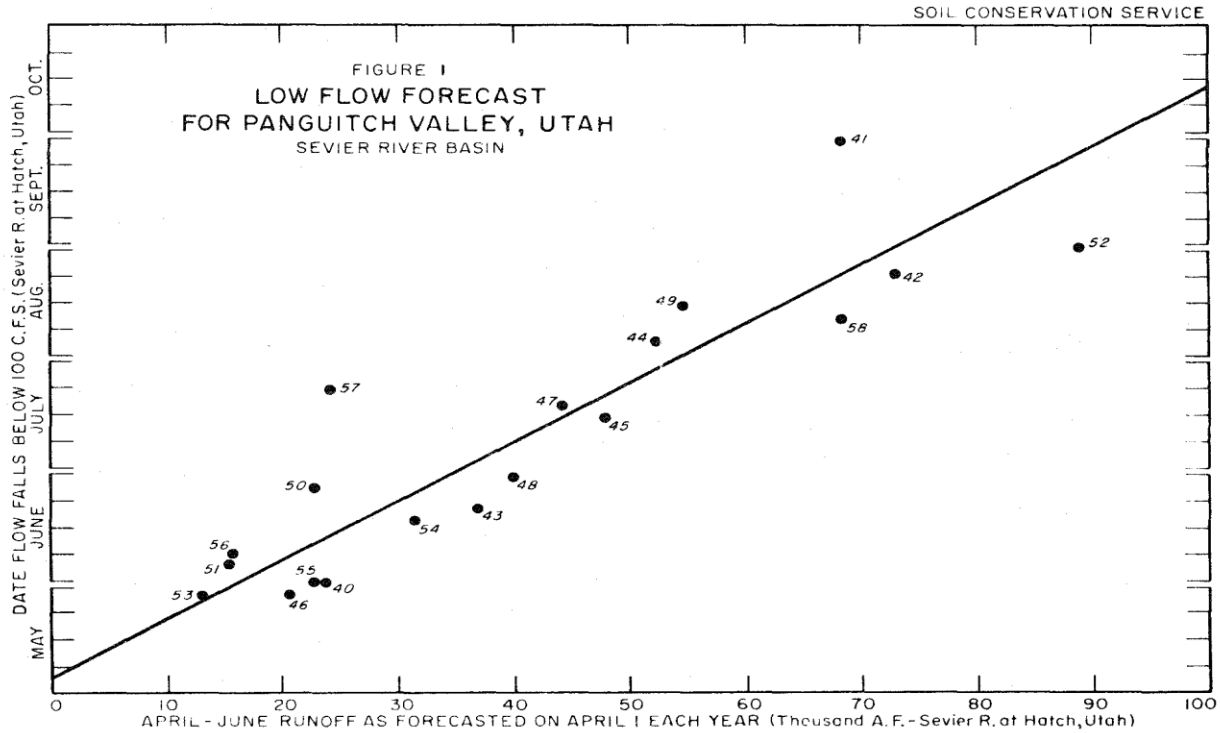
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FIGURE 1
LOW FLOW FORECAST
FOR PANGUITCH VALLEY, UTAH
SEVIER RIVER BASIN
DATE FLOW FALLS BELOW 100 C.F.S. (Sevier R. at Hatch, Utah)
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
0
10
20
30
40
50
60
70
80
90
100
APRIL - JUNE RUNOFF AS FORECASTED ON APRIL 1 EACH YEAR (Thousand A.F. - Sevier R. at Hatch, Utah)
41
52
42
49
58
44
57
47
45
50
48
43
54
56
51
55
40
53
46

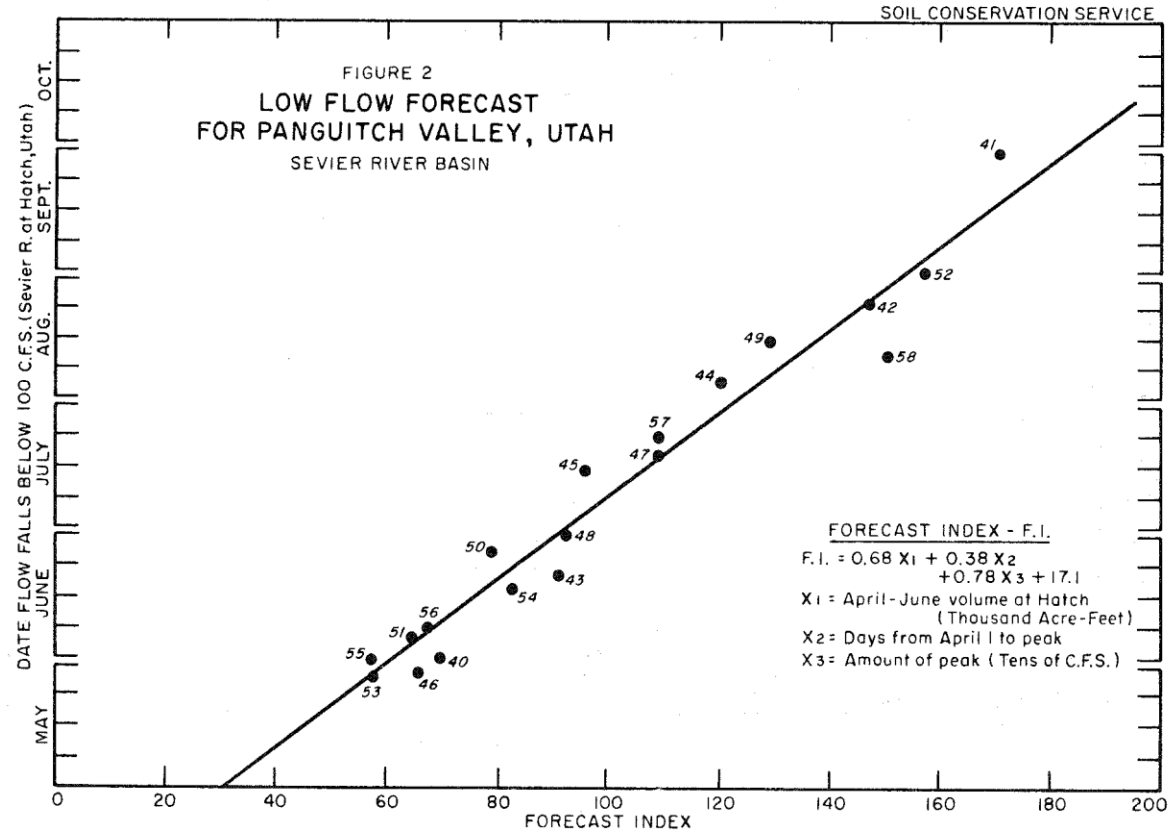
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FIGURE 2
LOW FLOW FORECAST
FOR PANGUITCH VALLEY, UTAH
SEVIER RIVER BASIN
DATE FLOW FALLS BELOW 100 C.F.S. (Sevier R. at Hatch, Utah)
OCT.
SEPT.
AUG.
JULY
JUNE
MAY
0
20
40
60
80
100
120
140
160
180
200
FORECAST INDEX
41
52
42
49
58
44
57
47
45
48
50
43
54
56
51
55
40
53
46
FORECAST INDEX - F.I.
F.I. = 0.68 X1 + 0.38 X2
+0.78 X3 + 17.1
X1 = April-June volume at Hatch
(Thousand Acre-Feet)
X2 = Days from April 1 to peak
X3 = Amount of peak (Tens of C.F.S.)

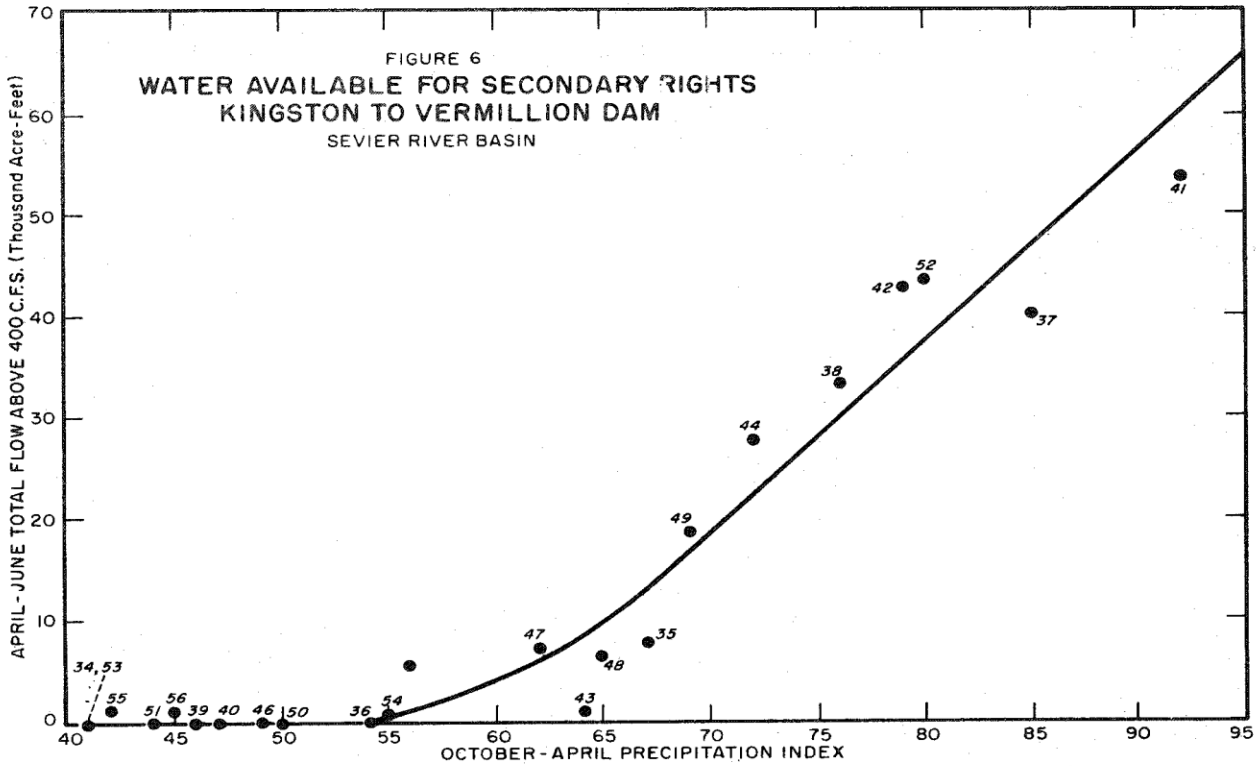
FIGURE 6
WATER AVAILABLE FOR SECONDARY RIGHTS
KINGSTON TO VERMILLION DAM
SEVIER RIVER BASIN
APRIL-JUNE TOTAL FLOW ABOVE 400 C.F.S. (Thousand Acre-Feet)
OCTOBER-APRIL PRECIPITATION INDEX
0
10
20
30
40
50
60
70
40
45
50
55
60
65
70
75
80
85
90
95
34,53
55
51
56
39
40
46
50
36
54
47
48
43
35
49
44
38
42
52
37
41

particularly interested in the total volume of water, since they have no reservoir storage. Their main concern is to know if they will have full rights, or, if not, what percent of their right. The forecast for percent of primary is based on the relationship with volume. Figure 3 shows such a relationship for Circle Valley. Circle Valley seldom experiences a season of full primary rights.

The main source of water for Sevier Valley is from the South Fork of the Sevier River near Kingston and Clear Creek at Sevier. However, the total water used for a season is greater than the inflow from the two streams. This is mostly the result of a high return flow and re-use from irrigation of lands within the basin itself. To determine the total amount of water available to the basin each season, the daily diversions to the ten major canals were totaled and a correction made for change in reservoir storage. Figure 4 shows the relationship of the total April-June inflow from South Fork and Clear Creek with the computed April-June water supply of the valley. The displacement of the mean curve from the 45 degree line shows the additional water used which comes principally from return flow.

Figure 5 gives the relationship of the April-September total inflow from South Fork and Clear Creek with the percent of primary available for the April-September period each year. It is expected that additional study will improve this relationship. The section of the lower Sevier River from Vermillion Dam to Gunnison receives a large contribution from groundwater, a carryover influence from previous years water supplies. It also receives a sizable amount of water from return flow from irrigation during the current season. Very little water is from direct channel flow during the high water season. Total inflow in this reach during the March-June period is determined from the flow of four major diversion canals, outflow past the Gunnison gage, less water coming from Sevier Valley past Vermillion Dam. In a very few years water from the San Pitch River flows into the Sevier River in this section. In such rare years, this discharge is subtracted, leaving only that which is developed in this section of the river. The volume forecast is prepared from a combination of indices representing the current year's weather and a base flow factor. Because a large amount of water is derived from groundwater sources, reasonable accurate forecasts of monthly flows are possible.

The effect of the base flow index varies considerably for the different forecasts. Understandably its greatest effect is for the month of March, since this is prior to water contributions derived from the current season. The April forecast is the poorest since the amount of flow is largely dependent upon temperature. The effect of the base flow decreases steadily through April, May and June with greater weight going to the current season's precipitation. During July, August and September, the forecasts show that these late season low flows are primarily related to the total volume of the spring runoff period.

AVAILABLE STORAGE WATER

At present the total water that will be available for storage each year is not being forecasted. To be of most value for planning, forecasts of the water available for storage from winter flow must be made in late fall or early winter. By April this is, of course, determined by reservoir storage.

Since the winter flow is primarily a residual from the previous year's streamflow, this can be readily estimated in the late fall months. To date, however, the river commissioner's reports have not segregated the winter storage water from other rights. The winter storage of previous seasons is currently being developed by the commissioners. Water available for storage during the spring months is related to the peak flow. When total flow exceeds 400 cfs in Sevier Valley and 360 cfs in the reach from Vermillion Dam to Gunnison, water is available for additional rights. The first 10,000 acre-feet belongs to Class D rights. Any additional is available for use by those with storage rights in Piute and Sevier Bridge Reservoirs. In order to determine the amount of water that may be available for storage, it was necessary to prepare forecasts of amounts of water expected to exceed the primary flow rights of 360 cfs and 400 cfs. For the Sevier Valley the total flows above 400 cfs is related to the combined flows of the South Fork and Clear Creek. Thus, the forecasts for these streams can be used for predicting the desired flows. A direct precipitation index proved to be the most reliable as shown in Figure 6.

For the lower reach from Vermillion Dam to Gunnison, a similar forecast procedure is used. The relationship is quite accurate in forecasting whether or not there will be any flow above 360 cfs. In years when flows are above this point the forecasts are not as accurate principally because of variable temperature effects.

CONCLUSIONS

Because good records are available for most of the Sevier River, it has been possible to develop these forecasts within reasonable accuracy. In some cases, better diversion records and more streamflow records would have been helpful.

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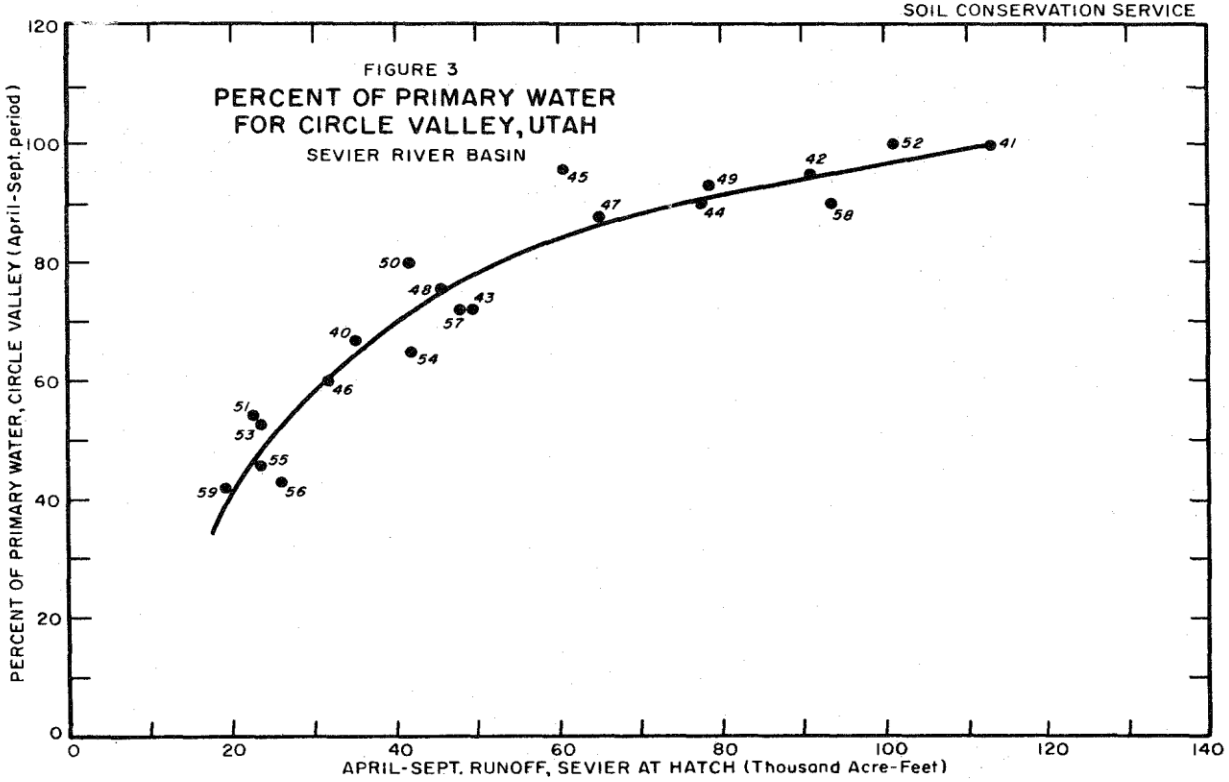
FIGURE 3

PERCENT OF PRIMARY WATER FOR CIRCLE VALLEY, UTAH

SEVIER RIVER BASIN



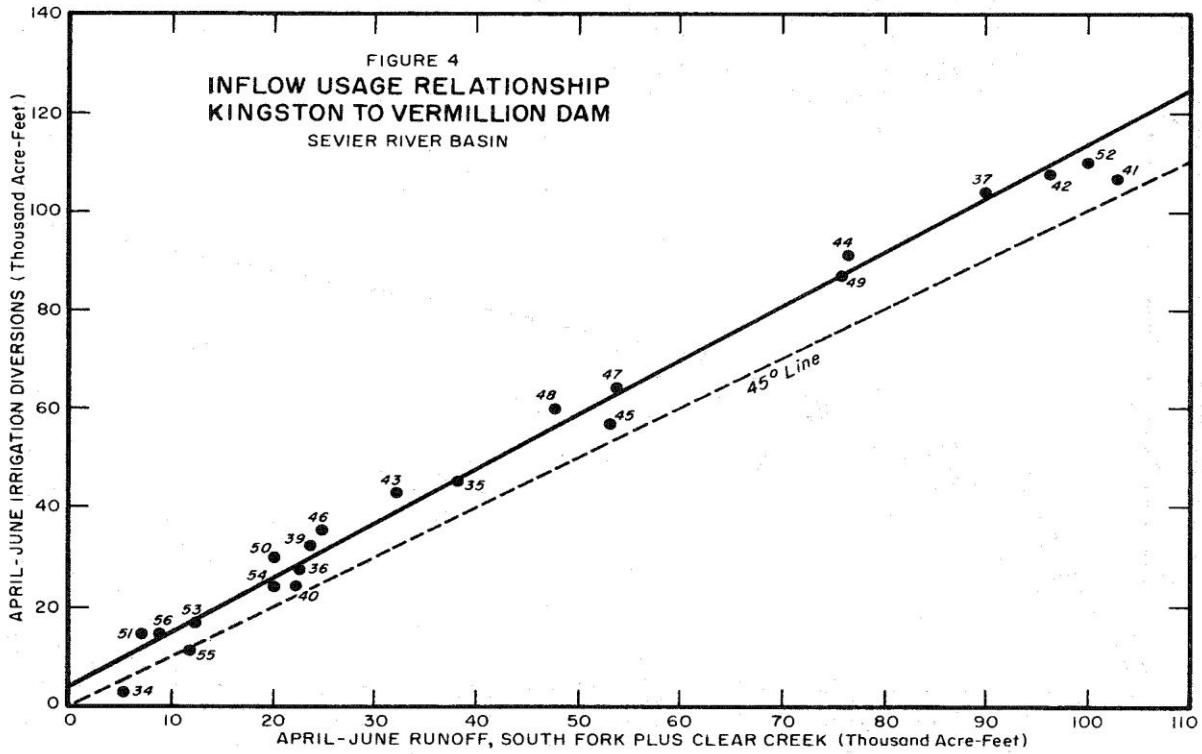


FIGURE 4
INFLOW USAGE RELATIONSHIP
KINGSTON TO VERMILLION DAM
SEVIER RIVER BASIN
APRIL-JUNE IRRIGATION DIVERSIONS (Thousand Acre-Feet)
APRIL-JUNE RUNOFF, SOUTH FORK PLUS CLEAR CREEK (Thousand Acre-Feet)
45° Line
0
20
40
60
80
100
120
140
0
10
20
30
40
50
60
70
80
90
100
110
34
55
51
56
53
54
50
39
46
40
36
43
35
48
47
45
44
49
37
42
52
41

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FIGURE 5

PERCENT OF PRIMARY WATER FOR SEVIER VALLEY, UTAH

SEVIER RIVER BASIN