RIVER OPERATION STUDIES FOR IDAHO

Idaho Water Resource Board

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INTRODUCTION

At the present time the role of land and water resource planning in resource use is being subjected to a great degree of examination. As the increasing population has forced greater competition between incompatible resource uses, individuals and special interest groups have begun to react more to proposed resource development.

Water resource planners must question whether previous concepts of planning are adequate for the future. The public has already voiced the opinion that the old methods are not good enough. Previous planning consisted of designing structures at the best physical locations and detailing the operation and use of those structures. Today very few of these sites remain undeveloped. Increased recreational water use and waste production have forced water planning to assume a much greater scope.

Again, it is doubtful that concepts in water planning have advanced enough to provide an adequate product by today's standards. A tributary within a river basin can no longer be analyzed separately, but must be evaluated as part of a river system. Tributary management may have significant effects far downstream or upstream. Alternative management plans can no longer be evaluated by the benefit-cost ratio because of intangible effects. Choosing among alternatives to be studied is no longer an obvious task. The interrelated factors which must be considered in a system analysis are infinite. The need for accurate data and proper study methods has mushroomed with broadened scope of planning.

It is the responsibility of water planners to use their experience and ingenuity to relate to current concepts. Regardless of the many assumptions and cursory evaluations that must be made to treat these concepts, water planning efforts can result in currently meaningful studies which can be used to regulate otherwise haphazard development.

The following report is a description of one of the initial steps taken by the water planners of the Idaho Water Resource Board to more adequately plan for water management in Idaho. A computer program was developed to evaluate the hydrologic effects of varying management plans on a river system. In Idaho little basin-wide planning was done or considered necessary in the past. A mixture of individual, private and public development has resulted in inefficient systems with many conflicts among water uses and users. Lack of planning has resulted in misconceptions of physical systems and their potential uses. Through the application of the river operation program, many of these misconceptions can be avoided.

The program was written to provide a balance between flexibility to allow a wide range of applications and simplicity to permit ease of use. However, despite the capabilities of the program itself, the program is limited by the quality of the input data. In view of the magnitude of water development in Idaho, many basins are very limited in land and water data needed for proper planning. Often data must be estimated with very little verification.

This report contains a description of the use of the river operation program on the Upper Snake River along with a description of the operation program itself. It is intended to be a guide for others who use the program. Secondly, it can be used to gain a better understanding of how the program operates for better interpretation and application of study results. Presently, the program is also being used to study the management of the Bear River, Wood River, Central Snake River (including the Boise and Payette), and the Middle Snake River from Weiser to Lewiston. Separate descriptions of these rivers will be added to this report when completed.

It should be emphasized that the river operation program is a planning tool in hydrology and should not alone be used to evaluate alternatives. Inputs must be brought together from all related land and water disciplines for complete planning.

SECTION I. RIVER OPERATION METHODS-
GENERAL DESCRIPTION

The following report is a description of the IWRB Fortran IV river operation computer program as of July, 1972.

PURPOSE

The IWRB river operation program was developed to enable the calculation of flows and reservoir contents of a river system operated under varying criteria of river basin management.

PRESENT CAPABILITY

Using monthly input data, the program can operate river system consisting of up to 50 separate reaches. Operation of the river includes the following for each reach:

a. Natural inflow accumulation.

b. Inclusion or exclusion of a reservoir of any size.

c. Reservoir evaporation.

d. Assigned outflows.

e. Irrigation diversions and return flows.

f. Municipal and industrial diversions.

g. Flood control operation.

h. Reservoir storage operation.

PRESENT USE

The program is now adapted for use on the Upper Snake, Wood, Central Snake, Middle Snake, and the Bear rivers. Major tributaries such as the Henrys Fork, Boise, Payette, and Clearwater are included in these segments. Total flows and reservoir contents can be predicted on the Upper Snake, Wood River, Central Snake, and Middle Snake for the period of 1928 to 1968. Similar data can be obtained for the Bear River from Bear Lake to Bear River Bay for the period of 1927 to 1965. Results are in terms of 1000 acre-feet per month.

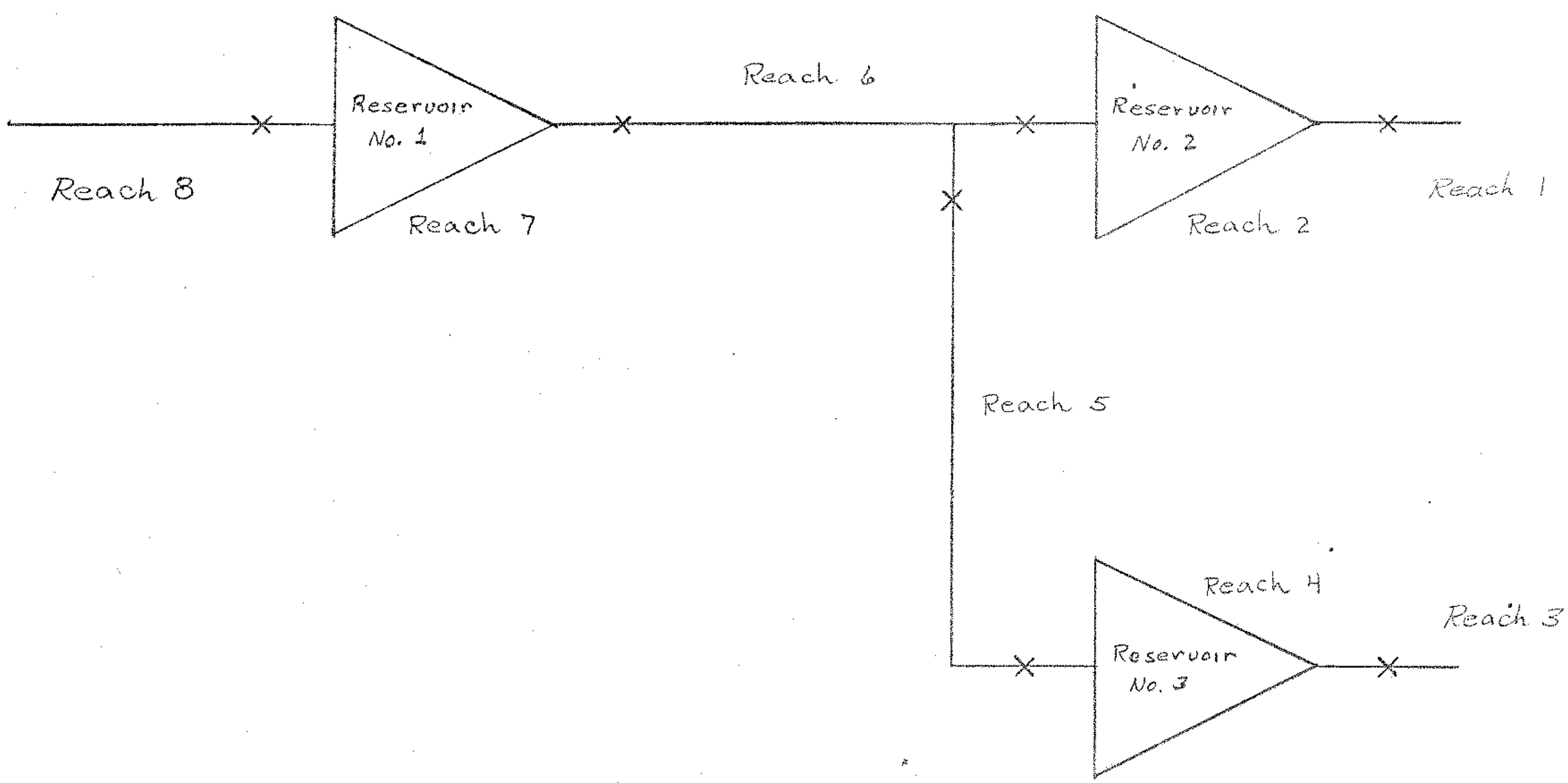
GENERAL OPERATION

Organization: The basic unit of the river operation study is the reach, a point-to-point section of the river for which all inflow and outflow data are known or estimated. The particular river system under study is divided into reaches, and operational criteria are established for each reach depending on study objectives. Figure 1 shows a sample river system configuration consisting of eight reaches and three reservoirs. Operation takes place reach by reach in downstream order with the outflow from the reach being operated becoming the inflow to the next reach. As shown in Figure 1, a reach can receive the outflow of two or more other reaches. The number of reaches and reservoirs is limited only by the storage capacity of the computer system being used.

All reaches use the same decision process for flow and storage allocation, thus allowing a looping procedure in the computer program. Three passes are made through the entire system for each month of operation. These three passes attempt to satisfy diversion, discharge, and flood space requirements. Other functional uses of water such as recreation, power, and water quality impose constraints during the entire operation. Choice of input data determines the impact of each water use function. For all operations, storage routing and travel time effects are ignored.

The program consists of one main program and five subprograms or subroutines. The main program calls for input data, calculates all intermediate data used in the subroutines, and calls for final output. The five subroutines perform (1) the input of all indicators and system constraining data, (2) the initial reach and reservoir operation, (3) the identification and release of storage water for unsatisfied demands, (4) the routing of water from the storage location downstream

Figure 1. Sample river system schematic.



to the point of demand and (5) the output and organization of final data. Each of these subroutines is called as needed by all reaches for all functions. A simplified flow chart of the entire operation is shown in Figure 2.

Main Program: Before calculations begin for the first year of operation, monthly gains and irrigation diversion requirements are entered in the main program for each reach of the system. On the first pass, surface and groundwater gains are accumulated and routed downstream; all diversions are met, if possible, and the remaining natural inflows are stored at the nearest downstream reservoir. On the second pass, an attempt is made to meet all assigned reach outflows; and on the third pass, flood control space is provided, if needed. After the third pass, flows calculated for each pass are totaled at all reach end points and calculations begin for the next month. The following paragraphs describe this operation in further detail.

Initial Reach Operation: A check is made to determine if there is a negative groundwater gain (channel loss) in the reach. If it is negative, the loss is subtracted from the reach inflow before diversions are removed. If positive, the diversions are subtracted first and then surface gain, groundwater gain, and return flows are added. Diversions exceeding the reach inflow must be satisfied from upstream storage; the surface gains, groundwater gains, and return flows cannot be used until they pass to the next reach. Before storage is called, the entire reach inflow must first be diverted.

The outflow of a reach on the first pass can be expressed as:

OUTFLOW = REACH INFLOW - DIVERSIONS + SURFACE GAIN + GROUNDWATER GAIN + RETURN FLOW

The outflow is simply the result of adding and subtracting the various components to the reach inflow received from the above reach. The calculated outflow will become the reach inflow to the next reach.

Figure 2. Flow chart of river system operation program.

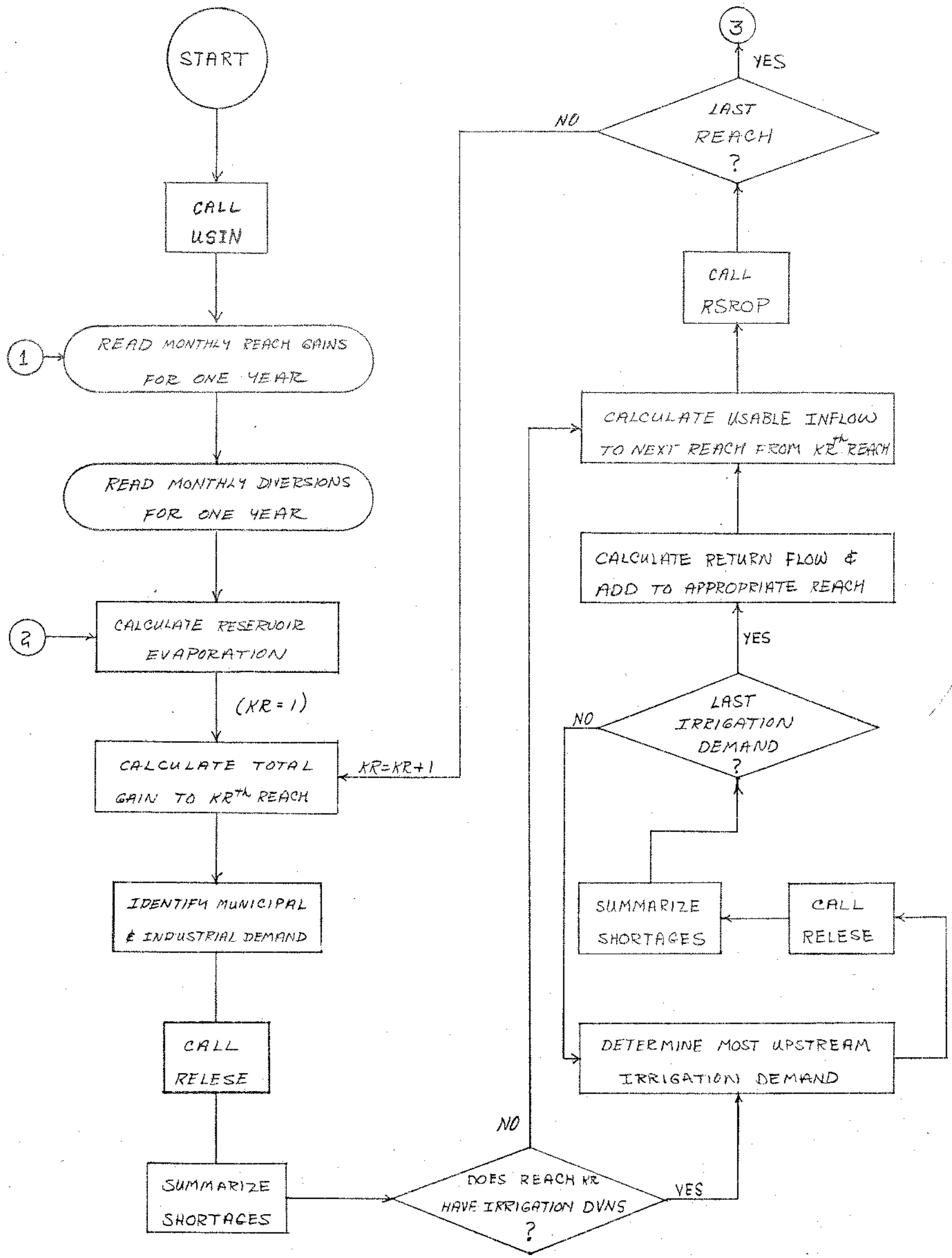


Figure 2. (continued)

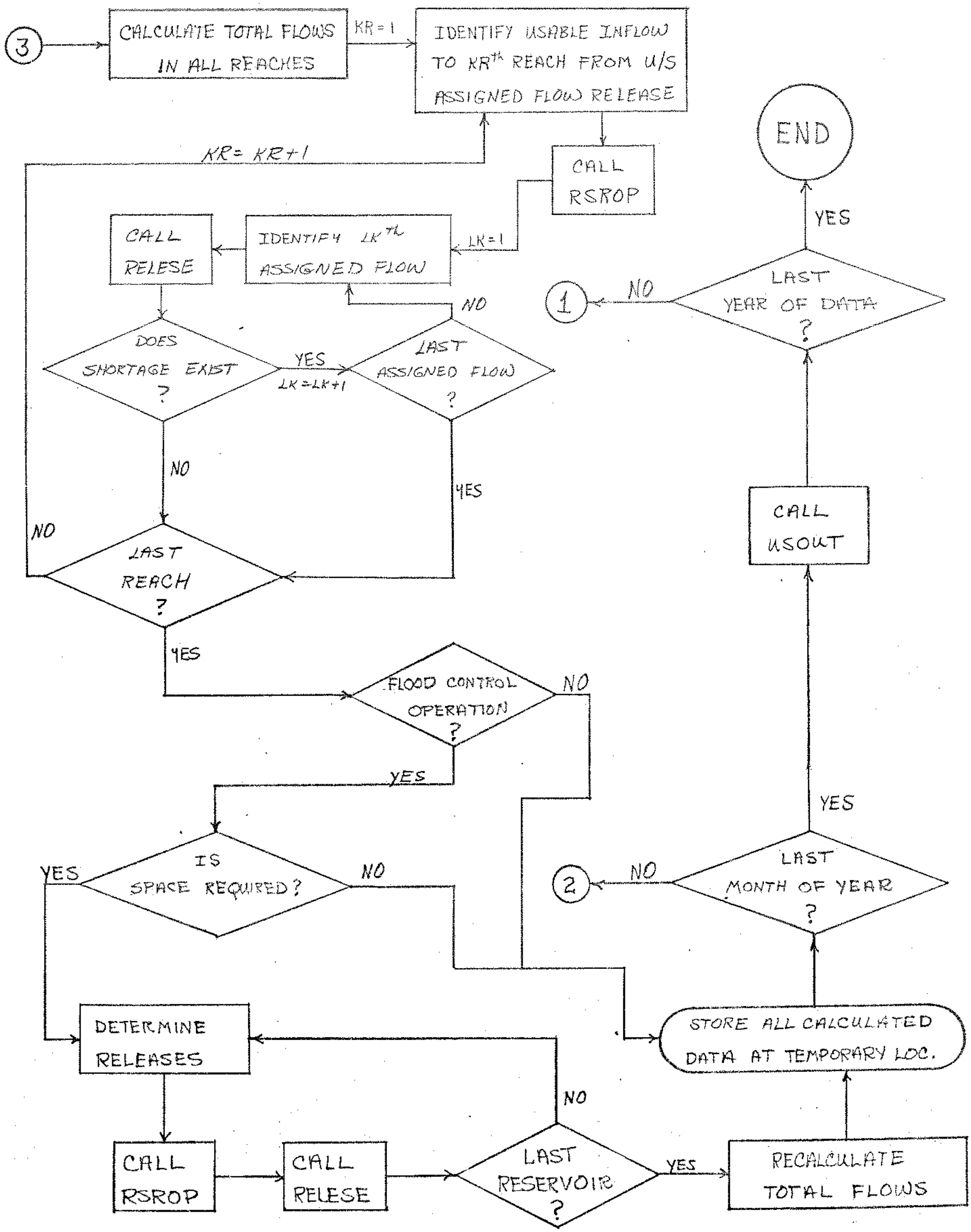
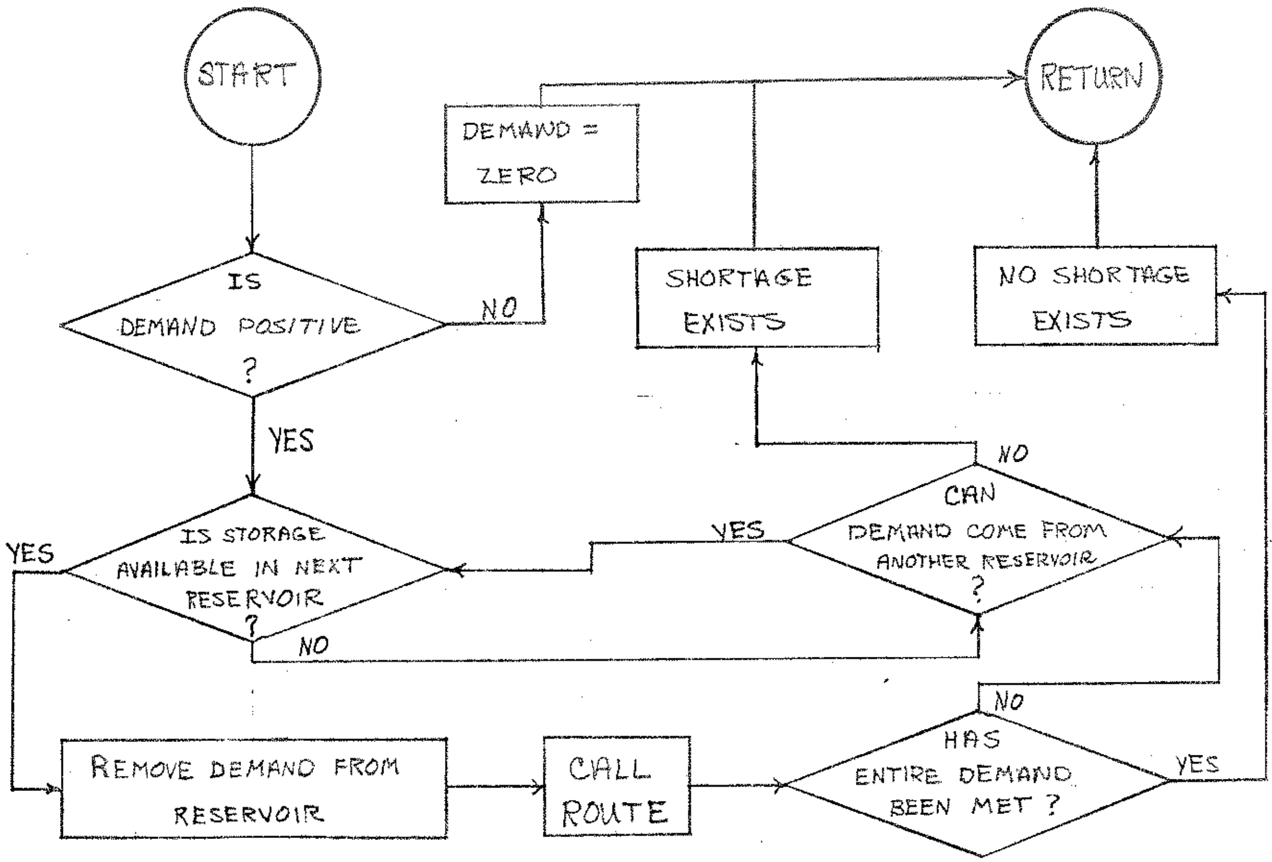


Figure 2. (continued)

SUBROUTINE RELESE



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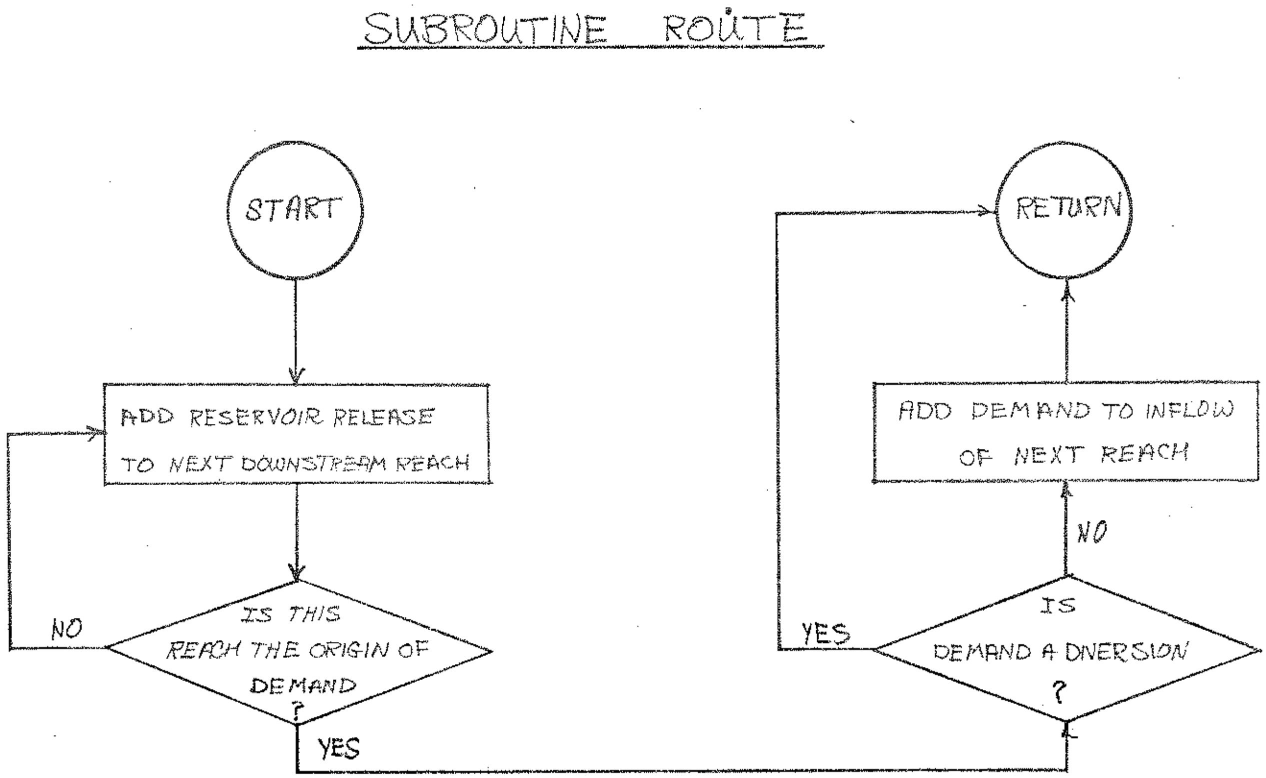


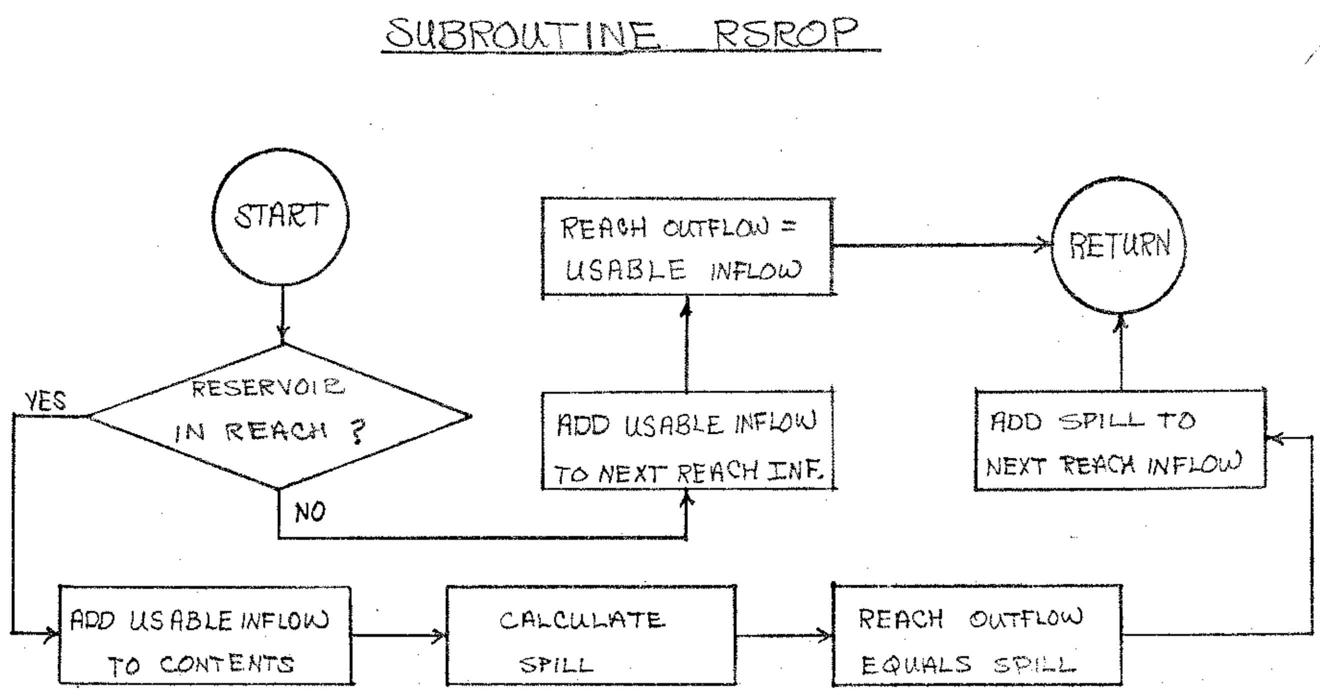
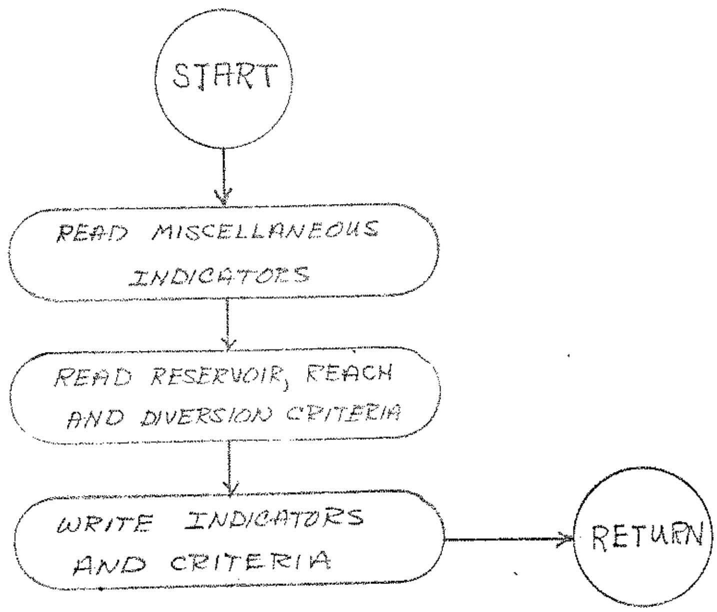
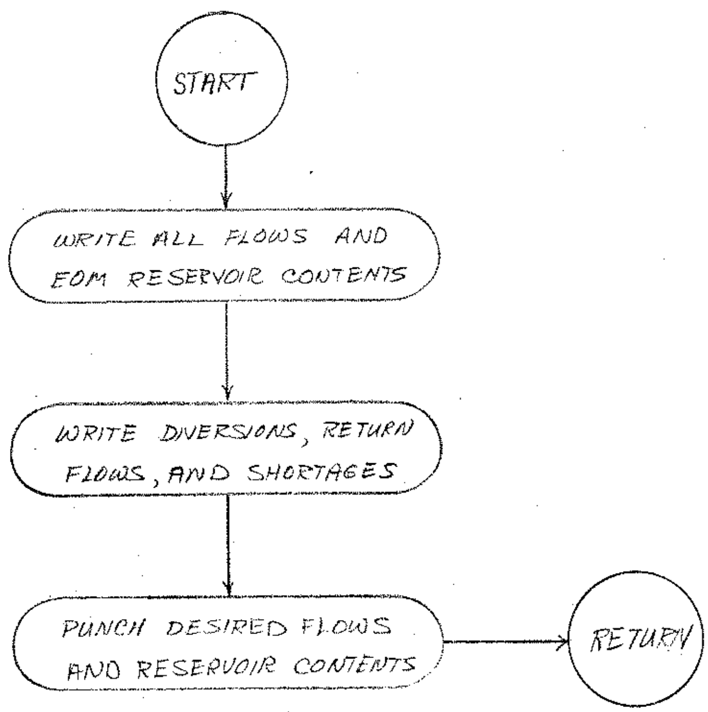


Figure 2. (continued)

SUBROUTINE USIN



SUBROUTINE USOUT



<u>Diversions</u>: Any number of diversions can be included in one reach. Each diversion is given a series of numbers representing the order of reservoirs to be called on for storage. Together with the use of four reservoir storage levels, these order numbers provide a method for varying the pattern of releases when two or more reservoirs are physically capable of satisfying a diversion demand. The use of these numbers and levels is further discussed under the RELESE subroutine.

<u>Return Flows</u>: Return flows are calculated immediately after a diversion has taken place. Each diversion is given from one to ten lag factors which are used to determine the portion of the total diversion which will return that month and each of the following nine months. For diversions whose return flow had not been removed from reach gains during reach gain derivation, lag factors of zero are used (see data preparation section). The return flow is added to the system when the appropriate month and reach receiving the flow is operated. Each diversion can have only one return flow destination reach and one set of lag factors. Return flow from municipal and industrial diversions is returned the same month to the reach of diversion and is assumed to be 45 percent of the diversion.

<u>Assigned Flows</u>: Input data include three monthly flows assigned to the outflow point of each reach. These values correspond to three reservoir storage layers in each reservoir designated as a source for meeting flow requirements (see discussion of storage layers under RELESE Subroutine description). On the second pass through the system, all reach outflows generated by the first pass are compared to the three assigned flows. For a particular reach, if the first assigned flow is less than the generated flow, the amount needed to match the assigned flow is withdrawn from the first storage layer of a reservoir designated as the primary storage source. No reservoir will be lowered below the first layer to meet the first assigned flow. Similarly, the second assigned flow is

met from the second storage layer and the third assigned flow is met from the third layer. Assigned flows must be of decreasing magnitude (for example, layer 2 flow must be less than layer 1 flow). Only one assigned flow-storage layer combination can be chosen for flow shortage designation when that assigned flow cannot be met. The portion of the assigned flow not satisfied appears in the output as "assigned flow shortage." The most critical flow is selected for the shortage calculation and is identified by an input indicator (see data card type 14, Table 1). If the remaining two assigned flows cannot be met, the difference is ignored.

The sequencing of reservoir releases is accomplished by a set of reservoir order numbers given to each reach. A demand not satisfied from the storage layer of one reservoir is transferred to the next reservoir in the order. After all reservoirs have been examined for available storage, assigned flow releases are routed downstream to the point of demand. These flows become available for storage in downstream reservoirs or, if no storage exists, are passed through the system.

The assigned flow provision in the computer program can be used for several different purposes. The flows might be used to regulate reservoir outflows for power, water quality, recreation, or other uses. As the reservoir contents decrease, the flows for these uses can also be decreased. The first assigned flow can be a very desirable flow while the third flow can be a minimum flow. When more than one reservoir is involved, the assigned flows also provide a method for balancing contents among reservoirs.

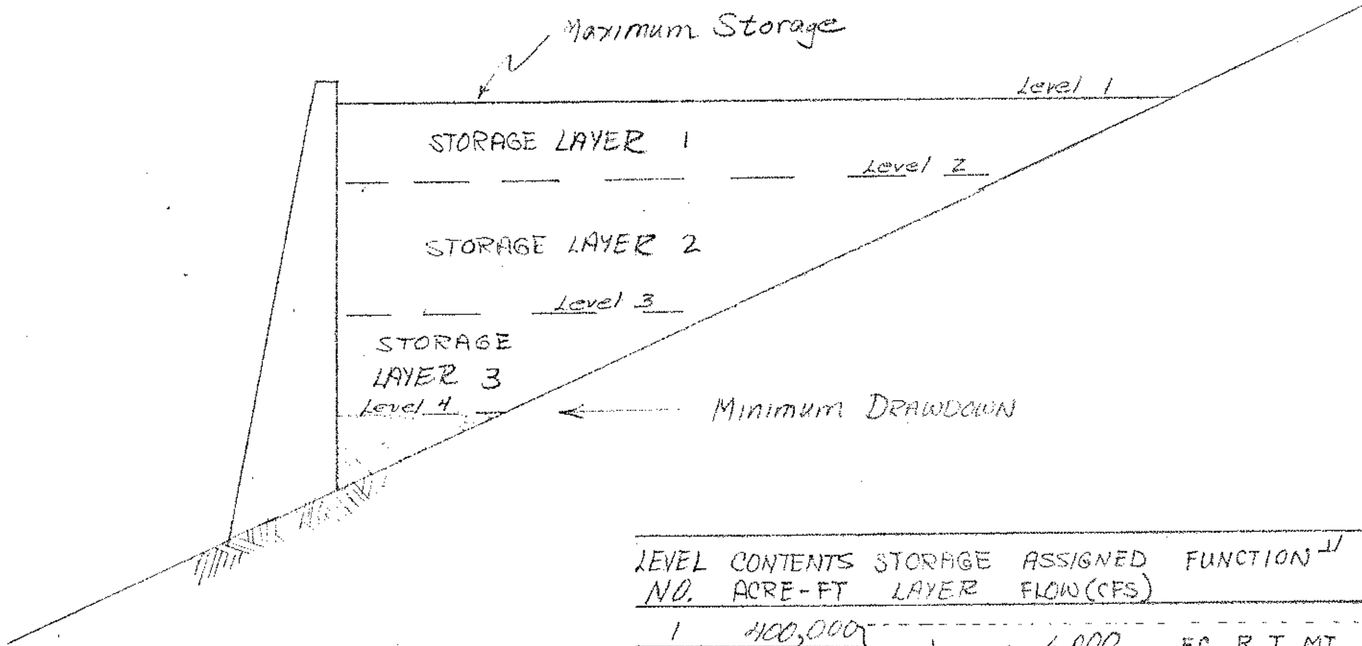
Flood Control: The procedure for determining flood control space required is unique to each river system and must, therefore, be discussed relevant to the system being operated. If storage space is needed in a reach, that amount is released and routed downstream to the next reservoir or, if no storage space remains downstream, is passed through the system.

Reservoir Evaporation: The above operations are made for each month of the year of operation. At the beginning of each month, reservoir evaporation for that month is calculated and removed from the reservoir prior to operation. Evaporation is based on the average monthly unit evaporation and the surface area at the beginning of the month. Determining evaporation using beginning of month contents introduces some error since average monthly contents will usually be less or greater. However, the annual error will not be significant in most river systems.

Reservoir and Reach Operation (RSROP): The RSROP subroutine allocates the outflow after a reach has been operated. Before RSROP is executed, the main program has added return flows, groundwater gains, and surface gains to the reach inflow after diversions have been removed. The RSROP subroutine then identifies the reach outflow and passes it on to the proper reach where it becomes a new reach inflow. If the reach is a reservoir reach, RSROP will store as much of the flow as possible. Any amount in excess of the maximum monthly reservoir content is noted as a spill and becomes inflow to the next reach. If the reach does not include a reservoir, the entire amount is passed on the next reach. This subroutine is always used after any reach is operated, thus assuring that all water being stored is initially at the most upstream reservoir location.

Storage Release (RELESE): When a diversion or instream requirement cannot be met by the existing flow, reservoirs which have been specified as potential sources of water for a given reach are checked for available storage in the RELESE subroutine. The demand is withdrawn from these reservoirs in any desired order, depending on choice of input data. Each reservoir has three layers defined by four levels from which water can be withdrawn (Figure 3). These levels determine the amount of water available for withdrawal before the next reservoir in the order is called upon. Levels can be chosen to represent flood space, power head, recreation levels, or to provide buffer storage for other functions which

Figure 3. Typical reservoir operation criteria.



LEVEL NO.	CONTENTS ACRE-FT	STORAGE LAYER	ASSIGNED FLOW (CFS)	FUNCTION 1/
1	400,000			
		1	6,000	FC, R, I, MI
2	350,000			
		2	2,000	FC, I, MI
3	200,000			
		3	500	MI
4	50,000			

1/ FC - FLOOD CONTROL
R - RECREATION
I - IRRIGATION
MI - MUNICIPAL & INDUSTRIAL

have a varying priority of use. When the top layer has been exhausted in all reservoirs, the second layer becomes available for use, and similarly when the second layer is exhausted, the third can be used. The upper level is the maximum monthly content, and the lower level represents the allowable monthly drawdown. By varying these levels, any amount of storage (or none) can be taken from a reservoir or sequence of reservoirs before releases are made from the uppermost reservoir.

Since reservoir orders are assigned to each diversion and reach, it can be arranged so that a requirement can be satisfied by only a specific reservoir or series of reservoirs. Demands remaining after all three layers in all available reservoirs have been used are noted as shortages. Shortages can be made to occur even though storage water remains by placing the bottom level above the level of dead storage. Similarly a reservoir can be prevented from filling by placing the top level below the maximum storage level.

To use the reservoir layers as buffer storage for uses which are given a higher priority than others, space is reserved in the bottom one or two layers specifically for those uses. For instance, if a system contains both irrigation and municipal diversions, the availability of water for municipal purposes can be assured by restricting irrigation releases to the top two layers and sizing the bottom layer large enough to provide municipal water over any water short period (see example, Figure 3). To accomplish this, each function is given a "level limit number" which indicates the maximum drawdown of that function's available storage. An exception to this is the assigned flow function for which there is a specific flow for each storage layer (see assigned flow discussion). The level limit number must be greater than one if storage is available because the first level corresponds to the top of the reservoir (see Figure 3).

Together with the assigned flows, the reservoir levels provide a method of balancing contents when the river system contains more than one reservoir. If the system has a flood control operation, the levels can be set to maintain the desired flood space distribution among reservoirs. The level limit for flood control is automatically placed at the maximum monthly drawdown so that a flood control operation can utilize all three storage layers if needed.

Release Routing (ROUTE): The ROUTE subroutine is called by the RELESE subroutine whenever storage water is taken from a reservoir. The amount of water released is added to the flow in each reach between the reservoir and the reach originating the demand. Storage releases for diversions are terminated within the reach and, therefore, are reflected in the reach inflow, but not the reach outflow. Releases for assigned flows and flood control are passed downstream as inflow to the next reach. In this manner, all storage releases are routed downstream and accounted for in the intermediate reaches between the reservoir and the demand.

Input (USIN): Table 1 lists the required input data for the USIN subroutine together with the proper format and variable name.

Output (USOUT): Output is made at the end of each year of operation by the USOUT subroutine. Normally, output consists of monthly (1) total flows at key points, (2) contents of all reservoirs, (3) reservoir evaporation, (4) flood control space provided, and (5) an annual summary of diversions, return flows, and shortages. Optional output consists of a monthly breakdown of the diversions, return flows, and irrigation and minimum flow shortages. These values are summarized by branches of the system. A branch can include from one to several reaches depending on the importance of the reaches. Printout headings vary with river system and must be set up individually for each river system.

TABLE 1. Input Data For IWRB River Operation Program

Card Type #	Number Required	Format	Variable(s)	Variable Description
1	1	(12I3)	NR, ND, NP, NB, NO, NY, NYR, NRG, NDA, NCD, NEF, NVM	Respectively, the number of (1) reaches, (2) diversions, (3) reservoirs, (4) branches, (5) the study, (6) years of operation, (7) the initial year, (8) reaches having tributary gains, (9) irrigation diversions to be determined from acreage data, (10) diversions which are constant for each year of operation and do not have to be determined from acreages, (11) the number of base flows, and (12) the number of minimum flows which vary with year.
2	1	(5I3)	IP1, IP2, IP3, IP4, IP5	If positive, will cause additional output to be made on printer. The first two allow output of (1) a monthly tabulation of diversions, return flows, and shortages; and (2) a listing of intermediate data used normally only for debugging purposes. The last three variables are not presently used.
3	Variable	(40I2)	KALU (I)	I values, equal to the number of flow and reservoir content values given in the primary output. If positive, the monthly data of the Ith output value will be punched on cards.
4	1	(12A3)	O (I)	Twelve monthly abbreviations (Oct, Nov, etc.).
5	1	(12F2.0)	DAY (I)	Twelve values, equal to the number of days in each month of the water year.
6	NP(one card per reservoir)	(3A4.8X, 4F5.1,I3)	RNAME (I1, I2) RES (I1, 1) FULL (I1) DEAD (I1) ARINT (I1) ICR (I1)	Reservoir name; I2 = I,3 Initial reservoir content Maximum annual reservoir content Reservoir dead storage Increment of storage between successive values on surface area-reservoir content table Number of reach in which reservoir is located (I1 = Reservoir number)

Card Type #	Number Required	Format	Variable(s)	Variable Description
7	4 * NP (Four cards per reser- voir)	(2X, I1, I2, 5X, 12F5.1)	K J RLVL (J,I,K)	Reservoir level number (varies from 1 to 4) Reservoir number Monthly reservoir contents for Kth level and Jth reservoir, twelve values of water year. I = month of water year.
8	NP	(12F5.3)	PE (I1,I2)	Monthly potential evaporation at each reservoir (ac-ft/ac) I1 = reservoir number; I2 = month of water year.
9	NP	(11F5.1)	SA (I1,I2)	Surface area values of surface area-reservoir content table for each reservoir. I1 = reservoir number, I2 = surface area value.
10	NP	(24I2)	KDS (I1,I2)	Order of reaches downstream from each reservoir. I1 = reservoir number I2 = successive reach
11	1	(40I2)	INR (I)	One value for each reach; If a reservoir exists in the Ith reach, the value is equal to that reservoir number.
12	13	(3(9I2,2x), JORDR(39,9), 20X)	JORDR(I1,I2)	Thirty-nine groups of nine numbers denoting possible reservoir storage call orders. Values are equal to reservoir numbers and are in order of storage priority. I1 = group; I2 = successive reservoir number.

ard ype #	Number Required	Format	Variable(s)	Variable Description
13	1	(40I2)	MRO (I)	One value for each reach equal to reservoir order (from #12 cards) to be used for minimum flow demand. I = reach number
14	1	(40I2)	MLL (I)	One value for each reach equal to one greater than the number of reservoir levels from which storage can be used for minimum flows. I = reach number
15	1 or 2	(26I3)	KORDR (I)	Reach numbers, listed in order of desired operation I = order
16	1	(40I2)	NDR (I)	One value for each reach, equal to the number of diversions in each reach. I = reach number
17	NR (one card per reach)	(15,15X, 12F5.0)	K FMIN (K,I)	Reach number Monthly minimum flow (CFS). I = month of water year.
18	1	(40I2)	IOI (I)	One value for each reach, equal to the number of the reach receiving the outflow from the Ith reach. I = reach number
19	ND (One card per diver-sion)	(4A5, 5I5)	DNAME (I1, I2) JND (I2) JVD (I2) IRO (I2) JDR (I2) ILL (I2)	Diversion name. I1 = I,4 Diversion identification number Positive if diversion is variable from year to year Reservoir order (from #12 cards) to be used if storage is needed for the I2th diversion Reach number in which diversion is made Number of reservoir levels plus 1 from which storage can be used. I2 = diversion order.
20	ND(one card per reach)	(10F5.3,25X, I5)	RLF (I1, I2) IDST (I1)	Return flow lag factors I2 = number of months elapsed following diversion Number of reach receiving return flow I1 =

Card Type #	Number Required	Format	Variable(s)	Variable Description
21	NB(one card per branch)	(3A4,8X,4I2)	BRN(I1,I2) IBR(I3,I1)	Branch name. I2 = 1,3. Reach numbers included in the I1th branch. I1 = Branch number; I3 = reaches in branch
22	NCD(one for each constant diversion)	(I3,5X, 12F6.1)	K DIV(K,I)	Order diversion is made in river system. Monthly diversions for Kth diversion. I = month of water year.
23	NR(one card per reach)	(10X,12F5.1)	EMI(I1,I2)	Monthly M & I diversions for each reach. I1 = reach number. I2 = month of water year.
24	variable	(10X,12F5.3)	RQ(I1,I2,I3)	Monthly diversion requirements per acre for diversions expressed in irrigated area. I1 = month of water year, I2 = climatic area number. I3 = designation for full service (1) or supplemental (2) land.
25	NDA(one per acreage location)	(2I2,6X, 2F10.1)	NZ(I1) NW(I1) ACRE(I1,I2)	Order diversion is made in river system. Climatic area number for selection of diversion requirement. Full service and supplemental acreages for which diversions are to be made. I1 = Order of acreage in river system. I2 = Full service (1) or supplemental (2) designation
26-34	variable with river system			Flood control or other data unique to the river system.

Card Type #	Number Required	Format	Variable(s)	Variable Description
35	NR(one card per reach)	(2I3,2X, 12F6.1)	IA	Reach
			MM	Year
			GW (I1, I2)	Monthly groundwater gains or losses to each reach I1 = reach, I2 = month of water year
36	NR(one card per reach)	(2I3,2X, 12F6.1)	IE	Reach
			LY	Year
			RCHGN (I1, I2)	Monthly surface water gain to each reach I1 = reach, I2 = month of water year
37	Number of variable diversions	(2I3, I2, 12F6.1)	IV	Diversion identification number
			IH	Reach in which diversion is made
			IY	Year
			DIV (I1, I2)	Monthly diversion amount. I1 = diversion order, I2 = month of water year.

NOTES: Card types 23 and 24 are omitted if NDA = 0.
Any or all card types 35, 36, and 37 repeat in order for each year of operation if data varies with year.

DATA PREPARATION

Reach Determination: The first step in adapting a river system to the operation program is to define the portion of the system which is to be operated and to divide the system into reaches. Normally, all gage points with sufficient historical record are used as division points between reaches. At each location where total flow is desired, it is necessary to begin a new reach; flows are summarized only at the reach terminal.

It may be necessary or desirable to define reaches at locations other than gaging stations. When two or more reaches converge, the junction point must terminate all reaches involved, and a new reach must begin. This causes the separate flows to be totaled and entered into one reach. For every location where a new or existing reservoir is to be included, there must be a separate reach for the reservoir itself. This arrangement is necessary because the program logic assumes that all diversions in a reservoir reach are made directly from the reservoir itself, not above or below the reservoir. Therefore, a reach containing a reservoir should begin near the backwater and end directly below the outlet.

The location of surface gains and return flows relative to nearby diversions can also affect reach organization. Since these gains are added to the reach outflow after all diversions have been made, a reach should not include major inflow from surface runoff or return flow in the upstream end together with large diversions at the downstream end. This might cause stored water to be used to satisfy a demand when, in fact, the demand could be met from the gains. A system can include any number and arrangement of streams which converge. Special routines must be written for streams which diverge.

Reach Gains: Tributary and surface gains are added to each reach as a single term, the reach gain. Derivation of the reach gain term requires identification of the historical flow at each end of the reach and the diversion-return flow pattern in the reach. For each month of historical data, the total change in flow from one end of the reach to the other is separated into its various parts. The tributary and surface gains can be expressed as:

REACH GAIN = OUTFLOW - INFLOW $\pm$ GROUNDWATER - RETURN FLOW
+ DIVERSION + EVAPORATION $\pm$ CHANGE IN STORAGE
$\pm$ ADJUSTMENT TO PRESENT CONDITIONS

In the above equation, reach outflow and inflow can generally be obtained from existing records. Groundwater effects, which can be gains or losses, must be obtained from detailed studies of the reach channel. Groundwater effects that are small can usually be ignored. All diversions or return flows which are not identified will be reflected in the reach gain. For small diversions or any stable diversion for which no reoperation is anticipated, it is not necessary to make any correction since it will be accounted for properly in the reach gain. The most vague term is usually the return flow. Based on the diversion practices and topography, assumptions can be made to estimate the percent return flow. Undefined return flows will be included in the reach gain. Evaporation can be considered negligible unless the reach has an unusually large surface area because of a reservoir, natural lake, or swampy area that would vary during reoperation of the system. If a reach contained a reservoir for any portion of the historical period, the effects of storage must be removed from the reach gain by adding or subtracting the monthly change in content.

If, throughout the period of historical record, the river basin has undergone development which has significantly changed the magnitude of diversions, an additional correction must be made to adjust the reach gains to a state similar to the present level of development or other stable condition. This adjustment does not have to be made for diversions which have been removed from the reach gain, but only for those not identified and those made on tributaries to the reach. For identified diversions (those which are operated), the adjustment can be applied to the diversion, and the correction will automatically be made during reoperation.

Diversions and Return Flows: The irrigation diversions which are identified during the derivation of reach gains are adjusted to a stable condition and used directly as input data (data card type #37, Table 1). Additional irrigation diversions representing future development can be in one of two forms: monthly amounts constant from year to year (data card type #22, Table 1), or simply as new or supplemental acreages (data card type #25, Table 1). Acreages that are entered must be accompanied by corresponding total diversion requirements in acre-feet per acre. Each diversion must be assigned a list of reservoir numbers denoting which reservoirs can supply storage water for that diversion and the order in which the reservoirs are to be called on. Each diversion is also given a "level limit number" as described in the RELESE subroutine description.

A series of monthly factors must be derived to account for return flow from irrigation diversions. Each diversion can have as many as ten factors which will lag the return flow over several months. The factors represent the percent of the total diversion that is returned to the river each month following the diversion. Return flow factors are necessary for all new or modified diversions and for all diversions whose return flow was removed from the reach gain.

Reservoir Characteristics: For all existing and proposed reservoirs, a surface area-content table is needed to determine approximate monthly evaporation. Several surface area values are taken at equal content intervals and used as input data. The content interval is chosen such that straight line interpolation of the surface area curve will not result in significant error. Unit evaporation data are obtained from average monthly pan evaporation measurements near the reservoir site. Other input data necessary for reservoirs are the four content values which define the three release layers described under the RELESE subroutine.

Flood Control: Flood control operations vary with river basin and, therefore, data inputs also vary. Usually flood control operations require criteria which are used to determine flood releases. This criteria can be used in conjunction with a forecast procedure or separately in the form of a fixed, content-release pattern.

Period of Operation: The river system can be operated for as many years as the necessary historical records are available. If possible, the period should be of sufficient length to be representative of the hydrologic characteristics of the basin. Often the years of least runoff are of greatest interest. For this reason, a shorter period of record can often be used for intermediate trial and error studies of alternative levels of development to conserve computation time.

SECTION II. UPPER SNAKE RIVER OPERATION

INTRODUCTION

The following section describes the adaptation of the general river operation computer program to the Upper Snake River system. Several changes were made to the general program to account for conditions unique to the Upper Snake system. All of the program features described in the Section I are retained in the Upper Snake program, but some were not used.

Much of the material described in this section may be revised in the future but at present is considered a fixed part of the operation. Criteria and data which are frequently varied for the purpose of studying management alternatives are discussed under individual study writeups.

OPERATION

Shown in Figure 4 are the reaches, diversions, and reservoirs currently operated in the Upper Snake system. Table 2 lists the 43 reaches which cover the Snake River and tributaries from Jackson Lake in Wyoming to the King Hill gaging station in Idaho. The tributaries operated are the Henrys Fork, Teton, and Falls rivers. All other tributaries are not specifically operated. Seven existing reservoirs are operated. These are: Jackson Lake, Palisades, American Falls, and Lake Walcott on the main Snake; Henrys Lake and Island Park on the Henrys Fork; and Grassy Lake in the Falls River drainage. A total of 38 diversions are made throughout the system (see diversion section).

Output data are in units of 1000 acre-feet per month and can be produced for a 41 year period, 1928 to 1968. Annual operation is successive with the end of year reservoir content being used to begin the next year.

REACH GAINS

The reach gains for the Upper Snake include all gains that could not be identified as arising from a known or estimated source. During operation the gains are added to the reach outflow after diversions have taken place as described in Section I.

All reach gains above the Milner gaging station were derived by the USBR, Snake River Planning Office. The gains were found by correcting gage differences for diversions, return flows, and channel gain or loss to groundwater. Reach gains for reaches including reservoirs were also corrected for change in storage and evaporation. The derivation of each of these gains is given in Table 3 along with the reach in which they are added during operation.

Figure 4. Reaches, diversions, and reservoirs - Upper Snake operation.

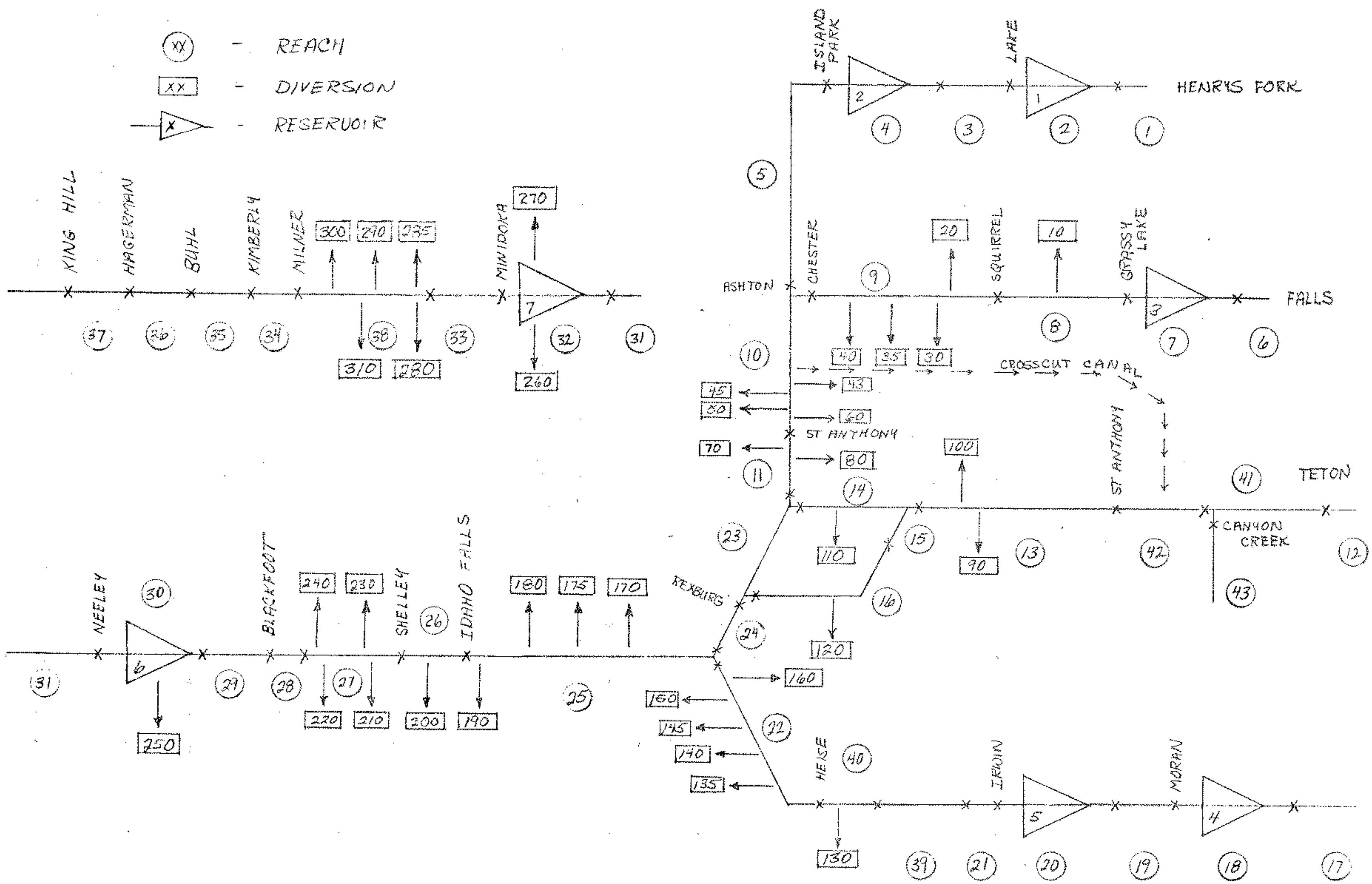


Table 2. Upper Snake Reach Descriptions.

Reach Number	Description
1	Above Henrys Lake Reservoir
2	Henrys Lake Reservoir
3	Lake to Island Park
4	Island Park Reservoir
5	Island Park to Ashton
6	Above Grassy Lake Reservoir
7	Grassy Lake Reservoir
8	Grassy Lake to Squirrel
9	Squirrel to Chester
10	Ashton to St. Anthony
11	St. Anthony to confluence with North Fork Teton
12	Above Teton Reservoir site
13	St. Anthony to division of Teton River
14	North Fork Teton River
15	South Fork Teton River above diversions
16	South Fork Teton River
17	Above Jackson Lake Reservoir
18	Jackson Lake Reservoir
19	Moran to Palisades Reservoir
20	Palisades Reservoir
21	Irwin to Lynn Crandall Reservoir site
22	Heise to confluence of Snake and Henrys Fork
23	Mouth of North Fork Teton to Rexburg
24	Rexburg to mouth of Henrys Fork
25	Mouth of Henrys Fork to Idaho Falls
26	Idaho Falls to Shelley
27	Shelley to Blackfoot River
28	Blackfoot River to Blackfoot gage
29	Blackfoot to American Falls Reservoir
30	American Falls Reservoir
31	Neeley to Lake Walcott Reservoir
32	Lake Walcott Reservoir
33	Minidoka to Milner Lake
34	Milner Lake to Kimberly
35	Kimberly to Buhl
36	Buhl to Lower Salmon Falls
37	Lower Salmon Falls to King Hill
38	Milner Lake
39	Lynn Crandall Reservoir site
40	Lynn Crandall Reservoir site to Heise
41	Teton Reservoir site
42	Teton Reservoir site to St. Anthony
43	Canyon Creek

TABLE 3
UPPER SNAKE REACH GAIN DERIVATION TO MILNER
(From USBR, Snake River Planning Office)

Reach Number	Derivation
1	+ Henrys Fork near Lake + Δ Content Henrys Lake + Henrys Lake Evaporation
3	+ Henrys Fork near Island Park - Henrys Fork near Lake + Δ Content Island Park + Island Park Evaporation
5	+ Henrys Fork near Ashton - Henrys Fork near Island Park
6	Estimated Grassy Lake Inflow
8	+ Falls River near Squirrel - Grassy Lake Inflow + Δ Content Grassy Lake + Grassy Lake Evaporation + Diversions Grassy Lake to Squirrel
9	+ Falls River near Chester - Falls River near Squirrel + Diversions Squirrel to Chester - Estimated Return Flow
10	+ Henrys Fork near St. Anthony - Henrys Fork near Ashton - Falls River near Chester + Diversions Ashton to St. Anthony - Estimated Return Flow
12	+ Teton River near St. Anthony + 50 cfs Channel Loss - Canyon Creek + Canyon Creek Canal - Crosscut Canal
43	Canyon Creek
23	+ Henrys Fork near Rexburg - Henrys Fork at St. Anthony - Teton River near St. Anthony + Diversions St. Anthony to Rexburg - Estimated Return Flow

Table 3 (Cont.)

Reach Number	Derivation
17	+ Snake River at Moran + Δ Content Jackson Lake + Jackson Lake Evaporation
19	+ Snake River near Irwin - Snake River at Moran + Δ Content Palisades + Palisades Evaporation
21	+ Snake River near Heise - Snake River near Irwin * 0.824 of above difference
40	+ Snake River near Heise - Snake River near Irwin * 0.176 of above difference + Riley Canal Diversion
26	+ Snake River near Shelley - Snake River near Heise - Henrys Fork near Rexburg + Diversions Heise to Shelley - Estimated Return Flow + Groundwater Loss
28	+ Snake River near Blackfoot - Snake River near Shelley + Diversions Shelley to Blackfoot - Estimated Return Flow + Groundwater Loss
29	+ Snake River at Neeley - Snake River near Blackfoot + Δ Content American Falls + American Falls Evaporation + Diversions Blackfoot to Neeley - Estimated Return Flow - Groundwater Gain
31	+ Snake River near Minidoka - Snake River at Neeley + Δ Content Lake Walcott + Lake Walcott Evaporation + Diversions Neeley to Minidoka - Estimated Return Flow

Table 3 (Cont.)

Reach Number	Derivation
38	+ Snake River at Milner - Snake River near Minidoka + Diversions Minidoka to Milner - Estimated Return Flow

The reach gains from Milner to King Hill were determined by an alternate method. The gain in the four reaches between the Milner, Kimberly, Buhl, Lower Salmon Falls, and King Hill gaging stations largely originates from spring flow adjacent to the river. For the period of operation, 1928 to 1968, the gain has increased significantly in all four reaches. In order to adjust the gains to a more stable condition, an attempt was made to correlate these gains with several factors that were considered possible causes for the increase. The historical gain data were analyzed for short term response of two years or less. Response of the gain due to occurrences greater than two years previous to the historical gain were not analyzed. For the reaches Milner to Lower Salmon Falls, the reach gains used in the correlation analysis were simply the differences between gaging stations. In these reaches, little information is available concerning gains and losses exclusive of the spring flows. The gains used for the Lower Salmon Falls to King Hill reach were equal to the gage difference minus the Big Wood River at Gooding.

Significant relationships were found for the reach gains in all reaches except for the Milner to Kimberly reach. Quantities used for the independent variables were various combinations of (1) the sum of the Milner-Gooding and Northside canal diversions, and (2) the sum of the discharges Big Wood River below Magic Reservoir and the Little Wood River near Richfield. Table 4 gives the equations which best approximate the annual historical gains in the three reaches from Kimberly to King Hill. All equations contain a lag varying from one to three months. For example, the Kimberly to Buhl equation relates the October through September reach gain to the preceding August through July diversions of the Milner-Gooding and Twin Falls Northside canals, a lag of two months.

Table 4. Reach Gain Equations - Kimberly to King Hill.

All gains in 1000 acre-feet per water year (Oct-Sep).

Kimberly to Buhl (reach 35).

$$GAIN = 0.246 (x) + 846.7$$

where x = Aug-Jul sum of Milner-Gooding and Northside canal diversions.

Buhl to Lower Salmon Falls (reach 36).

$$GAIN = 0.301 (x) + 2465.5$$

where x = Jul-Jun sum of Big Wood below Magic Reservoir, Little Wood near Richfield, and Milner-Gooding and Northside canals.

Lower Salmon Falls to King Hill (reach 37).

$$GAIN = 0.170 (x) + 645.7$$

where x = Sep-Aug sum of Big Wood below Magic Reservoir, Little Wood near Richfield, and Milner-Gooding and Northside canals.

The equations in Table 4 were used with adjusted diversions (see following section) to calculate new reach gains for the 1928-68 period of operation. This calculation is not a part of the river operation program; a change in the adjusted diversions used by the equations would require external derivation of new Kimberly to King Hill reach gains. Since the equations use only annual values, monthly reach gains were estimated by applying the average historical (1928-68) monthly distribution to the annual values. For the Milner to Kimberly reach, the 1970 monthly actual gain was used for the entire period.

GROUNDWATER

A groundwater term was used in the derivation of five of the reach gains above Milner. These values, listed in Table 5, are the estimated gain or loss to the groundwater system via the river channel. In other reaches, the groundwater term is either insignificant or unidentified and, consequently, is included in the reach gain data. During river operation, the groundwater term is added back into the system (see Initial Reach Operation, Section I). All groundwater data were estimated by the USBR, Snake River Planning Office in Boise.

DIVERSIONS

There are more than 100 recorded canal diversions in the Upper Snake system. To simplify calculations, these canals were divided into 38 groups. Canal diversions were grouped according to similarity of location and return flow pattern. The historical data for these groups were adjusted upward or downward to reflect present diversion practices. Some canals did not exist for the entire 1928-68 period, and others have markedly changed in the timing and quantity of diversions. Diversion data were analyzed month by month to determine

Table 5. Groundwater gains and losses - Upper Snake (1000 ac-ft).

Reach Number	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
26	-30.7	-29.7	-30.7	-30.7	-28.8	-30.7	-29.7	-30.7	-29.7	-30.7	-30.7	-29.7
28	-8.0	-8.5	-9.5	-11.5	-14.5	-20.0	-30.0	-35.7	-37.0	-38.0	-35.0	-26.8
29	170.9	162.7	173.7	173.7	156.9	173.1	166.0	166.0	152.9	157.1	158.3	157.1
42	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0

the nature of present and past diversion levels. Past diversions were adjusted up or down by the ratio of present to past level. This method preserved the year to year relationship among years for a particular month, but not necessarily the month-to-month relationship within a year. Adjusted data were not allowed to fall outside of the high and low values of the present level period.

The 38 canal groups and the individual canals are listed in Table 6. Group numbers correspond to the diversion numbers in Figure 4. Also given in Table 6 is the reach number in which the diversions occur.

RETURN FLOWS

Return flows from irrigation are lagged from one to five months. The percentage of return for all existing diversions is given in Table 7, along with the reach which receives the flow. These percentages were estimated by the USBR, Snake River Planning Office. Because few measurements of actual return flow from irrigation exist in the Upper Snake, the accuracy of Table 7 is limited and the estimates should be used accordingly. The return flow factors were used with historical diversions in the reach gain derivation. For river reoperation, they are used with adjusted diversions.

Diversions 280 through 310 have no return flow values. The return flow from these diversions enter the Milner to King Hill portion of the river for which the entire gain, including return flow, was determined by correlation (see Reach Gains section).

RESERVOIRS

The program has the capability of operating Jackson Lake, Palisades, Henrys Lake, Island Park, Grassy Lake, American Falls, and Lake Walcott reservoirs. For these seven existing reservoirs, total inflow, outflow, and end-of-month contents can be generated. Inflow and outflow only can be generated

Table 6. Upper Snake Canal Groupings.

Group Number	Group Name	Reach Number	Canals
10	YELLOWSTONE - MARYSVILLE	8	YELLOWSTONE MARYSVILLE
20	FARMERS OWN	9	FARMERS OWN BELL McBEE SILKEY
30	ENTERPRISE	9	ALMY ENTERPRISE
35	FALL RIVER	9	FALL RIVER
40	CHESTER-CURR	9	CHESTER CURR
43	FALL RIVER VIA CROSSCUT	10	CROSSCUT DIVERSION TO FALL RIVER CANALS
45	LAST CHANCE - DEWEY	10	LAST CHANCE DEWEY
50	ST ANTHONY UNION	10	ST ANTHONY UNION
60	FARMERS FRND - SALEM U	10	TWIN GROVES FARMERS FRIEND SALEM UNION

Table 6. Upper Snake Canal Groupings. (continued)

Group Number	Group Name	Reach Number	Canals
70	EGIN-INDEPENDENT	11	EGIN ST ANTHONY UNION FDR INDEPENDENT
80	CONSOLIDATED FARMERS	11	CONSOLIDATED FARMERS
90	SIDDOWAY - W JOHNSON	13	SIDDOWAY TETON IRRIGATION WOODMANSEE - JOHNSON
100	WILFORD - STEWART	13	WILFORD GOOD LUCK PIONEER STEWART
110	TETON ISLAND	14	EAMES - THOMPSON MC CORMICK - ROWE PINCOCK - BYINGTON PINCOCK - GARNER GARDNER TETON ISLAND FDR NORTH SALEM ISLAND WARD ROXANA SAURY - SUMMERS
120	REXBURG	16	REXBURG IRRIGATION CITY OF REXBURG

Table 6. Upper Snake Canal Groupings. (continued)

Group Number	Group Name	Reach Number	Canals
130	RILEY	40	RILEY
135	PROGRESSIVE - ENTERPRISE	22	EAGLE ROCK & ANDERSON FARMERS FRIEND ENTERPRISE
140	HARRISON - KITE & NORD	22	HARRISON BOOMER-RUDY KITE & NORD
145	BURGESS	22	BURGESS
150	LOWER DRY BED	22	ARNSBERGER NELSON MATSON-CRAIG BUTLER ISLAND ROSS & RAND STEELE CHENEY LOWDER-JENNINGS CLARK & EDWARDS EAST LABELLE DILTS ISLAND RIGBY LONG ISLAND & W. LABELLE PARKS & LEWISVILLE N. RIGBY WHITE ELLIS BRAMWELL

Table 6. Upper Snake Canal Groupings. (continued)

Group Number	Group Name	Reach Number	Canals
160	SUNNYDELL-TEXAS FEEDER	22	SUNNYDELL LENROOT REED TEXAS FEEDER HILL-PETTINGER NELSON - COREY
170	BUTTE & MARKET LAKE	25	BUTTE & MARKET LAKE
175	OSGOOD	25	OSGOOD
180	GREAT WESTERN & PORTER	25	KENNEDY GREAT WESTERN & PORTER BEAR ISLAND & SMITH WOODVILLE
190	IDAHO	26	IDAHO
200	SNAKE RIVER VALLEY	26	SNAKE RIVER VALLEY
210	RESERVATION	27	RESERVATION
220	BLACKFOOT - CORBETT	27	BLACKFOOT CORBETT SLOUGH NELSON - HANSEN

Table 6. Upper Snake Canal Groupings. (continued)

Group Number	Group Name	Reach Number	Canals
230	NEW LAVA SIDE - PARSONS	27	NEW LAVA SIDE RIVER SIDE DANSKIN TREGO WEARYRICK WATSON SLOUGH PARSONS
240	PEOPLES - ABERDEEN	27	PEOPLES ABERDEEN SPRINGFIELD
250	MICHAUD	30	FORT HALL MICHAUD MICHAUD
260	BURLEY SOUTH SIDE	32	BURLEY SOUTH SIDE
270	MINIDOKA NORTH SIDE	32	MINIDOKA NORTH SIDE
280	SOUTH SIDE TWIN FALLS	33	SOUTH SIDE TWIN FALLS
285	MINIDOKA NORTH SIDE PUMP	33	MINIDOKA NORTH SIDE PUMP
290	MILNER GOODING	33	MILNER GOODING
300	NORTH SIDE TWIN FALLS	33	NORTH SIDE TWIN FALLS
310	MILNER LOW LIFT	33	MILNER LOW LIFT

Table 7. Return flow percentages for diversion groups.

DIVERSION	ORDER	NUMBER	DIVERSION * REACH	PERCENT RETURN FLOW LF1	LF2	LF3	LF4	LF5	LF6	LF7	LF8	LF9	LFC	RETURN REACH
YELLOWSTN-MARYSVILLE	1	10	8	18.0	5.1	1.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	9
FARMERS OWN	2	20	9	6.0	1.8	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	9
ALMY-ENTERPRISE	3	30	9	12.0	3.6	1.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	15
FALL RIVER	4	35	9	12.0	3.6	1.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	13
CHESTER-CURR	5	40	9	18.0	5.1	1.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	10
FALL R VIA CROSSCUT	6	43	10	12.0	3.6	1.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	13
LAST CHANCE-DEWEY	7	45	10	10.0	7.1	2.7	0.9	0.3	0.0	0.0	0.0	0.0	0.0	10
ST ANTHONY UNION	8	50	10	0.0	9.2	3.7	1.5	0.6	0.0	0.0	0.0	0.0	0.0	23
FARMERS FRND-SALEM U	9	60	10	12.0	3.6	1.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	23
EGIN-INDEPENDENT	10	70	11	0.0	9.2	3.7	1.5	0.6	0.0	0.0	0.0	0.0	0.0	23
CONSOLIDATED FARMERS	11	80	11	12.0	3.6	1.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	23
SIDDOWAY-W JOHNSON	12	90	13	12.0	3.6	1.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	15
WILFORD-STEWART	13	100	13	12.0	3.6	1.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	13
TETON ISLAND	14	110	14	12.0	3.6	1.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	23
REXBURG	15	120	16	8.0	8.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24
RILEY CANAL	16	130	40	8.0	8.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22
PROGRESSIVE-ENTERPRI	17	135	22	8.0	8.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25
HARRISON-KITE & NORD	18	140	22	8.0	8.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25
BURGESS CANAL	19	145	22	8.0	8.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25
LOWER DRY BED	20	150	22	8.0	8.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25
SUNNYDELL-TEXAS FOR	21	160	22	8.0	8.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24
BUTTE & MARKET LAKE	22	170	25	8.0	8.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25
OSGOOD CANAL	23	175	25	8.0	8.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27
GRT WESTERN & PORTER	24	180	25	8.0	8.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27
IDAHO CANAL	25	190	25	8.0	8.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27
SNAKE RIVER VALLEY	26	200	26	8.0	8.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27
RESERVATION CANAL	27	210	27	6.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
BLACKFOOT-CORBETT	28	220	27	6.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27
N LAVA SIDE-PARSONS	29	230	27	6.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27
PEOPLES-ABERDEEN	30	240	27	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29
MICHAUD	31	250	30	5.0	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30
BURLEY SOUTH SIDE	32	260	32	0.0	4.0	7.0	7.0	3.0	0.0	0.0	0.0	0.0	0.0	33
MINIDOKA NORTH SIDE	33	270	32	0.0	4.0	7.0	7.0	3.0	0.0	0.0	0.0	0.0	0.0	33
SOUTH S TWIN FALLS	34	280	38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
MINIDOKA N SIDE PUMP	35	285	38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
MILNER GOODING	36	290	38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
NORTH SIDE	37	300	38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
MILNER LOW LIFT	38	310	38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0

at Lake Milner. Additional reservoirs can be added at any location by adding an extra reach and deriving inflow data. Reservoir sites for which this has been done are the Lynn Crandall and Teton sites on the Snake and Teton rivers, respectively.

Evaporation rates for the seven existing Upper Snake Reservoirs are given in Table 8. These evaporation rates, together with historical change in content values were used to calculate reach gains. The same rates are used during reoperation along with new reservoir content values to determine evaporation losses.

ASSIGNED FLOWS

Assigned flow operation is identical to that described in Section I.

FLOOD CONTROL

Jackson Lake and Palisades are the only reservoirs operated for flood control. These reservoirs are used to control flows particularly in the Heise to Roberts reach of the Snake River.

Actual flood routing through Jackson Lake and Palisades requires day-to-day operation and accurate computation of travel time. The daily forecasting and operating rules were modified to produce approximate end of month reservoir contents using only monthly data. From an examination of historical operation, a monthly space reservation diagram was developed for the program similar to the daily reservation diagram developed by the USBR and Corps of Engineers. Table 9 gives the resulting flood space required in Jackson Lake and Palisades as a function of runoff forecast at Heise and date of forecast. Since the values chosen for this table are based on judgment, the table does not necessarily reflect flood operation as originally designed, but does provide an approximate method for modeling present operation.

Table 8. Upper Snake reservoirs and monthly evaporation rates (feet).

NO.	RESERVOIR	OCT	APR	MAY	JUN	JUL	AUG	SEP
1	HENRYS LAKE	0.150	0.142	0.275	0.392	0.442	0.400	0.275
2	ISLAND PARK	0.150	0.142	0.275	0.392	0.442	0.400	0.275
3	GRASSY LAKE	0.150	0.142	0.250	0.400	0.442	0.433	0.267
4	JACKSON LAKE	0.150	0.142	0.250	0.400	0.442	0.433	0.267
5	PALISADES	0.175	0.200	0.300	0.417	0.475	0.442	0.283
6	AMERICAN FALLS	0.203	0.302	0.415	0.468	0.542	0.491	0.327
7	LAKE WALCOTT	0.276	0.392	0.482	0.621	0.759	0.673	0.484

Table 9. Flood control space required above Heise - (1000 ac-ft)

NUMBER	FORECAST	FEB 1	MAR 1	APR 1	MAY 1	JUN 1	JUL 1
1	0	-	-	-	-	-	-
2	200	-	-	-	-	-	-
3	400	-	-	-	-	-	-
4	600	-	-	-	-	-	-
5	800	-	-	-	-	-	-
6	1000	-	-	-	-	-	-
7	1200	-	-	-	-	-	40
8	1400	-	-	-	-	50	110
9	1600	-	-	-	-	170	220
10	1800	-	-	-	-	280	350
11	2000	-	-	-	-	410	500
12	2200	-	-	-	-	550	620
13	2400	-	-	-	300	680	700
14	2600	-	-	-	340	830	770
15	2800	-	-	420	400	950	800
16	3000	-	-	470	520	1030	800
17	3200	-	375	420	680	1080	800
18	3400	-	405	500	850	1100	800
19	3600	-	445	600	1010	1100	800
20	3800	-	490	720	1180	1100	800
21	4000	-	545	840	1320	1100	800
22	4200	-	605	960	1400	1100	800
23	4400	550	675	1050	1400	1100	800
24	4600	550	740	1130	1400	1100	800
25	4800	550	785	1180	1400	1100	800
26	5000	550	800	1200	1400	1100	800
27	5200	550	800	1200	1400	1100	800
28	5400	550	800	1200	1400	1100	800

Flood control operation takes place on the third pass through the system after all diversions and assigned flows have been met. To eliminate use of hindsight, an estimated beginning of month Heise forecast is used along with Table 9 to determine the required end of month space. This space is compared to the already available space and, if additional space is required, the correct amount is released at Palisades. To prevent an artifically caused flood downstream, the release is limited to the nominal channel capacity at Heise (about 20,000 cfs). January through June forecasts of total runoff through July 31 at Heise were reconstructed for the 1928-68 period for use in the flood operation. These forecasts, shown in Table 10, were derived by the USBR, Snake River Planning Office.

The balancing of flood space between Palisades and Jackson Lake is achieved through the use of the reservoir storage layers. The required release for flood control as determined above is placed below Palisades as a demand. This demand then removes the storage from both reservoirs layer by layer, and the correct balance is produced.

SPECIAL ROUTINES

Three special routines were added to the Upper Snake program to account for unique operations.

(a) The reach gain from Grassy Lake to Squirrel on the Falls River (reach 8) is allowed to enter above Yellowstone-Marysville diversion so that diversion can utilize the gain.

(b) Demands arising from the Teton River reaches 13, 14, 15, and 16 can utilize storage in Island Park Reservoir via the Crosscut Canal which diverts from the Henrys Fork (see Figure 4).

Table 10. Forecasted runoff at Heise from date to July 31.
(1000 ac-ft)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
28				3952	3704	3109	3957	3598	1726			
29				3033	3063	2840	2747	2521	1782			
30				2704	2730	2553	2152	1696	937			
31				3018	2413	1937	1503	1248	745			
32				3451	3277	3404	2952	2680	1655			
33				3369	3433	3417	2841	2603	2015			
34				2681	2521	2252	1729	1372	740			
35				3888	3608	3104	2951	2623	1901			
36				2794	3495	4109	3923	3496	1841			
37				2653	2787	2813	2770	2552	1563			
38				4238	3601	3682	3494	3073	2021			
39				3432	3524	3218	2548	2059	1076			
40				2500	2634	2610	2050	1761	934			
41				3689	3100	3026	2507	2259	1436			
42				3863	3062	3099	2435	1976	1245			
43				4583	5085	4719	4826	4053	2887			
44				2791	2792	2106	2683	2044	1449			
45				3675	3059	3275	3113	2906	2069			
46				4118	3679	3515	2853	2093	839			
47				4268	3711	3536	3449	3121	1867			
48				3525	3373	3059	2977	2677	1598			
49				4577	3778	4106	3445	2990	1751			
50				3617	3939	3586	4001	3575	2598			
51				3507	4018	4239	4055	3534	2162			
52				4106	3849	3569	3497	2999	1539			
53				2738	3641	3480	2946	2652	2037			
54				3441	3720	3531	3730	3378	2094			
55				3675	2670	2494	2658	2456	1772			
56				4973	4852	4640	4477	3690	2244			
57				3637	3433	3250	3664	3314	2294			
58				3297	3215	3091	2689	2426	1159			
59				3570	3582	3515	3191	2891	2211			
60				2692	2658	2420	2216	1854	1157			
61				3660	2925	2585	2307	2058	1316			
62				4042	3867	3763	3794	3166	1963			
63				2974	2814	2721	3079	2187	1302			
64				3619	3448	3040	3551	3291	2315			
65				4774	4505	4312	4330	3841	2731			
66				3431	3101	3558	2414	2015	1085			
67				3584	3560	3381	3391	3160	2310			
68				3620	3411	3315	3100	2848	2107			

In actual practice, the Crosscut Canal diverts to the Teton River and also supplements Fall River Canal diversions. The entire Crosscut Canal diversion is rediverted by canals on the Teton River or by Fall River canals. Because the computer program does not contain logic for rediverting a diversion, a special routine was written for this operation. To simplify the operation, the Crosscut Canal diversion is separated into two separate parts. The portion diverted by the Fall River canals is considered a single diversion from the Henrys Fork and is called "Fall River via Crosscut" (Group 43, Table 6). The remainder of the Crosscut diversion is not treated as a separate diversion. Whenever a use on Teton River cannot be satisfied from natural flow, storage from Island Park Reservoir can be utilized, if available, and the amount needed is removed from the reservoir and added to the Teton at the Crosscut Canal outlet. The stored water is then routed downstream and accounted for by the particular use on Teton River for which it was released.

(c) Lack of data concerning the division of flows between the North and South Fork of the Teton River requires simplification of actual operation. The general program does not contain logic for streams such as the Teton which diverge. It was assumed, therefore, that all flows exceeding the canal diversion requirements on both forks pass through the South Fork of the Teton. In reality, this flow represents the sum of the North and South Fork flows entering the Henrys Fork.

ADDITIONAL INPUT DATA

Table 11 lists data card types 26 through 30 which are unique to the Upper Snake system. With each variable is given the proper format and description. Data card types 1 through 25 are the same as given in Table 1 in the General Description.

TABLE 11. ADDITIONAL INPUT DATA FOR UPPER SNAKE OPERATION

Data Card Type	Number Required	Format	Variables	Variable Description[1/]
26	1	(8I3)	KKDS(I)	Reach numbers downstream from Henrys Lake to Teton River via Crosscut Canal. I = downstream order.
27	28	(6F5.0)	FLRS(I1,I2)	Monthly flood space required at Jackson Lake and Palisades reservoirs for forecasted runoff at Heise in 200,000 acre-foot increments. I1 = month (Jan = 1) I2 = increment.
28	NY	(12F5.0)	FCST(I1,I2)	Monthly forecasted runoff through July at Heise. I1 = month (Jan = 1) I2 = year order.
29	1	(6F5.0)	API(I)	Average monthly runoff at Heise. I = month (Jan = 1)
30	1	(6F5.0)	FMX(I)	Maximum monthly flow at Heise resulting from flood control release.

1/ All flow and content data in 1000 acre-feet unless otherwise noted.

OUTPUT

Primary and optional output are as explained in Section I. Table 12 shows a sample form of the main output of flows and reservoir contents. Table 13 lists the column headings and their descriptions. The summary of diversions, return flows, and shortages is summarized by branches as described in Section I. The reaches which were combined to form the branches are listed in Table 14.

CONCLUSIONS AND RECOMMENDATIONS

Certain conclusions can be drawn from the experience gained in adapting the Upper Snake River to the operation program. It was found that the data requirements of the program can be obtained for an actual river system. The relationships among gains, diversions, flows, and reservoir contents do not appear unrealistic. Consideration will be given to making some of the special routines a permanent part of the general river operation program.

Many of the data limitations were not studied in depth and should be improved as soon as possible. In particular the diversion-return flow relationships, channel losses, and Milner to King Hill reach gains should be studied further. Development of a groundwater model of the Snake River aquifers would greatly assist in predicting the groundwater gains and losses to the river.

Based on the success with the Upper Snake, it is recommended that the portion of the Snake River below King Hill be completed as soon as possible.

Table 12. Sample form of main output - Upper Snake operation (1000 ac-ft).

UPPER SNAKE RIVER OPERATION STUDY NUMBER 0.

W-YR MO	HENRYS LAKE IN	HENRYS LAKE EOM	HENRYS LAKE OUT	ISLAND PARK IN	ISLAND PARK EOM	ISLAND PARK OUT	HN FK ASHTN	GRASSY LAKE IN	GRASSY LAKE EOM	GRASSY LAKE OUT	FALLS N SQL	FALLS N CHS	HN FK ST AN	TETON IN	TETON EOM	TETON OUT	CSCUT CANAL
50 OCT	3.0	67.6	0.6	31.6	36.9	30.7	79.1	0.1	11.1	0.0	34.0	18.9	55.3	37.4	0.0	36.8	0.0
50 NOV	3.5	71.1	0.1	27.3	49.3	14.9	59.9	0.1	11.2	0.0	30.2	29.2	83.0	32.9	0.0	33.9	0.0
50 DEC	2.9	73.9	0.1	26.3	64.8	10.8	53.6	0.6	11.8	0.0	26.5	28.5	74.3	27.5	0.0	28.2	0.0
50 JAN	2.6	76.3	0.2	26.5	82.0	9.2	51.1	0.2	12.0	0.0	25.6	28.4	72.0	26.3	0.0	26.8	0.0
50 FEB	2.9	78.7	0.6	21.4	95.1	8.3	45.7	0.2	12.2	0.0	22.7	25.4	68.2	32.7	0.0	33.7	0.0
50 MAR	3.3	81.4	0.6	24.1	115.0	4.2	46.7	0.3	12.5	0.0	25.4	28.6	75.0	34.3	0.0	35.5	0.0
50 APR	4.7	83.4	1.8	30.6	130.0	14.5	80.9	0.4	12.8	0.0	33.6	35.8	104.5	50.9	0.0	54.1	0.0
50 MAY	7.3	85.9	3.1	60.7	135.0	53.5	145.5	1.6	14.3	0.0	86.4	89.7	172.2	69.1	0.0	78.4	0.0
50 JUN	10.9	90.4	3.9	54.6	135.0	51.3	123.7	2.6	15.2	1.6	130.2	123.9	181.9	129.0	0.0	137.2	0.0
50 JUL	8.5	85.0	11.0	42.2	107.0	71.6	123.0	1.7	14.0	2.8	84.3	60.0	126.3	97.2	0.0	101.2	0.0
50 AUG	5.2	76.9	10.8	41.1	63.7	76.7	123.0	0.8	12.0	2.7	33.5	15.1	76.7	51.9	0.0	53.0	0.9
50 SEP	3.2	72.4	4.0	35.3	55.3	42.3	89.3	0.7	11.0	1.6	33.4	23.5	85.2	44.2	0.0	45.2	0.0
50 TOTAL	58.0		38.6	421.5		388.0	1021.5	9.3		8.7	565.8	507.0	1214.5	633.4		666.0	0.9

W-YR MO	TETON ST AN	TETON NGS F	HN FK PFXBG	HN FK MOUTH	JACKSON LAKE IN	JACKSON LAKE EOM	JACKSON LAKE OUT	PALISADES IN	PALISADES EOM	PALISADES OUT	L CDL IN	L CDL EOM	SNAKE L CDL	SNAKE HEISE	SNAKE HN FK	SNAKE I FLS	SNAKE SHLLY
50 OCT	35.8	23.2	128.8	137.5	35.2	500.0	81.7	258.3	966.7	123.0	152.4	0.0	152.4	158.7	21.5	171.7	188.8
50 NOV	30.9	25.1	107.7	112.6	26.9	509.0	17.9	172.7	1000.0	139.3	161.5	0.0	161.5	166.2	166.3	306.4	274.8
50 DEC	25.2	23.1	51.4	53.0	23.9	514.5	18.4	154.0	1000.0	154.0	172.0	0.0	172.0	175.9	175.9	277.8	248.1
50 JAN	23.8	22.8	87.9	88.1	35.5	531.6	18.4	142.1	1049.9	92.2	107.8	0.0	107.8	111.1	111.1	199.3	146.2
50 FEB	30.7	30.5	95.8	95.9	34.2	549.1	16.7	128.7	1123.0	55.5	73.1	0.0	73.1	76.8	76.8	172.7	130.3
50 MAR	32.5	32.2	107.3	107.3	33.9	558.4	24.6	150.9	1185.6	88.3	111.3	0.0	111.3	116.2	116.2	223.6	196.8
50 APR	51.1	43.6	143.1	143.4	43.7	450.0	148.8	486.1	760.7	908.1	948.0	0.0	948.0	956.5	921.0	1060.1	1049.4
50 MAY	75.4	38.7	176.8	181.2	166.3	530.0	80.6	824.3	909.5	672.4	734.4	0.0	734.4	747.1	559.9	684.8	620.5
50 JUN	134.2	72.5	258.3	267.5	452.2	839.8	133.1	1328.3	1300.0	932.9	973.3	0.0	973.3	980.9	703.1	883.9	864.6
50 JUL	98.2	31.1	152.6	166.9	238.5	847.0	220.0	1037.9	1380.0	950.6	976.6	0.0	976.6	980.6	604.2	661.8	653.2
50 AUG	50.9	0.0	75.1	93.0	81.0	700.0	216.9	538.2	1313.7	597.4	626.7	0.0	626.7	631.6	283.3	294.0	256.0
50 SEP	42.2	13.4	106.5	119.6	46.9	609.4	130.9	371.5	1360.0	320.7	347.5	0.0	347.5	352.8	129.2	214.4	198.8
50 TOTAL	630.9	356.3	1534.2	1606.1	1218.2		1108.0	5593.0		5034.6	5384.8		5384.8	5454.6	3868.7	5150.3	4827.3

W-YR MO	SNAKE BLKFT	AMERICAN FALLS IN	AMERICAN FALLS EOM	AMERICAN FALLS OUT	LAKE WALCOTT IN	LAKE WALCOTT EOM	LAKE WALCOTT OUT	MILNR INFLD	SNAKE MILNR	SNAKE KMBLY	SNAKE BUHL	SNAKE HGRMN	BIG W GDING	SNAKE KG HI
50 OCT	170.9	370.7	479.9	158.2	165.2	87.0	139.7	182.6	12.3	35.0	157.8	443.5	2.5	535.8
50 NOV	285.9	455.6	876.5	59.5	80.8	50.0	117.8	132.5	64.4	85.7	193.7	467.6	4.7	566.9
50 DEC	245.0	411.9	1104.1	184.5	206.5	40.0	216.5	228.2	219.0	239.1	343.3	615.5	3.3	714.7
50 JAN	136.2	322.8	1250.0	176.9	199.7	40.0	199.7	213.2	213.2	233.3	330.0	593.3	3.7	693.0
50 FEB	129.7	298.1	1242.0	266.1	283.7	60.0	263.7	274.0	274.0	291.2	376.1	612.5	9.9	711.7
50 MAR	196.2	392.9	1550.0	124.9	139.1	90.0	109.1	113.8	102.3	120.0	208.8	463.5	14.5	578.2
50 APR	1031.1	1227.0	1700.0	1060.2	1081.2	97.0	1035.7	1027.8	866.4	882.4	978.7	1217.3	42.4	1343.2
50 MAY	458.4	675.4	1700.0	647.0	667.3	97.0	511.3	520.7	16.6	35.6	142.2	384.2	29.9	482.3
50 JUN	690.9	909.1	1760.0	872.0	892.4	97.0	749.6	766.0	246.3	265.9	377.9	627.3	14.5	711.5
50 JUL	441.9	667.8	1500.0	822.4	826.6	97.0	619.3	646.2	39.7	61.7	173.4	417.8	4.3	493.6
50 AUG	86.1	301.1	1032.4	733.1	737.5	97.0	568.8	596.3	20.3	44.0	161.9	413.7	6.0	497.4
50 SEP	110.1	300.4	815.6	497.4	515.3	95.0	415.0	446.7	14.9	39.6	158.6	439.0	9.2	519.1
50 TOTAL	3982.5	6332.9		5602.2	5795.3		4946.0	5147.9	2089.3	2333.4	3602.3	6700.5	144.9	7847.3

TABLE 13. PRIMARY OUTPUT COLUMN DESCRIPTIONS.

Order	Column Heading		Description
1	HENRYS LAKE	IN	Inflow to Henrys Lake Reservoir
2		EOM	End of month contents at Henrys Lake Reservoir
3		OUT	Total flow from Henrys Lake Reservoir
4	ISLAND PARK	IN	Inflow to Island Park Reservoir
5		EOM	End of month contents at Island Park Reservoir
6		OUT	Total flow from Island Park Reservoir
7	HN FK ASHTN		Total flow at Henrys Fork near Ashton stream gage
8	GRASSY LAKE	IN	Inflow to Grassy Lake Reservoir
9		EOM	End of month contents at Grassy Lake Reservoir
10		OUT	Total flow from Grassy Lake Reservoir
11	FALLS N SQL		Total flow at Falls River near Squirrel stream gage
12	FALLS N CHS		Total flow at Falls River near Chester stream gage
13	HN FK ST AN		Total flow at Henrys Fork near St. Anthony stream gage
14	TETON	IN	Total flow directly above proposed Teton Reservoir
15		EOM	Not used
16		OUT	Total flow at Teton Reservoir site
17	CSCUT CANAL		Total flow entering Teton River from Crosscut Canal
18	TETON ST AN		Total flow at Teton River near St. Anthony stream gage
19	TETON N&S F		Combined flow of North and South Fork of Teton River at Henrys Fork
20	HN FK REXBG		Total flow at Henrys Fork near Rexburg stream gage
21	HN FK MOUTH		Total flow of Henrys Fork at confluence with Snake River
22	JACKSON LAKE	IN	Inflow to Jackson Lake Reservoir
23		EOM	End of month contents at Jackson Lake Reservoir
24		OUT	Total flow from Jackson Lake Reservoir
25	PALISADES	IN	Inflow to Palisades Reservoir
26		EOM	End of month contents at Palisades Reservoir
27		OUT	Total flow from Palisades Reservoir
28	L CDL	IN	Total flow directly above Lynn Crandall Reservoir site
29		EOM	Not used
30	SNAKE L CDL		Total flow at Lynn Crandall Reservoir site
31	SNAKE HEISE		Total flow at Snake River near Heise stream gage
32	SNAKE HN FK		Total flow of Snake River above confluence with Henrys Fork
33	SNAKE I FLS		Total flow of Snake River at Idaho Falls
34	SNAKE SHLLY		Total flow at Snake River near Shelley stream gage

Table 13 (Cont.)

Order	Column Heading		Description
35	SNAKE BLKFT		Total flow at Snake River near Blackfoot stream gage
36	AMERICAN FALLS	IN	Inflow to American Falls Reservoir
37		EOM	End of month contents at American Falls Reservoir
38		OUT	Total flow from American Falls Reservoir
39	LAKE WALCOTT	IN	Inflow to Lake Walcott Reservoir
40		EOM	End of month contents at Lake Walcott Reservoir
41		OUT	Total flow from Lake Walcott Reservoir
42	MILNR INFLO		Inflow to Milner Lake
43	SNAKE MILNR		Total flow at Snake River at Milner stream gage
44	SNAKE KMBLY		Total flow at Snake River near Kimberly stream gage
45	SNAKE BUHL		Total flow at Snake River near Buhl stream gage
46	SNAKE HGRMN		Total flow at Snake River near Hagerman stream gage
47	BIG W GDING		Total flow at Big Wood River near Gooding stream gage
48	SNAKE KG HL		Total flow at Snake River at King Hill Stream gage

Table 14. Reaches grouped into branches - Upper Snake River.

BRANCH	REACHES INCLUDED
FALLS	6, 7, 8
TETON	12, 43, 41, 42, 13, 14, 15, 16
HENRYS FORK	1, 2, 3, 4, 5, 10, 11, 23
ABOVE HEISE	17, 18, 19, 20, 21, 39, 40
HEISE - SHELLEY	22, 24, 25, 26
SHELLEY - BLACKFOOT	27, 28
BLACKFOOT - NEELEY	29, 30
NEELEY - MINIDOKA	31, 32
MINIDOKA - MILNER	33, 38
MILNER - KING HILL	34, 35, 36, 37

APPENDIX A
UPPER SNAKE BASIN - BASE STUDY
July, 1972

OBJECTIVE

Indicators and criteria were chosen to approximate a "present condition" study (1) to verify the capability of the operation program to realistically model a level of management, and (2) to provide a base study for evaluation of subsequent studies of various management alternatives.

CONCEPT

Conditions in the Upper Snake Basin are constantly changing as a result of changes in man-made structures and method of control. A "present condition" operation could consist of many different data sets and rules for data use. For this study, general assumptions were made defining a present condition operation which would best meet the objectives given above. The three basic assumptions are: (a) the "present" is the year 1970 or any period immediately preceding 1970 which indicates a stable condition for the particular data or criteria being considered; (b) all present structural controls exist throughout the entire period of operation; and (c) all structures are operated throughout the period to reflect the type of operation prevailing in 1970.

The above assumptions determined partially or wholly the methods used to derive hydrologic data for the Base Study and in the selection of operational constraints.

HYDROLOGIC DATA

All reach gain, diversion, and groundwater data used in the Base Study are as described in the Upper Snake River Operation description (Section II). These data were derived according to the present condition assumptions. Although the data are subject to variation with study of objective, most or all of the data will also be used repeatedly in future studies.

SYSTEM DESCRIPTION

The Base Study operation includes 44 reaches and 38 diversions as described in Section II. No additional reaches or diversions were added.

Table 15 lists the seven reservoirs which were operated together with their initial, maximum, and minimum contents. The initial reservoir contents used to begin the study were assumed equal to the 1965-69 average end of September contents as shown in Table 16.

Figure 4 accurately represents the system configuration for the Base Study.

INDICATORS AND CONTROL DATA

Assuming a fixed configuration of reaches, diversions, and reservoirs, operation of the river system can vary greatly depending on the choice of indicators and other controlling input data. These variables are:

(a) assigned flow reservoir call order

(b) diversion reservoir call order

(c) diversion level limits

(d) assigned flows

(e) reservoir levels

The above variables were used as described in the Section I. They are extremely interrelated and, therefore, cannot be chosen independently. For the Base Study, the indicators were chosen by examination of the recent (1959-70) discharge and content records, and by using trial and error methods to approximate the historical pattern of operation.

Tables 17 through 20 list all indicators and control data used in the Base Study. The following paragraphs attempt to describe, in general, the reasoning used in the selection of these numbers. It is possible that some of the indicators did not control the operation because they were over-ridden by other criteria.

Table 15. Base study reservoir data - Upper Snake River.

NUMBER	RESERVOIR	INITIAL CONTENTS	MAX CONTENTS	MIN CONTENTS
1	HENRYS LAKE	71.9	84.4	0.0
2	ISLAND PARK	78.9	135.0	0.0
3	GRASSY LAKE	8.7	15.2	0.0
4	JACKSON LAKE	572.5	847.0	0.0
5	PALISADES	1001.0	1400.0	200.0
6	AMERICAN FLS	503.0	1700.0	0.0
7	LAKE WALCOTT	85.4	97.0	0.0

Table 16. Determination of initial reservoir contents - Upper Snake (1000 ac-ft).

YEAR	SEPTEMBER END OF MONTH CONTENTS					YEAR 1/	SEPTEMBER EOM CONTENTS	
	JACKSON LAKE	PALISADES	AMERICAN FALLS	LAKE WALCOTT	GRASSY LAKE		ISLAND PARK	HENRYS LAKE
65	631.6	1361.0	1023.0	95.3	11.3	64	68.7	62.8
66	516.8	471.0	9.0	49.7	6.6	65	102.8	70.4
67	558.8	1028.0	494.0	95.8	9.6	67	80.8	75.6
68	585.5	1295.0	751.0	94.0	9.2	68	90.2	77.8
69	569.7	849.0	239.0	92.3	7.0	69	52.1	72.6
AVG	572.5	1001.0	503.0	85.4	8.7	AVG	78.9	71.9

1/ 1966 NOT USED BECAUSE OF ABNORMAL OPERATION.

Table 17. Base Study assigned flow reservoir call orders.

REACH	ASSIGNED FLOW STORAGE							
1	0	0	0	0	0	0	0	0	0
2	1	0	0	0	0	0	0	0	0
3	1	0	0	0	0	0	0	0	0
4	2	0	0	0	0	0	0	0	0
5	2	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	3	0	0	0	0	0	0	0	0
8	3	0	0	0	0	0	0	0	0
9	3	0	0	0	0	0	0	0	0
10	2	1	0	0	0	0	0	0	0
11	2	1	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0
18	4	0	0	0	0	0	0	0	0
19	4	0	0	0	0	0	0	0	0
20	5	0	0	0	0	0	0	0	0
21	5	0	0	0	0	0	0	0	0
22	8	5	4	0	0	0	0	0	0
23	2	1	0	0	0	0	0	0	0
24	2	1	0	0	0	0	0	0	0
25	8	5	4	0	0	0	0	0	0
26	8	5	4	0	0	0	0	0	0
27	8	5	4	0	0	0	0	0	0
28	8	5	4	0	0	0	0	0	0
29	8	5	4	0	0	0	0	0	0
30	6	0	0	0	0	0	0	0	0
31	6	8	5	4	0	0	0	0	0
32	6	0	0	0	0	0	0	0	0
33	6	8	5	4	0	0	0	0	0
34	6	8	5	4	0	0	0	0	0
35	6	8	5	4	0	0	0	0	0
36	6	8	5	4	0	0	0	0	0
37	6	8	5	4	0	0	0	0	0
38	6	8	5	4	0	0	0	0	0
39	8	5	4	0	0	0	0	0	0
40	8	5	4	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0

Table 18. **Base Study diversion reservoir call orders and diversion level limits.**

DIVERSION	ORDER	NUMBER	STORAGE CALL ORDER									LEVEL LIMIT
YELLOWSTN-MARYSVILLE	1	10	3	0	0	0	0	0	0	0	0	4
FARMERS OWN	2	20	3	0	0	0	0	0	0	0	0	4
ALMY-ENTERPRISE	3	30	3	0	0	0	0	0	0	0	0	4
FALL RIVER	4	35	3	0	0	0	0	0	0	0	0	4
CHESTER-CURR	5	40	3	0	0	0	0	0	0	0	0	4
FALL R VIA CROSSCUT	6	43	2	1	0	0	0	0	0	0	0	4
LAST CHANCE-DEWEY	7	45	2	1	0	0	0	0	0	0	0	4
ST ANTHONY UNION	8	50	2	1	0	0	0	0	0	0	0	4
FARMERS FRND-SALEM U	9	60	2	1	0	0	0	0	0	0	0	4
EGIN-INDEPENDENT	10	70	2	1	0	0	0	0	0	0	0	4
CONSOLIDATED FARMERS	11	80	2	1	0	0	0	0	0	0	0	4
SIDDOWAY-W JOHNSON	12	90	2	0	0	0	0	0	0	0	0	4
WILFORD-STEWART	13	100	2	0	0	0	0	0	0	0	0	4
TETON ISLAND	14	110	2	0	0	0	0	0	0	0	0	4
REXBURG	15	120	2	0	0	0	0	0	0	0	0	4
RILEY CANAL	16	130	8	5	4	0	0	0	0	0	0	4
PROGRESSIVE-ENTERPRI	17	135	8	5	4	0	0	0	0	0	0	4
HARRISON-KITE & NORD	18	140	8	5	4	0	0	0	0	0	0	4
BURGESS CANAL	19	145	8	5	4	0	0	0	0	0	0	4
LOWER DRY BED	20	150	8	5	4	0	0	0	0	0	0	4
SUNNYDELL-TEXAS FOR	21	160	8	5	4	0	0	0	0	0	0	4
BUTTE & MARKET LAKE	22	170	8	5	4	0	0	0	0	0	0	4
OSGOOD CANAL	23	175	8	5	4	0	0	0	0	0	0	4
GRT WESTERN & PORTER	24	180	8	5	4	0	0	0	0	0	0	4
IDAHO CANAL	25	190	8	5	4	0	0	0	0	0	0	4
SNAKE RIVER VALLEY	26	200	8	5	4	0	0	0	0	0	0	4
RESERVATION CANAL	27	210	8	5	4	0	0	0	0	0	0	4
BLACKFOOT-CORBETT	28	220	8	5	4	0	0	0	0	0	0	4
N LAVA SIDE-PARSONS	29	230	8	5	4	0	0	0	0	0	0	4
PEOPLES-ABERDEEN	30	240	8	5	4	0	0	0	0	0	0	4
MICHAUD	31	250	6	8	5	4	0	0	0	0	0	4
BURLEY SOUTH SIDE	32	260	6	8	5	4	7	0	0	0	0	4
MINIDOKA NORTH SIDE	33	270	6	8	5	4	7	0	0	0	0	4
SOUTH S TWIN FALLS	34	280	6	8	5	4	7	0	0	0	0	4
MINIDOKA N SIDE PUMP	35	285	6	8	5	4	7	0	0	0	0	4
MILNER GOODING	36	290	6	8	5	4	7	0	0	0	0	4
NORTH SIDE	37	300	6	8	5	4	7	0	0	0	0	4
MILNER LOW LIFT	38	310	6	8	5	4	7	0	0	0	0	4

Table 19. Upper Snake Base Study Assigned Reach Outflows.

		ASSIGNED FLOWS (CFS)											
REACH	LEVEL	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
2	1	30.	30.	30.	30.	30.	100.	200.	200.	10.	175.	175.	100.
2	2	10.	10.	10.	10.	10.	10.	30.	50.	10.	100.	100.	60.
2	3	1.	1.	1.	3.	3.	3.	5.	5.	10.	90.	70.	30.
4	1	800.	800.	800.	300.	300.	500.	400.	15.	850.	1000.	1000.	500.
4	2	500.	250.	175.	150.	150.	200.	40.	15.	650.	1000.	1000.	500.
4	3	20.	20.	8.	8.	8.	15.	15.	15.	650.	1000.	1000.	500.
5	1	0.	0.	0.	0.	0.	0.	0.	0.	1700.	2000.	2000.	1500.
5	2	0.	0.	0.	0.	0.	0.	0.	0.	1500.	2000.	2000.	1500.
5	3	0.	0.	0.	0.	0.	0.	0.	0.	1500.	2000.	2000.	1300.
18	1	400.	400.	400.	400.	400.	400.	400.	400.	1000.	2800.	2800.	2200.
18	2	200.	300.	300.	300.	300.	300.	200.	100.	1000.	2800.	2800.	1000.
18	3	100.	200.	200.	200.	200.	200.	100.	50.	50.	2800.	2800.	500.
20	1	2000.	3000.	3000.	3000.	3000.	1200.	2000.	7500.	1200.	1200.	1200.	1200.
20	2	2000.	1500.	1500.	1500.	1000.	1000.	1200.	7500.	1200.	1200.	1200.	1200.
20	3	1800.	1200.	1200.	1200.	900.	900.	1000.	1200.	1200.	1200.	1200.	1200.
23	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	1200.	1200.	1200.
23	2	0.	0.	0.	0.	0.	0.	0.	0.	0.	1000.	1000.	1000.
23	3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	1	2000.	2300.	2300.	2300.	2300.	2300.	2300.	5000.	5000.	5000.	4000.	3000.
26	2	2000.	2300.	2300.	2300.	2300.	2300.	2300.	5000.	5000.	5000.	4000.	3000.
26	3	2000.	2300.	2300.	2300.	2300.	2300.	2300.	5000.	5000.	5000.	4000.	3000.
28	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	1400.	1400.	1000.
28	2	0.	0.	0.	0.	0.	0.	0.	0.	0.	1400.	1400.	1000.
28	3	0.	0.	0.	0.	0.	0.	0.	0.	0.	1400.	1400.	1000.
30	1	500.	3000.	3000.	3000.	200.	300.	2000.	0.	0.	0.	0.	0.
30	2	500.	1000.	2000.	200.	200.	200.	0.	0.	0.	0.	0.	0.
30	3	500.	500.	200.	200.	200.	200.	0.	0.	0.	0.	0.	0.
38	1	200.	300.	400.	500.	500.	300.	150.	70.	20.	330.	330.	250.
38	2	200.	300.	400.	500.	500.	300.	150.	70.	20.	100.	250.	90.
38	3	200.	300.	400.	500.	500.	300.	150.	70.	20.	5.	5.	5.

Table 20. Upper Snake Base Study reservoir storage levels.

RESERVOIR	LVL	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
HENRYS LAKE	1	78.0	79.0	82.0	86.0	87.0	87.0	87.0	88.0	90.4	85.0	80.0	77.0
	2	75.0	78.0	79.0	81.0	83.0	85.0	85.0	86.0	80.0	75.0	75.0	70.0
	3	50.0	76.0	77.0	77.0	77.0	80.0	80.0	83.0	70.0	50.0	50.0	50.0
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ISLAND PARK	1	90.0	105.0	110.0	120.0	130.0	135.0	135.0	135.0	135.0	125.0	105.0	105.0
	2	85.0	95.0	100.0	110.0	120.0	130.0	130.0	0.0	130.0	95.0	95.0	75.0
	3	25.0	30.0	30.0	75.0	95.0	115.0	120.0	0.0	100.0	50.0	50.0	20.0
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GRASSY LAKE	1	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	14.0	12.0	11.0
	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JACKSON LAKE	1	650.0	650.0	650.0	650.0	650.0	650.0	680.0	847.0	847.0	847.0	700.0	650.0
	2	500.0	590.0	600.0	600.0	610.0	530.0	530.0	530.0	800.0	780.0	640.0	550.0
	3	350.0	100.0	100.0	120.0	150.0	450.0	450.0	500.0	600.0	550.0	500.0	350.0
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PALISADES	1	1340.0	1300.0	1250.0	1250.0	1250.0	1400.0	1400.0	1400.0	1400.0	1380.0	1360.0	1360.0
	2	1000.0	1000.0	1000.0	1100.0	1200.0	920.0	920.0	920.0	1300.0	1200.0	1200.0	1200.0
	3	300.0	750.0	800.0	950.0	1000.0	800.0	800.0	800.0	800.0	650.0	600.0	400.0
	4	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0
AMERICAN FLS	1	1100.0	1200.0	1282.0	1282.0	1282.0	1550.0	1700.0	1700.0	1700.0	1500.0	1200.0	1100.0
	2	200.0	1000.0	1050.0	1250.0	0.0	0.0	0.0	0.0	0.0	1000.0	900.0	200.0
	3	150.0	400.0	1000.0	1200.0	0.0	0.0	0.0	0.0	0.0	300.0	100.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAKE WALCOTT	1	87.0	50.0	40.0	40.0	60.0	90.0	97.0	97.0	97.0	97.0	97.0	95.0
	2	40.0	40.0	40.0	40.0	40.0	85.0	95.0	95.0	95.0	95.0	95.0	50.0
	3	25.0	40.0	40.0	40.0	40.0	85.0	90.0	92.0	92.0	92.0	55.0	35.0
	4	5.0	40.0	40.0	40.0	40.0	50.0	70.0	80.0	60.0	40.0	30.0	15.0

The assigned flow reservoir call order (Table 17) lists the identification number from Table 15 of the reservoir from which storage was specified to be used in the Base Study to satisfy assigned flows. The numbers are given in the order of priority of stored water use. In most cases for a given reach, all upstream reservoirs were included. An exception to this is the Snake River below Henrys Fork which did not utilize storage on the Henrys Fork in the Base Study. Also, in most cases, the assigned outflow at a reservoir was used to regulate only that reservoir and did not utilize storage further upstream.

The diversion reservoir call order is a similar storage source control for irrigation diversions. Table 18 shows a separate call order for each diversion operated in the Base Study. In the Upper Snake system, a stored water right in one reservoir can physically be satisfied from another reservoir if other rights are not harmed. Storage can be exchanged, rented, and/or borrowed among water right holders. Because of these factors, diversions were not limited to withdrawal of storage from a single reservoir, but in general were satisfied from all upstream reservoirs. Henrys Fork reservoirs were not called upon to supply the main Snake River diversions because the Henrys Fork is in general operated independently of the Snake. Diversions were allowed to use all three storage layers (level limit 4) as shown in Table 18 because present operation does allow all reservoirs to empty in years of extremely low runoff.

Assigned flows and reservoir levels were chosen simultaneously in most cases since they are interdependent in producing a desired operation. In general, the maximum monthly storage in a reservoir was limited to the historical maximum for that month. Also, assigned flows from layer three were chosen as the approximate historical minimum. The term "historical" here means the actual measurements during the 1959 to 1970 period. During this period, all reservoirs and most diversions did exist and all reservoirs had historically filled and reached a normal operation. This period contained years of both very high and very low runoff. From examination of historical records, it was evident that nonreservoir reaches often are important control points in the system operation. For these points assigned flows were selected in conjunction with upstream reservoir levels as described in the following paragraphs. Tables 19 and 20 list the assigned reach outflows and the reservoir levels chosen for the Base Study. The levels and flows are discussed below for each reservoir, for non-reservoir reaches, and as a system. A basic assumption in using levels and flows is that there is a correlation between discharge and reservoir content.

OPERATION OF CRITICAL CONTROL POINTS

Henrys Lake - Island Park: Henrys Lake and Island Park Reservoir levels were chosen to achieve a balance in storage between the two reservoirs throughout the year. The levels increase from November through May to simulate a filling operation. Assigned flows decrease with decrease in content based on the historical records. Assigned flows are small at Henrys Lake since that reservoir is considered difficult to fill after a large drawdown. The minimum flow at both reservoirs is equal to the leakage or slightly greater. If Henrys Lake has not filled by June and Island Park has not filled by May, outflows are reduced greatly. During the irrigation season, May through October, flows are usually controlled by irrigation demands.

Grassy Lake: To reproduce actual operation of Grassy Lake, only the irrigation diversions on Falls River were allowed to use this storage. Maximum levels July through September were set to achieve minimum drawdown. Because the reservoir is offstream and used only for irrigation, no assigned flows were used.

<u>Jackson Lake - Palisades</u>: Jackson Lake and Palisades reservoir levels were chosen to achieve a balance of storage between the two reservoirs during the flood control and irrigation season.

From October through February, control at both reservoirs is based only on a flow versus contents relationship. An attempt is made to store only a small amount at Jackson Lake if its contents are near 600,000 acre-feet. During this period, Jackson Lake storage is generally limited to about 650,000 for flood control. At contents less than 650,000, storage is permitted and outflows are reduced (reach 18). The level of Palisades Reservoir is maintained as high as possible for power production and releases (reach 20) above 1500 cfs are desirable for the same purpose.

From February to June, a large runoff forecast may result in releases for flood control much greater than the assigned flows. During this period, the levels serve as a balancing mechanism to provide the correct amounts of flood space in each reservoir. At least 200,000 acre-feet of space is held in Jackson Lake each year until late in April regardless of the forecasted runoff. It is attempted to fill Palisades as soon after March 1 as possible and to fill Jackson Lake by the end of May.

Irrigation demands control the Palisades outflow from June to October while the levels again balance storage with Jackson Lake. The assigned flows at Jackson Lake do control during the irrigation season when storage is being released from Palisades. This procedure provides a smoother and more realistic reservoir operation. At the end of the irrigation season, Jackson Lake is drawn down to at least 650,000 acre-feet, but it is desirable not to go below 550,000 if possible. Below this level, outflow is reduced significantly.

American Falls: American Falls Reservoir is operated primarily for irrigation. A secondary function of the reservoir is to provide flow for power at Minidoka Dam (Reach 32) during the winter. From November to February, as much as 3000 cfs is released if carryover has been good. It is attempted to fill American Falls to 1,282,000 acre-feet by February and still maintain power flows. Therefore, the levels rise each month to the one level of 1,282,000 in February. Because of the danger of dam failure from ice loading, this level cannot be exceeded until the ice layer melts and reduces stress on the dam. It is assumed that the ice leaves about March 15 and that a level of 1,550,000 acre-feet is attainable by the end of March. In February and March, outflows are greatly reduced (about 200 cfs) if the reservoir is below the maximum levels.

There is no flood control operation at American Falls. Irrigation demands control releases from April to October. The reservoir is normally full by the end of April but in some years heavy spring diversions delay filling. From April through June, irrigation demands are allowed to use any amount of American Falls storage before using storage further upstream. From July through October, the American Falls levels were chosen in relation to Palisades - Jackson Lake levels to simulate the historical release pattern. The levels chosen cause most of the downstream storage to be used before drafting Palisades space and all of it to be used before drafting Jackson Lake space.

Lake Walcott: Storage in Lake Walcott is used to provide head for power production. By the end of December, the lake is drawn down to 40,000 acre-feet to prevent ice buildup against the top of the dam. This level is maintained throughout the winter. When the ice danger has passed, the lake is gradually filled, reaching near capacity by the end of April in a normal year. Releases are generally controlled by the American Falls outflow. During the summer, contents are kept as great as possible for power head as flows past the dam are downstream irrigation demands on American Falls Reservoir. Lake Walcott storage is used for irrigation only after American Falls is nearly empty. As shown in Table 18, Lake Walcott (reservoir 7) is the last reservoir in the storage call order for all downstream diversions.

Reach 5 - Henrys Fork near Ashton: Except in years of large runoff, the flows from June through September at the Ashton gage on the Henrys Fork are fairly stable from year to year regardless of irrigation demand. Flows ranging from 1500 to 2000 cfs were assigned for these four months. These flows then cause varying releases from Island Park and Henrys Lake depending on the gain from Island Park to Ashton.

Reach 23 - Henrys Fork near Rexburg: Assigned flows at Rexburg together with those at Ashton are necessary to model present operation of the Henrys Fork system in the late summer. Flows in excess of diversion requirements pass Rexburg during the irrigation season and ultimately add to the storage in American Falls Reservoir. Flows of 1000 to 1200 cfs were assigned to the Rexburg gage. These are particularly important in the month of September when releases are made in the Henrys Fork expressly for prior rights on the main Snake River. In the winter, flows at Rexburg are the result of return flows, natural runoff, and minor storage releases.

Reaches 26 and 28 - Snake River near Shelley and Blackfoot: The Upper Snake Watermaster attempts to maintain approximate minimum flows past Shelley and Blackfoot on Snake River for irrigation below these points. To simulate actual operation, a flow at Shelley of 5000 cfs was selected for May through July, 4000 cfs in August, 3000 cfs in September, and 2000 cfs in October. At Blackfoot, a flow of 1400 cfs was established in July and August and 1000 cfs in September. For other months, Shelley flows alone are controlling. From

November to March, a 2300 cfs minimum was selected for Shelley. In years of good runoff, this flow is greatly exceeded.

Reach 38 - Snake River at Milner: The various entities which manage the Snake River presently consider any and all water passing Milner Dam as "waste." The flows at Milner are, therefore, kept as small as possible while still satisfying downstream power rights held by Idaho Power Company. From November through March assigned flows range from 300 to 500 cfs to model this operation. In most years, these flows are exceeded at Milner because of either power releases at American Falls for the Minidoka power plant or flood releases above Heise combined with natural inflow not storable at American Falls.

Unless flood releases are being spilled at American Falls, flows past Milner in May and June are almost zero as a result of the filling of upstream reservoirs. In July, August, and September, about 300 cfs passes Milner in average or good winter years to satisfy the Idaho Power Company storage release of 45,000 acre-feet from American Falls Reservoir. However, in short water years, this right is usually not exercised and flows approach zero.

VERIFICATION

Indicators and control data were changed until the operation study produced a reasonable reproduction of the 1959-1968 historical data. In verification studies, actual September, 1958, end of month reservoir contents were used for initial reservoir contents.

Average flows and reservoir contents produced by the present condition operation are compared to the historical values in Table 21. Differences can be explained by the generalized criteria necessary for the reoperation. Also in some cases, the present condition data and constraints did not exist over the entire historical period. Significant factors which have varied in the ten year

Table 21. Comparison of Historical and Base Study Verification Discharge and Content Data. (1000 ac-ft) (values are 1959-68 averages)

CONTENTS JACKSON LAKE NR MORAN

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
HISTORICAL	478.4	485.6	493.4	500.5	492.0	478.5	485.3	618.3	800.3	721.1	581.0	494.8
STUDY	489.4	498.3	508.2	513.1	521.9	520.2	532.5	683.3	812.9	762.0	596.8	508.8

CONTENTS PALISADES RESERVOIR NEAR IRWIN

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
HISTORICAL	809.3	859.1	901.0	938.3	978.5	1002.2	1079.6	1090.8	1287.6	1135.1	945.9	845.5
STUDY	797.8	836.1	862.7	900.0	943.5	983.3	1052.8	1084.1	1296.0	1119.5	928.1	820.1

DISCHARGE SNAKE RIVER NEAR HEISE

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
HISTORICAL	216.9	142.1	135.9	130.5	134.5	164.5	247.9	745.2	872.4	840.6	639.5	437.4	4707.3
STUDY	201.1	151.9	149.1	132.8	113.7	136.7	250.3	707.4	909.9	835.5	665.7	446.4	4700.6

DISCHARGE HENRYS FORK NEAR REXBURG

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
HISTORICAL	100.6	101.2	98.3	89.6	93.8	98.2	111.9	168.7	210.1	87.8	80.3	83.6	1324.3
STUDY	99.4	101.9	99.8	93.2	95.9	96.5	110.1	165.1	203.1	89.0	77.3	77.7	1309.1

Table 21 (continued).

CONTENTS AMERICAN FALLS RES @ AMERICAN FALLS

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
HISTORICAL	418.0	676.9	941.8	1159.7	1357.1	1569.0	1648.3	1519.9	1365.6	904.1	535.7	357.5
STUDY	413.2	733.1	1023.4	1221.3	1281.7	1540.8	1627.7	1481.2	1356.9	877.2	516.5	349.7

DISCHARGE SNAKE RIVER AT NEELEY

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
HISTORICAL	201.8	94.0	110.9	127.3	162.4	180.2	376.0	742.4	766.2	801.6	693.2	464.1	4720.2
STUDY	188.2	112.1	95.3	148.4	279.8	103.6	368.9	715.3	760.6	804.4	697.1	455.4	4729.1

DISCHARGE SNAKE RIVER AT MILNER

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
HISTORICAL	52.5	79.1	137.4	142.0	162.3	149.8	119.9	116.9	137.7	18.0	14.5	15.5	1145.7
STUDY	19.4	89.5	128.2	172.7	279.4	74.0	118.5	88.8	125.9	14.6	13.8	10.7	1135.6

DISCHARGE SNAKE RIVER AT KING HILL

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
HISTORICAL	587.6	574.6	623.1	600.9	579.7	592.6	562.2	566.9	609.4	462.6	490.9	514.4	6764.9
STUDY	554.2	585.7	612.7	630.7	695.0	513.6	562.1	537.3	600.3	457.4	486.2	504.3	6739.4

period are (1) gains below Milner, (2) diversions, and (3) the ice restrictions at American Falls and Lake Walcott.

RESULTS

Reach gain and diversion data for the entire period (1928-1968) were operated using the same criteria developed from the verification period (1958-68). Primary output showing discharges and reservoir contents (see output discussion in Section II) was obtained for each year. This output together with summary listings of each major reach and reservoir are available upon request from the Idaho Water Resource Board.

APPENDIX B

UPPER SNAKE COMPUTER PROGRAM LISTING

```
      SUBROUTINE USIN
      COMMON INR(50),NDR(50),IOI(50),STF(50),IRO(50),MPO(50),ILL(50)
      COMMON MSL(50),KORDR(50),GW(50,12),EMI(50,12),FMIN(50,12,3)
      COMMON RF(50,12)
      COMMON RNAME(12,3),RFS(12,2),KDS(12,24),SA(12,11),EVAP(12,12)
      COMMON PE(12,12),DEAD(12),FULL(12),ARINT(12),RLVL(12,12,4)
       COMMON DIV(50,12),RLF(50,10),IDST(50),JVD(50)
      COMMON BRN(20,4),B(6,20),IBR(26,20),S(6,20),SB(6)
      COMMON FLRS(6,28),FCST(6,43),SPAV(7),RQSP(6),API(6),PLSP(6),FMX(6)
      COMMON DAY(12),O(13),KPCH(51),KKDS(8),JORDR(39,9)
      COMMON IP,KO,MO,LL,KKUT,NR,ND,NP,NB,NO,NY,NYR,NRG,NDA,NCD,NEF,NVM
      COMMON NMI,NCU,NIR,NCL
      COMMON IP1,IP2,IP3,IP4,IP5,JYR,CCSUM
      DIMENSION DNAME(5,50),JND(50),AND(50,2),ARF(50),JDR(50),NW(50)
      DIMENSION NZ(40),RQ(12, 4,2),ACRE( 4,2),AD(2),ICR(12),PRET(10)
      READ(1,34)NR,ND,NP,NB,NO,NY,NYR,NRG,NDA,NCD,NEF,NVM,NMI,NCU,NIR,
     2 NCL
   34 FORMAT(20I3)
      READ(1,34)IP1,IP2,IP3,IP4,IP5
      READ(1,101)(KPCH(J),J=1,51)
  101 FORMAT(40I2)
      READ(1,12)(O(I),I=1,13)
   12 FORMAT(13A3)
      READ(1,77)(DAY(I),I=1,12)
   77 FORMAT(12F2.0)
      READ(1,35)(( RNAME(I,J),J=1,3),RES(I,1),FULL(I),DEAD(I),ARINT(I),I
     ICR(I),I=1,NP)
   35 FORMAT(3A4,8X,4F5.1,I3)
      DO 153 M=1,NP
  153 READ(1,146) (K,J,(RLVL(J,L,K),L=1,12),I=1,4)
  146 FORMAT(2X,I1,I2,5X,12F5.1)
      READ(1,27)((PE(I,J),J=1,12),I=1,NP)
   27 FORMAT(12F5.3)
      READ(1,31)((SA(I,J),J=1,11),I=1,NP)
   31 FORMAT(11F5.1)
      READ(1,100)((KDS(I,J),J=1,24),I=1,NP)
  100 FORMAT(24I2)
      READ(1,28)(INR(I),I=1,NR)
      READ(1,131)((JORDR(I,J),J=1,9),I=1,39)
  131 FORMAT   (3(9I2,2X),20X)
      READ(1,28)(MPO(I),I=1,NR)
      READ(1,28)(MSL(I),I=1,NR)
      READ(1,99)(KORDR(I),I=1,NR)
   99 FORMAT(26I3)
      READ(1,28)(NDR(I),I=1,NR)
      READ(1,76) ((K,L,(FMIN(K,J,L),J=1,12),M=1,3),I=1,NR)
   76 FORMAT(2I5,10X,12F5.0)
      READ(1,28)(IOI(I),I=1,NR)
   28 FORMAT(40I2)
      DO 248 I=1,NR
      DO 248 J=1,12
      RF(I,J)=0.0
  248 EMI(I,J)=0.0
```

```
0052          DO 261 I=1,ND
0053          JND(I)=0.0
0054          DO 261  J=1,12
0055      261 DIV(I,J)=0.0
0056          READ(1,132)((DNAME(I,J),I=1,5),JND(J),JVD(J),IRO(J),JDR(J),ILL(J),
             1J=1,ND)
0057      132 FORMAT(5A4, 5I5)
0058          READ(1,39)(((RLF(I,J),J=1,10),IDST(I)),I=1,ND)
0059       39 FORMAT(10F5.3,25X,I5)
0060          READ(1,98)(((BRN(I,J),J=1,4),(IBR(LI,I),LI=1,26)),I=1,NB)
0061       98 FORMAT(4A3,8X,26I2)
0062          IF(NIR)22,22,23
0063       23 READ(1,179) (I,(RF(I,J),J=1,12),K=1,NIR)
0064       22 IF(NCD) 40, 40,241
0065      241 DO 180 I=1,NCD
0066      180 READ(1,179) K,(DIV(K,J),J=1,12)
0067      179 FORMAT(I3,5X,12F6.1)
0068       40 IF(NMI) 247,247,240
0069      240 READ(1,200)(I,(EMI(I,J),J=1,12),K=1,NMI)
0070      200 FORMAT(I2,8X,12F5.1)
0071      247 READ(1,201)(((PQ(I,J,K),I=1,12),J=1,4),K=1,2)
0072      201 FORMAT(10X,12F5.3)
0073          IF(NDA)243,243,242
0074      242 READ(1,202)(NZ(J),NW(J),(ACRE(J,I),I=1,2),J=1,NDA)
0075      202 FORMAT(2I2,6X,2F10.1)
0076      243 READ(1,159)(KKDS(I),I=1,8)
0077      159 FORMAT(8I3)
0078          READ(1,122) ((FLRS(I,J),I=1,6),J=1,28)
0079      122 FORMAT(6F5.0)
0080          READ(1,105)((FCST(I,J),I=1,6),J=1,NY)
0081      105 FORMAT(12F5.0)
0082          READ(1,122) (API(I),I=1,6)
0083          READ(1,122)(FMX(I),I=1,6)
0084          READ(1,33)((IA,MM,(GW(I,J),J=1,12)),I=1,NR)
0085       33 FORMAT(2I3,2X,12F6.1)
0086          WRITE(2,6)ND,NR,ND
0087        6 FORMAT(1H1, 5X,'SNAKE RIVER OPERATION STUDY NUMBER',I4,'.',12X,'NO
             1 OF REACHES =',I4,8X,'NO OF DIVERSIONS =',I4/ )
0088          WRITE(2,8)
0089        8 FORMAT(1H ,15X,'REACH   NO DIVERSIONS   RESERVOIR   OUTFLOW RCH  S
             1HORTAGE LVL          ASSIGNED FLOW STORAGE'/)
0090          DO 666 I=1,NR
0091          K=MRO(I)
0092      666 WRITE(2,9) I,NDR(I),INR(I),IOI(I),MSL(I), (JORDR(K,J),J=1,9)
0093        9 FORMAT(6X,5(9X,I4),12X,9I3)
0094          WRITE(2,133)
0095      133 FORMAT(1H1,45X,1H*,12X,'PERCENT RETURN FLOW',23X,'*'/,1H ,'DIVERSI
             1ON',13X,'ORDER  NUMBER   REACH  LF1  LF2  LF3  LF4  LF5  LF6  LF7
             2 LF8  LF9  LF0 REACH    STORAGE CALL ORDER       LVL'/)
0096          DO 137 J=1,ND
0097          DO 319 K=1,10
0098      319 PRET(K)=RLF(J,K)*100.
0099          LT=IRO(J)
```

```
0100      137 WRITE(2,134)  (DNAME(I,J),I=1,5),J,JND(J), JDR(J),( PRET(K),K=1,10
             1),IDST(J),(JORDR(LI,L),L=1,9),ILL(J)
0101      134 FORMAT(1X,5A4,1X,I4,4X,I4,4X,I4,2X,10F5.1,I4,2X,9I3,I4)
0102          WRITE(2,139) (O(I),I=1,12)
0103      139 FORMAT(1H1,57X,'ASSIGNED FLOWS (CFS)'//16X,'REACH  LEVEL',
             112(5X,A3)/)
0104          DO 140 I=1,NR
0105          IF(I.EQ.13) WRITE(2,139) (O(L),L=1,12)
0106          IF(I.EQ.25) WRITE(2,139) (O(L),L=1,12)
0107          IF(I.EQ.37) WRITE(2,139) (O(L),L=1,12)
0108          K=KORDR(I)
0109      140 WRITE(2,141) (K,L,(FMIN(K,J,L),J=1,12),L=1,3)
0110      141 FORMAT(16XI3,I7,2X,12F8.0/16XI3,I7,2X,12F8.0/16XI3,I7,2X,12F8.0/)
0111          WRITE(2,10)
0112       10 FORMAT(1H1,15X,'RESERVOIR',7X,'INITIAL CONTENTS   MAX CONTENTS   M
             1IN CONTENTS'/)
0113          WRITE(2,11)((RNAME(I,J),J=1,3),RES(I,1),FULL(I),DEAD(I),I=1,NP)
0114       11 FORMAT(16X,3A4,3F15.1)
0115          WRITE(2,151)(O(I),I=1,12)
0116      151 FORMAT('1'  ,15X,'RESERVOIR    LVL',12(5X,A3))
0117          DO 154 I=1,NP
0118      154 WRITE(2,152) (RNAME(I,J),J=1,3),(K,(RLVL(I,L,K),L=1,12),K=1,4)
0119      152 FORMAT(/16X,3A4,I3,1X,12F8.1/(28X,I3,1X,12F8.1))
0120          IF(NDA)245,245,244
        C                      SUMMARIZE PROJECT DATA
0121      244 DO 206 J=1,NDA
0122          WRITE(2,204)
0123      204 FORMAT(1H1,40X,'SUMMARY OF NEW PROJECT DIVERSIONS AND DEPLETICNS')
0124          WRITE(2,205)
0125      205 FORMAT(//35X,              'PROJECT',31X,'ACRES',5X,'DIVERSION',
             13X,'DEPLETION'/)
0126          TAU=0.0
0127          TADU=0.0
0128          TDU=0.0
0129          L=NW(J)
0130          K=NZ(J)
0131          AND(K,1)=0.0
0132          AND(K,2)=0.0
0133          DO 203 I=1,12
0134          AND(K,1)= AND(K,1)+(ACRE(J,1)*RQ(I,L,1))
0135          AND(K,2)= AND(K,2)+(ACRE(J,2)*RQ(I,L,2))
0136      203 DIV(K,I)=(ACRE(J,1)*RQ(I,L,1))+(ACRE(J,2)*RQ(I,L,2))
0137          ARF(K)=0.0
0138          DO 208 I=1,5
0139      208 ARF(K)=ARF(K)+RLF(K,I)
0140      207 ADF=1.0-ARF(K)
0141          AD(1)=ADF*AND(K,1)
0142          AD(2)=ADF*AND(K,2)
0143          WRITE(2,209)  (DNAME(I,K),I=1,5),(ACRE(J,M),AND(K,M),AD(M),M=1,2)
0144      209 FORMAT(/35X,         5A4,5X, '(NEW)',3F12.1/59X,'(SUPP)',3F12.1)
0145          TAU=TAU+ACRE(J,1)+ACRE(J,2)
0146          TADU=AND(K,1)+AND(K,2)+TADU
0147          TDU=TDU+AD(1)+AD(2)
```

```
  206 CONTINUE
      WRITE(2,210) TAU,TADU,TDU
  210 FORMAT(  35X,'PROJECT TOTAL',17X,3F12.1)
  245 WRITE(2,218)
  218 FORMAT('1',35X,'CONSTANT DIVERSIONS BY DIVERSION NUMBER (1000 AC-F
     1T)')
      LO=1
      IF(ND.GT.20) LO=2
      IF(ND.GT.40) LO=3
      DO 224 IO=1,LO
      JB=1+((IO-1)*20)
      JE=JB+19
      IF(IO.EQ.LO) JE=ND
      WRITE(2,246) (JND(I),I=JB,JE)
  246 FORMAT(///  ' MON',20I6)
      WRITE(2,21)
   21 FORMAT(1H )
      DO 224 J=1,12
  224 WRITE(2,220)  U(J),(DIV(I,J),I=JB,JE)
  220 FORMAT(1X,A3,20F6.1)
      WRITE(2,221)
  221 FORMAT('1',50X,'M AND I REQUIREMENTS BY REACH (1000 AC-FT)')
      LO=1
      IF(NR.GT.20) LO=2
      IF(NR.GT.40) LO=3
      DO 323 IO=1,LO
      JB=1+((IO-1)*20)
      JE=JB+19
      IF(IO.EQ.LO) JE=NR
      WRITE(2,246)(I,I=JB,JE)
       WRITE(2,21)
      DO 323 J=1,12
  323 WRITE(2,220)  U(J),(EMI(I,J),I=JB,JE)
      RETURN
      END
```

```
      COMMON INR(50),NDR(50),IOI(50),STF(50),IRO(50),MRO(50),ILL(50)
      COMMON MSL(50),KORDR(50),GW(50,12),EMI(50,12),FMIN(50,12,3)
      COMMON RF(50,12)
      COMMON RNAME(12,3),RES(12,2),KDS(12,24),SA(12,11),EVAP(12,12)
      COMMON PE(12,12),DEAD(12),FULL(12),ARINT(12),RLVL(12,12,4)
       COMMON DIV(50,12),RLF(50,10),IDST(50),JVD(50)
      COMMON BRN(20,4),B(6,20),IBR(26,20),S(6,20),SB(6)
      COMMON FLRS(6,28),FCST(6,43),SPAV(7),RQSP(6),API(6),PLSP(6),FMX(6)
      COMMON DAY(12),D(13),KPCH(51),KKDS(8),JORDR(39,9)
      COMMON IP,KO,MO,LL,KKUT,NR,ND,NP,NB,NO,NY,NYR,NRG,NDA,NCD,NEF,NVM
      COMMON NMI,NCU,NIR,NCL
      COMMON IP1,IP2,IP3,IP4,IP5,JYR,CCSUM
      DIMENSION SID(50),SFD(50),SED(50),SMD(50),SCD(50),TSH(50),DV(50)
      DIMENSION RET(50),SHRTI(50),SHRTF(50),SHRTE(50),TF(50),RCHIN(50)
      DIMENSION RCHOU(50),RCHGN(50,12),FLM(50,3),FCSP(20)
      CALL USIN
      N=1
      DO 43 J=1,12
      DO 163 L=1,NP
  163 EVAP(L,J) =0.0
      DO 43 I=1,NR
   43 RCHGN(I,J)=0.0
   18 DO 138 I=1,NRG
      READ(1,36) IE,IU,LY,(RCHGN(IE,J),J=1,12)
   36 FORMAT(2I3,I2,12F6.1)
      IF(LY)23,23,224
  224 IF(IU)138,138,225
  225 WRITE(2,226)
  226 FORMAT('1DIVERSION READ AS REACH GAIN')
      GO TO 23
  138 CONTINUE
      IVV=0
      NVD=ND-NDA-NCD
      IF(NVD)176,176,24
   24 DO 270 I=1,ND
      IF(JVD(I))270,270,195
  195 READ(1,36)  IV,IH,IY,(DIV(I,J),J=1,12)
      IF(IV-IVV)171,171,170
  171 WRITE(2,173)
  173 FORMAT('1DIVERSIONS OUT OF ORDER')
      GO TO 23
  170 IVV=IV
  270 CONTINUE
      IF(IY-LY)174,176,174
  174 WRITE(2,175)
  175 FORMAT(' GAINS NOT SAME YEAR AS DIVERSIONS')
      GO TO 23
  176 IF(NVM)230,230,231
  231 DO 232 I=1,NVM
  232 READ(1,76) (K,L,(FMIN(K,J,L),J=1,12),M=1,3)
   76 FORMAT(2I5,10X,12F5.0)
  230 DO 21 LI=1,NR
   21 STF(LI)=0.0
```

```
      DO 72 I=1,6
   72 SB(I)=0.0
      DO 47 I=1,6
      DO 47 J=1,NB
   47 B(I,J)=0.0
      GTSH=0.0
      CCSUM=0.0
      REWIND  9
      REWIND  10
      REWIND  11
      REWIND 12
      REWIND 13
      REWIND 14
      REWIND 15
      REWIND 16
      REWIND 17
      DO 32 MO=1,12
      DO 30 I=1,NP
      FCSP( I)=0.0
   30 RES(I,2)=RES(I,1)
C                         CALCULATE RESERVOIR EVAPORATION
      DO 22 IR=1,NP
      IF(FULL(IR).LT.0.1) GO TO 22
      RIDX=RES(IR,2)/ARINT(IR)
      IF(RIDX.LT.0.0)  RIDX=0.0
      IIDX=RIDX
      RIIDX=IIDX
      DIFF=RIDX-RIIDX
      IIDX=IIDX+1
      IIGX=IIDX+1
      IF(IIGX-11)60,60,61
   61 WRITE(2,62)
   62 FORMAT(36H1CONTENTS EXCEED AREA-CAPACITY CURVE)
   60 AREA=SA(IR,IIDX)+(DIFF*(SA(IR,IIGX)-SA(IR,IIDX)))
      EVAP(IR,MO)=AREA*PE(IR,MO)
   22 CONTINUE
      DO 1 I=1,NR
      DV(I)=0.0
      SID(I)=0.0
      SFD(I)=0.0
      SCD(I)=0.0
      SED(I)=0.0
      SHRTI(I)=0.0
      SHRTF(I)=0.0
      SHRTE(I)=0.0
      RCHOU(I) =0.0
    1 RCHIN(I)=0.0
      DO 74 LI=1,NB
      DO 74 J=1,6
   74 S(J,LI)=0.0
      RD=0.0
      NN=0
      NX=0
```

```
C                            CORRECT FEBRUARY FOR LEAP YEAR
      IF(MO-5)80,82,80
   82 YR=LY
      GF=YR/4.
      J=GF
      TK=J
      IF(TK-GF)80,81,80
   81 DY=29.
      GO TO 253
   80 DY=DAY(MO)
  253 DO 2 KG=1,NR
      KR=KORDR(KG)
      IR=INR(KR)
      DO 262 I=1,3
  262 FLM(KR,I)=FMIN(KR,MO,I)*(.0019835*DY)
      RGN=RCHGN(KR,MO)+GW(KR,MO)
      IF(IR.GT.0.AND.FULL(IR).GE.0.1)RGN=RGN-EVAP(IR,MO)
      IF(KR.EQ.8)  RGN=0.0
      IF(RGN)3,4,4
    3 RNEG=RGN*(-1.)
      RPOS=0.0
      GO TO 5
    4 RPOS=RGN
      RNEG=0.0
    5 DVN=0.0
      IF(KR-13)157,156,155
  155 IF(KR-16)156,156,157
  156 KKUT=1
      GO TO 158
  157 KKUT=0
  158 KO=MRO(KR)
      SUSDMD=0.0
      LL=4
      IP=0
      SUR=RCHIN(KR)-RNEG
      IF(KR.EQ.8)  SUR=RCHIN(KR)+RCHGN(KR,MO)
      CALL RELESE  (SUR,KR,N,STD,USDMD,RD)
      SHRTE(KR)=SHRTE(KR)+USDMD
C                            SATISFY MUNICIPAL & INDUSTRIAL REQ'MNTS
      SUR=SUR-(EMI(KR,MO)*0.55)
      CALL RELESE  (SUR,KR,N,SED,USDMD,RD)
      SHRTE(KR)=SHRTE(KR)+USDMD
C                            ARE THERE DIVERSIONS IN THIS REACH ?
      IF(NDR(KR))52,52,37
   37 NN=NX+1
      NX=NX+ NDR(KR)
C                            SUM REACH DIVERSIONS
      DO 38 I=NN,NX
      DVN=DVN+DIV(I,MO)
      SUR=SUR        -DIV(I,MO)
      KO=IRO(I)
      LL=ILL(I)
C                            RELEASE DEMAND FROM STORAGE AND ROUTE
```

```
              C                   FLOW THROUGH REACHES TO DESTINATION
0154                CALL RELESE (SUR,KR,N,SID,USDMD,RD)
0155                SUSDMD=SUSDMD+USDMD
0156             38 SHRTI(KR)=SHRTI(KR)+USDMD
              C                   CALCULATE RETURN FLOWS
0157                DIVRTD=DVN-SUSDMD
0158                DV(KR)=DIVRTD
0159                IF(DIVRTD)52,52,65
0160             65 DIVR=DIVRTD
0161                DO 40 I=NN,NX
0162                DIVR=DIVR-DIV(I,MO)
0163                IF(DIVR)45,41,41
0164             41 DIVN=DIV(I,MO)
0165                NS=1
0166                GO TO 43
0167             45 DIVN=DIV(I,MO)+DIVR
0168                NS=2
0169             46 KF=IDST(I)
0170                IF(KF)286,286,187
0171            187 KA=MO-1
0172                DO 42 J=1,5
0173                KA=KA+1
0174                IF(KA-13)49,44,44
0175             44 KA=1
0176             49 RF(KF,KA)=RF(KF,KA)+(RLF(I,J)*DIVN)
0177             42 CONTINUE
0178            286 GO TO (40,52),NS
0179             40 CONTINUE
0180             52 JO=IOT(KR)
              C                   CALCULATE USABLE FLOW AT REACH TERMINAL
0181             51 UI=SUR+RF(KR,MO)+RPOS
0182                RET(KR)=RF(KR,MO)
0183                RF(KR,MO)=0.0
              C                   PASS OR STORE USABLE FLOW
0184                CALL RSROP (UI,N,IR,JO,KR,RCHIN,RCHOU)
0185              2 CONTINUE
0186                DO 75 LI=1,NR
0187                TF(LI)=SID(LI)+SED(LI)+RCHOU(LI)+SFD(LI)
0188                RCHOU(LI)=0.0
0189             75 RCHIN(LI)=0.0
              C                   MODIFY RELEASES FOR OTHER FUNCTIONS
              C
              C                   TRY TO MEET MINIMUM FLOWS
0190             79 DO 78 J=1,NR
0191                I=KORDR(J)
0192                IR=INR(I)
0193                JO=IOT(I)
0194                UI=RCHIN(I)
0195                CALL RSROP (UI,N,IR,JO, I,RCHIN,RCHOU)
0196                IP=1
0197                KO=MRO(I)
0198                MS=MSL(I)
0199                FMET=0.0
```

```
      DO 263 LK=1,3.
      LL=LK+1
      SUR=TF(I)-FLM(I,LK)+RCHOU(I)+FMET
      CALL RELESE (SUR,I,N,SFD,USDMD,RD)
      IF(LL.EQ.MS)SHRTF(I)=USDMD
      IF(USDMD.EQ.0.0) GO TO 264
      FMET=FMET+RD
  263 CONTINUE
  264 RCHIN(JO)=RCHIN(JO)+SFD(I)
   78 CONTINUE
      DO 7 LI=1,NR
      TF(LI)=TF(LI)+SFD(LI)+RCHOU(LI)
      RCHOU(LI)=0.0
    7 RCHIN(LI)=0.0
C                   FLOOD CONTROL OPERATION
      LL=4
      IF(MO.LE.3.OR.MO.GE.10) GO TO 106
      MON=MO-3
C                   DETERMINE REQUIRED EOM FLOOD SPACE
      JYR=LY-NYR+1
      FCNM=FCST(MON,JYR)-API(MON)
      IF(FCNM)142,142,143
  142 REQSPC=0.0
      GO TO 144
  143 RIDX=FCNM/200.
      IIDX=RIDX
      RIIDX=IIDX
      DIFF=RIDX-RIIDX
      IIDX=IIDX+1
      IIGX=IIDX+1
      IF(IIGX-27)112,112,114
  114 WRITE(2,115)
  115 FORMAT(1H1,'FORECAST EXCEEDS RESERVATION DIAGRAM')
  112 REQSPC =   FLRS(MON,IIDX)+(DIFF*(FLRS(MON,IIGX)-FLRS(MON,IIDX)))
  144 AVLSPC=FULL(4)+FULL(5)+FULL(8)-RES(4,I)-RES(5,I)-RES(8,I)
C                   DETERMINE RELEASE REQUIRED FOR FLOOD CONTROL
      FCSP(8)=REQSPC-AVLSPC
      IF(FCSP(8))147,147,150
  150 FLD=FCSP(8)+TF(39)-FMX(MON)
      IF(FLD)147,147,148
  148 FCSP(8)=FCSP(8)-FLD
  147 PLSP(MON)=FCSP(8)
      RQSP(MON)=REQSPC
      DO 113 J=1,NR
      I=KORDR(J)
      IR=INR(I)
      JO=IOT(I)
      UI=RCHIN(I)
      CALL RSROP (UI,N,IR,JO,I,RCHIN,RCHOU)
      IF(IR)117,117,118
  118 SUR=FCSP(IR)*(-1.)
      GO TO 119
  117 SUR=0.0
```

```
0250        119 IP=1
0251            KO=MRO(I)
0252            CALL RELESE (SUR,I,N,SCD,USDMD,RD)
0253            RCHIN(JO)=RCHIN(JO)+SCD(I)
0254        113 CONTINUE
0255            DO 121 LI=1,NR
0256        121 TF(LI)=TF(LI)+SCD(LI)+RCHOU(LI)
0257        106 DO 20 LI=1,NR
0258            TSH(LI)=SHRTI(LI)+SHRTF(LI)+SHRTE(LI)
0259         20 STF(LI)=STF(LI)+TF(LI)
0260            DO 25 LI=1,NR
0261         25 GTSH=GTSH+TSH(LI)
0262            DO 89 LI=1,NB
0263            DO 88 II=1,26
0264            LZ=IBR(II,LI)
0265            IF(LZ)89,89,87
0266         87 S(1,LI)=S(1,LI)+DV(LZ)
0267            S(2,LI)=S(2,LI)+RET(LZ)
0268            S(3,LI)=S(3,LI)+SHRTI(LZ)
0269            S(4,LI)=S(4,LI)+SHRTF(LZ)
0270            S(5,LI)=S(5,LI)+SHRTE(LZ)
0271         88 S(6,LI)=S(6,LI)+TSH(LZ)
0272         89 CONTINUE
0273            DO 73 J=1,6
0274            DO 73 LI=1,NB
0275         73 B(J,LI)=B(J,LI)+S(J,LI)
0276            CRSCUT=SFD(42)+STD(42)
0277            CCSUM=CCSUM+CRSCUT
0278            OM=O(MO)
0279            WRITE( 9,58) LY,OM,TF(1),RES(1,1),TF(2),TF(3),RES(2,1),TF(4),TF(5)
               1,TF(6),RES(3,1),TF(7),TF(8),TF(9),TF(10),TF(12),RES(9,1),TF(41),
               2 CRSCUT
0280         58 FORMAT(1H ,I3,1X,A3,2X,17F7.1)
0281            WRITE(10,58) LY,OM,TF(42),TF(16),TF(23),TF(24),TF(17),RES(4,1),
               1TF(18),TF(19),RES(5,1),TF(20),TF(21),RES(8,1),TF(39),TF(40),
               2TF(22),TF(25),TF(26)
0282            WRITE(11,58) LY,OM,TF(28),TF(29),RES(6,1),TF(30),TF(31),RES(7,1),
               2TF(32),TF(33),TF(38),TF(34),TF(35),TF(36),TF(44),TF(37)
0283            WRITE(12,58) LY,OM,(S(1,I),I=1,NB)
0284            WRITE(13,58) LY,OM,(S(2,I),I=1,NB)
0285            WRITE(14,58) LY,OM,(S(3,I),I=1,NB)
0286            WRITE(15,58) LY,OM,(S(4,I),I=1,NB)
0287            WRITE(16,58) LY,OM,(S(5,I),I=1,NB)
0288            WRITE(17,58) LY,OM,(S(6,I),I=1,NB)
0289            IF(IP2.EQ.0) GO TO 32
0290            IF(MO.EQ.1) WRITE(2,162)
0291            IF(MO.EQ.5) WRITE(2,162)
0292            IF(MO.EQ.9) WRITE(2,162)
0293        162 FORMAT(1H1)
0294            LO=1
0295            IF(NR.GT.20) LO=2
0296            IF(NR.GT.40) LO=3
0297            DO 323 IO=1,LO
```

```
0298        JB=I+((IO-1)*20)
0299        JE=JB+19
0300        IF(IO.EQ.LO) JE=NR
0301        WRITE(2,161)(I,I=JB,JE)
0302    161 FORMAT(    'OREACH',4X,20(I6) )
0303    323 WRITE(2,160) LY,OM,(RFT(I),I=JB,JE),(SID(I),I=JB,JE),(SFD(I),I=JB,
           1JE),(SED(I),I=JB,JE)
0304    160 FORMAT(1H ,I2,1X,A3,' R ',20F6.1/8X,'I ',20F6.1/8X,'M ',20F6.1/8X,
           1'O ',20F6.1)
0305     32 CONTINUE
0306        ENDFILE  9
0307        ENDFILE 10
0308        ENDFILE 11
0309        ENDFILE 12
0310        ENDFILE 13
0311        ENDFILE 14
0312        ENDFILE 15
0313        ENDFILE 16
0314        ENDFILE 17
0315        DO 93 I=1,6
0316        DO 93 LI=1,NB
0317     93 SB(I)=SB(I)+B(I,LI)
0318        CALL USOUT
0319        GO TO 18
0320     23 STOP
0321        END
```

```
0001              SUBROUTINE USOUT
0002              COMMON INR(50),NDR(50),IOI(50),STF(50),IRO(50),MRO(50),ILL(50)
0003              COMMON MSL(50),KORDR(50),GW(50,12),EMI(50,12),FMIN(50,12,3)
0004              COMMON RF(50,12)
0005              COMMON RNAME(12,3),RES(12,2),KDS(12,24),SA(12,11),EVAP(12,12)
0006              COMMON PE(12,12),DEAD(12),FULL(12),ARINT(12),RLVL(12,12,4)
0007               COMMON DIV(50,12),RLF(50,10),IDST(50),JVD(50)
0008              COMMON BRN(20,4),B(6,20),IBR(26,20),S(6,20),SB(6)
0009              COMMON FLRS(6,28),FCST(6,43),SPAV(7),RQSP(6),API(6),PLSP(6),FMX(6)
0010              COMMON DAY(12),C(13),KPCH(51),KKDS(8),JORDR(39,9)
0011              COMMON IP,KO,MO,LL,KKOT,NR,NO,NP,NB,NO,NY,NYR,NRG,NDA,NCD,NEF,NVM
0012              COMMON NMI,NCU,NIP,NCL
0013              COMMON IP1,IP2,IP3,IP4,IP5,JYR,CCSUM
0014              DIMENSION IAL(12),VAL(12,51)
0015              REWIND  9
0016              REWIND  10
0017              REWIND  11
0018              REWIND 12
0019              REWIND 13
0020              REWIND 14
0021              REWIND 15
0022              REWIND 16
0023              REWIND 17
0024              WRITE(2,52)NO
0025           52 FORMAT(1H1,39X,'UPPER SNAKE RIVER OPERATION STUDY NUMBER',I6,'.'/)
0026              WRITE(2,55)
0027           55 FORMAT  (130H          *----HENRYS LAKE-----*----ISLAND PARK-----*
                1 HN FK *----GRASSY LAKE----* FALLS  FALLS  HN FK *-------TETON----
                2---* CSCUT /130H W-YR MO        IN     EOM     OUT      IN     EOM     O
                3UT  ASHTN      IN     EOM     OUT  N SQL  N CHS  ST AN      IN     EOM
                4    OUT  CANAL /)
0028              DO 15 IH=1,12
0029              READ ( 9,58) LY,OM, (VAL(IH,J),J=1,17)
0030           15 WRITE( 2,58) LY,OM, (VAL(IH,J),J=1,17)
0031              WRITE(2,26) LY,(STF(LI),LI=1,9),STF(10),STF(12),STF(41),CCSUM
0032           26 FORMAT(/1H ,I3,' TOTAL',2(F7.1,7X,F7.1),2F7.1,7X,5F7.1,7X,2F7.1)
0033              WRITE(2,56)
0034           56 FORMAT(/ 130H             TETON  TETON  HN FK  HN FK*----JACKSON LA
                1KE----*-----PALISADES------*----L COL----* SNAKE  SNAKE  SNAKE  SN
                2AKE  SNAKE /130H W-YR MO     ST AN  N&S F  REXBG  MOUTH      IN     E
                3OM     OUT      IN     EOM     OUT      IN     EOM  L COL  HEISE  HN FK
                4 I FLS  SHLLY /)
0035              DO 16 IH=1,12
0036              READ (10,58) LY,OM, (VAL(IH,J),J=18,34)
0037           16 WRITE( 2,58) LY,OM, (VAL(IH,J),J=18,34)
0038              WRITE(2,13) LY,STF(42),STF(16),STF(23),STF(24),(STF(LI),LI=17,21),
                1STF(39),STF(40),STF(22),STF(25),STF(26)
0039           13 FORMAT(/1H ,I3,' TOTAL',5F7.1,3(7X,2F7.1),3F7.1)
0040              WRITE(2,57)
0041           57 FORMAT(/ 130H             SNAKE *--AMERICAN FALLS---*----LAKE WALCO
                1TT----* MILNR  SNAKE  SNAKE  SNAKE  SNAKE  BIG W  SNAKE
                2          /130H W-YR MO     BLKFT      IN     EOM     OUT      IN     E
                3OM     OUT  INFLO  MILNR  KMBLY   BUHL  HGRMN  GDING  KG HL
```

```
              4               /)
 0042           DO 17 IH=1,12
 0043           READ (11,58) LY,OM, (VAL(IH,J),J=35,NCL)
 0044        17 WRITE( 2,58) LY,OM, (VAL(IH,J),J=35,NCL)
 0045        58 FORMAT(1H ,I3,1X,A3,2X,17F7.1)
 0046           WRITE(2,14) LY,(STF(LI),LI=28,33),STF(38),(STF(LI),LI=34,36),
               1STF(44),STF(37)
 0047        14 FORMAT(/1H ,I3,' TOTAL',2(2F7.1,7X),8F7.1)
 0048           WRITE(2,97)LY
 0049        97 FORMAT(1H1,40X,'DIVERSIONS    AND    SHORTAGES     WATER YEAR',I4)
 0050           WRITE(2,96)
 0051        96 FORMAT(//14X,'BRANCH',13X,'DIVERSIONS',4X,'RETURN FLOW',4X,'IRRIG
               1SHORT', 5X,'FLOW SHORT',4X,'OTHER SHORT',4X,'TOTAL SHORT'/)
 0052           WRITE(2,95)(((BRN(I,J),J=1,4),(B(LI,I),LI=1,6)),I=1,NB)
 0053        95 FORMAT(14X,4A3,F14.1,5F15.1)
 0054           WRITE(2,83)(SB(I),I=1,6)
 0055        83 FORMAT(/14X,'SYSTEM TOTAL',F14.1,5F15.1)
 0056           WRITE(2,123)
 0057       123 FORMAT(//////1H ,40X,'FLOOD CONTROL OPERATION - ABOVE HEISE'///
               138X'JAN',12X,'FEB',12X,'MAR',12X,'APR',12X,'MAY',12X,'JUN'/)
 0058           WRITE(2,145) (FCST(I,JYR),I=1,6),(RQSP(J),J=1,6)
 0059       145 FORMAT(14X,'FORECAST',4X,6F15.1/14X,'REQUIRED SPACE',F13.1,5F15.1)
 0060           WRITE(2,125)(PLSP(I),I=1,6)
 0061       125 FORMAT(14X,'SPACE PROVIDED',F13.1,5F15.1)
 0062           WRITE(2,135) (U(I),I=1,12)
 0063       135 FORMAT(/////1H ,40X,'RESERVOIR EVAPORATION  (1000 ACRE FEET)'///
               11H ,13X,'RESERVOIR',5X,12(4X,A3)/)
 0064           WRITE(2,136) ((RNAME(I,J),J=1,3),(EVAP(I,K),K=1,12),I=1,NP)
 0065       136 FORMAT(1H ,13X,3A4,3X,12F7.1)
 0066           IF(IP1)102,102,84
 0067        84 WRITE(2,66) ((BRN(I,J),J=1,2),I=1,NB)
 0068        66 FORMAT(1H1,10X,17(1X,2A3))
 0069           WRITE(2,61) ((BRN(I,J),J=3,4),I=1,NB)
 0070        61 FORMAT(1H ,'W-YR MO   ',17(1X,2A3))
 0071           WRITE(2,67)
 0072        67 FORMAT(50X,'DIVERSIONS')
 0073           DO 48 IH=1,12
 0074           READ (12,58) LY,OM,(S(1,I),I=1,NB)
 0075        48 WRITE( 2,58) LY,OM,(S(1,I),I=1,NB)
 0076           WRITE(2,59) LY,(B(1,I),I=1,NB)
 0077           WRITE(2,68)
 0078        68 FORMAT(//50X,'RETURN FLOWS')
 0079           DO 71 IH=1,12
 0080           READ (13,58) LY,OM,(S(2,I),I=1,NB)
 0081        71 WRITE( 2,58) LY,OM,(S(2,I),I=1,NB)
 0082           WRITE(2,59) LY,(B(2,I),I=1,NB)
 0083           WRITE(2,69)
 0084        69 FORMAT(//50X,'IRRIGATION SHORTAGES')
 0085           DO 70 IH=1,12
 0086           READ (14,58) LY,OM,(S(3,I),I=1,NB)
 0087        70 WRITE( 2,58) LY,OM,(S(3,I),I=1,NB)
 0088           WRITE(2,59) LY,(B(3,I),I=1,NB)
 0089           WRITE(2,66)
```

```
      WRITE(2,54)
   54 FORMAT(50X,'MINIMUM FLOW SHORTAGES')
      DO 63 IH=1,12
      READ (15,58) LY,OM,(S(4,I),I=1,NB)
   63 WRITE( 2,58) LY,OM,(S(4,I),I=1,NB)
      WRITE(2,59) LY,(B(4,I),I=1,NB)
      WRITE(2,53)
   53 FORMAT(//50X,'OTHER SHORTAGES')
      DO 64 IH=1,12
      READ (16,58) LY,OM,(S(5,I),I=1,NB)
   64 WRITE( 2,58) LY,OM,(S(5,I),I=1,NB)
      WRITE(2,59) LY,(B(5,I),I=1,NB)
      WRITE(2,50)
   50 FORMAT(//50X,'TOTAL SHORTAGES')
      DO 29 IH=1,12
      READ (17,58) LY,OM,(S(6,I),I=1,NB)
   29 WRITE( 2,58) LY,OM,(S(6,I),I=1,NB)
      WRITE(2,59) LY,(B(6,I),I=1,NB)
   59 FORMAT(/1H ,I3,' TOTAL',17F7.1/)
  102 DO 303 J=1,51
      K=KPCH(J)
      IF(K)303,303,103
  103 DO 223 LI=1,12
  223 IAL(LI)=VAL(LI,J)*10. +0.00001
      WRITE(3,104) K,NO,LY,(IAL(LI),LI=1,12)
  104 FORMAT(2I3,I2,12I6)
  303 CONTINUE
   18 RETURN
      END
```

```
      SUBROUTINE RELESE (SUR,KR,N,SRD,U,D)
      COMMON INR(50),NDR(50),IOI(50),STF(50),IRO(50),MRO(50),ILL(50)
      COMMON MSL(50),KORDR(50),GW(50,12),EMI(50,12),FMIN(50,12,3)
      COMMON RF(50,12)
      COMMON RNAME(12,3),RFS(12,2),KDS(12,24),SA(12,11),EVAP(12,12)
      COMMON PE(12,12),DEAD(12),FULL(12),ARINT(12),RLVL(12,12,4)
       COMMON DIV(50,12),RLF(50,10),IDST(50),JVD(50)
      COMMON BRN(20,4),B(6,20),IBR(26,20),S(6,20),SB(6)
      COMMON FLRS(6,28),FCST(6,43),SPAV(7),ROSP(6),API(6),PLSP(6),FMX(6)
      COMMON DAY(12),O(13),KPCH(51),KKDS(8),JORDR(39,9)
      COMMON IP,KO,MO,LL,KKUT,NR,ND,NP,NB,NO,NY,NYR,NRG,NDA,NCD,NEF,NVM
      COMMON NMI,NCU,NIR,NCL
      COMMON IP1,IP2,IP3,IP4,IP5,JYR,CCSUM
      DIMENSION SRD(50)
      D=0.0
C                   IS STORED WATER REQUIRED
      IF(SUR)1,2,2
    1 U=SUR*(-1.)
      DO 3 J=2,LL
      DO 3 L=1,9
       IO=JORDR(KO,L)
C                   DOES REACH HAVE STORAGE U/S ?
      IF(IO)3,3,4
    4 AV=RES(IO,N)-RLVL(IO,MO,J)
      IF(AV)5,6,6
    5 AV=0.0
    6 EXC=AV-U
      IF(EXC)7,8,8
    7 RES(IO,N)=RES(IO,N)-AV
      IF(AV)10,10,11
   11 D=AV
      CALL ROUTE(D,IO,KR,SRD)
   10 U=EXC*(-1.)
    3 CONTINUE
      GO TO 9
    8 RES(IO,N)=RES(IO,N)-U
      D=U
      CALL ROUTE(D,IO,KR,SRD)
      U=0.0
    9 SUR=0.0
      RETURN
    2 U=0.0
      RETURN
      END
```

```
      SUBROUTINE ROUTE(RMF,IO,KR,SRD)
      COMMON INR(50),NDR(50),IOI(50),STF(50),IRO(50),MRO(50),ILL(50)
      COMMON MSL(50),KORDR(50),GW(50,12),EMI(50,12),FMIN(50,12,3)
      COMMON RF(50,12)
      COMMON RNAME(12,3),RES(12,2),KDS(12,24),SA(12,11),EVAP(12,12)
      COMMON PE(12,12),DEAD(12),FULL(12),ARINT(12),RLVL(12,12,4)
       COMMON DIV(50,12),RLF(50,10),IDST(50),JVD(50)
      COMMON BRN(20,4),B(6,20),IBR(26,20),S(6,20),SB(6)
      COMMON FLRS(6,28),FCST(6,43),SPAV(7),RQSP(6),API(6),PLSP(6),FMX(6)
      COMMON DAY(12),O(13),KPCH(51),KKDS(8),JORDR(39,9)
      COMMON IP,KU,MO,LL,KKUT,NR,ND,NP,NB,NU,NY,NYR,NRG,NDA,NCD,NEF,NVM
      COMMON NMI,NCU,NIR,NCL
      COMMON IP1,IP2,IP3,IP4,IP5,JYR,CCSUM
      DIMENSION SRD(50)
      J=0
    3 J=J+1
      IF(J.LT.25)  GO TO 7
      WRITE(2,6)
    6 FORMAT(' REACH OF DEMAND WAS NOT FOUND DOWNSTREAM FROM RESERVOIR')
    7 K=KDS(IO,J)
      IF(KKUT.EQ.1.AND.IO.EQ.2) K=KKDS(J)
      IF(K-KR)1,2,1
    2 IF(IP)4,4,5
    1 SRD(K)=SRD(K)+RMF
      GO TO 3
    5 SRD(K)=SRD(K)+RMF
    4 RETURN
      END
```

```
      SUBROUTINE RSROP (UI,N,IR,JO,KR,RIN,ROU)
      COMMON INR(50),NOR(50),IOI(50),STF(50),IRO(50),MRO(50),ILL(50)
      COMMON MSL(50),KORDR(50),GW(50,12),FMI(50,12),FMIN(50,12,3)
      COMMON RF(50,12)
      COMMON RNAMF(12,3),RES(12,2),KDS(12,24),SA(12,11),EVAP(12,12)
      COMMON PE(12,12),DEAD(12),FULL(12),ARINT(12),RLVL(12,12,4)
        COMMON DIV(50,12),RLF(50,10),IDST(50),JVD(50)
      COMMON BRN(20,4),B(6,20),IBR(26,20),S(6,20),SB(6)
      COMMON FLRS(6,28),FCST(6,43),SPAV(7),ROSP(6),API(6),PLSP(6),FMX(6)
      COMMON DAY(12),O(13),KPCH(51),KKDS(8),JORDR(39,9)
      COMMON IP,KU,MO,LL,KKUT,NR,NO,NP,NB,NO,NY,NYR,NRG,NDA,NCD,NEF,NVM
      COMMON NMI,NCU,NIR,NCL
      COMMON IP1,IP2,IP3,IP4,IP5,JYR,CCSUM
      DIMENSION ROU(50)
      DIMENSION RIN(50)
C                    DOES REACH INCLUDE A RESERVOIR ?
      IF(IR)5,5,4
    4 RES(IR,N)=RES(IR,N)+UI
      SPIL=RES(IR,N)-RLVL(IR,MO,I)
      IF(SPIL)2,2,1
    1 RES(IR,N)=RLVL(IR,MO,I)
      GO TO 3
    2 SPIL=0.0
    3 RIN(JO)=RIN(JO)+SPIL
      ROU(KR)=SPIL
      RETURN
    5 RIN(JO)=RIN(JO)+UI
      ROU(KR)=UI
      RETURN
      END
```