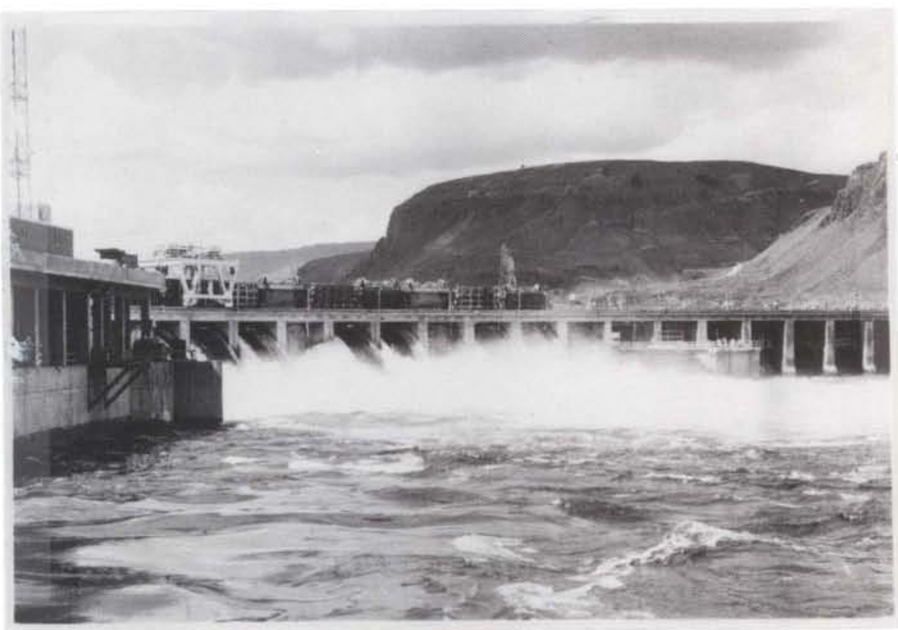
Research Technical Completion Report
Project A-071-IDA

EVALUATION OF MODELS AND PROCEDURES USED FOR RIVER OPERATIONS AND PLANNING IN THE UPPER SNAKE AND BOISE RIVERS IN IDAHO

by

Kyung Hak Yoo and J.R. Busch
College of Engineering/College of Agriculture



Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho

August 1981

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Submitted to

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Idaho Water & Energy Resources Research Institute
Agricultural Experiment Station
University of Idaho
Moscow, Idaho

August, 1981

ACKNOWLEDGEMENTS

Support for the work reported was provided by the U.S. Department of the Interior Office of Water Research and Technology and the Idaho Agricultural Experiment Station.

The authors wish to thank the personnel of the following public and private organizations for their cooperation in providing the necessary information: Idaho Department of Water Resources, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, Soil Conservation Service, Bonneville Power Administration, Idaho Power Company, and Water District No. 01.

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ABSTRACT

The planning models and procedures used by operational agencies in the Upper Snake and Boise River basins in Idaho were investigated. These models and procedures have been developed and updated to improve accuracy and meet changing conditions by both public agencies and private companies in the area. Each model and procedure has different objectives according to the organizations' intended purposes. The organizations contacted and interviewed to gather the information presented in this report are:

1. Idaho Department of Water Resources, Boise, Idaho
2. Water District No. 01, Idaho Falls, Idaho
3. U.S. Department of the Interior Bureau of Reclamation, Boise and Burley, Idaho
4. U.S. Army Corps of Engineers, Walla Walla, Washington
5. U.S. Department of Agriculture Soil Conservation Service, Boise, Idaho
6. U.S. Department of Energy Bonneville Power Administration, Vancouver, Washington
7. Idaho Power Company, Boise, Idaho

The models and procedures are used to predict runoff from snow pack data, to predict natural stream flows based on various hydrologic data, to predict reservoir levels necessary to meet flood control and refill criteria, to account for water diversions from rivers, and to evaluate the effects of alternative future demands on the surface and ground water in a hydrologic basin. Most of the models and procedures used are computerized, but some of them are still operated by hand. In most cases, there are no published references related to the procedures and models, or if they exist, they are published only for in-house purposes. Those in-house reports can be obtained by any interested person from each public agency.

The operation of the models and procedures requires a great deal of input data. Several agencies are now cooperating in establishing and maintaining automated hydrometeorological data acquisition systems. The accuracy and immediate availability of input data by these systems will greatly facilitate the timing of decisions that must be made during critical operations such as flood control.

River operations and planning procedures depend quite heavily upon the ability to predict various parameters. Accurate prediction of streamflow using various hydrologic parameters have received a great deal of attention, and yet it is considered to be one of the weakest links in many of the predictive and modeling procedures. Equally important is the need to predict various instream uses and diversions along a river. If available, these predictions allow for better water control within the river system and thereby promote water conservation.

CHAPTER I

INTRODUCTION AND OBJECTIVES

The water resources of southern and southeastern Idaho have been a key element in the development of the region. The Upper Snake and Boise River Basins provide irrigation water for nearly four million acres of irrigated cropland in addition to water for municipal and industrial uses in an area where 750,000 people live. Water resource systems have been developed that also provide for flood control, electric power generation, recreation, fish and wildlife.

As the water resources of the Upper Snake and Boise Rivers have been developed, methods and procedures have been used to more effectively control and utilize water in the systems. These procedures have been developed by both public agencies and private companies and have different objectives according to their intended purpose. The various objectives are not necessarily complimentary. For example, the objective of flood control is to provide ample reservoir storage space to accommodate an expected flood while that of irrigation is to fill the storage to provide an ample water supply for irrigation. Operational procedures and models have been used to allow for the simultaneous evaluation of various objectives to achieve the most desirable method of river operation. In addition, models of the water resources systems have been developed to allow planners to efficiently evaluate the effects of various aspects of future development of water resources in the region

As the demand for water has increased over the years, better management of water in the river systems has become necessary. In addition to control structures, more sophisticated operational models and planning procedures have been developed for use. Many models are now programmed in digital computers that provide capabilities for large amounts of data storage and complex modeling procedures. The models and procedures are continually being upgraded and changed to improve their accuracy, to reflect changing conditions within the river systems and to generate more useful results.

Data collected for input to the models and procedures as well as the output have importance and uses for more than their intended purposes. In addition, the modeling procedures themselves may be of value in other than the original applications. A comprehensive and integrated understanding of the currently used river operations and planning models and procedures would be very helpful to various agencies and organizations involved with river operations and planning. This information would also be useful to researchers conducting water resources related research. It is important that existing models and procedures be investigated and evaluated to determine their merits and possible application to other water resources related operations, planning and research.

The overall objective of the work reported was to evaluate existing models and procedures supported and used by agencies and organizations involved with river operations and planning in the Boise and Snake River Basins. The specific objectives were:

1. To investigate river operations, planning, water allocation, and aquifer system simulation models and procedures used in the Upper Snake and Boise River Basins.
2. To determine the functional characteristics of the existing models and procedures including data input requirements, methodologies used and generated output.

CHAPTER II

PROCEDURES

Organizations involved with planning and operations in the Upper Snake and Boise River Basins were contacted to provide information about models and procedures used for river operations and planning. Those contacted were:

Idaho Department of Water Resources, Boise, Idaho

Water District No. 01, Idaho Falls, Idaho

U.S. Department of Agriculture Soil Conservation Service, Boise, Idaho

Idaho Power Company, Boise, Idaho

U.S. Army Corps of Engineers, Walla Walla, Washington

U.S. Department of the Interior Bureau of Reclamation, Boise and Burley, Idaho

U.S. Department of Energy Bonneville Power Administraton, Vancouver, Washington

In addition to collecting written information, a representative from each organization was interviewed. Information was collected to determine what models and procedures were being used and what were the functional characteristics of each. The models and procedures were not evaluated to determine their accuracy and reliability. It was assumed that the methodology of each was reasonable for its intended purposes, and no modifications were recommended by the investigators in this study.

Information collected from each organization included:

1. The objective(s) of the agency or firm in the operations of the Upper Snake and/or Boise River systems.
2. Descriptions of the models and procedures used including:
    a. Descriptions of the procedures and algorithms along with the assumptions incorporated.

b. Input data requirements.

c. Output generated and types of reports produced (in-house and published).

d. Manuals, references and other printed materials related to the operational role.

e. Descriptions of the equipment used.

f. The interface with models and procedures used by other organizations.

g. Annual budget and manpower requirements for developing and using the models and procedures.

h. The number of people in the organization familiar with the procedures and the time requirement for training replacements.

3. Evaluations by the organization concerning:

   a. Advantages

   b. Disadvantages

   c. Problems encountered

   d. Improvements needed

CHAPTER III

RESULTS

The results consist of a narrative summary of the information collected from each organization using the outline described. Descriptions and evaluations presented are those furnished by the organizations themselves. The information for each organization is presented separately.

ORGANIZATION: Idaho Department of Water Resources
Hydrology Section
Statehouse
Boise, Idaho 83720

CONTACT PERSONS: Alan Robertson
Robert Sutter

OBJECTIVES IN THE OPERATION OF THE UPPER SNAKE AND BOISE RIVERS:

A. To allocate daily natural flows and determine daily stored water releases to allocate it to various uses, most of which are diversions for irrigation according to water right schedules.

B. To simulate present river management and proposed changes in river management through the use of planning models.

MODELS AND PROCEDURES USED:

A. Water Allocation Model

B. River Planning Model

C. Ground Water Model

DESCRIPTION AND EVALUATIONS:

A. Water Allocation Model. A model was developed by the Idaho Department of Water Resources (IDWR) in 1978 and has been used to account for water deliveries in Water District No. 01. This district includes most of the Upper Snake River and its tributaries above Milner Dam in Idaho. The model is primarly an accounting procedure for daily bookkeeping of water allocations, water storage use and water diversions at each diversion point.

The model is used: (1) to determine the natural flow at several points throughout the river system, (2) to allocate the natural flow to various water diverted if their diversions exceed the natural flow right.

A manual and description of the program is being prepared for publication by the Hydrology Section of the Idaho Department of Water Resources (Sutter and Robertson, 1981). A portion of the output from this model and a brief description are included in the Watermaster's Report from Water District No. 01 (Water District No. 01, 1979).

Input data required by the model include daily measurements of river streamflow, diversions and reservoir contents. Data are entered at remote terminals that are linked to the computer in the State Auditor's Office in Boise. Terminals are located in the Water District No. 01 Office in Idaho Falls, and the U.S. Bureau of Reclamation Office in Burley. Close cooperation between Water District No. 01, the Idaho Department of Water Resources, and the U.S. Bureau of Reclamation is necessary as the U.S. Bureau of Reclamation is in charge of river operations, and Water District No. 01 is in charge of water deliveries in accordance with water right priorities. In addition, federal agencies' forecasts are used to predict upstream snowmelt conditions.

Output generated by the Water Allocation Model includes the natural flow available at the lower end of each reach in the Upper Snake River and the reach gain if any, the natural flow allocations in order of water right priority and the reservoir storage water diverted. The river is broken into 37 reaches as shown schematically in Figure 1. Time lags are included at appropriate locations to account for flow travel times when computing natural flows at the various reach boundaries.

UPPER SNAKE SYSTEM FOR DISTRICT I WATER RIGHT ACCOUNTING

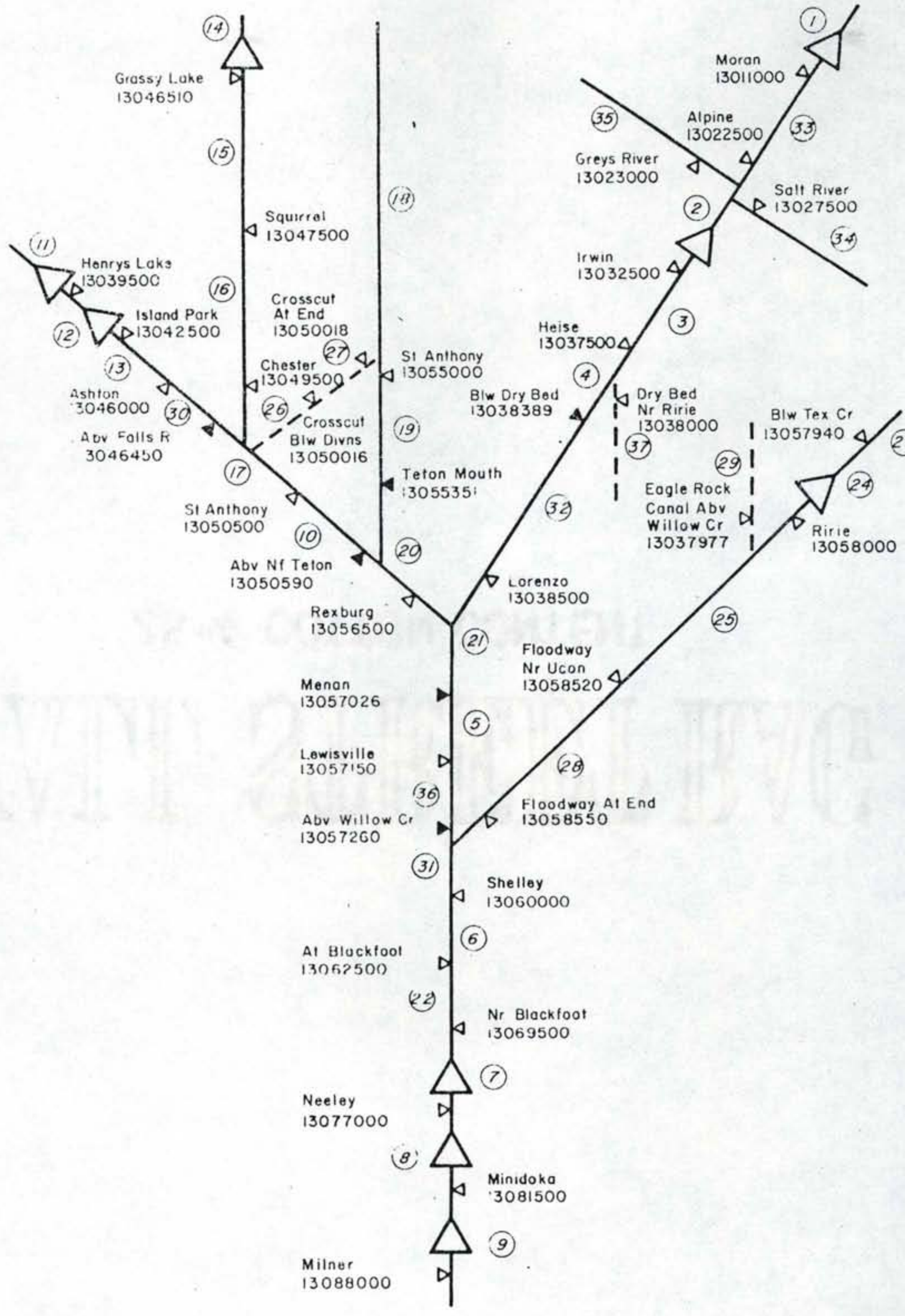


Figure 1. Upper Snake River system in Water District No. 01 Water Right Accounting (after Idaho Department of Water Resources).

There are three persons involved with the Allocation Model in the Hydrology Section of IDWR. They are involved in the preparation of a manual and documentation, improvement of the model and modification of the model for application in other river basins in Idaho. There are not many persons who are intimately familiar with the model; therefore, if there were a change in personnel in either the Watermater's Office in Water District No. 01 in Idaho Falls or the Hydrology Section of the Idaho Department of Water Resources, the operation of the model might be in jeopardy.

Use of the model enables river operations personnel to obtain accurate information on water use in the Upper Snake River including natural flow and storage. This information can be obtained on a daily basis. However, the model is quite large and requires considerable computer time to operate on a daily basis. There are predictive procedures incorporated in the model, but this capability has not yet been fully utilized. It would be quite helpful if the Watermaster or other river operations personnel could estimate required diversions as much as five days in advance in order to save water in upstream storage. No pressing problems exist in the model other than to improve existing model operations to meet changing needs in the river system.

B. River Planning Model. This model is used to simulate the effects of possible changes in river management and future demands on the flows. The model is first calibrated to simulate conditions of the river in recent years. By using a trial and error method, reservoir contents and natural flows are simulated for the past five or six years. Once calibrated, the model is run using monthly data from a rather large data base (1928 through 1977 for the Snake River) for each river reach where there is a gage or reservoir. The output consists of the computed flow in each reach of the river and computer contents in each reservoir. The model can thereby be used to simulate the effects of future changes on a river system such as new diversions, changes in diversions, and new reservoirs.

No published reports or references are available for this model. It has been used mainly to generate in-house information and answer "what if" questions pertaining to river operations.

Four persons are involved with the development and running of the planning model, and it has been applied to six river basins. Two individuals are involved with the Snake River planning aspects (one from the headwater to King Hill, Idaho and the other from King Hill to Clarkston, Washington), one for the Wood River and Weiser River, and one for the Bear River and Priest River.

The model has been used beneficially to allow planners to evaluate the effects of possible changes imposed on a river system by future demands and/or changes. The model requires a large amount of time and effort to calibrate a major river system because of the large amount of data involved.

C. Ground Water Model. Ground water simulation models have been developed and used to simulate water table levels and aquifer responses to various input conditions. These models have been developed for the Upper Snake River Plain and the Boise Valley. As with the River Planning Model, this model is calibrated using hydrologic data including water balance data from irrigated areas and ground water levels. These data are used to calibrate the model by determining aquifer properties.

The Idaho Department of Water Resources has published no report for this model; however, the methodology used is explained by de Sonneville (1974). Three persons in the department are assigned to the development, calibration and application of this model.

The Ground Water Model requires a great deal of data input to assure accurate calibration. The accuracy is also limited as the aquifer systems being modeled are not yet fully understood. More revisions and modifications of the model are necessary in order to simulate ground water systems more accurately.

ORGANIZATION: Water District No. 01
Idaho Department of Water Resources
150 Shoup
Idaho Falls, Idaho 83401

CONTACT PERSONS: Ronald Carlson
Lyle Swank

OBJECTIVES IN THE OPERATION OF THE UPPER SNAKE RIVER:

To distribute the natural streamflow of the Upper Snake River to the various users according to their decreed and licensed priorities, to regulate the use of water when stream flows are insufficient to supply all water rights, and to convey and distribute stored water to the diversions which are entitled to its use.

MODELS AND PROCEDURES USED:

Water Allocation Model

DESCRIPTIONS AND EVALUATIONS:

This model is used to generate daily reports of water allocations, storage rights and diversions at all diversion points. The functional characteristics are described in the Idaho Department of Water Resources portion of this report.

Input data for the model are entered and massaged on a Datapoint computer system in the Watermaster's Office located in Idaho Falls. These data are then sent via telephone line to the computer in the State Auditor's Office on which the computer model is stored and run. The input data consists of staff gage readings and streamflows. Some readings must be estimated if the data for a given location are late in being reported.

The output obtained from the model is very similar to that contained in the annual Watermaster's report (Water District No. 01, 1979). In addition to the natural flows diverted, the output lists reservoir contents and changes in the reservoir contents. The model accounts for the natural flow and/or stored water diverted at each point, and also maintains an accounting of the stored water diverted at each diversion point. As a result, use of the model provides the Watermaster with accurate data for making priority cuts because it calculates both the amount of natural flow available in a given reach and the downstream demand. This capability is very important for a comlex system such as the Upper Snake River System that may have many different priorities in effect throughout the system on any given day.

The U.S. Bureau of Reclamation works cooperatively with Water District No. 01 and the Idaho Department of Water Resources in supplying input data for the model. The Bureau of Reclamation holds all of the major storage rights on the Upper Snake River except for Henry's Lake, and is in charge of daily reservoir operations for the entire year, and river operations throughout the flood control season which usually lasts between January 1 and June 1.

One of the biggest problems in using the allocations model is the quantity of data required to accurately account for all of the diversions. Also, if a reading for a station is missing for one day it must be estimated, and the model presently has no means of flagging estimated data that can be later corrected. Another problem is that of accounting for several minor diversions that have no water flow recording devices. The model is presently used to account for water delivered to over 650 water rights at 314 different locations. There are a total of 661 recognized diversions in Water District No. 01; however, the 650 water rights accounted for represent

95.7 percent of the total water delivered in the district. Those diversions not presently included in the computerized accounting process are administered separately by traditional methods. The accounting model will also benefit greatly from an automated hydrometerological data collection system (HYDROMET). This system will supply river flow data at critical points throughout the system. It is also anticipated that the HYDROMET system will automatically collect and log diversion data from the major diversions in Water District No. 01.

ORGANIZATION: U.S.D.A. Soil Conservation Service
Snow Survey
Room 346, 304 North Eighth Street
Boise, Idaho 83702

CONTACT PERSON: Jack A. Wilson

To gather snow course and other hydrometeorological data for use by the U.S.D.A. Soil Conservation Service and other agencies and to forecast seasonal streamflow and water supplies.

MODELS AND PROCEDURES USED:

Multiple regression procedures are used to predict runoff from snow course data.

DESCRIPTIONS AND EVALUATIONS:

Although there are a number of automated data collection sites throughout the state using the SNOTEL system and snow pillows, snow course data collected manually are those used in the predictive procedures. The snow courses on a watershed which give the best correlation between snow measurement data and runoff are measured and the data are manipulated using multiple regression techniques to obtain the best prediction. A forecast formula for a given forecast point is developed and used. This forecast may be adjusted based on knowledge of the watershed and soil moisture conditions which provide the best forecast.

Runoff forecasts are published monthly by the Soil Conservation Service. The regression procedures have all been developed for in-house use, and there are no published references. However, any interested person can obtain access to the procedures. The multiple regression techniques used are satisfactory for seasonal forecasting. For short term forecasting further procedures and/or models might be required.

The SCS office in Boise has a computer terminal connected to the USDA computer located at Fort Collins, Colorado. This system is used to develop and run the regression models, and to obtain frequency analyses and summary reports. Another SCS computer in Portland, Oregon is used to log daily snow course data from numerous remote stations. These data are available to other state and federal agencies.

There is one operator in the SCS office in Boise. It would take considerable time for someone else to become intimately familiar with the waterhsheds, snow courses, and predictive procedures. Use of the existing procedures requires considerable judgment influenced by many factors for which data are difficult or impossible to obtain. There is room for improvement in most aspects of the forecasting process.

ORGANIZATION: Idaho Power Company
P. O. Box 70
Boise, ID 83707

CONTACT PERSONS: Jim Collingwood
Jim Boyles
John Pirrong
John Wilmorth

OBJECTIVES IN THE OPERATION OF THE UPPER SNAKE RIVER:

To produce and distribute electrical power and to plan for future generation operations.

MODELS AND PROCEDURES USED:

A) Planning model

B) Operating model

DESCRIPTIONS AND EVALUATIONS:

A) The planning model is used to project the future need and utilization of electrical energy production resources based on the reoccurrence of historical stream flow runoff and recognizing stream flow constraints below Hells Canyon. Inputs include system energy loads, expected maximum thermal resource energy output and hydro plant stream flow estimates. A month is the smallest input increment. Stream flow data are utilized based on the 1977 level of river development as provided by the Idaho Department of Water Resources. The model output generally provides an indication of the adequacy of power supply resources. The model is run from remote terminals off the company's corporate IBM 3031 computer. One person is used to maintain the model. Three other computers can run the model. The model is also utilized to supply monthly hydro energy production to a production costing model.

B) The operations model does not yet exist, but it is in the development stage. Implementation of the model is one to two years away at this time. It will be computerized and tied in with the company's system data logging equipment which is already in operation. Inputs to the model will be actual reservoir elevations and contents, project releases from those projects beyond the control of the company, and projection requirements for the facilities included in the model. Constraints will include plant efficiencies, reservoir fluctuation limits, flow times between projects, minimum or maximum flow requirements and production costs at various facilities. The outputs of the model will be the generation schedules for each of the plants. Utilization of such a model will allow the system operators to approach getting the maximum amount of generation from the Company's facilities at the minimum cost while assuring that all of the facilities are operated within their particular constraints. At present, the system is operated on a real time basis utilizing a data logging system which records among other things, system load and resource information. This data system is maintained on a Hewlett-Packard 2100 computer system which is used to collect the data and prepare hard copy for company use.

ORGANIZATION: U.S. Army Corps of Engineers
Hydrology Section
Walla Walla, Washington 99362

CONTACT PERSONS: David Reese
Robert Rickel

OBJECTIVES IN THE OPERATION OF THE UPPER SNAKE AND BOISE RIVERS:

To provide reservoir regulation for flood control purposes of federal projects.

MODELS AND PROCEDURES USED:

A. Reservoir regulation manuals and flood control procedures

B. Runoff forecasting procedures and models

DESCRIPTIONS AND EVALUATIONS:

The flood control procedures used in the Upper Snake and Boise Rivers are based upon runoff and volume forecast procedures that normally start each year on January 1. The flood control season extends until the natural inflows into the reservoir are decreased to near base flow levels. The timing for each year is different, but normal flood forecasting runs through the first of June. The first portion of the flood control season is the evacuation season when reservoir storage is drawn down in preparation for probable floods. The second portion is the refill when the flows are stored for later use by irrigation and other purposes after the flood control season is ended. Inflows are forecasted using a combination of snow pack and precipitation data.

Reservoir regulation manual flood control parameter curves and storage volume parameter curves are generated as shown in Figures 2 and 3. These curves are based upon runoff volumes, forecast errors, and timing sequence probabilities. Volume projection equations are developed from historical records and give statistical relationships of time and volume for historical hydrologic conditions. Critical timing sequences and volume forecast errors are generated for flood control. Maximum required flood control spaces in a

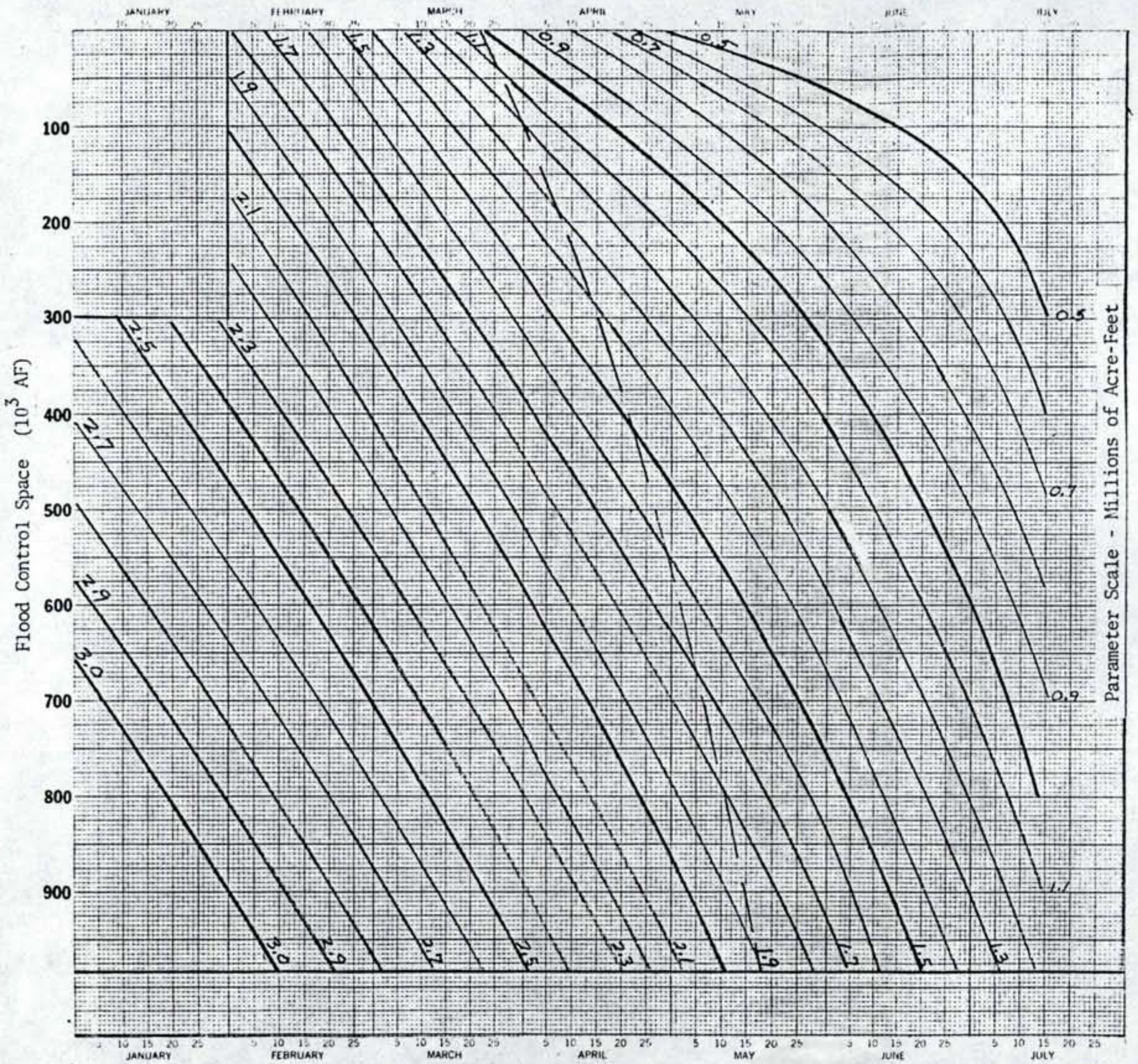


Figure 2. Flood control parameter curves (after U.S. Army Corps of Engineers, Walla Walla, Washington)

FLOOD CONTROL PARAMETER CURVE

NOTES:

1. Parameters represent forecasted Lucky Peak Lake natural inflow volumes between the forecast date and 31 July. Parameter curves were derived on the following assumptions:

a. Project Release Schedule:

Date	Max. Discharge (cfs)	Min. Discharge (cfs)
1 Jan-14 Feb	6,500	200
15 Feb-14 Mar	6,500	900 1/
15 Mar-31 Mar	6,500	200
1 Apr-30 Apr	8,320	2,600
1 May-30 Jun	10,300	4,800
1 Jul-31 Jul	10,000	4,600

1/ Includes transfer of water to Lake Lowell.

b. Flood Control: Flood control space values to the left of the dashed line are based on (1) the 1% volume forecast error, and (2) the 95% upper confidence limit timing sequence. The area to the right of the dashed line is the portion of the diagram where computed flood control requirements exceed computed 95% storable volumes; and the values shown are the arithmetic average between 1% flood control space and 95% storable volume.

c. Standard Error for Runoff Volume Forecasts:

Forecast Date	Standard Error (AF)	Forecast Error (1%) (2.3267)x(Standard Error)(AF)
1 January	370,000	860,000
15 January	335,000	780,000
1 February	300,000	700,000
15 February	275,000	640,000
1 March	250,000	580,000
15 March	210,000	490,000
1 April	170,000	400,000
15 April	165,000	380,000
1 May	160,000	370,000
15 May	155,000	360,000
1 June	150,000	350,000
15 June	150,000	350,000
1 July	150,000	350,000
15 July	150,000	350,000

2. To determine total vacant space required on any forecast date in all three reservoirs, select parameter corresponding to predicted runoff between that date and 31 July; then read the ordinate of this parameter corresponding to forecast date. This ordinate is the total space required to control the predicted runoff and limit regulated discharge at Strawberry Glen Bridge to 6,500 cfs.

The following allocation has been made of the acre-feet of storage capacity available.

Reservoir	Flood Control	Dead	Total
Anderson Ranch	418,000	75,000*	493,000
Arrowrock	285,000	0	285,000
Lucky Peak	280,000	26,000	306,000
Total Space	983,000	101,000	1,084,000

* Additional drawdown of 5,000 acre-feet may be made for power production.

At least 60 percent of this flood control space must be available in Lucky Peak and Arrowrock Reservoirs. Lucky Peak must contain a minimum of 20,000 acre-feet of flood control space from 1 November to 1 March each year. A total of at least 300,000 acre-feet of space is required in the three reservoirs from 1 October to 31 January each year.

SYSTEM FLOOD CONTROL PARAMETER CURVES

Boise River Reservoirs
Corps of Engineers, Walla Walla District
Hydrology Section

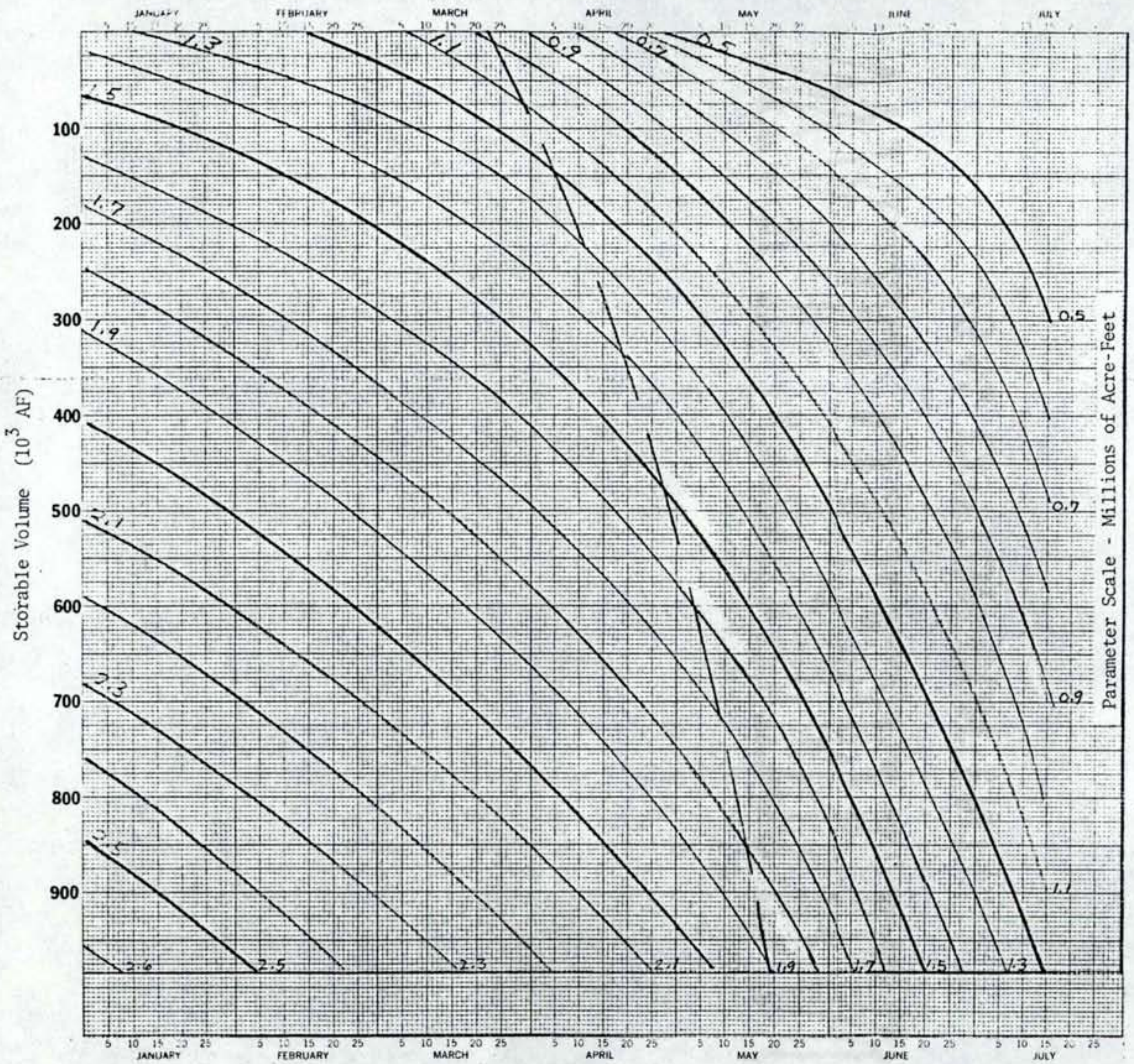


Figure 3. Storable volume parameter curves (after U.S. Army Corps of Engineers, Walla Walla District)

STORABLE VOLUME PARAMETER CURVE

NOTES:

1. Parameters represent forecasted Lucky Peak Lake natural inflow volumes between the forecast date and 31 July. Parameter curves were derived on the following assumptions:

a. Project Release Schedule:

Date	Max. Discharge (cfs)	Min. Discharge (cfs)
1 Jan-14 Feb	6,500	200
15 Feb-14 Mar	6,500	900 1/
15 Mar-31 Mar	6,500	200
1 Apr-30 Apr	8,320	2,600
1 May-30 Jun	10,300	4,800
1 Jul-31 Jul	10,000	4,600

1/ Includes transfer of water to Lake Lowell.

b. Refill: Storable volume values to the left of the dashed line are based on: (1) the 95% volume forecast error, and (2) the 40%, 70%, 85%, and 95% confidence limits on the expected timing sequence. The area to the right of the dashed line is the portion of the diagram where computed 1% flood control requirements exceed computed 95% storable volumes, and the values shown are the arithmetic average between 1% flood control requirements and 95% storable volumes.

c. Standard Error for Runoff Volume Forecasts:

Forecast Date	Standard Error (AF)	Forecast Error (95%) (1.645)x(Standard Error)(AF)
1 January	370,000	610,000
15 January	335,000	550,000
1 February	300,000	490,000
15 February	275,000	450,000
1 March	250,000	410,000
15 March	210,000	350,000
1 April	170,000	280,000
15 April	165,000	270,000
1 May	160,000	260,000
15 May	155,000	250,000
1 June	150,000	250,000
15 June	150,000	250,000
1 July	150,000	250,000
15 July	150,000	250,000

2. To determine total volume available for refill on any forecast date in all three reservoirs, select parameter corresponding to predicted runoff between that date and 31 July; then read the ordinate of this parameter corresponding to forecast date. This ordinate is the total volume available for refill of the system.

The following allocation has been made of the acre-feet of storage capacity available.

Reservoir	Flood Control	Dead	Total
Anderson Ranch	418,000	75,000*	493,000
Arrowrock	285,000	0	285,000
Lucky Peak	280,000	26,000	306,000
Total Space	983,000	101,000	1,084,000

* Additional drawdown of 5,000 acre-feet may be made for power production.

STORABLE VOLUME PARAMETER CURVES
Boise River Reservoirs
Corps of Engineers, Walla Walla District
Hydrology Section

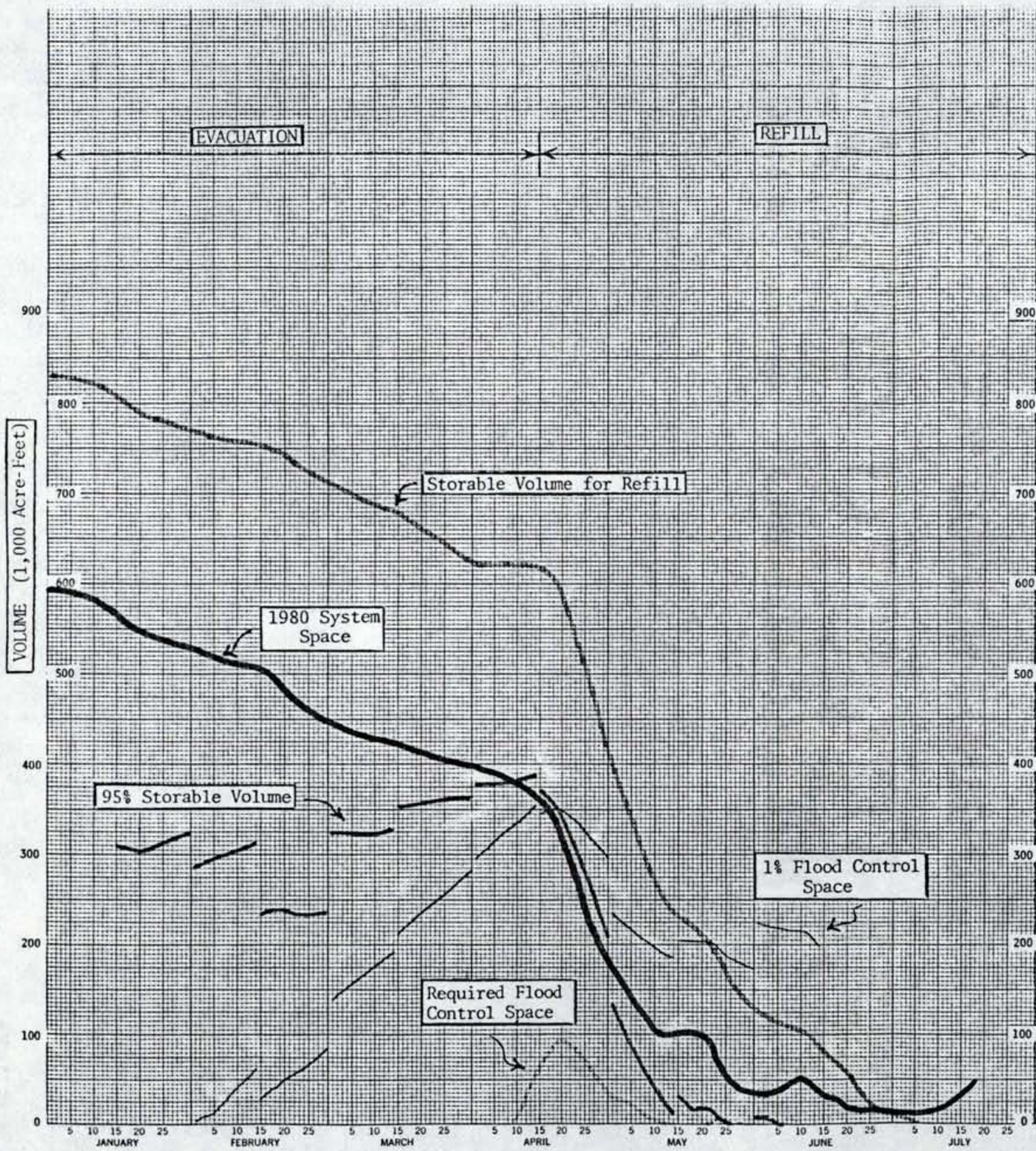
By: R. Emmert Date: July 1980

reservoir or reservoirs are computed for various volume forecast errors. Such parameter curves have traditionally been developed using historical records to compute the flood control requirements and plot the points with respect to time and then envelope the points. There were no volume forecast error ranges or timing probabilities accounted for in this process.

The first step of the flood control procedure is to designate operational criteria as shown in Figures 4 and 5. The second step is to determine reservoir schedules to meet the targets shown on the parameter curves (Figures 2 and 3). The amount of reservoir release is then determined so that flood control requirements are met. The SSARR (Streamflow Synthesis and Reservoir Regulation) program is one key program which is used in the process to predict streamflows and reservoir inflow volumes. This program is used primarily for short time period predictions (less than 30 days), and these predictions can then be used as input to the flood control procedures. The SSARR program is well documented and can be obtained from the U.S. Army Corps of Engineers (U.S. Army Corps of Engineers, 1972).

All standard hydrologic data (streamflow, temperatures, precipitation and snow) for a river basin are used in the flood control procedures. The reports obtained from the flood control procedures are used in-house by the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation for river operations. The manuals describing the procedures are written for in-house use but can be obtained by any interested person.

During the flood control season, the Corps of Engineers and the Bureau of Reclamation jointly regulate the projects. After the flood control season, the latter solely regulates the river system. There are occasional contacts with the Idaho Department of Water Resources and the Watermaster of Water District No. 01 in Idaho Falls, but these are mostly for information



BOISE RESERVOIRS - OPERATIONAL CRITERIA

(1980 Season Example)

1. Lucky Peak Release Assumptions:

Date	Assumed Minimum Allowable Irrigation Releases (Cfs)	Assumed Minimum Allowable Flood Control Releases (Cfs)	
1 Jan-14 Feb	200		6,500
15 Feb-14 Mar	900 1/		6,500
15 Mar-31 Mar	200		6,500
1 Apr-30 Apr	2,600	6,500 + 1,820 =	8,320
1 May-30 Jun	4,800	6,500 + 3,800 =	10,300
1 Jul - 31 Jul	4,600	6,500 + 3,500 =	10,000

1/ Includes 40,000 A.F. transfer to Lake Lowell.

2. Volume Forecast Errors:

Forecast Date	Standard (Error (A.F.)	95% Error 1/ (A.F.)	1% Error 2/ (A.F.)
1 January	370,000	610,000	860,000
15 January	335,000	550,000	800,000
1 February	300,000	490,000	700,000
15 February	275,000	450,000	640,000
1 March	250,000	410,000	580,000
15 March	210,000	350,000	490,000
1 April	170,000	280,000	400,000
15 April	165,000	270,000	380,000
1 May	160,000	260,000	370,000
15 May	155,000	250,000	360,000
1 June	150,000	250,000	350,000
15 June	150,000	250,000	350,000
1 July	150,000	250,000	350,000
15 July	150,000	250,000	350,000

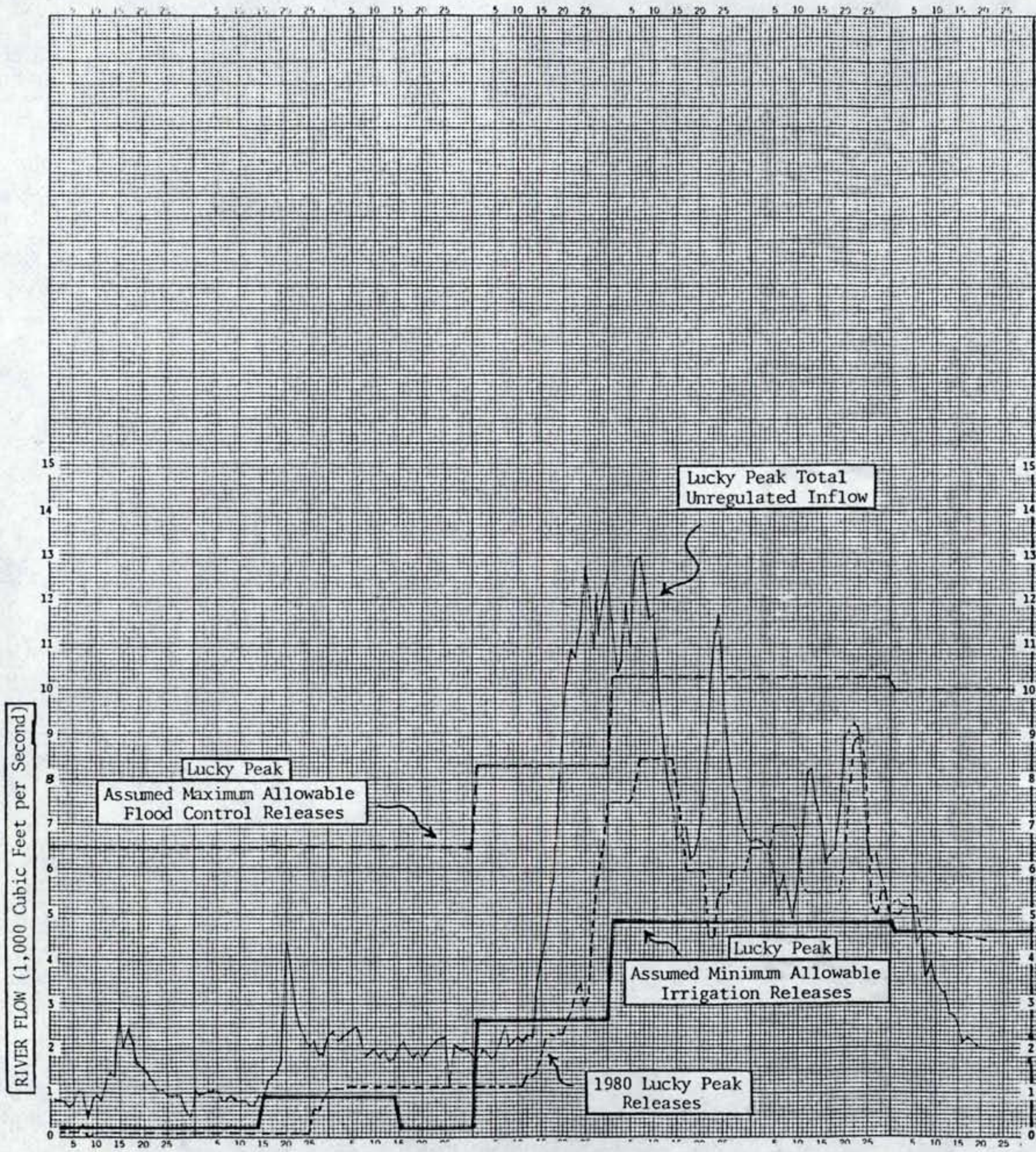
1/ 95% error is 1.6450 times standard error.

2/ 1% error is 2.3267 times standard error.

3. Hydrograph Timing Sequences:

The shape of the hydrograph in addition to the volume affects both storable volume and flood control space. Operational criteria must evaluate and utilize abnormal timing sequences to develop the parameter curves. Nine timing patterns (50% and upper and lower 40%, 70%, 85%, and 95%) were used to generate critical hydrographs with time for the computation of storable volume and flood control criteria.

Figure 4. Operational criteria curves (after U.S. Army Corps of Engineers, Walla Walla District)



BOISE RESERVOIRS - OPERATIONAL CRITERIA

(1980 Season Example)

1. Lucky Peak Release Assumptions:

Date	Assumed Minimum Allowable Irrigation Releases (Cfs)	Assumed Maximum Allowable Flood Control Releases (Cfs)	
1 Jan-14 Feb	200		6,500
15 Feb-14 Mar	900 1/		6,500
15 Mar-31 Mar	200		6,500
1 Apr-30 Apr	2,600	6,500 + 1,820 =	8,320
1 May-30 Jun	4,800	6,500 + 3,800 =	10,300
1 Jul - 31 Jul	4,600	6,500 + 3,500 =	10,000

1/ Includes 40,000 A.F. transfer to Lake Lowell.

2. Volume Forecast Errors:

Forecast Date	Standard (Error (A.F.)	95% Error 1/ (A.F.)	1% Error 2/ (A.F.)
1 January	370,000	610,000	860,000
15 January	335,000	550,000	800,000
1 February	300,000	490,000	700,000
15 February	275,000	450,000	640,000
1 March	250,000	410,000	580,000
15 March	210,000	350,000	490,000
1 April	170,000	280,000	400,000
15 April	165,000	270,000	380,000
1 May	160,000	260,000	370,000
15 May	155,000	250,000	360,000
1 June	150,000	250,000	350,000
15 June	150,000	250,000	350,000
1 July	150,000	250,000	350,000
15 July	150,000	250,000	350,000

1/ 95% error is 1.6450 times standard error.

2/ 1% error is 2.3267 times standard error.

3. Hydrograph Timing Sequences:

The shape of the hydrograph in addition to the volume affects both storable volume and flood control space. Operational criteria must evaluate and utilize abnormal timing sequences to develop the parameter curves. Nine timing patterns (50% and upper and lower 40%, 70%, 85%, and 95%) were used to generate critical hydrographs with time for the computation of storable volume and flood control criteria.

Figure 5. Operational criteria curves (after U.S. Army Corps of Engineers, Walla Walla District)

exchange. The Corps of Engineers, the Bureau of Reclamation and the Idaho Department of Water Resources have also been involved with the revision of the reservoir regulation manual as necessary.

There are four people at the Walla Walla District Office working on flood control procedures. Approximately fifty percent of their time is used in developing and revising criteria and manuals. The remainder of their time is used in real time flood control operations. It would require a person with a good background in hydrology and hydraulics about one year to become acquainted with the procedures. However, it would require four to five years to achieve the expertise to be a decision maker. The organizational structure of the Corps of Engineers is designed to cover any personnel absences without jeopardizing the integrity of the procedures.

Computing facilities at the Walla Walla and Portland Corps of Engineers office are used for developing and running the procedures. There are also many other computer facilities to which the district personnel can obtain access. To maintain all necessary Upper Snake River hydrologic data on one system so that all users can access it, an automatic collection of hydrometeorological data for use in the operational management of water resource projects has been installed by the U.S. Bureau of Reclamation in Boise (Suttron system-VAX Computer).

A main advantage of the flood control procedures being worked on are that they present a very realistic and objective approach to reservoir regulation. As the procedures are being refined, the problem of reservoir refill can be considered along with the problem of maintaining adequate flood control storage. To obtain more accurate and dependable regulation, volume forecasting procedures must be continually improved and updated. Future volume forecasting could be improved by using technical studies to coordinate satellite data showing snow covered areas and snow course data obtained from ground observations.

ORGANIZATION: U.S. Bureau of Reclamation
River Operations Divison
550 West Fort Street, Box 043
Boise, Idaho 83724

CONTACT PERSONS: Harold Brush
Joe Wensman

OBJECTIVES IN THE OPERATION OF THE UPPER SNAKE AND BOISE RIVERS:

To fill allocated storage space in reservoirs in conjunction with flood control operations.

MODELS AND PROCEDURES USED:

A. SSARR Model (Streamflow Synthesis and Reservoir Regulation)

B. Snowband Model

DESCRIPTIONS AND EVALUATIONS:

The SSARR model developed by the U.S. Army Corps of Engineers is used to predict natural streamflow conditions for a given period of time. Historical data from the past fifteen years are used to develop average daily streamflows. These average flows are adjusted up or down to fit the forecast for a particular year. No statistical variations between years or within any given year are computed for the data in this process. The SSARR model and a non-regulational program are used to determine the amount of volume to be released or retained in a reservoir. In the prediction process, a decision is made as to whether or not the reservoir is filled. If the predictions indicate that there will be more than enough to fill the reservoir, the reservoir will be lowered at an earlier date than normally scheduled for strict flood control operation. The same type of operations have been used to determine if earlier releases are necessary in the spring for uses other than irrigation.

The Snowband model is run with input from a year which has the same volume runoff as that forecasted for the current year. Then the actual data for the current year are input to the model and the runoff for the remainder of the runoff season is predicted. An adjustment in the running of the Snowband model is to input temperature and precipitation predictions for the next five to ten days as obtained from the National Weather Service.

Output from the procedures consists of monthly runoff forecast reports and weekly volume forecast reports for each reservoir based mainly on snow water content and precipitation data. None of the reports are published as the output is used strictly for in-house decision making. The in-house information includes monthly data of reservoir storage, previous outflow for the month and last year's averages. The reports include current storage capacities, the volume amounts required to control floods and recommended releases for the next sixty to ninety days for reservoirs which are under flood control operations.

All the routines are supported and run on the U.S. Bureau of Reclamation (USBR) computer systems. A small system is maintained in the regional office in Boise, and all larger jobs are run on a large computer system located in Denver via remote entry from the regional office. The Boise machine also acts as a data acquisition center for an automatic hydrometeorological data acquisition system commonly known as HYDROMET. This is the same HYDROMET system referred to in the section for Water District No. 1. Data are automatically entered on a three-hour interval. The system also has the capability to automatically monitor sensor outputs and report when unusual events occur at any site. Also, the number of data entries will increase as the rate of change for a parameter increases. All data collected from the HYDROMET network will be furnished "real time" to the CROHMS databank supported by the Corps of Engineers. When completed, this automatic data acquisition network will greatly facilitate all operational procedures by furnishing accurate data from many stategic locations on a real time basis.

More and better data acquisition will allow for more refinement of the procedures and models currently used to obtain more dependable results. Such upgrading would require considerable man hours that are currently not available from personnel in USBR. Another helpful addition to the procedures used to predict inflows from hydrologic events would be to predict diversions throughout the river system thereby minimizing excessive releases from upstream reservoirs, especially during water short years.

The USBR cooperates with the U.S. Army Corps of Engineers in operating the reservoirs and rivers during the flood control season that usually extends from November 1 through June 15. During this type of operation, USBR tries to maintain river flows that are as uniform as possible. In its river operations, this office also maintains contacts with other agencies such as the Idaho Department of Fish and Game in maintaining river flows suitable for wildlife habitat. Close liaison is also maintained with the Watermaster of Water District No. 01 in Idaho Falls.

ORGANIZATION: U.S. Bureau of Reclamation
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CONTACT PERSON: Parry Harrison, Chief Water Resources Branch

OBJECTIVES IN THE OPERATION OF THE SNAKE AND BOISE RIVERS:

As present demands require nearly all of the water in the Snake and Boise Rivers in a dry year, any additional use of the resource requires an evaluation of the impacts on the current users. To facilitate these evaluations computer models of the river systems and hydrologic basins have been developed. For planning purposes the models are used to rapidly test various alternatives and plans to meet future needs and to demonstrate the compatibility and desirability of each plan. In river operations the models are used to aid the operators in the daily operation and scheduling of reservoir releases.

MODELS AND PROCEDURES USED:

At the present time the U.S. Bureau of Reclamation (USBR) has developed or modified for use two digital computer models for simulating river flow in the Snake River. One digital model of the Lower Snake River developed by the Idaho Department of Water Resources (IDWR) has been modified to include operations on the Boise River. The information for this model is presented in the Idaho Department of Water Resources section of this report. The model for the Upper Snake River was developed in the late 1960's and is currently being used by the Water Resources Branch of the Planning Division. An analog model was also developed simulating the Snake Plain aquifer and the ground water movement. This particular model is physically located in the Engineering and Research Center in Denver, Colorado. The SSARR model developed by the U.S. Army Corps of Engineers (1972) is used as a model for river operations and reservoir regulation.

DESCRIPTIONS AND EVALUATIONS:

Upper Snake River System Models

Upper Snake River surface water models include two digital models which are currently being used in the USBR. The USBR models include an Upper Snake River Monthly Operations Model and the SSARR (Streamflow Synthesis and Reservoir Regulation) Model. For modeling purposes the Snake River is divided into short reaches. The boundary of each reach is located at a river gaging station wherever possible.

The USBR monthly model is used for long-range planning. It is used to help identify alternative water supplies and evaluate impacts on the system. It includes an accounting of water supplies for individual canal companies. The individual water rights, including storage ownership, are used as the basis for computing water availability. Each account is kept separately as the water is diverted to meet demands. Demands are based upon historic patterns modified to reflect present levels of development conditions. The resulting printout for each canal shows the amount of storage allocated for its use at the beginning of the irrigation season, the availability of natural flow, and the use of both sources to meet monthly demands. The program also computes shortages each canal might anticipate following the depletion of its water sources in a water short year. The model sums the individual needs (demands) into reach requirements, then into system requirements. The requirements are met to the extent possible from natural flows, then reservoir storage. The model also includes a similar operation for other functional uses such as stream maintenance flows, flood control space, and power production.

Use of the model allows various planning alternatives to be quickly evaluated to determine the effects on the existing users. The results are obtained on a monthly basis including end-of-month contents in reservoirs and discharge volumes past selected stations on the river.

The SSARR model was developed by the U.S. Army Corps of Engineers to make rapid evaluation of alternative river system and flood control operations. Its primary purpose is to help make decisions during normal system operation. It actually includes several submodels or phases that are useful to operators. Two submodels, the River System and the Reservoir Regulation submodels, are presently used by USBR for daily operations in several basins. The Forecast submodel is utilized in the spring of the year to assist the River Operations Branch. Its purpose is to help with the forecasting of natural runoff. Use of the SSARR model by the River Operations Branch is described in that section of this report.

USBR Analog Model

In 1963, the USBR developed an electrical analog model of the Snake Plain aquifer. The model is a rectangular array of resistors and capacitors mounted on a map of the Snake Plain. Between resistors are contact points or nodes where voltage can be induced or measured. Nodes are spaced to represent 2 miles on the map.

The model is calibrated by simulating known events and observing the model's response. The results are compared with historical data. If the model does not simulate known events as shown by historical records, then, aquifer characteristics, recharge or discharge are adjusted and the process is repeated. This continues until a satisfactory simulation is obtained.

The model has been modified into a hybrid which combines the advantages of an analog model with the rapid analytical capability of computers to take advantage of the best aspects of both digital and analog systems. General influence relationships (effects) are worked out in the analog model, and detailed operating problems are then solved by computer. The digital computer combines the analog-produced influence curves with aquifer inputs and other parameters in various ways to examine different aspects of each problem.

The model is used to predict the effects of existing and proposed recharge and pumping projects. These effects are predicted in terms of water table elevation changes and changes in flow exchange between the aquifer and the Snake River. Pumping or recharge rates can be varied on a monthly basis. The resultant water level change is presented as a long-term hydrograph at any selected observation site. Complete hydrographs at various sites can be obtained quickly from the computer plotter.

Currently geologic and hydrologic data are being collected in the Idaho Falls-American Falls area. The data collection is a cooperative effort with IDWR, USBR, and Bingham County Planning and Zoning Department. The work includes the review of existing ground water data, core drilling and geophysics, water level measurements, and water quality analyses. These data and other available information will be analyzed to gain a better understanding of the nature and source of the springs and general ground water movement in the American Falls area. When the analysis is complete the interpretation will be used to improve the analog model in that vicinity.

Manuals and References

The USBR surface model was initially completed in the late 1960's, at which time an introduction manual was prepared. The manual contains a brief description of the functioning and computation capability of the model as well as examples of the different type of output that can be made available. This manual is on file at the Water Resources Branch of the Planning Division of the Pacific Northwest Regional Office at Boise. All support data for this model are also on file and are available for inspection upon request.

The SSARR model was created by the U.S. Army Corps of Engineers, who also prepared the current users manual. The USBR office utilizes the model essentially the same form as it was created, with minor modifications.

The analog ground water model has been described in various progress reports prepared by the Engineering and Research Center in Denver entitled "Snake Plain Aquifer, Electric Analog Studies". These reports are in a document that describe the input requirements, assumptions included and expected output. This report is on file at the Water Resources Branch also, and is available upon request.

Equipment Used and Personnel Requirements

The surface model is currently maintained on the USBR's CDC (Control Data Corporation) CYBER Model 74 computer system in Denver which is linked to Boise via remote terminals. The terminals allow for either interactive or submit usage.

The SSARR model is currently loaded on the VAX computer system located in the Northwest Regional Office data center in Boise. It is possible to transmit data between the VAX and the CYBER systems which has added additional flexibility in processing and conjunctivley using the different models. The VAX software has been developed to allow for interfacing with other agencies such as the CROHMS system of Bonneville Power Administration.

The outputs from the analog model are digitized for input into the digital system which contains the water table response to the given inputs at the desired locations.

It is the intent of the Water Resources Branch to have at least one and preferably two people familiar with the surface and ground water models at all times. This requires continuous application and training on the operation and updating of the models. The SSARR model is currently manned by personnel from the River Operation Branch.

Evaluations of the Models

The USBR surface model of the Upper Snake River allows planners and project personnel the opportunity to evaluate potential impacts of proposed operation modification. This model is the most comprehensive of any that has been developed to date for planning use on the Upper Snake River. The model needs periodic updating to accurately represent the present level of development and diversion rate. Also, any new and additional data defining reach gains and return flows are added as they become available. An immediate need involves an update to designate the date of water right priority within a month and to segregate natural flow and storage as it is presently done by Water District No. 01.

As forecasting techniques and data improve, the SSARR model will be upgraded to reflect the improvements. The ease and rate at which alternatives can be tested are the positive aspects of the usage of this model.

The analog ground water being located in Denver causes some inconvenience in its use. The fact that the model can simulate a dynamic input, as opposed to a steady state, allows for conditions such as an annually varied pumping rate to be evaluated. IDWR has a steady state ground water model on a digital computer with output describing reach gains and losses which can be linked into the surface water model. Having the flexibility of linking the two models is very desirous in some analyses. It is the intent of the USBR to call upon IDWR, as needed, to perform ground water studies using their digital model as well as using the analog model.

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CONTACT PERSON: Leo Busch

OBJECTIVES IN THE OPERATION OF THE UPPER SNAKE RIVER:

A. To protect the safety and integrity of the structures in the Upper Snake River Basin.

B. To control flows in the river as dictated by the demands of flood control, water diversions from the river, fish and wildlife needs, recreation needs, and power generation requirements.

MODELS AND PROCEDURES USED:

A. Dam safety program (SEED; Safety Evaluation of Existing Structures, and ROM; Review of Maintenance)

B. Procedures for flood control

C. Procedures for supplying irrigation diversion requirements

DESCRIPTIONS AND EVALUATIONS:

For the dam safety program, geologic records and dam design data are evaluated, including hydrologic characteristics of dams and design flood criteria. Investigations are conducted to collect and evaluate any missing data or records.

Procedures for flood control are those developed by the U.S. Army Corps of Engineers. These include rule curves such as flood control parameter curves and storage volume parameter curves as described in the Corps of Engineers section of this report. There are several legal agreements with the Corps of Engineers on flood control operations at Palisades and Jackson Reservoirs which are authorized by Congress. During the irrigation season, reservoir releases are scheduled to maximize withdrawal of water from reservoirs at lower elevations in the system. This procedure is designed to store water at higher elevations and thus minimize evaporation losses and provide for more flexibility in releases and diversions later in the season. Close contact is maintained with Water District No. 01. Throughout the irrigation season the U.S. Bureau of Reclamation (USBR) supplies river flow and diversion data to the Water Allocation Model of Water District No. 01 for river flows and diversions downstream from American Falls Dam. These data are supplied by means of a remote computer terminal located in the USBR office in Burley that is furnished by the Idaho Department of Water Resources.

The SSARR model is used to predict water supply in the Upper Snake system. By inputting precipitation data to this model, water storage volumes can be predicted at various times for each reservoir. An in-house routine, B-107, is used to obtain storage forecasts at Jackson, Palisades, American Falls, and Minidoka Reservoirs in advance on a weekly and monthly basis for the Bonneville Power Administration. This information is used to predict future power generation in the system by BPA.

The USBR cooperates with many different entities affected by reservoir and river operations. The service cooperates with Grand Teton National Park concerning water levels and operations at Jackson Lake and with the U.S. Forest Service at Palisades Reservoir. Agreements are also maintained with the State and counties that deal mainly with recreational facilities. These agreements, with the exception of Grand Teton National Park, do not greatly affect river and reservoir operations.

There is an official report published annually that summarizes the previous water years operations (U.S. Bureau of Reclamation, 1979). It includes summaries of reservoir, river and irrigation water management programs conducted by the Minidoka Project Office of USBR. Three persons in the office are involved with planning operations and report preparation. These individuals are trained so that operations would not be jeopardized in the absence of a key individual.

Use of planning and operations models and procedures has allowed USBR to better serve the interests of water users in the Upper Snake River system. However, problems may be encountered when conflicting objectives must be considered in actual operations. In addition to more accurate water supply and flood forecasting, the agency could use more and better predictions of water use, especially timing in water short years. More complete and automated data acquisition for hydrologic data such as provided by the HYDROMET system maintained by USBR in the Regional Office in Boise will also assist in planning and operations procedures. More detailed and accurate data are constantly being sought.

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Ross Complex
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OBJECTIVES IN THE OPERATION OF THE UPPER SNAKE AND BOISE RIVERS:

To generate the maximum amount of power as constrained by other river operations and flood control procedures.

MODELS AND PROCEDURES USED:

No power models are used in the Upper Snake or Boise River systems.

DESCRIPTION AND EVALUATION:

The Bonneville Power Administration (BPA) does not have a significant interest in the operations of the Upper Snake and Boise Rivers in southern and southeastern Idaho. Federal power producing facilities in this area produce only one percent of the total power that BPA administers. For flood control and power scheduling from the area, BPA cooperates with the Corps of Engineers and the U.S. Bureau of Reclamation. BPA also contributes to the Soil Conservation Service budget for snow data collection. These data are used for volume runoff forecasting and power generation scheduling.

The U.S. Bureau of Reclamation, Central Snake Projects Office in Boise and Minidoka Projects Office in Burley, Idaho, notify the BPA Power Scheduling personnel in Burley daily of the water releases and river fluctuations to be allowed or planned. BPA schedules the hourly and daily generation within these water release guidelines to most efficiently meet load patterns and limit imported energy required to meet system loads.

The USBR also provides BPA with long-range water storage and release forecasts from time to time to enable planning for power and energy requirements on a seasonal or yearly basis.

CHAPTER IV

SUMMARY

Organizations involved with river operations in the Snake and Boise River Basins in southern and southeastern Idaho have different interests and objectives according to the mission of the organization. River operations include flood control, refill of reservoir storage, filling of legal water rights, power generation, maintaining the safety of dams and other structures, maintaining minimum stream flows, and meeting various demands for fish, wildlife, and recreation.

Due to the complexity of the river systems, it is necessary that established procedures and/or models be used to assist in developing information necessary to meet prescribed objectives. Most of the models and procedures used in the study area are computerized due to their size and complexity. Various models are used to predict runoff from snow pack data, to predict natural stream flows based on various hydrologic data, to predict reservoir levels necessary to meet flood control and refill criteria, to account for water diversions from rivers, and to evaluate the effects of alternative future demands on the surface and ground water in a hydrologic basin. The methods and procedures used are constantly being upgraded to improve the accuracy of the results obtained.

In most cases there are no published references or manuals related to the procedures and models. An exception is the SSARR model (U.S. Army Corps of Engineers, 1972). The results obtained from the procedures and models are mostly for in-house purposes and are not published. However, this information is often contained in agency reports. Any interested person can obtain information about those models and procedures developed and used by public agencies.

Most of the computerized models are written in FORTRAN and are maintained on agency or company computer systems. Most of these systems have time-sharing capability and can be accessed by computer terminals in different locations.

Most computerized models and procedures, even those supported on the same computer system, are not linked together. The output of one model might be used as input to another; however, it is usually inspected and verified before further use in the next step.

Most procedures and models require a great deal of input data. Most data is input by hand even in the computerized procedures. Several agencies are now cooperating in establishing and maintaining automated hydrometeorological data acquisition systems (U.S. Bureau of Reclamation Suttron System-VAX Computer). Data are automatically obtained and transmitted to a central data logging facility. Once logged, these data can be obtained by different interested parties. Every effort is being made to incorporate into the automated data acquisition systems the ability to sense and record extreme events and rapid changes in hydrologic parameters. The accuracy and immediate availability of input data will greatly facilitate the timing of decisions that must be made during critical operations such as flood control.

Using computerized procedures, large amounts of information can be obtained quite rapidly. It is necessary to evaluate the output generated by most procedures in order to identify any unreasonable results that might be generated. Operators and decision makers must constantly be aware of this problem and cannot ignore common sense, even when using sophisticated procedures. Properly applied, the procedures and models used by the various organizations produce satisfactory results. However, most are constantly being revised and modified to improve accuracy and meet changing conditions.

Maintaining a staff of adequately trained personnel is necessary for any organization involved with using complex models and procedures for river operations and planning. Most organizations maintain a staff of three or more people who are knowledgeable and competent in using the procedures and interpreting the results obtained. This backup is necessary to maintain continuity and provide needed results during critical operations such as flood control and fulfilling water rights during water short periods.

River operations and planning procedures depend quite heavily upon the ability to predict various parameters. Accurate prediction of streamflow using various hydrologic parameters has received a great deal of attention, and yet is considered to be one of the weakest links in many of the predictive and modeling procedures. Equally important is the need to predict various instream uses and diversions along a river. If available, these predictions allow for better water control within the river system and thereby promote water conservation. Cooperation between various groups, including researchers has produced procedures that greatly aid in providing safe operation of the river systems and providing the beneficial use of water resources.

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SELECTED WATER RESOURCES ABSTRACT

Input Transaction Form

1. *Report No.*

2.

3. *Accession No.*

4. *Title* Evaluation of Models and Procedures Used for River Operations and Planning in the Upper Snake and Boise Rivers in Idaho

5. *Report Date*

6. August 1981

8. *Performing Organization Report No.*

7. *Author(s)*

J.R. Busch and K.H. Yoo

9. *Organization*

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10. *Project No.*

A-071-IDA

11. *Contract/Grant No.*

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Office of Water Research and Technology

15. *Supplementary Notes*

16. *Abstract*

The planning models and procedures used by operational agencies in the Upper Snake and Boise River basins in Idaho were investigated. These models and procedures have been developed and updated to improve accuracy and meet changing conditions by both public agencies and private companies in the area. Each model and procedure has different objectives according to the organizations' intended purposes.

The models and procedures are used to predict runoff from snow pack data, to predict natural stream flows based on various hydrologic data, to predict reservoir levels necessary to meet flood control and refill criteria, to account for water diversions from rivers, and to evaluate the effects of alternative future demands on the surface and groundwater in a hydrologic basin.

River operations and planning procedures depend quite heavily upon the ability to predict various parameters. Accurate prediction of streamflow using various hydrologic parameters have received a great deal of attention, and yet it is considered to be one of the weakest links in many of the predictive and modeling procedures. Equally important is the need to predict various instream uses and diversions along a river. If available, these predictions allow for better water control within the river system and thereby promote water conservation.

17a. *Descriptors* Effects of control programs and devices on the stage and time distribution of streams; stream forecasts; application of systems analysis to project planning; water quality and quantity requirements of various uses, both diversion and consumptive; selected search and retrieval of an organized document collection in response to specific user request.

17c. *COWRR Field & Group*

4A, 6A, 6D, 10B

18. *Availability*

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19. *Security Class. (Report)*

20. *Security Class. (Page)*

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