PROPOSED WATER TEMPERATURE STUDIES RELATING TO HIGH MOUNTAIN SHEEP DAM

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INTRODUCTION

Seven more hydroelectric dams are scheduled to be constructed on the Snake River below Oxbow Dam. Each dam potentially could increase river temperature by increasing surface exposure and decreasing channel velocity. Increasing temperatures in this key area could be of serious consequence to all of the migrating anadromous populations of Salmon and Snake Rivers and their tributaries.

The Snake River contains both high- and low-head dams, either existing or in the planning stage. In general, the low-head dams produce an increase in river temperature, whereas high-head dams produce a decrease if properly planned and operated. Prediction of future water temperatures of on-river reservoirs and their effluents allows for the proper planning of hydroelectric structures to prevent undesirable thermal increases.

The purpose of this proposal is to have one of the key high-head dams investigated to determine what the physical characteristics of the water will be before, during, and after it leaves the dam complex. The ability to manipulate a water temperature control system that is inherent to High Mountain Sheep and the associated regulatory dams may make it possible to compensate for the temperature increases downstream.

Thirteen reports dealing with water temperature predictions have been prepared to date for the Snake River Basin (see bibliography). Dr. Wayne Burt, oceanographer at Oregon State University, has been the principal investigator in all of these studies. A brief summary of the subject matter in pertinent report follows.

Three reports are concerned with Brownlee Reservoir and downstream water temperature from Brownlee Dam. One report relates to Brownlee water effluent to and through Oxbow and Hell's Canyon Dams.

Two articles deal with temperature predictions in High Mountain Sheep Reservoir. The first report gave agencies some optimism in river thermal planning, for in the normal operation of single-level intakes, the river water would be cooled a maximum of 15^{o} F. In the second article, Dr. Burt reported on the use of a single high intake (one of ten) at this site (5,000 c.f.s. at 1,300 feet). Results indicated that a 2^{o} to 3^{o} F. temperature reduction would be achieved over a 7-day period during peak temperature conditions. More important was that

minor temperature reductions of .5 to 1.0° F. could be gained during the month of October, with only one "multiple" intake. It is important that "multiple" intakes be considered in the planning of High Mountain Sheep Dam. A portion of this proposal deals with collection of prediction data needed for "multiple" intake planning decisions.

The last report considered water of an optimum temperature from High Mountain Sheep Dam moving down through all the completed lower Snake River dams. Based on extended predictions of mean water temperatures (mean flow year) through the lower six Snake River dams, it would appear that temperature increases would be expected in the magnitude of .8° F. for each of all six dams. What benefits would be realized from High Mountain Sheep, and how far downstream would a benefit be projected if actual hydroelectric installation scheduling is considered?

A tabular summary has been prepared (table 1) to show predicted temperatures at Brownlee, Oxbow, Hell's Canyon, High Mountain Sheep, and the mouth of the Snake River (mouth of Snake considered with all dams installed).

Recorded mean temperatures for Swan Falls, Oxbow, and Clarkston are included for comparison. Temperature benefits from the originally planned intakes at High Mountain Sheep Dam would be realized from March until September (until cool water storage in High Mountain Sheep is used up). It is anticipated from Dr. Burt's predictions that critical maximum temperatures would be present from mid-September through October.

PROPOSAL

The following studies are requested in order that we may understand fully the potential of High Mountain Sheep Dam for affecting the temperature regime of the Snake River.

1. Daily Flow Release Schedules at Hell's Canyon, High Mt. Sheep, and China Garden Dams.

In the past, the approach to the prediction of flow release schedules has been to project flow as a function of the annual mean. It is proposed in this study that flow be expressed in terms of the amount of flow and percentage of time at each flow for any given hour of any day (24 hours) for minimum, mean, and maximum flow years.

Table 1.--Estimated and recorded* temperatures for Snake River downstream of the respective dam sites

Date		(1959)* Swan Falls	Brownlee 6/	Oxbow 6/	(1959)* Oxbow	Hell's Canyon 6/	High Mt. Sheep 8/	(1959)* Clarkston	Mouth 13/	Diff. between predicted mouth and Swan Falls
Jan.	1	44	39	38.7	42	38.5	40.5	41.5	45.1	+ 1.1
	11	40	39	38.8	42	38	39.0	42	43.6	+ 3.6
	21	40	39	38.8	41	38.2	39.0	38	43.6	+ 3.6
Feb.	1	44	39	38.9	38	38.5	39.0	39	43.6	- .4
	11	42	39	39.0	38	38.8	39.0	38	43.6	+ 1.6
	21	44	39	39	39	39.1	39.0	41	43.6	- .4
Mar.	1	47	39.4	39.4	41	39.4	39.0	42.5	43.6	- 3.4
	11	45.5	40.0	40.1	42	40.2	40.5	42	45.1	- .4
	21	45.5	42.3	42.0	43	41.8	41.5	44	46.1	+ 1.4
Apr.	1	51	44.9	44.7	46	44.2	42.5	46	47.1	- 3.9
	11	54	48.1	47.9	50	47.5	43	48.	47.6	- 6.4
	21	54.5	50.7	50.6	52	50.3	43	--	47.6	- 6.9
May	1	57	53.3	53.2	53	53.2	43	51.5	47.6	- 9.4
	11	56.5	55.0	55.0	56	55.3	43	51	47.6	- 8.9
	21	58.5	57.0	56.9	56.5	57.2	44	--	48.6	- 9.9
June	1	62	59.6	59.6	59	59.7	45	--	49.6	- 12.4
	11	66	61.5	61.6	61.5	61.9	46.5	54.5	51.1	- 14.9
	21	71	63.5	63.6	63.5	63.8	48	61	52.6	- 18.4
July	1	69	65.6	65.8	65.5	65.8	49	61	53.6	- 15.4
	11	70	67.1	67.3	67	67.4	50.5	65	55.1	- 14.9
	21	73	68.3	68.4	69	68.4	52	71.5	56.6	- 16.4

Continued...

Table 1.--Estimated and recorded* temperatures for Snake River downstream of the respective dam sites (continued)

Date	(1959)* Swan Falls	Brownlee 6/	Oxbow 6/	(1959)* Oxbow	Hell's Canyon 6/	High Mt. Sheep 8/	(1959)* Clarkston	Mouth 13/	Diff. between predicted mouth and Swan Falls
Aug. 1	73	69.3	69.2	69	69.2	54	70.5	58.6	- 14.4
11	69.5	70.2	70.0	--	69.4	55.5	70.5	60.1	- 9.4
21	67	70.7	70.4	70	69.9	57	66.5	61.6	- 5.4
Sept. 1	66	70.6	70.3	71	69.8	59	67.5	63.6	- 2.4
11	66	69.9	69.6	69	69.3	60.5	67	65.1	- .9
21	62	68.5	68.4	69	68.3	62.5	64	67.1	+ 5.1
Oct. 1	57	66.1	66.0	64	66.0	64.5	57.5	69.1	+ 12.1
11	56	62.8	63.0	61	63.4	66.5	55.5	71.1	+ 15.1
21	55	60.6	60.6	58	60.3	61.0	55	65.6	+ 10.6
Nov. 1	52	57.2	57.2	56	57.5	57.5	49	62.1	+ 10.1
11	47	54.3	54.2	53	54.3	54.5	45.5	59.1	+ 12.1
21	44	51.2	51.2	50	51.3	52	44	56.6	+ 12.6
Dec. 1	43	48.1	48.2	45.5	48.2	49	42	53.6	+ 10.6
11	40.5	45.1	45.1	44	45.3	46.5	40.5	51.1	+ 10.6
21	39	42.0	42.2	44	42.5	43.5	40	48.1	+ 9.1

_/ Numbers indicate publication source for predicted downstream temperatures.

* 1959 Data - Water temperature studies for 1959 -- Middle Snake River drainage U.S. Dept. of the Interior, FWS, BCF, Portland, Oregon, Mat 1960, in ^{o} F.

It is proposed that this study be undertaken to determine:

a. Hourly flow release schedules throughout the year for

(1) Hell's Canyon before and after High Mt. Sheep.

(2) High Mt. Sheep before and after China Gardens.

(3) China Gardens.

b. Hourly flow release from High Mt. Sheep expressed as a percentage of maximum, minimum, and mean Salmon River discharges throughout the year.

c. Minimum flow releases for each project in terms of percentage to maximum, mean, and minimum flow (Hell's Canyon, High Mt. Sheep, and China Gardens).

Hourly information in terms of cubic feet per second should be presented in graphic form for yearly and daily flows for a minimum, mean, and maximum year and on IBM punch cards for predicted hourly flows and percentage time at each flow per hour in relation to daily release (24 hours) throughout the year for a minimum, mean, and maximum flow year.

2. Projections of Reservoir Fluctuations at China Gardens.

It is proposed that information on predicted reservoir fluctuation be projected in terms of feet elevation on an hourly basis throughout the year for a minimum, mean, and maximum flow year.

The above information should be presented in graphic form and IBM card form.

3. Water Temperature Predictions.

The present predictions of water temperature in the Snake River are based on mean flow years and mean water temperatures. It is proposed that predicted temperatures in this study be expressed in terms of ^{o} F. for hourly flow conditions expected during maximum, mean, and minimum flow years. Further, it is proposed that mean and maximum thermal conditions be imposed on maximum, mean, and minimum flows to determine the predicted river temperatures on an hourly basis throughout the year for areas immediately below:

a. High Mt. Sheep before and after China Gardens Dam. Predicted downstream river temperatures under the following conditions are requested:

(1) With low turbine intakes.

(2) In multiple intakes at the 1,450-, 1,400-, 1,350-, and 1,300-foot levels for 1 to 10 turbines.

b. China Gardens Dam.

Predictions are to relate to maximum, mean, and minimum Salmon River flows and maximum and mean temperatures.

c. Ice Harbor Dam.

Temperature predictions on an hourly basis throughout the year at Ice Harbor after High Mt. Sheep Dam is operational are requested for the following conditions, assuming this order to be the sequence of installation:

(1) With Lower Monumental Dam installed and operational.

(2) With Lower Monumental Dam and Little Goose Dam installed and operational.

(3) With Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam installed and operational.

(4) With Lower Monumental Dam, Little Goose Dam, Lower Granite Dam, and Asotin Dam installed and operational.

The above information also should be presented both graphically and on IBM cards.

BIBLIOGRAPHY ON SNAKE RIVER BASIN WATER TEMPERATURE PREDICTIONS

All Papers by Dr. Wayne V. Burt, Oregon State College:

1. 1957 (July 18)
A PRELIMINARY ESTIMATE OF TEMPERATURE CONDITIONS IN THE BROWNLEE RESERVOIR AND IN THE SNAKE RIVER BELOW BROWNLEE DAM. Oregon State College, School of Science, Ref. 57-2.

2. 1957 (September 25).
EVALUATION OF SNAKE RIVER BASIN THERMOGRAPH PROGRAM FOR RESERVOIR TEMPERATURE STUDIES. Oregon State College, School of Science, Ref. 57-3.

3. 1957 (October 12).
RESULTS OF TRIP TO SNAKE RIVER, 28 SEPTEMBER-4 OCTOBER 1957. Oregon State College, School of Science, Ref. 57-4.

4. 1957 (October 31).
A SECOND FORECAST OF TEMPERATURE CONDITIONS IN BROWNLEE RESERVOIR AND IN THE SNAKE RIVER BELOW BROWNLEE DAM. Oregon State College, School of Science, Technical Report No. 4, Ref. 57-5.

5. 1957 (December 3).
A FORECAST OF TEMPERATURE CONDITIONS IN THE OXBOW AND LOW HELL'S CANYON RESERVOIRS AND IN THE SNAKE RIVER BELOW HELL'S CANYON DAM. Oregon State College, School of Science, Ref. 57-6.

6. 1958 (December).
HEAT BUDGET TERMS FOR MIDDLE SNAKE RIVER RESERVOIRS. Oregon State College, School of Science, Technical Report No. 6, Ref. 58-7.

7. 1959 (December 31).
A PRELIMINARY FORECAST OF TEMPERATURE CONDITIONS FOR THE RESERVOIR BEHIND THE PROPOSED HIGH MOUNTAIN SHEEP RESERVOIR. Prepared for the Pacific Northwest Power Company.

8. 1960 (May 15).
A FORECAST OF EXPECTED WATER TEMPERATURE CHANGES IN THE TAILRACE TEMPERATURES FOR THE PROPOSED HIGH MOUNTAIN SHEEP DAM IF ONE TURBINE INTAKE IS PLACED AT AN ELEVATION OF 1,300 FEET. Pacific Northwest Power Company.

9. 1960 (September 9).
A FORECAST OF TEMPERATURE AND FLOW CONDITIONS BEHIND THE PROPOSED NEZ PERCE DAM BASED ON THE ASSUMPTION OF LAMINAR FLOW WITHIN THE RESERVOIR. BCF, Columbia Fisheries Program Office.

10. 1960 (April 22).
A FORECAST OF TEMPERATURE CONDITIONS FOR THE RESERVOIR BEHIND THE PROPOSED BRUCES EDDY DAM. U.S. Army, Engrs. Dist., Walla Walla, C of E, Report No. 1.

11. 1960 (June 29).
A SECOND FORECAST OF TEMPERATURE CONDITIONS FOR THE RESERVOIR BEHIND THE PROPOSED BRUCES EDDY DAM. C of E Report No. 2.

12. 1960 (November 30).
A FORECAST OF TEMPERATURE CONDITIONS IN THE CLEARWATER RIVER BELOW THE PROPOSED BRUCES EDDY DAM. C of E Report No. 3.

13. 1963 (November)
PRELIMINARY STUDY ON THE PREDICTED WATER CHANGES OF THE LOWER SNAKE RIVER DUE TO THE EFFECTS OF PROJECTED DAMS AND RESERVOIRS.
(PART 1: FORECASTING WATER TEMPERATURE CHANGES DUE TO FLOW THROUGH INTERMEDIATE DEPTH RESERVOIRS).
Water Research Associates, Corvallis, Oregon.