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SACRAMENTO AND TRINITY RIVER SYSTEMS: A DEMONSTRATION OF RIVER TEMPERATURE MANAGEMENT FOR THE 90'S

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by

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Sacramento and Trinity River Systems: A Demonstration of River Temperature Management for the 90's

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Abstract

Drought in Northern California resulted in the potential that summer and early fall, 1992, Sacramento and Trinity River temperatures would exceed critical levels for sustaining salmon populations. As a result, extraordinary efforts, both operational and structural, were undertaken to manage cold water releases from the reservoir system.

Introduction

The U.S. Bureau of Reclamation's Central Valley Project (CVP) is a large water project that serves much of California. The project includes 16 storage dams, 3 diversion dams, nearly 1000 km of canals, 39 pumping plants, and 9 powerplants with a combined capacity of 1850 mW. Although developed primarily for irrigation, this multipurpose project also provides flood control, improves Sacramento River navigation, supplies domestic and industrial water, generates electric power, conserves fish and wildlife, creates opportunities for recreation, and enhances water quality.

One part of the CVP, the Shasta and Trinity River Divisions include Trinity and Lewiston Dams on the Trinity River and Shasta and Keswick Dams on the Sacramento River. Water is also diverted from the Trinity River at Lewiston

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Dam, through Whiskeytown Reservoir, to Keswick Reservoir and the Sacramento River. The reservoir system has a dominate influence on discharge and water temperature in the Trinity River below Lewiston Dam and in the Sacramento River below Keswick Dam.

Salmon populations on both rivers are in decline. The runs on the Trinity River are of major concern to the Hoopa Tribe and are being addressed by a multi-agency task force. The "winter run" of Chinook salmon on the Sacramento River has been listed as threatened under the Endangered Species Act. The "spring run" population has also declined and listing may follow.

California has been in an extended drought. As a consequence reservoir storage has been low and volumes of stored cold water limited. Nineteen-ninety-two was a critical low water year. The potential existed that reservoir release temperatures coupled with in river warming could generate lethal water temperatures for egg incubation and juveniles. As a consequence the Bureau of Reclamation initiated an aggressive program to modify operations and add structural features that would optimize cold water releases.

Reservoir and river system numerical models were used to develop operating guidelines. The models defined release rates that would yield an extended supply of cold water. The models were used to estimate atmospheric warming and tributary influences for predicting the reaches of river over which adequate temperatures could be maintained.

Operational Modifications

Water deliveries to project contracts, both agricultural and urban, were reduced. Water releases to meet project requirements for water quality and the limited deliveries, to the extent practicable, were supplemented from other reservoirs. Project operators coordinated extensively with federal and state resource agencies to develop operations plans to maximize temperature control in both the Trinity and Sacramento Rivers.

As the season progressed it became apparent that colder releases could be supplied from both Trinity Dam and Shasta Dam by curtailing power operations and by making all releases through outlet works. At both dams the power intakes are positioned higher than the low level outlets. Power releases were bypassed at Shasta Dam for 170 days and at Trinity Dam for 110 days in water year 1992. Approximately $10,000,000 in power revenues were lost.

Release Temperature Control Structures

Selective Withdrawal - A retrofit multilevel intake for Shasta Dam has been designed but has not yet been installed (Johnson et al 1991). After consideration of numerous alternatives, the Shasta design consists of a gated steel frame, with sheet pile skin, that is placed over the power intakes and attached to the face of the dam. Studies for the multilevel intake show that to achieve optimum cooling, release must be made from high in the reservoir early in the season saving large volumes of cold water for late summer and early fall. The study shows that in critically dry years there is insufficient cold water in the system to allow both maintenance of historic releases and adequate river temperatures.

Light weight curtain structures for release temperature control were studied as an option for Shasta Dam (Johnson 1990). The curtains show substantial cost benefit over more traditional selective withdrawal intakes. However, because of structure size and structural uncertainties a curtain was not pursued for Shasta. Because of cost advantages and growing need for temperature control, Reclamation initiated a research program to install a field curtain. In the summer of 1992, under a very tight schedule, a curtain was installed in Lewiston Reservoir (O'Haver 1992). The curtain design had been developed with use of numerical and physical models (Brown et al 1992). The 250 m long, 10 m deep curtain was suspended from surface floats and was retained by a cable and anchor system. The curtain was used to exclude epilimnion withdrawal thus cooling both water diverted to the Sacramento River and Trinity River releases. Field performance data have been collected but are not reduced as of this writing.

Pneumatic Diffuser - In early October 1992, a pneumatic diffuser or bubbler was installed to allow access to approximately 1.0×10^8 m^3 of hypolimnion water that was unaccessible with the low level outlet works at Shasta Dam. The diffuser was used to upwell the cold water to the intake. Based on experience of the California Department of Water Resources, garden soaker hose was used as a diffuser line to generate 2.0 to 3.0 mm diameter bubbles. Experiments were run varying air flow rate, diffuser size, diffuser position, diffuser depth, release discharge, and intake velocity to the outlet works. Initial evaluation indicated that the diffuser could be used to reduce released temperatures at least 0.5°C. Again the collected data has not been reduced as of this writing.

Results

The operational measures, particularly the bypass of powerplant releases, have been effective in sustaining reduced water temperatures. Structural alternatives (curtains, pneumatic diffusers, selective withdrawal) show promise for further management of water temperatures.

References

Brown, R.T., Yates, G., and Johnson, P.L. (1992). "Physical and 2-D Computer Models of Skimmer Curtain Effects on Lewiston Reservoir and Outlet Temperatures." Proceedings of the Hydraulic Engineering sessions at Water Forum '92, ASCE, August 2-6, 1992.

Johnson, P.L. (1991). "Hydraulic Features of Flexible Curtains Used for Selective Withdrawal." Proceedings of the Hydraulics Division National Conference, ASCE, July 29 - August 2, 1991.

Johnson, P.L., LaFond, R., and Webber, D.W. (1991). "Temperature Control Device for Shasta Dam." Proceedings of Technical Exchange between the Japan Dam Engineering Center and the U.S. Bureau of Reclamation.

O'Haver, G. (1992). "Temperature Control Curtains - Lewiston Lake and Hatchery." Presented at the Power O&M Workshop, U.S. Bureau of Reclamation, Mid-Pacific Region, October 20, 1992.