Session 2: Temperature Challenges in the San Joaquin River

Millerton Lake Temperature Monitoring – A decade of extremes

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For more than a decade, a temperature monitoring effort has been documenting Millerton Lake inflow and outflow temperatures, along with the temperature stratification characteristics of Millerton Reservoir. These data have been used to calibrate and validate the CE-Qual-W2 (W2) model of Millerton Lake. CE-Qual-W2 model output of Friant Dam release temperatures are used as input for the Hydrologic Engineer Center's System Water Quality (HEC-5Q) model used for predicting San Joaquin River temperatures.

I will present the long-term record of Millerton Lake water temperature profile data that has been collected since 2004. These data show how Friant Dam release temperatures to the San Joaquin River are impacted by flood and drought conditions. In addition, I will present data that illustrate the seasonal variability of the cold water pool in Millerton Lake and how release water temperature could be managed using selective withdrawal structures. I hope this presentation will generate a discussion on the limited amount of cool water storage in Millerton Lake and how this will impact the San Joaquin River Restoration Project.

Two-dimensional water temperature modeling in-channel and hydraulically connected off-channel zones in Reach 1A of the San Joaquin River

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The San Joaquin River Restoration Project (SJRRP) Office of Reclamation has requested the Technical Service Center (TSC) analyze water temperature dynamics in Reach 1A of the San Joaquin River. A desired outcome of the SJRRP is to restore and maintain fish populations in "good condition" in the mainstem San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish. Reach 1A of the San Joaquin River just downstream of Friant Dam has been identified for potential spawning habitat. Appropriate water temperature is critical for survival of fish as they move through the system. Water temperature is affected by flow characteristics and local meteorology; the presence of large hydraulically connected off-channel pools in Reach 1A potentially complicates the local thermal dynamics, impedes fish passage, and provides refuge for predatory species. A module in development at the TSC for computing two-dimensional water temperature dynamics was adapted for application to Reach 1A of the San Joaquin River. The water temperature module is coupled to the SRH-2D computational software package, which contains a two-dimensional flow and mobile bed sediment transport solver. The two-dimensional temperature model was generally successful in simulating the gross spatial and temporal thermal dynamics within the system and may be useful for informing habitat suitability and management decisions. Results are presented for a range of hypothetical restoration hydrographs consistent with weather-driven water year types.

Availability of thermal stratification and thermal refugia in the middle San Joaquin River system

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Water temperature is a concern for the reintroduction of Chinook salmon (*Oncorhynchus tshawystcha*) in the San Joaquin River system. During periods of high stream temperature between April and October, thermal stratification in pools can create thermal refugia that provide cold water habitat below Chinook thermal tolerances. River pool water temperature was measured in the Eastside Bypass, Reach 4B2, and Reach 5 of the San Joaquin River system between July and November 2012 to quantify the availability of thermal stratification and thermal refugia in the system. Vertical water temperature profiles were measured in 53 river pools to assess the general abundance of thermal stratification and thermal refugia. Six pool sites were also instrumented for two to three week periods with temperature sensor arrays and piezometers to evaluate diurnal and weekly trends in thermal refugia.

Thermal stratification was found in 82% of the 53 river pools in the San Joaquin River during the July survey. Differences in vertical water temperature ranged from less than 3 °C to as much as 11.4 °C in pools with depths from 0.64 m to 6.37 m. Vertical water temperature differences did not correlate with pool depth. In the six pools with sensor arrays, thermal stratification formed and collapsed daily in response to solar radiation and air temperature fluctuations. Both the thermal stratification and the volume of thermal refugia correlated with the daily maximum change in air temperature. These correlations occurred because when air temperature fell below pool water temperature each night, surface water cooling produced convective mixing that collapsed daily thermal stratification. Nightly cooling at the air-water surface “reset” the daily thermal stratification gradient and created thermal refugia along the pool bottom. In addition to air temperature, surface stream flow was observed to influence the availability of thermal refugia in one pool. The interaction of stream flow with pool geometry determines mixing conditions in pools. In one pool with minimal complexity, increasing stream flow from 0.3 m^3/s to 1.6 m^3/s eliminated thermal refugia.