Study 33

Reducing Spring Water Temperatures Blow Sack Dam

Public Draft
2014 Monitoring and Analysis Plan

SAN JOAQUIN RIVER RESTORATION PROGRAM

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San Joaquin River Restoration Program

2014 Monitoring and Analysis Plan

Reducing Spring Water Temperatures below Sack Dam

1. Statement of Need:

Predictions from the initial HEC-5Q water temperature model (SJRRP 2008a) suggest that the daily maximum water temperatures in reaches 4B and 5 will exceed the lethal threshold for adult spring-run Chinook salmon at a Friant release of 4,500 cfs by April 24 during median (P = 0.52 exceedance) meteorological conditions (Figure 1). When the model was recalibrated with 2009-2010 interim flow data, the lethal threshold was exceeded by April 28 (SJRRP 2012). If the recalibrated model reflects current conditions, then only up to 30% of the adults may be able to migrate to Reach 1 based on migration timing data from Mill and Butte creeks (Johnson et al. 2006; Greg Blair, ICF, personal communication). During the same period, juveniles are also experiencing critical temperatures and few would be expected to survive (Figure 1). A consequence of using pulse flows in April and May for adults is the inability to release prolonged pulse flows earlier in the year to benefit juvenile salmon. If no more than 30% of the adults can successfully migrate to Reach 1 where they could spawn and flow for juvenile passage must be limited to brief pulses, restoration actions to cool temperatures may be needed to reach the population viability target. The objective of this study is to determine what restoration actions will be necessary to reduce spring water temperatures in reaches 4B and 5 to the extent necessary to provide passage for adult spring-run through early May at flow releases of 4,500 cfs or less. Analysis of the potential temperature changes that could be influenced by SJR low-flow channel improvements to reduce in-stream heating through two potential temperature management measures:

1. Reduced top width and potential velocity increases
2. Modifying the local micro-climate through vegetation to increase shading and reduce local meteorological values that influence in-stream heating.

2. Background:

Although the Sets 4 and 5 Sensitivity Analyses (SJRRP 2008b) evaluated the effects of riparian shading and channel narrowing on daily maximum water temperatures primarily upstream of Mendota Pool, the results may not be applicable to reaches 4B and 5. The riparian shading study (Set 4) used solar radiation measurements from a Stanislaus River site that was shaded for approximately half the day and those data were used in a conceptual analysis of the median of the maximum daily temperatures in 5-foot deep pools at four sites including: Gravelly Ford, below Chowchilla Bypass, Sack Dam, and above Mendota Pool. There was uncertainty in the results due to a lack of data on the effects of shade trees on wind speed and humidity, both of which would partially negate the benefits of providing shade and were not included in the sensitivity study. The results suggested that a half day of heavy riparian shade could reduce daily maximum water temperatures by about 2°F at Gravelly Ford in late spring and summer at a flow release of 1,500 cfs, assuming there were no negative effects of reduced wind speed and increased humidity. Temperature reductions due to riparian shading would likely decline as flows increase above 1,500 cfs. Furthermore, if the effects of wind speed and humidity were included in the analysis, the benefits of riparian shading would be less than 2°F at Gravelly Ford at a flow release of 1,500 cfs. The results for the Sack Dam site, which was only conducted at a flow of 350 cfs, suggest that the effects of riparian shading would be less at Sack Dam than at Gravelly Ford. There are several limitations of this study. First, it does not fully address the effect of riparian shading on both banks of the river below Sack Dam. The reaches below Sack Dam are particularly important to study, because the effects of riparian shading would be less in channels flowing toward the North (Restoration Area below Mendota Pool) compared to channels flowing toward the West (Restoration Area above Mendota Pool). Second, the study does not consider the cumulative effect of providing shade throughout the Restoration Area. Presumably, water temperatures in reaches 4B and 5 are partially dependent on the temperature of the water flowing in from the upstream reaches.

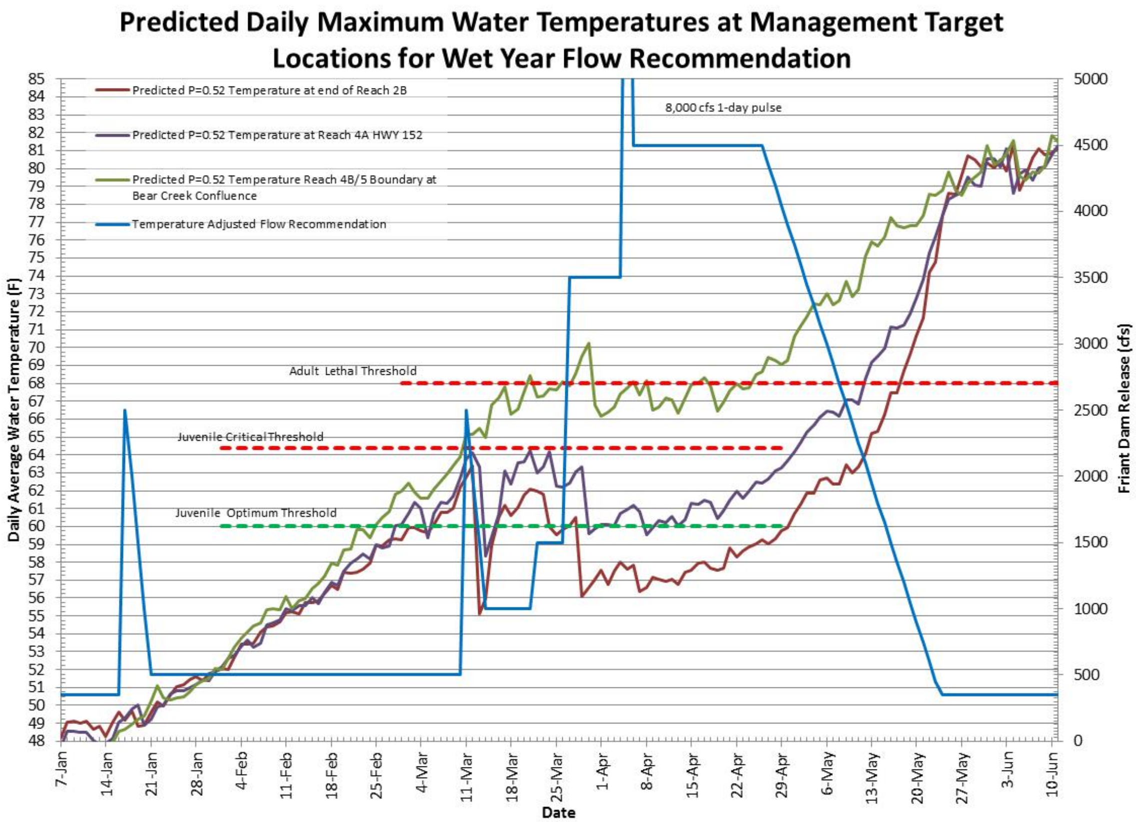

Figure 1. Possible Wet Year flow recommendation designed to maximize adult spring-run passage and two brief pulse flows for juvenile passage relative to the predicted daily maximum water temperatures (SJRRP 2008a) during average meteorological conditions from 1980 to 2005 (P = 0.52 exceedance) just upstream of Mendota Pool (Reach 2B), at Highway 41 (Reach 4A), and the confluence with Bear Creek (Reach 4B-5 boundary). The lethal threshold for adult salmon is a 7-day mean daily maximum temperature of 68°F and so temperatures that exceed the threshold for fewer than 7 days would not be lethal. The water temperature predictions in reaches 4B and 5 in this figure may exceed actual temperatures by about 2°F in April and by 1-2°F in May (SJRRP 2012).

The channel narrowing analysis (Set 5) evaluated the effects of three channel modifications on the median of the maximum daily water temperatures in conceptual 5-foot deep pools at Gravelly Ford, below Chowchilla Bypass, and above Mendota Pool at flow releases of 350 and 700 cfs: (1) 25% width reduction and no change in depth, (2) 25% width reduction and a 33% depth increase, and (3) a 50% reduction in width and depth. The results suggest that 50% reductions in channel width and depth might reduce May daily maximum temperatures by about 6°F at a flow of 700 cfs at Gravelly Ford. Flow magnitude had no effect on the temperature reduction as long as flows remained in the low flow channel (≤ 700 cfs). The benefits of channel narrowing and deepening were smaller at the Below Chowchilla and Above Mendota Pool sites compared to the Gravelly Ford site, presumably because the existing channel was wider at these sites than at Gravelly Ford. No analysis was done for the reaches below Mendota Pool where shading may affect daily maximum water temperatures in the northerly flowing channel differently from those modeled at Gravelly Ford and above Mendota Pool which flow toward the West.

Another potential action that has not been studied for the Restoration Area is wide riparian canopies (as opposed to narrow bands of trees to shade the river). Wide riparian canopies reduce air temperatures at the river and reduced air temperatures may reduce water temperatures (Moore et al. 2005). Studies in upper watersheds in northern California indicated that a 30-meter wide riparian tree canopy reduced above stream air temperatures by 8.6°F compared to sites without riparian trees (Moore et al. 2005). The rate of decline in air temperature due to riparian tree canopies is highest up to a width of 30 meters and only 0.36°F for each additional 10 meters of width. It would be possible to use estimates of air temperature reduction, increases in humidity, and reduction in wind speed in a conceptual modeling analysis based on the data provided in Moore et al. (2005). However, there is a lack of meteorological data that could be used to quantify the effects of riparian canopy width along the San Joaquin River below Mendota Pool where the river flows toward the North.

3. Anticipated Outcomes:

The results of these temperature analyses would be used to help plan design-level grading and revegetation approaches for the Reach 2B, Reach 4B, and Channel Capacity/Levee Stability projects. A critical evaluation factor for these projects is whether they provide suitable conditions for the passage of juvenile and adult salmon. Reach 4B currently does not provide suitable water temperatures for adult spring-run salmon later in the year and it is possible that the Reach 2B Project Description may need to be revised to help improve temperatures in reaches 4B and 5. This study will also inform whether Channel Capacity projects should consider adding wide riparian forests, and potentially trigger subsequent studies to determine if levee setbacks would be needed to allow a sufficiently wide riparian forest to mature without impeding flood flow releases or Restoration Flow releases.

- Suggested grading approach (i.e., narrowness of the low flow channel, amount of flow allowed onto floodplains versus concentrated in the channel for cooler temps)
- Revegetation approach (whether the program should build riparian forests, widths of riparian forests)

4. Methods:

This study would be conducted in two phases. The objective of Phase 1 would be to modify the existing SJRRP HEC-5Q model to determine the combined effect of narrowing the base-flow channel and restoring a dense forest canopy from levee to levee on daily maximum water temperatures in the San Joaquin River near the confluence with Bear Creek. The model would also be used to determine where channel narrowing and heavy planting would be required to create suitable water temperatures for adult spring-run salmon through mid-May in Reaches 4 and 5. This phase would be implemented by MWH and Don Smith, Resource Management Associates (RMA), who developed the HEC-5Q for the Restoration Area.

Phase 1 Tasks:

Task 1 - Develop analysis capability by updating existing HEC-5Q model and performing initial analysis of the two potential mechanisms to improve temperatures in the lower reaches of the San Joaquin River in the Restoration area.

Subtask 1.1 Determine "low-flow" for each reach of SJR - Review daily flows from SJRRP Alt A modeling from Friant to the confluence with the Merced River. Determine “low-flow” channel capacity for each reach of the SJR.

Subtask 1.2 Update HEC-5Q SJR temperature model with new cross-section data - New HEC-RAS models with updated channel geometry of the SJR will be supplied by Reclamation. These models will be used to generate new cross-section, and flow-stage curves that will be used to create an updated HEC-5Q San Joaquin River Temperature model. The results of this revised model will be compared to the results of the existing model to estimate potential differences. The revised model will not be re-calibrated.

Subtask 1.3 Add “low-flow” channel to updated HEC5Q SJR temperature model. -

Develop a “typical” trapezoidal channel that minimizes the top width for the “low-flow” from Subtask 1.1 in that reach based on the hydraulic slope and reasonable constructible side slope. Using the new HEC-RAS models from Reclamation generate new cross-section and flow-stage curves for input to HEC-Q. Prepare new HEC-5Q input data to include new cross sections and stage-flow curves.

Subtask 1.4 Modify HEC5-Q shading and meteorological data - Modify HEC-5Q input data assuming

- Planting trees to shade the low flow channel, assuming mature, fully leafed-out cottonwoods that reduce solar radiation, and
- Planting a 30-meter wide canopy of trees to reduce air temperatures at the river by 8.6^{o}F (4.8^{o}C), reduce relative humidity by 12.5%, and reduce wind speed by 85% (Moore et al. 2005).

Modify the “CIMIS to HEC5Q” utility program to account for stream orientation, canopy assumptions, riparian temperature, wind speed increments, etc. Note that the 8.6^{o}F reduction is for the daily maximum, daily minimum temperatures would be slightly elevated. (e.g., -8.6 to +1.0^{o}F maximum/minimum adjustment). Relative humidity would increase with lower temperatures. A safe assumption is that the dew point temperature is unchanged or slightly higher.

Subtask 1.5 HEC-5Q Simulation of full implementation – Update HEC5-Q model with new data from Subtasks 1-4 and perform period from 1978 through 2003 to match the time period of previous SJRRP temperature analysis to allow direct comparison of results with earlier work.

Subtask 1.6 Prepare Technical Memorandum – Prepare a Technical Memorandum (draft and final versions) documenting Task 1. The Memorandum will include:

a. Documentation of the development of the revised data sets, and developing specific HEC5-Q inputs from the data sets. (sufficient to allow reproduction of the results)

b. Documentation of assumptions and procedures included in the analysis

c. Summary of analysis results

Task 2 – (*Optional task if Reclamation determines that the results of Task 1.1 through 1.5 show sufficient promise to justify further investigation*.) Refine implementation of temperature management implementation to maximize the benefits and/or minimize potential implementation cost**.**

Subtask 2.1 Develop interface/methods to implement measures in selected reaches - Develop interface/ methods to assist in implementing selected temperature management mechanisms in selected reaches of the San Joaquin River in the HEC5-Q model. Reach selection will be limited to the San Joaquin River Restoration Program reaches 1-5 from Friant downstream to the confluence with the Merced River.

Subtask 2.2 Perform sensitivity analysis of different reach implementation - Using the newly developed modeling system perform sensitivity analysis of up to 4 partial implementation scenarios to investigate the potential temperature improvements from partial implementation of the temperature management mechanisms identifying the most promising locations and minimum extent of narrowing / planting necessary.

Subtask 2.3 Prepare Technical Memorandum – Modify the Technical Memorandum prepared under Task 1 to include Task 2. This includes documenting all data development, HEC5-Q input updates, and results of comparison with fishery temperature goals.

Task 3 – Proof of Concept Real Time San Joaquin River Temperature Model - The modeling tool will be based on the existing HEC5Q SJR water temperature model, modified as required to work in a predictive rather than a planning mode.

Subtask 3.1 Modify model, data, and tools for predictive application. - Modify San Joaquin River planning model for use in a predictive mode. The basic concept will be that the model will run with Friant flow and release data for the current year, historical for year to date, and forecast for remainder of year as the data for each year of the simulation. (This proposal does not include adding Millerton Lake to the San Joaquin River temperature model.) The results will represent a range of potential SJR temperatures for the remainder of the year. This may require changes in input data, and simulation processes, this is not anticipated to require changes to the actual HEC5Q model code.

Subtask 3.2 Develop desired outputs – Working with Reclamation define the desired format and content of final model outputs for use in real-time SJRRP release schedule generation.

Subtask 3.3 Create prototype user interface – Create a prototype of a user interface to allow entry of one year's Friant release flow and temperature, running a simulation, and output generation. The initial version of this interface will probably be developed using Microsoft Excel.

Subtask 3.4 Prepare user manual – Pr epare a user's manual that outlines the assumptions and procedures in the model and includes instructions use of the interface from Task 3-3.

Subtask 3.5 Present to Reclamation - Conduct a demonstration/workshop with Reclamation on the new tool to teach the proper use of the new tool.

Cost: $82,461.88

Schedule:

- Complete the full period simulation 4-6 weeks depending on time required to obtain the base HEC-RAS model.

- Complete sensitivity runs and tech memo in additional 4 weeks.

Phase 2 studies would develop a 2-dimensional water temperature model to evaluate temperature differences between floodplains and the main channel. In addition to temperature differentials, the study would identify whether planting floodplain habitats and thereby maximizing floodplain roughness would provide temperature reductions in the low flow channel for adult passage in late spring, but also allow warm, highly productive flows on the floodplains for juvenile salmon in winter and early spring. Presumably, floodplain roughness would minimize the exchange of flow between the low flow channel, which would have low temperatures, and floodplain habitats, which would have warm temperatures. This differential in temperatures would be particularly important if narrowing and deepening the channel to reduce temperatures in the low-flow channel resulted in a floodplain bench that would inundate at intermediate flows (e.g., $\geq$ 1,000 cfs). This analysis could only be conducted with a 2-D model, whereas the current HEC-5Q model is 1-D and reflects the mean temperature in both the river and floodplain. The results would be needed to design floodplain inundation thresholds in channels that would be narrowed and deepened. This phase would be implemented by the Technical Service Center staff in Denver, CO. The analysis would be focused on conditions in reaches 4B and 5 and flow releases between 2,000 cfs and 4,500 cfs.

Cost:

Schedule: done by February 2015

5. Deliverables: Draft Technical Memorandums

6. Point of Contact/ Agency PI: Katrina Harrison, Reclamation; Erica Meyers, CDFW; Carl Mesick, USFWS; Beth Wrege, NMFS.

7. References

Johnson P, B. Nass, D. Degan, J. Dawson, M. Johnson, B. Olson, C. Harvey-Arrison. 2006. Assessing Chinook salmon escapement in Mill Creek using Acoustic Technologies in 2006. Report submitted to the U.S. Fish and Wildlife Service Anadromous Fish Restoration Program, U.S. Department of the Interior. LGL Limited, Environmental Research Associates, North Bonneville, WA. November 2006.

Moore R.D., D.L. Spittlehouse, A. Story. 2005. Riparian microclimate and stream temperature response to forest harvesting: a review. Journal of the American Water Resources Association, 41(4): 813-834.

SJRRP. 2008a. Temperature Model Sensitivity Analyses Sets 1 & 2. Draft Technical Memorandum, February 2008.

SJRRP. 2008b. Temperature Model Sensitivity Analyses Sets 4 & 5. Draft Technical Memorandum, October 2008.

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