Study 26

Effect of Altered Flow Regime on Channel Morphology in Reach 1A

Final
2015 Monitoring and Analysis Plan

SAN JOAQUIN RIVER
RESTORATION PROGRAM

January 2015

1.0 Effect of Altered Flow Regime on Channel Morphology in Reach 1A

Theme(s): Flow management

- Rearing habitat
- Spawning and incubation
- Long-term monitoring

Related Question(s):

- SI-003b: Is gravel recruitment sufficient for spawning habitat in Reach 1A?
- SI-008: If new spawning habitat is created, or existing spawning habitat rehabilitated, will future sand (fine bedload) quickly infiltrate spawning habitat and reduce the quality (longevity) of spawning habitat? How frequently would gravel improvements be needed?

Additional questions that this would answer are:

1. **From the perspective of changes in bed texture at existing spawnable sites:** How do the spawning gravel sites evolve with time under the proposed flow releases? Do they expand as gravels are provided from upstream sources? Do they contract as gravels erode and deposit into less hydraulically suitable areas for spawning (e.g., in the downstream pool)?

2. **From the perspective of changes in hydraulics at existing spawnable sites:** How do the hydraulics (e.g., flow depth and velocity) change with erosion and deposition that result from the altered flow releases? Erosion typically leads to incision and channel narrowing while deposition does the opposite. Considering erosion is expected on the riffle surfaces where hydraulics and sediment are considered more likely to be suitable for spawners, will channel narrowing in these areas reduce the spawnable area for a given flow level by reducing the submerged bed surface area with suitable flow depth and velocity? Will channel narrowing and associated increases in flow velocity cause shortening of the riffle surface and similarly reduce the spawnable area?

3. **From the perspective of channel form:** How are boundary features evolving with the altered flow releases? Are pools depths shallowing from eroded riffle sediments? Or are pool-tails extending? Will the proposed future flow releases enhance the post-dam riffle spacing adjustment process? Would such adjustment increase spawnable area and/or create a different limiting characteristic habitat?

1.1 Statement of Need

The problem statements for smolt survival and mature spawners indicate the need for monitoring flow conditions and meso-habitats with the intention to maintain conditions that encourage food production, growth while rearing, protection from predators, and holding pools within Reach 1A. Channel boundary features are critical to salmonids throughout their freshwater life stages. The texture of the bed dictates successful incubation and emergence, flow complexity is beneficial to juvenile rearing, deep pools provide temperature and predation refuge and holding habitat, and overhanging banks provide protection from predation. The effect of Restoration Flows on the existing channel is not known, and this study takes advantage of Restoration Flows to measure changes in pertinent channel boundary features from which trends can be observed, computational models validated, and, in the end, predictions made as to changes in the availability of specific habitat types that result from these altered flow levels.

1.2 Background

Restoration Flows will be altered compared to the previous 60 years' hydraulic regime. Aspects of the channel boundary that are significant for salmon habitat quality, and that might change because of alteration of the flow regime, include pool depths; riffle/bar heights; bank location, height, and character; and bed texture.

Channel form features such as pools and bars affect flow complexity that is bioenergetically favorable to both adult and juvenile salmon (Trush et al., 2000). Edgewater areas are important for juvenile salmon rearing and pools are necessary resting places for adults returning to spawn. With current understanding of sediment mobility and flow stresses in Reach 1A, it is difficult to predict whether the increased duration of high flows will scour pools more deeply or make them shallower with sediment scoured from riffles immediately upstream.

In addition, the bed surface will undergo changes through scour and deposition as a result of sediment transport processes. These processes are known to present a risk to incubating embryos more typically found within bar and riffle subsurfaces. When scour occurs to the egg pocket depth, the eggs lose their protection from the effects of bed material transport. Additionally, subsequent deposition alters the texture of the material overlying the egg pocket (Haschenburger, 1999; Lapointe, et al., 2000; May, et al., 2009). Understanding how these features will be transformed by the Restoration Flows is necessary for assessing the altered flow regime's impact on adult and juvenile salmon habitat.

1.3 Anticipated Outcomes

The study will result in several outcomes directly related to changes in relevant channel morphology, including the following:

- Predictions of the fate of spawning gravels.
- Predicting the effect of different flow scenarios on erosion and deposition extent and magnitude.
    - Resulting changes in hydraulics.
    - Gravel replenishment or depletion of spawnable areas.
    - Evolution of pool depths, pool-tail and riffle area, and riffle spacing.
- A measure of the flow intensity required to produce bank erosion within the reach.
    - Will be used to produce a sediment supply rate from bank erosion per discharge rate and duration using realistic Restoration flow scenarios.

1.4 Methods

Type of Study: Combination of modeling and field studies

Reach: Upper Reach 1A

Most of the field efforts and measurement data for this study will be gained from other studies. Additional data analysis and hydraulic modeling will be required to make substantive conclusions on channel adjustment processes as they have occurred during the interim flows. The following data will be used for this effort:

1) Gravel and cobble transport thresholds will be used to define locations of bed material entrainment. These thresholds are measured as part of the 2014 Monitoring and Analysis Study 28: Reach 1A Mobility. Coarse material deposition will also be evaluated from that study’s gravel and cobble tracers’ travel distances and depositional environments. Areas predicted to have coarse material deposition will be compared with those areas’ hydraulics to determine if they will contribute to spawnable habitat.

2) Sediment transport rates and therefore supply volumes will be provided from 2014 Monitoring and Analysis Study 47: Sediment Mobility, which includes bed load transport rate measurements and monitoring with changes in discharge at the two study sites (see item 4 below). By incorporating the active bed layer depth as determined from 2014 Monitoring and Analysis Study 27: Scour and Deposition on Incubation Habitat, the magnitude of erosion and downstream deposition will be considered.

3) Channel narrowing and/or widening will be evaluated using repeated channel traversing topographic surveys. These surveys were performed after each pulse flow from 2009 through 2013. Changes in bed elevation and bank positions can

be discerned from the profiles and trends in their change with discharge will be evaluated.

4) University of California, Santa Barbara (UCSB) developed a 2-dimensional (2D) hydraulic model focused on a subreach extending for approximately 2.5 miles using the USGS's MD_SWMs interface. This subreach includes the two study areas at River Miles 260.7 and 261.6 known as Riffle 38 and 40, respectively. This model will be used to determine areas exceeding entrainment thresholds and downstream sites below distrainment thresholds.

    a. Several Restoration Flow scenarios will be simulated with the 2D model and changes in channel geometry will be made iteratively from volumetric erosion and depositional predictions.

    b. Changes in channel hydraulics will be illustrated so as to provide a quantitative prediction of changes in flow and depth for a baseline flow (e.g., summer or spawning season base flow).

    c. Flow conditions that encourage bank erosion will be evaluated and bank erosion rates associated with near bank flow intensity (function of flow velocity and direction relative to the bank) will be reported. This value should be useful for predicting bank erodability within the reach, which will also quantitatively be able to provide rates of sediment supply.

Considering this study is being conducted in the spawning reach the life stages supported will include adult spawners, incubation, and rearers for the short duration in which they remain within upper Reach 1A.

1.5 Deliverables and Schedule

The deliverable for this study will be a technical memorandum that documents the outcomes listed above. It is expected to be completed by early 2016 and depends on completion of the studies in which this study leans on. Additional field work that this study will benefit from includes the bed load transport rate monitoring that expected to be completed by Summer 2015.

1.6 Budget

The total cost estimate is $40,000 for 2015.

Table 1. Proposed 2015 Budget

Task	Cost
Review and Analyze Data	$10,000
Modeling	$25,000
Reporting	$5,000
Total	$40,000

1.7 Point of Contact / Agency Principal Investigator

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1.8 References

Haschenburger, J.K. 1999. A probability model of scour and fill depths in gravel-bed channels. *Water Resources Research, 35*(9): 2857-2869.

Lapointe, M., B. Eaton, S. Driscoll, and C. Latulippe. 2000. Modeling the probability of Salmonid egg pocket scour due to floods. *Canadian Journal of Fisheries Aquatic Science, 57*: 1120-1130.

May, C.L., B. Pryor, T.E. Lisle, and M. Lang. 2009. Coupling hydrodynamic modeling and empirical measures of bed mobility to predict the risk off scour and fill of salmon redds in a large regulated river. *Water Resources Research, 45*: W05402, doi:10.1029/2007WR006498.

Trush, W.J., S.M. McBain, and L.B. Leopold. 2000. Attributes of an alluvial river and their relation to water policy and management. *Proceedings of the National Academy of Sciences of the United States of America*, 97:22.

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