Proposal for Experimental Fund Support
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Development of an Information Base to Implement Trout Management Flows

1.0 Introduction

Trout Management Flows (TMFs) are an experimental element identified in the Glen Canyon Dam Long-Term Experimental and Management Plan (LTEMP) Environmental Impact Statement (EIS). These flows are intended to reduce the probability of large recruitment events of young rainbow trout in Glen Canyon. High levels of recruitment have been shown to lead to poor growth and population collapse which has negative effects on the trout fishery in Glen Canyon. High levels of recruitment in Glen Canyon can also increase the number of trout that disperse into Marble Canyon and lead to higher trout abundance at the Little Colorado River and have negative effects on humpback chub.

TMFs will be timed to coincide with the emergence of rainbow trout in Glen Canyon, which peaks between May, June, and July. Newly emerged trout are small and fragile and are limited to very shallow and low velocity areas in immediate shoreline areas. The premise of TMFs is that newly emerged fish will move into microhabitats newly inundated by the peak TMF flow, and that these fish will be stranded when the flows are rapidly reduced.

The conceptual model from the final LTEMP EIS does not recognize the many variables and uncertainty related to the characteristics that would comprise a successful TMF. Variables that we believe important to consider when designing a TMF include:

1. The maximum discharge at the peak of the TMF cycle, which relates directly to the area and amount of inundation. This discharge would depend on the distribution and elevation of floodplain habitats and other characteristics such as substrate, distance to the main channel, slope, and vegetation cover.
2. The length of time needed for young fish to colonize newly wetted areas inundated at the maximum peak of the TMF cycle (a key uncertainty).
3. The rate at which flows should be reduced to the minimum of the TMF cycle.
4. The minimum flow level at the end of the recession and the duration of the low flow period (which may be lower than the normal minimum flow in the month it is implemented).
5. The hydropower cost of a range of TMF flows and their potential impact on beaches, fine sediment storage, and water levels in Grand Canyon in areas used by native fish.

Due to the recent increase in brown trout in Glen Canyon, interest has been expressed in using TMFs to limit their recruitment. The characteristics of TMFs focused on brown trout will likely be similar to those for rainbow trout with the exception that they will likely need to be conducted earlier in the year to coincide with the period of brown trout emergence (February-April), which is prior to the May-August TMF window for rainbow trout allowed under the LTEMP Record of Decision. Verification is warranted for both the timing of brown trout emergence and the similarity of their habitat requirements relative to rainbow trout.

2.0 Workplan

This proposal summarizes work elements that will provide critical information on characteristics of TMFs in order to optimize their effectiveness at reducing recruitment while minimizing negative side-effects. TMFs could have negative effects on important LTEMP resources including native fish, beaches, and hydropower. It is therefore critical to do as much preliminary work on these flows as possible so that the first potential implementation of a TMF is successful and does not cause unintended harm. The work elements will be conducted in FY2019-20, ideally prior to the first TMF. It is proposed that the work described below will be supported under the Experimental Fund in the Glen Canyon Dam Adaptive Management Program's FY2018-20 Triennial Work Plan (FY18-20 TWP). The work elements are:

1. A literature review of micro-habitat requirements of recently emerged rainbow trout and brown trout. This review will establish the ideal depth, velocity, and substrate characteristics for each species (rainbow trout and brown trout) that will be targeted at the peak of the TMF cycle. This information will be used in element 2 below, to identify discharges that provide the optimal habitat and attracts as many recently emerged trout into flood plain habitats as possible during the peak flows of any TMF. Extensive literature indicates that the rate of stranding and mortality depends on the downramp rate, time of day (day or night), water temperature, and fish size. It is likely that other factors such as substrate type, shoreline complexity, and shoreline angle also play a role. This work element will review the available literature for guidance on the timing and flow rate of ascension and recession for a TMF and guidance for mesocosm experiments described below.

2. An analysis of Glen Canyon bathymetry, stage-discharge relationships, and 2D hydraulic model predictions of depth and velocity (based on recent modelling of S. Wright, USGS). This analysis will identify the discharge levels that maximize the area of low-angle shoreline inundated at the peak TMF flow. Information from the literature review (element 1) will be used to refine these calculations. Higher discharges (e.g., 20,000-25,000 ft^3/s) may provide greater areas of inundation and therefore result in higher rates of stranding. However, these discharge levels may result in greater hydropower losses and increase erosion of beaches. Thus, it is critical to quantify the relationship between discharge and the area of floodplain inundation so that managers can evaluate potential trade-offs between maximizing the effectiveness of TMFs and minimizing negative side effects.

3. Mesocosm experiments will be used as a low cost and low risk means of defining TMF characteristics such as the rate of ascension, the duration of the peak flow period required for colonization of inundated flood plain habitat by small trout, and the rate and timing (day vs. night) of the recession. Mesocosms will be constructed at a source of water adjacent to the National Park Service facility at Lees Ferry (behind the 14-day parking lot). Recently emerged rainbow trout will be collected in Glen Canyon in June and July to seed the mesocosms. These experiments will be used to define the length of time necessary to maintain the peak flow, colonize newly wetted areas, and to provide details on recession (rate of downramp, day vs. night, effectiveness on fish of different sizes, etc.).

4. A small-scale field experiment will be conducted to measure the rate of colonization as flows are increased, and to develop and test field techniques to determine the extent of colonization. This experiment will be conducted at a single location with a low angle cobble bar that is flooded over the range of flows (likely prop bar at RM -11). It will be timed to coincide with the normal June-July volume increases, with possible modification to maximize its utility. Minimum flows typically increase from ~ 7,000-10,000 ft3/s between June and July. Ideally the minimum flow during July could be increased to 15,000 ft^3/s or even 18,000 ft^3/s for 1-5 days. Shoreline, nighttime, backpack electrofishing will capture recently emerged rainbow trout during low flows of 5,000-8,000 ft^3/s. These small fish will be marked using alternate marking techniques (visual implant elastomer (VIE), clipping, batch dying). Flows will be increased to levels of approximately 15,000 ft^3/ after marking and a second electrofishing event will recapture marked fish to determine the rate and extent of colonization of recently inundated areas.

5. Addition of a single Trout Recruitment Growth Dynamics (TRGD) trip in July. The TRGD project funded in the FY18-20 TWP has trips scheduled for April, September, October, and January (4 trips/yr.). The October trip is used to reliably quantify annual recruitment using mark-recapture (most of the annual cohort are >=75 mm at that time). The September, October, and January trips quantify growth rates before and after High Flow Experiments (HFE). The April and September trips characterize the combined spring-summer growth rates. The proposed July trip will be critical to quantifying TMF-related mortality. TMFs will potentially result in high mortality during the summer. Differences in abundance between the additional July trip and the currently funded September trips will quantify TMF-related mortality. However, it is important to collect this information in years when TMFs are not conducted to provide a baseline to compare with years when they are implemented. This baseline is available in 2012-2017, and the proposed addition of a July trip would provide an extended baseline through 2020. September and October trips will determine if TMF-related losses are compensated by higher survival rates due to lower densities following the TMF (the rate of change in

abundance between July, September, and October trips will allow us to evaluate this potential compensation). The TRGD projects mark trout with passive integrated transponder (PIT) tags down to a minimum size of 75 mm. Large numbers of smaller trout are captured and enumerated during July and September trips; however, these fish will be too small to tag. Previously they have been marked with fin clips to provide estimates of abundance. To date these data have not been analyzed or integrated into existing mark-recapture models. This work element therefore also requires funding to analyze data and integrate it into the existing mark-recapture model. This model will provide a quantitative tool for evaluating the population-level effect of TMFs.

6. Economic and sediment loss evaluations and flow routing for a variety of TMFs will be conducted by GCMRC, Western Area Power Administration (WAPA), Reclamation, and cooperators using models developed for the LTEMP EIS. Unsteady flow modelling will be used to evaluate the extent to which the low flow component of the TMF is attenuated at increasing distance from Glen Canyon Dam. This will help define the maximum low flow period that can be implemented without having that low flow reach the Little Colorado River confluence. The recently updated suspended sediment rating curve model will be used to evaluate effects of peak TMF flows on sand storage. The WAPA planning model used to optimize hourly flows will be used to calculate the hydropower cost of TMF experiments.

3.0 Project Timeline

Project element 1 (literature review) will be conducted prior to conducting mesocosm experiments and the GIS analysis. Element 2 (bathymetry, stage, etc.) is underway and analysis of these data will be continued in FY19. Element 3 (mesocosm experiments) will be conducted in June and July of 2019 and 2020. Element 4 (small-scale field experiment) will be conducted in July of 2019 or 2020. Element 5 (July TRGD field trips) will be conducted in 2018, 2019, and 2020. Element 6 (economic, sediment loss, and flow-routing evaluations) will be conducted in 2018 and 2019.

Information from this project will provide sufficient resources to adequately define characteristics and evaluate the first potential implementation of a TMF in 2021. It will also inform the development of the FY21-23 Triennial Work Plan. If a spring HFE is implemented in 2020 (the first year allowed under the LTEMP EIS) and a large trout recruitment event results, information gained from this project prior to that date would be useful if it were deemed necessary to conduct a TMF to manage trout recruitment. Implementation of a TMF in summer of 2021 would be preferred, however, since it would allow for an additional year of data collection and synthesis leading to a more sound design.

4.0 Project Budget

The estimated cost for the proposed work is approximately $120,000 in FY2019 and $130,000 in FY2020. Specific details on cost for model development, analyses, logistics, labor and expenditures for field work and experimental mesocosms are provided in Table 1. The biological science technicians that will work on this project have not been identified yet. We intend on hiring qualified biological science technicians using an interim 180-day hire (GS 5-7), or alternatively, reallocating some of this funding to existing staff for conducting the mesocosm experiments at Lees Ferry.

Table 1. Trout Management Flow Experiment budget.

Component 1. Literature compilation and review of trout micro-habitat requirements

No cost - Covered by existing GCMRC staff

Component 2. Analysis of spatial and hydraulic data

No cost - Covered by existing GCMRC staff

Component 3. Mesocosm experiments

	2019	2020
Supplies & Materials	$ 1,000	$ 1,000
Technician Salaries	$ 21,117	$ 21,751
Travel	$ 14,280	$ 14,280
Overhead	$ 5,511.35	$ 9,367.99
SubTotal	$ 41,908.56	$ 46,398.72

Component 4. Small-scale field experiments (GCMRC Staff)

	2019	2020
Supplies & Materials	$ 1,000	$ 1,000
Technician Salaries	$ -	$ -
Travel	$ 1,830	$ 1,830
Overhead	$ 989	$ 1,678
SubTotal	$ 3,819	$ 4,508

Component 5. - Trout Recruitment Growth Dynamics (TRGD).

5.A - Annual July 7-day Trip

	2019	2020
Supplies & Materials	$ 5,562	$ 5,729
Logistics	$ 28,018	$ 28,859
Technician Salaries	$ 8,651	$ 8,910
Overhead	$ 5,709.36	$ 9,819.95
Ecometric	$ 9,000.00	$ 9,000.00
SubTotal	$ 56,940	$ 62,318

5.B - Integration of batch marks into existing mark-recapture models

	2019	2020
Ecometric	$ 13,000	$ 13,000

Component 6. Economic and sediment loss evaluations and flow routing

No cost - Covered by existing GCMRC, BOR, and WAPA staff

	2019	2020	
TOTAL COST	$ 119,486	$ 130,733	$ 250,219.34

Overhead rate: FY19 = 0.1557, FY20 = 0.26