April 11, 2018

To: Glen Canyon Leadership Team for Implementation of Experiments under the Long Term Experimental and Management Plan (LTEMP)

From: Glen Canyon Technical Team

Re: Final Recommendation to Implement Macroinvertebrate Production Flow (Bug Flows) Releases at Glen Canyon Dam May – August 2018

I. Introduction

The Glen Canyon Technical Team (Technical Team) recommends that experimental Macroinvertebrate Production Flows (Bug Flows) be implemented at Glen Canyon Dam beginning May 1 through August 31, 2018.

Bug Flows consist of steady weekend releases from Glen Canyon Dam and normal fluctuating releases during the weekdays. The steady weekend flows are expected to provide favorable conditions for insects to lay eggs along the Colorado River downstream of Glen Canyon Dam, while the minimum flows on weekdays are designed to be similar to flows on the weekends. This flow regime would decrease the amount of stage change in the river on the weekends, thus preventing the insect eggs that are laid along the river margins from drying out. Technical experts at the United States Geological Survey's (USGS) Grand Canyon Monitoring and Research Center (GCMRC) and Western Area Power Administration (WAPA) have coordinated the design of the recommended experiment to optimize the benefits for insects throughout the canyon while minimizing negative impacts to hydropower. This experiment is expected to have positive benefits to the aquatic and terrestrial ecosystems in Glen, Marble, and Grand Canyons. The purpose of the experimental flow is to test the effectiveness of Bug Flows on improving insect production and to increase the availability of food for aquatic species including the endangered humpback chub *(Gila cypha*) and rainbow trout (*Oncorhynchus mykiss*), an important sportfish, as well as terrestrial wildlife like birds and bats.

The purpose of this memorandum is to transmit this recommendation to the Glen Canyon Leadership Team and to the Department of the Interior (Department) in accordance with the LTEMP Record of Decision (ROD). The Technical Team includes technical representatives from the National Park Service (NPS), the Fish and Wildlife Service (FWS), the Bureau of Indian Affairs (BIA), USGS GCMRC, the Bureau of Reclamation (Reclamation), WAPA, the Arizona Game and Fish Department (AGFD), the seven Colorado River Basin States (States), and the Upper Colorado River Commission (UCRC).

The Technical Team has worked over the past several months to evaluate existing data and coordinate the potential implementation of the experiment. The Team incorporated the latest data from agency experts and considered multiple issues, as summarized below, in making this final recommendation.

If implemented, this will be the first experiment conducted under the LTEMP, and it demonstrates the utility of the LTEMP to allow for experiments when conditions warrant and the experiment would not cause unacceptable adverse impacts to other resources. The recommended Bug Flows experiment is expected to provide resource benefits in the near term and will also provide scientific information to be used in future decision making.

II. LTEMP Process for Implementing Experiments

The 2016 LTEMP ROD provides the framework for implementing flow-based experiments at Glen Canyon Dam when resource conditions warrant. The purpose of LTEMP experiments is to learn, through adaptive management, how to better protect, mitigate adverse effects to, and improve resources downstream of Glen Canyon Dam, while complying with relevant laws. Ongoing research and monitoring through the Glen Canyon Dam Adaptive Management Program ensures the best science and data is available for making decisions related to experimental releases.

Under the LTEMP, the Department may conduct flow-based experiments (High Flow Experiments, Bug Flows, Trout Management Flows, and Low Summer Flows) at Glen Canyon Dam when resource conditions warrant and if it is determined that there will not be unacceptable adverse impacts on other resources. This is the first year of implementing flow-based experiments under LTEMP, and Reclamation has been following a process similar to that established for High Flow Experiments under prior operational decisions. This process entails outreach to Glen Canyon Dam Adaptive Management Program (GCDAMP) partners through regular meetings and additional notification to Tribes inviting consultation. The process also entails coordination with the Technical Team to plan for the possible experiment, evaluate the status of resources, and make a technical recommendation regarding whether to conduct an experiment. The Technical Team presents its recommendation to the Glen Canyon Leadership Team, which makes a recommendation to the Department. The technical and leadership teams are made up of representatives from Reclamation, FWS, NPS, BIA, USGS, WAPA, AGFD, and one liaison from each Colorado River Basin State and one from the UCRC. The Assistant Secretary for Water and Science is the chair of the Leadership Team and makes the decision for the Department regarding the experimental release. The recommendation process used this year is consistent with the process that the Department has used in the past for making High Flow Experimental decisions; the Department may choose to retain or modify this recommendation process to more efficiently coordinate with stakeholders.

III. Recommended Experiment: Bug Flows

Purpose and Goal

The purpose of Bug Flows experimentation is to determine whether stable, low flows on weekends in spring and summer months (May – August) can improve the condition of the aquatic food base that fuels growth of humpback chub, rainbow trout, and other desired fish species. By releasing stable and low flows every weekend, Bug Flows will provide two days of ideal egg-laying conditions each week for aquatic insects that lay their eggs along river margins

and are susceptible to drying out under normal, daily hydropower flow fluctuations (see Figure 1, Kennedy and others, 2016). If successful, Bug Flows should result in a more abundant and potentially more diverse and stable aquatic food base available to fishes.

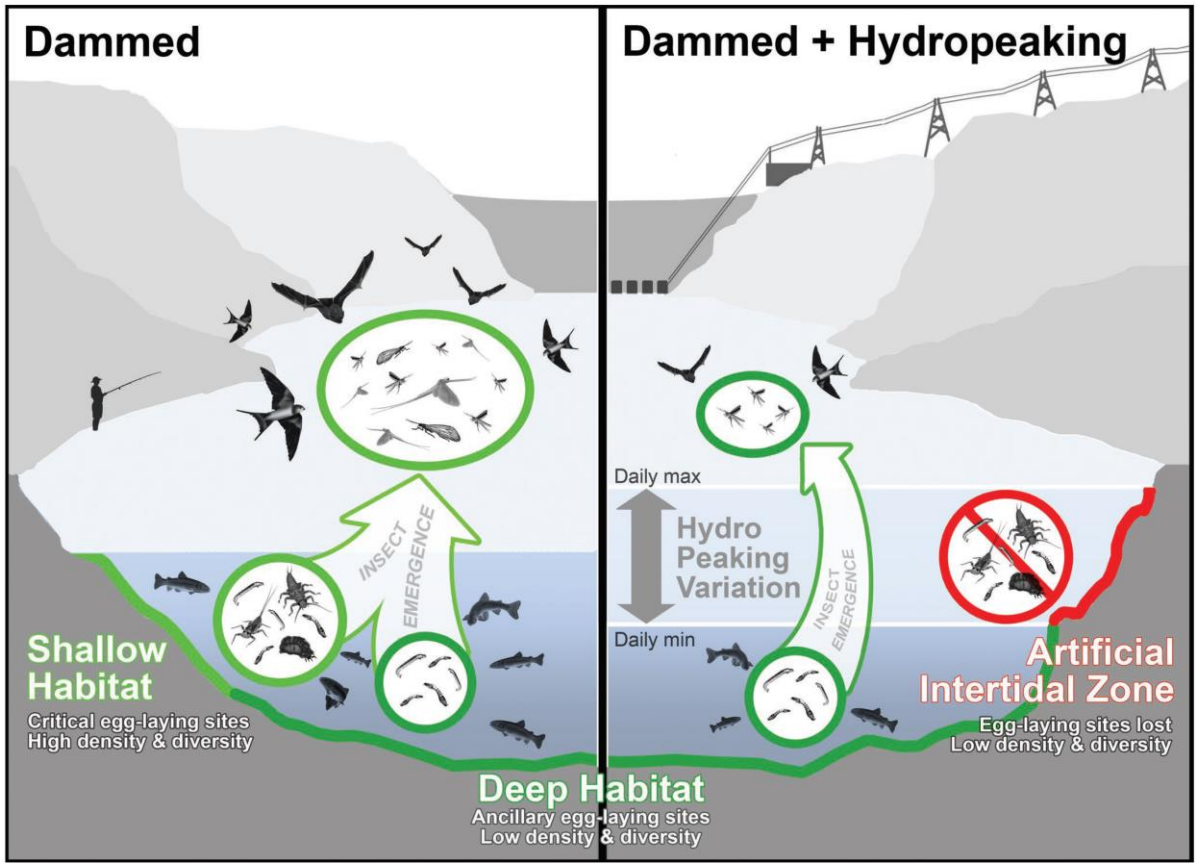

Figure 1. Aquatic insects play an essential role in river and riparian food webs. Aquatic insects are ubiquitous in freshwaters and are the primary prey for myriad species of wildlife living in and along rivers. These insects have complex life cycles that include a terrestrial winged adult life stage, whereas egg, larval, and pupal stages are aquatic. Ecologically important insect groups such as mayflies, stoneflies, and caddisflies cement their eggs along river-edge habitats, making them especially sensitive to dam water management practices such as hydropeaking that affect these edge habitats. Adapted from Kennedy and others (2016).

Experimental Design and Description

A Bug Flows hydrograph that incorporates weekend steady low flow releases that are 1,000 cubic feet per second (cfs) higher than weekday low flow releases in all months (May – August) is proposed for initial testing (see Figure 2). The recommended hydrograph was developed collaboratively by GCMRC and WAPA using an optimization process that determined a 1,000 cfs increase in weekend flows provides the best egg-laying conditions, river-wide, across all months. To meet downstream water delivery requirements, the stable, low flows on weekends need to be offset by relatively higher peak flows during the week than would otherwise be

achieved under normal operations. As currently designed, steady low-flow releases on weekends would begin after the normal down-ramp on Friday evening, with the down-ramp ending when flow releases match the designed Bug Flows weekend steady low flow. Dam releases would be steady throughout (except for system regulation and use of reserves) Saturday and Sunday and then dip briefly Monday morning for hydropower scheduling purposes to the designed weekday low flow, prior to ramping up at the normal rate until peaking later on Monday at the designed weekday high flow. Releases throughout the remainder of the week (Tuesday – Friday) would then be similar to releases on Monday. The exact timing of each of these peaks and low flow troughs varies from month to month according to scheduled monthly release volumes.

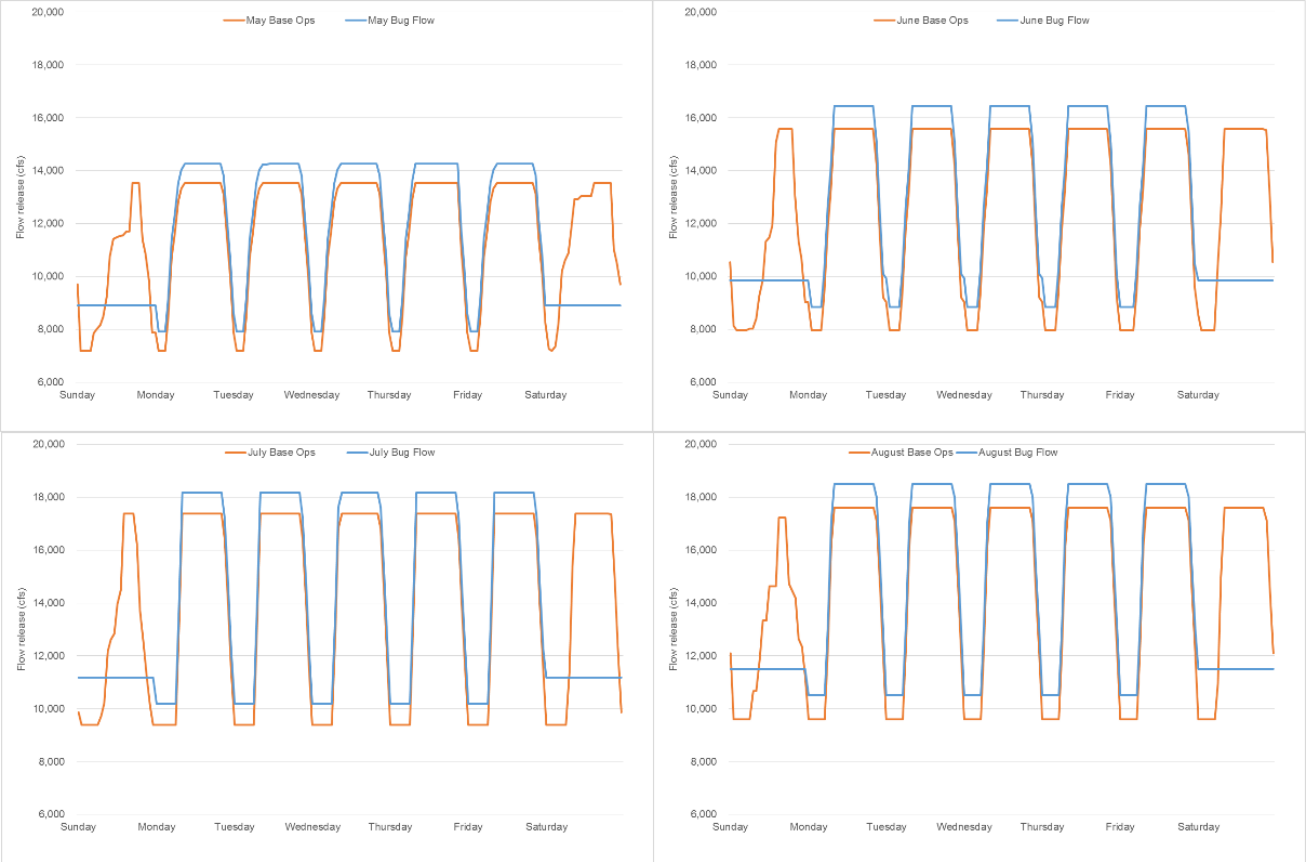

Figure 2. Proposed Bug Flows hydrographs during a single year of experimentation, from May – August. One week per month is shown; releases on subsequent weeks in the same month would be very similar. The orange line represents base operations without Bug Flows experimentation, the blue line represents the proposed Bug Flows hydrograph. Note the stable low flows on weekends that are 1,000 cfs higher than daily weekday low flows, and the slightly higher weekday peaks under Bug Flows experimentation relative to base operations.

IV. Monitoring Plan

GCMRC will monitor aquatic food base response to Bug Flows using standard monitoring methods. These include citizen science light trapping of adult aquatic insects throughout Glen,

Marble, and Grand Canyons, monthly aquatic invertebrate drift monitoring in Glen Canyon, annual or semi-annual, spatially-intensive drift sampling throughout Glen, Marble, and Grand Canyons, and semi-quantitative assessment of egg-laying conditions at targeted locations. These methods are cost effective and will yield robust data for quantifying the response of the aquatic food base to Bug Flows. The goals for these monitoring efforts are to document whether predicted increases in populations of extant aquatic insect species are realized, and to record any potential re-colonization of currently extirpated insect species to the mainstem Colorado River (particularly caddisflies).

Citizen Science Light Trapping

The principal mechanism for monitoring aquatic food base response to Bug Flows will be through citizen science light trapping. This project began in 2012 and comprises a group of river guides and student organizations that place a light trap at the river's edge every night in camp to collect adult aquatic insects. This effort yields a sample set of ~ 1000 traps per year throughout Glen, Marble, and Grand Canyons, predominantly during the commercial river guiding season through the spring, summer, and fall months when insects are most active. These citizen science light trapping data will be used to test the following predictions concerning insect population response to Bug Flows:

1) The overall baseline midge abundance is predicted to increase, and the current "sine wave" pattern of variable midge abundance progressing downstream from Glen Canyon Dam described by Kennedy and others (2016) is predicted to flatten as midge abundance increases in areas where it is currently low (see Figure 3). Statistical change detection of this sine wave pattern will be carried out using current state-of-the art methods in ecology, including a combination of mixed effects models (similar to that used by Kennedy and others 2016), and potentially Fourier analysis (Sabo and Post 2008) and ecological forecasting metrics (Dietze 2017) as appropriate, all within an information-theoretic frequentist or Bayesian framework (Burnham and Anderson 2002).
2) Annual average midge catches in light traps are predicted to show year-over-year increases and to eventually be higher than annual average catches observed in any of the six years of light trap sample collection prior to Bug Flows. Statistical analysis of these year-to-year differences will be carried out within an existing mixed effects modeling framework (Kennedy and others 2016).
3) On a seasonal timescale, the currently observed peak in light trap midge abundance occurs in June every year, then declines sharply through late summer and early autumn. Under Bug Flows, midge abundance is predicted to continue to increase over the summer, or to exhibit a less dramatic decline in late summer and early autumn, as favorable conditions for egg laying during Bug Flows in early summer result in more adult midges later in the summer. Statistical analysis of these seasonal differences will be carried out using time series analysis within an existing mixed effects modeling framework (Kennedy and others 2016, Dietze 2017).

Drift sampling

GCMRC staff will also monitor aquatic invertebrate drift monthly in Glen Canyon, and annually or semi-annually throughout Glen, Marble, and Grand Canyons. The monthly sampling in Glen Canyon will be a continuation of monitoring that has been ongoing since 2007, and includes sampling at approximately 3-mile intervals from Glen Canyon Dam to the head of Badger Rapid, encompassing a total distance of 24 river miles. Invertebrate drift sampling will also be used to look at the variation in drift concentrations based on flow velocities between weekday fluctuating flows and weekend steady releases. These data will allow determination of the extent to which Bug Flows result in weekly, seasonal, or inter-annual increases in the abundance of aquatic insects present in the drift. This monitoring effort will also be used to test predictions 2 and 3 in the Citizen Science Light Trapping section, above.

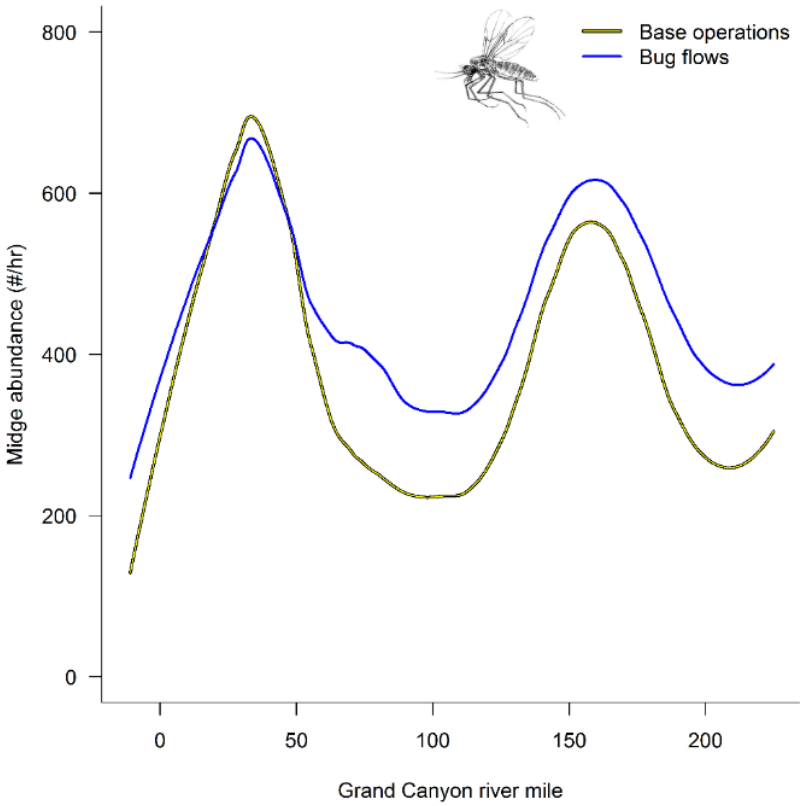

Figure 3. Spatial predictions of midge response to Bug Flows using citizen science light trapping. The yellow and black line is the pattern shown by Kennedy and others (2016), the blue line is a modeled prediction based on Bug Flows flow routing throughout Glen, Marble, and Grand Canyons. The river-wide net result is a 26% increase in midge production. Note that the model generally predicts a leveling out of the current "sine wave" pattern in midge production, as well as a raising of the overall baseline.

In addition, an annual spring river trip focused on quantifying invertebrate drift will be launched in 2018, 2019, and potentially subsequent years. Invertebrate drift will be collected at approximately 3-mile intervals throughout Glen, Marble, and Grand Canyons (about 270 river miles in total) to determine the extent to which spatial patterns in aquatic invertebrate drift respond to Bug Flows, complementary to prediction 1 in the Citizen Science Light Trapping section, above. These data will be compared to a spring 2017 drift sampling trip, which provides pre-experiment data using the same methods and approach. Additional samples from a fall 2017 drift sampling trip will also be compared to a proposed fall 2018 drift sampling trip. Combined, these trips will allow seasonal and spatial patterns in aquatic invertebrate drift to be compared and contrasted, under conditions with and without Bug Flows. Critically, such spring-fall comparisons will be useful in determining aquatic insect population responses to Bug Flows after only a single season of experimentation, which will help guide decision-making about whether to propose additional Bug Flows experiments in future years. All statistical analysis of drift data will be carried out within an existing mixed effects modeling framework that accounts for discharge at the time of drift collection, time of day, location of the drift measurement, and other relevant covariates (Kennedy and others, 2014).

Insect egg laying

During weekends of low, steady flows during the Bug Flows experiment, GCMC scientists will also pursue deploying egg-laying substrates at targeted locations along the Colorado River, particularly in the more accessible Lees Ferry reach. These substrates will consist of 1-m long, 4-inch diameter, black ABS pipes temporarily anchored to the river bed at the shoreline for ~ 48 h. Previous exploratory studies in Lees Ferry have indicated that midges will effectively lay eggs on these pipes, in clutch sizes that can range up to millions of eggs. The goal of deploying these substrates will be to identify relative numbers of eggs laid during base operations and during Bug Flows weekends, and to observe the extent to which eggs laid during weekends appear to remain wetted and thus avoid the desiccation and egg mortality observed during base operations. Current methods allow for semi-quantitative assessment of these factors (e.g., is the size of the egg mass larger or smaller, and is it wet or dry). Future methods refinement based on learning from initial Bug Flows egg-laying observations may eventually allow for a more quantitative approach to provide more precise estimates of the number of eggs laid and likely to survive in a given area. Nonetheless, these semi-quantitative data will identify whether the principle mechanism identified by Kennedy and others (2016) for low aquatic insect production downstream of Glen Canyon Dam, hydropower flows-related egg mortality, can be ameliorated by Bug Flows.

V. Assessment of Resources

Consistent with the LTEMP modeling, we did not find any information in our resource assessment that would indicate a Bug Flow experiment conducted May 1 through August 31, 2018 would have sufficient potential adverse effects to other resources that would lead to a decision to not conduct the experiment. This section summarizes the assessment of resources and expected effects of a Bug Flow experiment.

Aquatic food base

- The aquatic food base is expected to benefit from Bug Flows experimentation, as outlined in section IV, above. Specifically, aquatic insect populations of existing midge species are expected to increase on both seasonal and annual timescales, and currently low-abundance caddisfly species are expected to become more widespread and abundant. Non-insect aquatic food base components, specifically New Zealand mud snails and *Gammarus*, are expected to be insensitive to Bug Flows, as they do not have terrestrial adult stages or river margin egg-laying strategies that would be affected by the experiment.

Lees Ferry trout population

- Our analysis indicates Bug Flows do not pose any threats to the Lees Ferry trout population Age-0 rainbow trout are the life stage of trout that are most vulnerable to stranding. The abundance of age-0 trout typically increases in spring as larval fish emerge from the gravel, with peak abundance by mid-July Korman and Campana (2009) studied habitat use of age-0 trout and found these young fish do not move in response to hourly flow variation. This suggests there is minimal potential for stranding of age-0 rainbow trout when weekend flows are reduced down to levels at or slightly above the weekday minimum flow (Korman and Campana, 2009; Korman and others, 2009; Korman and others, 2011). The proposed stable weekend flow levels are very unlikely to cause any stranding of larger adult trout.

Lees Ferry fishery recreation experience quality

- No unacceptable adverse impacts on recreational fishing are foreseen from a Bug Flows experiment. At a recent AGFD sponsored public meeting (March 5, 2018) at Marble Canyon, AZ, anglers in attendance were supportive of Bug Flows to improve the food base in Glen Canyon. Boaters and boat anglers prefer to have flows at a minimum of 8,000 ft^3/s as that alleviates some concerns about running aground on cobble bars at lower flows, and the proposed Bug Flows will always be above this flow level. Boat angling and recreational boating activity is highest on weekends, and steady flows generally enhance these experiences. Steady flows generally limit stranding of boats with receding water, or the potential for boats floating away with rising water. However, boats in Glen Canyon anchoring on Friday afternoon during the Bug Flows experiment could be stranded as the water level will not rise as much as usual during the weekend days. Notification will be posted to alert boaters and anglers to the change. Steady flows should also enhance walk-in angling, because the risk of water rising while wading in the current is minimized. Additionally, most boaters appreciate a consistent water flow schedule, so they know what the water levels will be at specific times, and have complained about past unannounced changes in water levels.

Endangered humpback chub and other fish abundance

- Humpback chub populations may benefit from testing of Bug Flows. The adult humpback chub population in the Little Colorado River aggregation appears to be stable and above the Tier-1 threshold of 9,000 adults identified in the Biological Opinion for the LTEMP EIS (GCMRC unpublished data). Native Colorado River fishes evolved under conditions of extreme seasonal flow fluctuation and as such are adapted to life under changing flow conditions. Because of this, Bug Flows are unlikely to have negative effects on humpback chub or other native fish. Instability of nearshore environments in the mainstem Colorado River has been identified as a potential risk factor for survival of larval native fishes (Robinson and others, 1998). Bug Flows, however, create more stable nearshore environments so may actually reduce the risks of stranding for larval native fishes. If Bug Flows are successful at increasing aquatic insect populations, they may have a positive indirect effect on native fish through increases in the aquatic foodbase. However, short-term changes in the flow velocities on weekends could result in less drift in Lees Ferry (Kennedy and others, 2013) and potentially downstream which could temporarily reduce the availability of food for humpback chub and other native fishes. Condition factor of humpback chub in the Colorado River near the confluence of the Little Colorado River has been low since 2014 (GCMRC unpublished data). Adults with low condition factor may forego spawning as a result of having less energy available for reproduction. If Bug Flows are effective, creating a larger foodbase for fish may have an overall positive effect on humpback chub condition factor and spawning frequency.

Invasive species

- Warm-water invasive species are not predicted to benefit from the proposed Bug Flows. Invasive warm-water fishes are currently absent or maintained at low levels within the Colorado River in Glen, Marble, and Grand Canyons largely because of sub-optimal water temperatures for growth and reproduction. Minimizing the flow fluctuations of weekends will have the effect of making nearshore areas more stable on weekends, which may result in some slight warming of water within those shallow areas. However, Ross and Grams (2013) evaluated the effects of nearshore thermal gradients along margins of the Colorado River in Grand Canyon and concluded that warming was very minimal (< 0.2 C). Warming of this minimal magnitude only on weekends as a result of Bug Flows is unlikely to have population level effects on invasive warm-water fishes.

Riparian vegetation

- There is no evidence that the proposed Bug Flows will significantly impact riparian vegetation resources. The primary impact will be to slightly extend the active channel, which is the zone of daily inundation, upslope on weekdays. This may slightly extend the suitable habitat for obligate wetland herbaceous species that respond positively to inundation, though longer-lived perennial species are unlikely to respond significantly to this short-term increase in inundation (Butterfield and others, in review). Weekend low flows are also unlikely to have a significant impact, as sufficient water for plant metabolic activity is likely to be retained within sediments for the 2-day duration of the

low flows. Nonetheless, possible impacts of Bug Flows will be assessed through statistical modeling of changes in riparian vegetation composition based on 2018 vegetation surveys and hydrological variables, specifically inundation duration and elevation above base flows, calculated from the hydrograph and sandbar exceedance equations.

Sediment resources

- On the basis of the 2007-2017 suspended-sand data at the Colorado River above Little Colorado River near Desert View, AZ, gaging station (61 river miles downstream from Lees Ferry), the proposed Bug Flows will export slightly more sand from Marble Canyon than normal operations. During May, these flows will export ~7% more sand than would normal operations; during June, these flows will export ~4% more sand than would normal operations; during July, these flows will export ~2% more sand than would normal operations, and during August, these flows would export ~5% more sand than would normal operations. These effects on sediment resources are consistent with those identified in the LTEMP Environmental Impact Statement.

Water delivery

- The recommended Bug Flow experiment will not result in changes to the weekly release volume from Glen Canyon Dam, nor will it affect scheduled monthly release volumes. In addition, the experiment will have no effect on the annual release volume from Lake Powell in compliance with the 2007 Interim Guidelines. Reclamation currently projects the annual release volume for water year 2018 will be 9.0 million acre feet under the minimum, maximum, and most probable inflow scenarios.

- For each month of the experimental period (May through August), weekend low, steady releases will be maintained at 1,000 cfs greater than the weekday low for that month. Normal fluctuating releases will be maintained during the weekdays. The LTEMP maximum ramp rates (4,000 cfs per hour when increasing and 2,500 cfs per hour when ramping down) will be adhered to throughout the experiment, as will the maximum daily fluctuations (9 times the monthly release volume in May and June; and 10 times the monthly release volume in July and August). The daily fluctuating range is not to exceed 8,000 cfs. In addition, minimum releases of 5,000 cfs during the nighttime and 8,000 cfs during the daytime will be maintained.

- Implementation of Bug Flows would result in the following monthly release schedule at Glen Canyon Dam:
  - May volume release of 705,000 acre-feet, weekday fluctuations of 6,350 cfs, with peak flows of 14,250 cfs and weekday minimum flows of 7,900 cfs. Weekend low steady flows of 8,900 cfs.
  - June volume release of 760,000 acre-feet, weekday fluctuations of 7,600 cfs, with peak flows of 16,450 cfs and weekday minimum flows of 8,850 cfs. Weekend low steady flows of 9,850 cfs.

- July volume release of 860,000 acre-feet, weekday fluctuations of 8,000 cfs, with peak flows of 18,180 cfs and weekday minimum flows of 10,180 cfs. Weekend low steady flows of 11,180 cfs.
- August volume release of 900,000 acre-feet, weekday fluctuations of 8,000 cfs, with peak flows of 18,500 cfs and weekday minimum flows of 10,500 cfs. Weekend low steady flows of 11,500 cfs.

- Although every effort will be made to match the design of the experiment described above, Reclamation will continue to exercise the operational flexibility described in the LTEMP ROD.

Hydropower production and marketable capacity

- WAPA has firm electric power contracts and must meet these contract obligations either with generation from Colorado River Storage Project powerplants or from purchases from the wholesale electrical market. During the Bug Flow experiment, low-volume releases from Glen Canyon Dam during the weekend will require extra electrical purchases to meet WAPA's contract obligations. These expenses are only partially offset with extra electrical production during the weekdays. The estimated expense of implementing the Bug Flow experiment for the four summer months of 2018 is $335,000. This estimate is based on anticipated purchases and sales of electricity during the experiment and estimated market prices for 2018. Although the LTEMP EIS analysis anticipated Bug Flows would yield a capacity benefit current information indicates that electrical capacity in the Rocky Mountain and Desert Southwest Regions is in surplus and therefore, a capacity benefit is not anticipated for a Bug Flow experiment in 2018.

- Water releases from GCD during the Bug Flow experiment will be affected by electrical disturbances of the electrical system. Electrical system operations for these disturbances are required by Reclamation and WAPA under law, contracts, and other agreements. Changes in water releases at GCD to assist in recovery from electrical system disturbances are of two types, regulation and contingency reserves; both are managed by WAPA's Western Area Colorado-Missouri (WACM) Balancing Authority. Regulation is used to respond to frequency deviations on the electrical system. Glen Canyon Dam is the only CRSP powerplant capable of the immediate responses required for regulation. These responses can either slightly increase or decrease GCD water releases and can be as much as ±1,100 cfs (40 mw) for up to 1 hour and 59 minutes. Glen Canyon Dam is also normally selected to hold contingency reserves (reserves) because it typically has available electrical capacity for response to electrical system emergencies. When reserves are called upon to assist in an electrical emergency, the response is only in the upward direction (increased release), and would result in an increase in GCD water release up to 830 cfs (30 mw). Under certain circumstances, WAPA may be able to move these reserves to a different CRSP powerplant in order to minimize the impacts of electrical system operations on the experiment. A change in GCD water release for both regulation and reserves at the same time, in the same direction, and up to the allowed

limits would be extremely rare. However, the two potential responses combined in the upward direction could ramp GCD releases up by 1,930 cfs (70 mw) for up to 1 hour and 59 minutes.

- WAPA estimates that the Colorado River Basin Fund will end the 2018 fiscal year with a balance of $112 million. This does not meet WAPA's target for an end of year balance. The proposed Bug Flow experiment may reduce this balance by $335,000, and is not expected to have a substantial impact on the Basin Fund.

Cultural Resources

Archaeological site condition and stability

- Impacts from Bug Flows are anticipated to be minimally beneficial to archaeological site condition and stability, particularly in the May-June time frame when sand bars may have an opportunity to dry out and windy conditions may allow for the redistribution of sand from the bars to high elevation areas containing archaeological sites. Furthermore, the low weekend flows may result in river runners spending more time on the water and less time on shore, thereby reducing the potential for impacting archaeologist sites though visitation.

VI. Safety Considerations

Potential, but minimal effects on public health and safety could occur in conjunction with the proposed 2018 experimental Bug Flows, primarily impacting recreational anglers, boaters, kayakers, and campers. The proposed minimum flows are within the range experienced by recreational users in the past and those currently expected on a monthly basis. Reclamation and NPS coordinate to ensure that safety measures are implemented and will provide public notice about the timing of the experimental flows. NPS Boating Safety Rules always apply to all boaters using the river. Additionally, the three park service units affected, Glen Canyon National Recreation Area (GLCA), Grand Canyon National Park (GRCA), and Lake Mead National Recreation Area (LAKE) will collaboratively inform recreational river users about the timing and purpose of the experimental Bug Flows. The parks have coordinated communications plans, medical plans, and resource capabilities for search and rescue responses.

Flow and stage change information will be provided via public media, the individual park websites, and by on-site NPS staff at Lees Ferry and Phantom Ranch. Given that experimental flows between May 1, 2018 and August 31, 2018 are likely, a press release, and notifications to Colorado River permit holders and backcountry hikers within GRCA, GLCA and LAKE will occur.

In addition, safety considerations regarding sampling efforts by GCMRC have been incorporated into planning to ensure that safety of field staff is an overarching priority. USGS crews deployed during the experimental flows will be made aware of the timing of the experimental flows. The proposed minimum flows are within the range experienced by GCMRC and contracted boat operators in the past and those currently expected on a monthly basis.

VII. Communications Plan

The communications/public affairs aspect of these experimental flows will not include a public/media event at Glen Canyon Dam, but will include communications product development and media coordination.

Reclamation's Upper Colorado Region Public Affairs Office, in primary coordination with National Park Service, U.S. Geological Survey, Western Area Power Administration public affairs contacts and the Department, is leading development of communications product development. Should the Department decide to conduct these experimental Bug Flows, an initial media press release will be sent to alert media representatives and the public, with a summary purpose and expected start and finish dates. A more detailed news release, for publication on or near the experimental Bug Flows start date (May 1, 2018), may be prepared for distribution by the Secretary's Office. Social media outlets will also be used to communicate with the public leading up to and during the event—including to share imagery of the experiment.

VIII. Monitoring and Coordination During Experiment Implementation

Should the Department decide to implement the recommended Bug Flows, members of the Technical Team will continue to meet regularly throughout the implementation of the four-month experiment. This will occur through the regularly scheduled monthly Glen Canyon Dam operations coordination calls. Scientists conducting field surveys during the experiment and agency technical experts will report back on data collected and preliminary results to the Department and the GCDAMP at regularly scheduled meetings. Glen Canyon Dam operations will be adjusted accordingly in the event of unexpected impacts from Bug Flows.

IX. Post Experiment-Reporting and Feedback

- The Technical Team will coordinate to report initial findings at the 2018 GCDAMP Annual Reporting Meeting in January, 2019 in Phoenix, AZ.

- In addition, the Technical Team will report ongoing findings at meetings of the GCDAMP Technical Work Group (TWG) and Adaptive Management Work Group (AMWG). Reclamation has a commitment to provide an annual monitoring report to the FWS Arizona Ecological Services Office (AESO) in compliance with the 2016 Biological Opinion; this report will also include a summary of the effects of a Bug Flows experiment conducted under the LTEMP ROD. Reclamation will use the monitoring information and feedback from AESO and GCDAMP stakeholders to inform monitoring for future experiments, and to design and implement any measures necessary to address any adverse effects that may occur due to these flows.

- At the conclusion of the experiment, the Technical Team will review the planning process, implementation, and monitoring activities and develop a list of "lessons learned" to inform potential future experiments and experimental planning.

X. Planning for Future Experiments

- Monitoring of any aquatic invertebrate responses to Bug Flows would include citizen science light trapping and drift sampling as described in section IV. GCMRC will also collect data on water quality (including nutrients), sediment, aquatic biology, and other resources as described in the GCDAMP Fiscal Year (FY) 2018-20 Triennial Budget and Work Plan (Reclamation and GCMRC TWP, U.S. Department of the Interior, 2017). Nutrient inputs from the lake could influence total invertebrate biomass production and will be evaluated as a potentially confounding factor. GCMRC will use the information from these studies to evaluate the effects of Bug Flow experiments on downstream resources in Glen, Marble, and Grand Canyons and to help in the design of future experiments.

- Trout Management Flows were originally contemplated this year, but were not recommended for this year. GCRMC has proposed additional research to inform the design of any future Trout Management Flows including studies on flow optimization and the distribution and behavior of young trout in response to various flow scenarios in Glen Canyon. GCMRC will use the information from these studies to help in the design of future experiments.

- The Technical Team will meet in early 2019 to review the implementation and results of any 2018 activities, and to begin coordination on the evaluation of resources and potential experiments that may be conducted in 2019.

- In accordance with the LTEMP, the Department may make the decision to conduct future flow-based experiments (High Flow Experiments, Bug Flows, Trout Management Flows, and Low Summer Flows) at Glen Canyon Dam if it is determined that there are no unacceptable adverse impacts on other resource conditions. Information and data from this or other experiments will be considered in future recommendations and decisions.

XI. Consultation

Reclamation and GCMRC presented much of the information in this report that was available at that time to the AMWG at its February 14-15, 2018 meeting, as well as to the Adaptive Management Program Partners at the GCDAMP Annual Reporting Meeting on March 6-7, 2108. Notification of a potential for a 2018 Bug Flow was emailed to GCDAMP stakeholders on March 15, 2018. Representatives of the Colorado River Basin states and the Arizona Game and Fish Department participated in the development of this recommendation and concur with it. Reclamation also intends to present the findings and recommendation of this report to the TWG on April 23-24, 2018.

On March 22, 2018, the required 30-day advance notification and offer for consultation was mailed to the Tribes and parties to the LTEMP cultural Programmatic Agreement of the potential for a Bug Flow experiment beginning May 1, 2018. Upon request, on April 5, 2018 Reclamation

met with leadership from the Pueblo of Zuni to consult on the potential experiment. No other requests for consultation were received. A follow-up notification will be sent electronically to the Programmatic Agreement signatories, including Tribes, following the Department's decision regarding the proposed Bug Flow experiment.

XII. Conclusion

Determining whether to recommend the Bug Flows experiment required coordination of many details and effective communication among technical staff of multiple agencies. Technical Team members relied heavily on the staff in each of the agencies in making this recommendation. The Team has thoroughly evaluated the issues discussed above, and has taken into consideration the information and analysis included in the LTEMP EIS and ROD. The Team's recommendation to proceed with implementation of Bug Flows is based on the careful assessment of resources and best available science. The success of this important initiative is in large part due to the commitment of the Team to ensuring that the LTEMP experimental implementation process is a success.

References Cited

Burnham, K.P., and Anderson, D.R., 2002, Model selection and multimodel inference: a practical information-theoretic approach (2nd ed.): New York, New York, USA, Springer-Verlag.

Butterfield, B.J., Palmquist, E.C., and Ralston, B.E.. in review, Hydrological regime and climate interactively shape riparian vegetation composition along the Colorado River, Grand Canyon: Journal of Applied Vegetation Science.

Dietze, M.C., 2017, Ecological forecasting: Princeton, New Jersey, USA, Princeton University Press, 288 p.

Kennedy, T.A., Muehlbauer, J.D., Yackulic, C.B., Lytle, D.A., Miller, S.W., Dibble, K.L., Kortenhoeven, E.W., Metcalfe, A.N., and Baxter, C.V., 2016, Flow management for hydropower extirpates aquatic insects, undermining river food webs: BioScience, v. 66, no. 7, p. 561-575, http://dx.doi.org/10.1093/biosci/biw059.

Kennedy, T.A., Yackulic, C.B., Cross, W.F., Grams, P.E., Yard, M.D., and Copp, A.J., 2013, The relation between invertebrate drift and two primary controls, discharge and benthic densities, in a large regulated river: Freshwater Biology, v. (online), http://dx.doi.org/10.1111/fwb.12285

Korman, J., and Campana, S.E., 2009, Effects of hydropeaking on nearshore habitat use and growth of age-0 rainbow trout in a large regulated river: Transactions of the American Fisheries Society, v. 138, no. 1, p. 76-87, http://dx.doi.org/10.1577/T08-026.1.

Korman, J., Kaplinski, M., and Buszowski, J., 2006, Effects of air and mainstem water temperatures, hydraulic isolation, and fluctuating flows from the Glen Canyon Dam on the water temperatures in shoreline environments of the Colorado River in Grand Canyon: Flagstaff, Ariz., Ecometric Research Inc., Northern Arizona University, and Namtek Inc., submitted to U.S. Geological Survey, Grand Canyon Monitoring and Research Center, cooperative agreement no. 04WRAG00006, modification 1, 52 p.

Korman, J., Walters, C., Martell, S.J.D., Pine, W.E., III, and Dutterer, A., 2011, Effects of flow fluctuations on habitat use and survival of age-0 rainbow trout (Oncorhynchus mykiss) in a large, regulated river: Canadian Journal of Fisheries and Aquatic Sciences, v. 68, no. 6, p. 1097-1109, http://dx.doi.org/10.1139/f2011-045.

Korman, J., Yard, M., Walters, C.J., and Coggins, L.G., 2009, Effects of fish size, habitat, flow, and density on capture probabilities of age-0 rainbow trout estimated from electrofishing at discrete sites in a large river: Transactions of the American Fisheries Society, v. 138, no. 1, p. 58-75, http://dx.doi.org/10.1577/T08-025.1.

Robinson, A.T., Clarkson, R.W., and Forrest, R.E., 1998, Dispersal of larval fishes in a regulated river tributary: Transactions of the American Fisheries Society, v. 127, no. 5, p. 772-786, https://doi.org/10.1577/1548-8659(1998)127<0772:DOLFIA>2.0.CO;2.

Ross, R., and Grams, P.E., 2013, Nearshore thermal gradients of the Colorado River near the Little Colorado River confluence, Grand Canyon National Park, Arizona, 2010: U.S. Geological Survey Open-File Report 2013-1013, 65 p., http://pubs.usgs.gov/of/2013/1013/.

Sabo, J.L., and Post, D.M., 2008, Quantifying periodic, stochastic, and catastrophic environmental variation: Ecological Monographs, v. 78, no. 1, p. 19–40.

U.S. Department of the Interior, 2017, Glen Canyon Dam Adaptive Management Program Triennial Budget and Work Plan—Fiscal Years 2018-2020—Sept final submitted to the Secretary of the Dept. of Interior: Flagstaff, Ariz., U.S. Geological Survey, Grand Canyon Monitoring and Research Center and Salt Lake City, Utah, Bureau of Reclamation, Upper Colorado Region, 316 p.