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Memorandum

To: Vineetha Kartha, GCDAMP Technical Work Group, Chair

From: Scott VanderKooi, USGS Grand Canyon Monitoring and Research Center, Chief

CC: Camille Touton, Department of Interior, Counselor to the Assistant Secretary for Water and Science
Beverly Heffernan, Bureau of Reclamation, Upper Colorado Region Environmental Resources Division Manager

Date: December 9, 2015

Subject: Technical review of the Lees Ferry Recreational Trout Fishery Management Recommendations

The USGS Grand Canyon Monitoring and Research Center (GCMRC) has prepared this memo in response to the following motion that was passed by consensus at the Adaptive Management Work Group (AMWG) meeting held in Phoenix, Arizona on August 26-27, 2015,

> The AMWG requests the Secretary's Designee direct GCMRC to conduct a technical review of the Lees Ferry Recreational Trout Fishery Management Recommendations and report its findings to the TWG; and directs the TWG to evaluate the GCMRC review at their October 2015 meeting, and report its findings to AMWG at its February 2016 meeting.

An earlier version of this memo was submitted to DOI and Reclamation on October 19, 2015 and shared with the Technical Work Group (TWG) at its October 20-21, 2015 meeting. This updated and final draft was revised in response to comments and suggestions received from stakeholders and managers regarding points of clarification and topics that were not included in our initial review.

We appreciate the opportunity to review the final draft of the Lees Ferry Recreational Trout Fishery Management Recommendations and wish to thank the authors for engaging GCMRC and

cooperator scientists on multiple occasions during the development of this document. GCMRC and cooperator scientists were also afforded the opportunity to provide in-depth reviews of a draft that was completed and distributed to GCMRC as well as other agencies and organizations in April 2015. The reviews from individual scientists were provided to the authors in May 2015 and also shared in their entirety with the TWG and the Glen Canyon Dam Adaptive Management Program (GCDAMP) in an e-mail sent to the GCDAMP e-mail list by Linda Whetton on June 2, 2015.

We understand and appreciate the challenges of revising reports and manuscripts in the face of multiple and often contradictory reviews and wish to recognize the efforts put forward by the authors to address the comments and concerns of the many reviewers. We appreciate that several of the comments and concerns included in the reviews from GCMRC and cooperator scientists were addressed in this final draft. Our review follows.

In the final draft of the Lees Ferry Recreational Trout Fishery Management Recommendations, we believe the authors have done a good job of synthesizing key science issues in developing many of their management recommendations. However, there are some recommendations or portions of recommendations that have language and logic used to support them that we don't believe are consistent with current scientific understanding. There are also topics where scientific consensus is lacking. We identify areas of concern and discuss topics where there is disagreement in our comments below. Comments from GCMRC are limited to scientific and technical matters, thus for recommendations where no scientific or technical information is presented, we indicate that GCMRC was not able comment. As a science agency, USGS remains neutral on matters of policy and cannot support or oppose management recommendations. Therefore, we indicated which topics we believed fell in the realm of policy and areas where decisions would need to be made by management agencies. As stated above, GCMRC cannot comment on these topics or areas. Comments are organized by recommendation or section in the order they were presented in the final draft.

Aquatic Food Base Enhancement through Experimental Repatriation and "Bug Flows"

There are considerable amounts of data and a consensus among scientists that growth rates of trout in Lees Ferry can be poor and this, in turn, can limit the maximum size these fish can attain, so recommendations to explore options to improve growth by improving the food base make sense. There is not, however, consensus that experimental "bug flows" are likely to succeed. It was observed that past periods of steady flows, the summer and fall of 2000 and Memorial Day low flows for overflights for example, did not result in observations of insects from the orders Ephemeroptera, Plecoptera, or Tricoptera (EPT) following these events. The counter argument is that there was not any sort of organized or sustained efforts monitoring aquatic insects after the

2000 steady flows so any response may have been unobserved and that other periods of low flows may have been too brief or only isolated events, thus not sufficient in duration or frequency to elicit any sort of measurable response. In addition, establishing EPT is not the only reason for conducting experimental "bug flows". If the hypothesis that high mortality of eggs associated with hydropeaking is a critical factor limiting all aquatic insects, then the proposed flow experiment will benefit midge and blackfly production even in the absence of an EPT response. Given these reasons, GCMRC supports conducting experimental "bug flows" to improve our understanding of the aquatic food base in the Lees Ferry reach and the factors controlling productivity and diversity.

It should also be noted that there is uncertainty as to whether producing a more diverse invertebrate community is the only way to increase trout growth. For example, there are many lakes in British Columbia where large trout are produced in lakes with very small but highly abundant Daphnia and midge populations. One can grow larger trout with small bugs if the bug density is high. The authors may also wish to consider a broader range of alternatives than those presented in the document. For example, what about stream fertilization? There are many examples of increased production in small streams, and a few examples in very large systems (Arrow Lakes Kootenay Lake, Kootenai River below Libby Dam).

Any decisions concerning potential translocations of EPT species historically present in Glen Canyon are the responsibility of management agencies. If approved, experimental translocations could help answer questions and allow for the testing of hypotheses related to why EPT species are currently absent from Glen Canyon. We believe that this type of experimental approach would also speed learning.

Dam Operations

No scientific or technical information is presented regarding MLFF. In addition, any decision regarding revision of operations is a policy matter. For both these reasons, GCMRC cannot comment on this recommendation. We also note that revisions to Glen Canyon Dam operations are being evaluated as part of the ongoing Long Term Experimental and Management (LTEMP) Environmental Impact Statement (EIS) process. As mentioned above, we support conducting experimental "bug flows" to improve our understanding of the aquatic food base in the Lees Ferry reach and the factors controlling productivity and diversity.

Minimum Flows

There is little scientific evidence to date to support the recommendation to maintain minimum flows at 8,000 cubic feet/s (cfs) or at any other specific flow. We note that there have been months with 5,000 cfs minimum flows (most recently in fall before the fall steady flow

experiment) coincide with periods of normal growth and recruitment. We agree that research to evaluate effects of lower flows and to develop scientifically based minimum flows should continue. As stated above, revisions to Glen Canyon Dam operations are being evaluated as part of the ongoing LTEMP EIS process.

Fall and Spring High Flow Experiments (HFEs)

It is correct that the 2008 spring HFE enhanced the aquatic food base in Glen Canyon which, in turn, improved recruitment and survival of young rainbow trout. Conducting additional spring HFEs would provide additional information on how the aquatic ecosystem downstream from Glen Canyon Dam responds to these flows. It would also provide scientists an opportunity to quantify the responses of different resources and test a variety of hypotheses including those listed by the authors (i.e., controlling New Zealand mud snails, increasing aeolian sand availability and transport, re-establishing "natural ecological processes"). Spring HFEs are allowed under the HFE protocol currently in place, but require adequate sand inputs from the Paria River during winter and spring months in order to be triggered. Any decision to deviate from the HFE protocol is a policy matter on which GCMRC cannot comment. Potential revisions to the HFE protocol are being evaluated as part of the ongoing LTEMP EIS process.

Experimental Trout Management Flows

The authors state in this section that they believe the best approach to controlling trout densities is through increased invertebrate diversity and avoiding flows that result in excessing spawning and recruitment. It is likely that increasing diversity will provide some degree of stability for the invertebrate community and by extension redistribute the availability of invertebrates across more seasons (currently highest drift availability and growth occurs during the late spring early summer). This could benefit fish populations and also result in greater proportions of larger food items available to fish which, in turn, could improve growth particularly in larger fish. It should also be noted that an increase in food availability for fish could result in more spawning and, if environmental conditions are conducive for age-0 survival in summer and fall, an increase in recruitment.

The suggestion that trout management flows should only occur when the trout population is stable and includes a healthy abundance of all size classes is constraining and may be missing the underlying purpose of these flows. Trout management flows will only have utility when populations are becoming or already are unstable such as when recruitment rates are very high or populations are at unsustainable levels. It should also be noted that trout management flows are very likely to have a negligible effect on mature age classes (approximately 3 to 6 years old), and are designed to only impact young-of-year trout. Since the trout population is composed of approximately six age classes, trout management flows are likely to only affect one of the six

year classes making up the population at any one time. Given this, it seems unlikely that trout management flows pose a risk to the fishery or could result in a catastrophic loss to the fishery. Furthermore, trout management flows can be implemented in a forward titration mode to ensure that the resulting recruitment does not drop below the level required to achieve fishery objectives in the long term. This would be a very conservative approach so we add the caution that it would likely require many iterations, thus a considerable amount of time. We agree that a well thought out experimental design is a critical need prior to the implementation of any trout management flows.

We also note that there is not consensus that trout management flows are the best approach to managing the Lees Ferry trout population. The argument is that there is evidence that simple food webs, that are inherently unstable, are at least partly to blame for the boom-bust cycles in the Lees Ferry trout population. If correct, then efforts to address the root causes (e.g., by increasing invertebrate diversity and food web complexity or avoiding flows that result in overabundance of young trout) would help resolve issues of instability in this population.

Equalization Flows

The 2011 equalization flows did appear to have a strong effect on young rainbow trout survival and subsequent recruitment. The resulting year class led to the highest densities of rainbow trout ever observed in Glen Canyon and appeared to trigger a "boom and bust" cycle in the trout population that Arizona Game and Fish Department (AGFD) and GCMRC have monitored over the last few years. However, any recommendation to deviate from current equalization guidelines is a policy matter that GCMRC cannot comment on.

Fishing Regulations

While we understand the rationale for encouraging anglers to harvest trout in Lees Ferry, this would likely be a numerically ineffective method of reducing trout abundance in this reach of the river. This would be particularly true during periods of high trout abundance similar to what has been seen in recent years. We recognize, however, that revising fishing regulations is a management decision, thus is the responsibility of management agencies.

Marble Canyon Trout Fishery

Our previous comment applies here as well. We understand the rationale for encouraging anglers to harvest trout in Marble Canyon, however, this would likely be a numerically ineffective method of reducing trout abundance in this reach of the river and downstream. This would be particularly true during periods of high trout abundance similar to what has been seen in recent

years. Again, we recognize that revising fishing regulations is a management decision, thus is the responsibility of management agencies.

Riparian Vegetation Restoration

Any decision concerning riparian vegetation restoration in Glen Canyon is the responsibility of the National Park Service. As noted previously, the aquatic food base in Glen Canyon has low diversity and may be insufficient to support larger trout. Introduction of wood could improve productivity by providing habitat and refugia for species that comprise the aquatic food base as well as young trout. Experimental additions of dead tamarisk to the Colorado River in Glen Canyon could be used to test this hypothesis on a local basis. While riparian vegetation can support terrestrial insect abundance, the amount of habitat with shade and cover provided by shoreline vegetation in a river the size of the Colorado in Glen Canyon is proportionally quite small relative to other habitats available to fish. Given this, population level benefits to fish may be small and would be difficult to detect.

Stocking in the Event of a Catastrophic Fishery Failure

There are no criteria used for defining a catastrophic failure in the fishery so it's unclear when stocking would be implemented. Stocking criteria could be based on a number of metrics related to biology or population dynamics including trout abundance, survival, or growth. Angler satisfaction or catch rates could also be used, but it should be noted that these are likely to be more arbitrary and would not be as easy to quantify as measures of population status or trends. The authors might consider adding this topic to their list of Protocol Evaluation Panel (PEP) recommendations.

A notable observation that should be considered with regard to this recommendation is that the Lees Ferry fishery has survived over the last two decades without stocking, and has recovered on its own from two warm-temperature/high density situations (2004-2006, 2012-2014). While we agree with the authors' recommendation that any proposed stocking should not occur until after the causal factors of a failure have been identified and ameliorated, we note that excessive biomass of larger fish resulting from very large recruitment events may be the most likely cause of failures in this fishery. Prematurely adding biomass in these situations would only exacerbate the problem and slow down the natural recovery of the fishery.

We also caution that while stocking may have worked in the past, there is no guarantee that it will work now given differences in fish densities, the types and amount of food available to fish, and potentially other factors. Even under conditions where densities according to anglers are low, there still may be too many fish for the foodbase to support and have desirable growth rates. In this event, it is likely that stocked fish will simply be out-competed by the naturally produced

fish even if they are only present in low numbers. Developing a brood stock is a management decision. However, we believe it is highly uncertain that the timing of a collapse of the fishery could be determined accurately. Furthermore, anticipating a collapse far enough in advance such that stocking could occur more quickly than a natural recovery may not be possible.

As noted in our May 2015 review, we are skeptical of the feasibility of translocating trout from upper Marble Canyon to supplement the population upstream of Lees Ferry. One key issue is that population trends in upper Marble Canyon appear to track very closely with those upstream of Lees Ferry so there may not be many fish to move once trout numbers decline to the degree that translocations are deemed necessary.

Developing a contingency stocking plan and conducting any associated compliance is a management decision, thus is the responsibility of management agencies.

Low Dissolved Oxygen Response Protocol

Dissolved oxygen levels downstream from Glen Canyon Dam are directly influenced by conditions in Lake Powell which are, in turn, affected by a complex combination of factors. Concentrations of dissolved oxygen low enough to stress and even kill rainbow trout have been observed downstream of Glen Canyon Dam. Additional monitoring and reporting of dissolved oxygen levels can occur if approved by stakeholders and managers. Dissolved oxygen levels at the Lees Ferry gage are currently available online at GCMRC's website (http://www.gcmrc.gov/discharge_qw_sediment/station/GCDAMP/09380000). Developing an action plan to reduce or avoid negative effects of low dissolved oxygen is a management decision, thus is the responsibility of management agencies.

Temperature Control Device

Water temperature is a primary driver of biological processes in aquatic ecosystems. Predicted warming of water released from Glen Canyon Dam would increase the likelihood of invasive species becoming established in Glen and Grand Canyons. An invasion of warm water fishes would almost certainly have a strong adverse effect on native fish populations including the endangered humpback chub.

The ability to manipulate the temperature of water releases from Glen Canyon Dam would provide a means to experimentally determine flows and temperature regimes that could favor desired species and disadvantage undesired species. The recommendation to build a temperature control device, however, is a policy matter that GCMRC cannot comment on.

Bypass Tube Electrical Generation

Any decisions regarding structural modification to the Glen Canyon Dam outlet works to allow for power generation are policy matters thus, GCMRC cannot comment on this recommendation.

As stated by the authors, releases from the outlet works do immediately oxygenate the Colorado River downstream from the dam. They can also cool the temperature of the river when it is warm due to cooler reservoir temperatures at the depth of the intakes for the outlet works. It should be noted that these effects are temporary, only occurring during releases through the outlet works.

Introduce Turbidity

Rainbow trout predation rates on young humpback chub has been shown to be reduced even modest levels of turbidity in controlled laboratory trials. Field data, however, suggest that rainbow trout predation rates on young fish can be higher in the Colorado River at moderate turbidity levels. Differences between laboratory and field data suggest that in addition to turbidity, rainbow trout predation on humpback chub in the wild could be influenced by behavioral changes in both predator and prey, environmental conditions, or other factors. Given these differences, we believe additional research to improve understanding of how turbidity affects rainbow trout predation on humpback chub is warranted.

In our opinion, increasing Colorado River turbidity by artificially suspending Paria River sediment falls into the realms of policy and engineering rather than science thus, GCMRC cannot comment.

Monitoring and Measurement of Management Triggers

There is not consensus among cooperating agencies as to the best approaches and methods or appropriate level of effort to monitoring the Lees Ferry fishery. GCMRC scientists believe that while catch per unit effort (CPUE) based indices can be useful for tracking overall long-term trends in fish populations, they have limitations in terms of providing information regarding population dynamics (abundance, recruitment) and key process variables (survival, growth, movement, etc.) as well as testing hypothesis. Furthermore, GCMRC scientists believe that learning from flow alterations, including experimental management flows, will be more rapid if monitoring focuses on mark-recapture methods, which provide less ambiguous estimates of population responses to management actions.

In recognition of this lack of consensus, the following comment was included in the review of the May 2015 draft of this document provided by Scott VanderKooi and Charles Yackulic. Aside

from the specific reference to line numbers from the earlier draft, we believe the comment still applies so have included it here.

> Rather than identifying particular projects and agencies to conduct them, we believe it would be more useful to focus on what information is needed to 1) understand how environmental factors, operations, and management actions affect the aquatic ecosystem in Glen Canyon, including the food base and fish populations, and 2) to effectively manage the fishery. Some sections are already written like this or close to it, see Lines 464-467 and 487-489. GCMRC is planning to hold a Protocol Evaluation Panel (PEP) for the entire GCDAMP fisheries program in FY2016. We prefer to wait for the recommendations of that panel of experts to identify best methods and approaches for monitoring the Lees Ferry fishery and Glen Canyon trout population in order to meet the science needs of the GCDAMP rather than to have them identified for us and our cooperators in this document.

We agree that additional monitoring for invasive species could improve our ability to detect potentially harmful organisms and respond rapidly to mitigate these threats. Were this increased effort approved by stakeholders and managers, a carefully designed surveillance plan would help ensure this monitoring was conducted in an effective and efficient manner. Water quality monitoring downstream from Glen Canyon Dam will continue through FY2017 as described in the GCMRC FY2015-17 workplan. Future water quality monitoring will likely be proposed to continue in future workplans given the importance of this information.

We appreciate the authors providing recommendations of topics to include in the planned PEP review of the GCDAMP fishery program. We will take these recommendations into consideration as we work with cooperating agency scientists and others to plan the PEP.

Regarding the recommendation to develop a stock assessment model, Josh Korman provided the following comments.

> I don’t understand the recommendation to develop a stock assessment model. An annual stock assessment model was developed for Lees Ferry as part of the Grand Canyon Ecosystem Conceptual Modelling effort (which ran from approximately 1998-2003). There was a time where some Arizona Game and Fish Department (AGFD) staff used this model (Scott Rogers and Dave Speas), but model use by AGFD eventually stopped and I have never seen it used in annual reporting by AGFD to provide a more integrated and useful interpretation of the long-term CPUE data. A much more detailed monthly stock assessment model was published in 2012:

Korman, J., Martell, S.J.D., Walters, C.J., Makinster, A.S., Coggins, L.G., Yard, M.D., and W.R. Persons. 2012. Estimating recruitment dynamics and movement of rainbow trout (Oncorhynchus mykiss) in the Colorado River in Grand Canyon using an integrated assessment model. Can. J. Fish. Aquat. Sci. 69: 1827-1849.

This model was used to interpret the historical record of CPUE in Lees Ferry and Marble Canyon by the authors. AGFD does not use this model to interpret the CPUE data in their reporting. In summary, we already have two stock assessment models. I suggest this section be reworded to say that existing stock assessment models should be used to provide a more robust interpretation of the CPUE time series if that time series is to be continued. No need to reinvent the wheel here.

The 2012 stock assessment modelling effort (Korman et al. 2012) pointed out some key uncertainties influencing predictions about the contribution of Lees Ferry recruitment to the population of trout near the Little Colorado River confluence area used by endangered humpback chub. Those uncertainties led to the Natal Origins project (NO). The NO monitoring effort provides direct measurements of key population metrics (recruitment, abundance, survival, growth, movement). If that approach continues to be used, a stock assessment model isn't needed, because we measure the demographic parameters of interest directly (via mark-recapture methods).