Glen Canyon Dam Technical Work Group Meeting
June 24-25, 2014

Conducting: John Jordan, TWG Chair
Shane Capron, TWG Vice-Chair

Convened: 9:30 a.m.

Committee Members/Alternates Present:

Jan Balsom, NPS/GRCA
Cliff Barrett, UAMPS
Shane Capron, WAPA/TWG Vice-Chair
Jerry Lee Cox, Grand Canyon River Guides
Kevin Dahl, National Parks Conservation Assn.
Bill Davis, CREDA
Kurt Dongoske, Pueblo of Zuni
Craig Ellsworth, WAPA
Paul Harms, State of New Mexico
Loretta Jackson-Kelly, Hualapai Tribe
Tony Joe, Jr., Navajo Nation
Vineetha Kartha, State of Arizona
Robert King, State of Utah (phone)
Glen Knowles, Bureau of Reclamation
Ted Kowalski, Colo. Water Conservation Board
Jerry Myers, Federation of Fly Fishers
Don Ostler, State of Wyoming
Larry Stevens, Grand Canyon Wildlands Council
Jason Thiriot, State of Nevada
Mark Van Vlack, State of California
Michael Yeatts, Hopi Tribe
Kirk Young, FWS

Committee Members Absent:

Charley Bulletts, So. Paiute Consortium
Todd Chaudhry, NPS/GRCA
Kerry Christensen, Hualapai Tribe
Chris Harris, State of California
Chris Hughes, NPS/GLCA
Bill Stewart, Arizona Game and Fish Dept.
VACANT, State of Wyoming

Grand Canyon Monitoring and Research Center:

Lucas Bair, Economist
Helen Fairley, Social Scientist
Kyrie Fry, Communications Coordinator
Ted Kennedy, Aquatic Biologist (phone)
Ted Melis, Sediment Resources Mgr. (phone)
Jack Schmidt, Center Director
Scott VanderKooi, Biology Program Manager

Interested Persons:

Peter Bungart, Hualapai Tribe
Marianne Crawford, Bureau of Reclamation
Evelyn Erlandsen, State of Arizona
Dave Garrett, M^{3}Research/Science Advisors
Loretta Jackson-Kelly, Hualapai Tribe
Lisa Meyer, WAPA (phone)
Dr. Sarah Rinkevich, Tribal Liaison DOI (phone a.m.)
Seth Shanahan, SNWA
Steve Wolff, State of Wyoming

Meeting Recorder: Linda Whetton

Welcome and Administrative: Mr. Jordan welcomed the members and the public. Introductions were made and a quorum determined.

- Approval of April 8-9, 2014, Meeting Minutes. With two edits, they were approved by consensus.
- Review of Action Items (***Attachment 1***). Mr. Dongoske - It's been 14 years since the Tribal Consultation Plan was drafted and it's still in draft. This is symptomatic of the program not integrating tribal perspectives.
- Ad Hoc Group Updates. The CRAHG was asked to provide an update on the TWP later in the meeting or on a future webinar. The AHAHG needs to discuss what work can be done as part of the Public Outreach Ad Hoc Group.
- Old Business: None.
- New Business:
    - Reminder the TWG Chair and TWG Vice-Chair elections will be held tomorrow.
    - The next TWG Meeting will be October 28-29, 2014 in Phoenix. Doodle polls will be set up requesting meeting dates in 2015. The need to hold the Annual Reporting meeting annually will be discussed at the October meeting.

LTEMP EIS Update (***Attachment 2***) – Mr. Glen Knowles. The majority of the modeling for the LTEMP Draft has been completed. A decision regarding a preferred alternative has not and will not be made based solely on the structured decision analysis or the modeling results. He presented characteristics of an emerging hybrid alternative, sediment results, and the screening tool estimates of sediment transport that separate fluctuation and monthly volume effects. A comparison of RTCD with MLFF didn't indicate a lot of difference. The benefits of the hybrid alternative are:

- Blends multiple alternatives that were weighted highly by a wide variety of stakeholders in the structured decision analysis process.
- Uses the monthly volume pattern of RTCD that more closely matches power demand to improve hydropower performance and sediment conservation.
- Represents an improvement over CDAS and RTCD in terms of sediment transport and conservation
- Preserves beneficial effects of TMFs on humpback chub numbers
- Tests a variety of condition-dependent elements to improve sediment and HBC conservation
- Maintaining a 8,000 cfs fluctuation cap has benefits for sediment and recreation

A public draft will be available at the end of October.

Budget AHG Report – Mr. Shane Capron.

- Revision of GCDAMP 2010 Budget Process Paper.
- Update from BAHG Conference Calls. Two conference calls (***Attachment 3***) were held to discuss the FY15-17 TWP. The BAHG prioritized the Unfunded Projects List and got to FY15 as a balanced budget but it's unclear how to balance FY16-17.
- Discussion of FY15-17 Budget Issues. Presentations will be made by the individual principle investigators on the projects. The CRAHG hasn't had time to discuss the budget but will try to meet during the course of the 2-day meeting and report back to the TWG.

Using colored card (red=not ready to vote, yellow=have some concerns, green=ready to vote), the members indicated where they stood on making a budget recommendation:

- *There's been no discussion about the projects.*
- *Some projects entail the killing of fish. Disappointed these issues weren't presented to the Zuni.*
- *Need to understand hydrology and haven't seen the 2015 hydrograph.*
- *We can't make a recommendation to AMWG with the FY16-17 budgets out of balance.*
- *If unfunded projects exceed the budget, what are GCMRC priorities/recommendations?*
- *Beneficial to have a project timeline indicating length of projects and/or putting on shelf until funding becomes available. Also identify projects that are 2-3 years.*

Science Advisors Report (***Attachment 4***) – Dr. Dave Garrett (Dr. James Kitchell and Dr. Barbara Mills joined by phone.) The SA reviewed this plan over a 2-week period and found it to be the best plan they've ever reviewed. The report is broken into three parts (with some recommendations below):

1. General comments on overall plan, content and structure
    - Need for executive summary addressing all major plan elements
    - Introduction that provides basis for content, adaptive management purpose
    - Need for guide or pointers introducing sections, budget linkage, linkages to other sections
    - Need one page budget summary in introduction and detailed summary in appendix
2. Specific comments on project methods, design and outcomes
    - Physical Resources - Encourage greater integration regarding cultural resource science and management
    - Cultural Resources – Express more explicit linkages developed among projects critical to cultural resource assessments, i.e., 2, 3, 11, 13, etc.
    - Biological Resources – This program might best be evaluated as part of long-term monitoring given its important connectivity to cultural, aquatic, biological, and physical resources.
    - Fish Ecology – Understanding the issues of food base, habitat need and predation and their integration regarding HBC have greatest focus and hope for success in projects 7.1-7.5.
    - Rainbow Trout Ecology – A major shortfall is the lack of concrete evidence from the abundance of past work to justify approaches in 2015-17.

- Food Base – An argument might be that only small insects with rapid life cycles that are either filter feeders or collecters can use these habitats. A more thorough literature search and assessments could produce a more focused hypothesis.
- Socioeconomic Research – It is critical to assess values of tribal resources and tribal representatives need to be involved in all phases of the effort.

3. Recommendations related to general and specific comments
   - A long-term management plan with a science strategy is missing. There also needs to be agreements on critical management actions and stakeholder AM actions on critical monitoring activities.
   - It is not clear that optional management treatments were considered in each of the projects. It would benefit the proposed authors to create a project proposal template that includes separate sections for scientific rationale and management linkages under each element.

FY15-17 TWP Budget (***Attachment 5a*** = AIF and TWP).

Bureau of Reclamation Budget and Work Plan (***Attachment 5b***) – Mr. Glen Knowles. Reclamation's budget for the next three years will be with and without carryover:

FY15 = $3,492,477	FY16 = $4,092,201	FY17 = $4,664,828
w/o CO = $2,618,398	w/o CO = $2,681,307	w/o CO = $2,747,414

- A Facilitation Contract is being prepared for AMWG in FY15 for $79,556.
- Since 2010, there has been $100K in carryover funding for the POAHG. In FY15, $50K will be used to develop a Glen Canyon Dam Administrative History pilot project. This will include oral histories, a website and library database for information archival and retrieval, and a new participant's handbook for the AMP.
- TWG Chair/Facilitation will be $32,050 starting in FY15.
- Reclamation will begin administering the Science Advisors contract in FY15 at $75,000.
- The Non-native Fish Control Contingency Fund is $824,079 starting in FY15. Of that, $364,052 will go to GCMRC native fish projects in FY15.
- The Cultural Program is $1,272,477 in FY15 and will be used for Zuni associative values, support for GCMRC's project 4, Glen Canyon monitoring, a TEK ecological restoration project, and non-native fish removal consultation.

Comments:

- *That's a lot of money for facilitating two AMWG meetings.*
- *The Experimental Flow Fund seems vulnerable to raiding, i.e., FY13 sequestration.*
- *Use of lidar on archaeology sites to determine if site is maintaining its integrity. In their PA responsibility, BOR should be concerned with integrity of the site and not the surface of sites. Integrity has four categories: (1) Is associated with a nationally, regionally, or locally important event (2) Is associated with a nationally, regionally, or locally important person, (3) Is a good example of a master craftsman or a good example of a period or style, and (4) Has potential to yield important information in history or pre-history. Most archaeological sites are classified under #4 but integrity is "does the historic properties still convey those characteristics that make it eligible for the National Register?" if you have a site that is eroding and you're losing scientific information, then that's a threat to its integrity. Kurt said he thought BOR and NPS would be interested in that information because NPS has a Section 110 responsibility for managing over time these historic properties. You're not getting that kind of information from the lidar work. Need confirmation from Reclamation that what's proposed in terms of monitoring is going to meet its legal responsibilities.*
  Glen: There will be more discussions on this.

Status: Approved by consensus with concerns noted.

GCMRC Budget amd Work Plan Overview (***Attachment 5c***) – Dr. Jack Schmidt. In the three years he's been at GCMRC, the staff has worked very hard to manage science. The research groups are the guts of the program and research must be responsive to intellectual needs. There is a lot of interagency cooperation and collaboration. In response to a request on the last BAHG call on how much staff time was being used to support the LTEMP EIS, the following was provided:

Employee	Hours	Employee	Hours
L. Bair	100	D. Topping	40

H. Fairley	80	S. VanderKooi	80
P. Grams	168	C. Yackulic	480
T. Gushue	160		

- The proposal for FY15 is balanced at $8.7 million. (Appendix 2b) with $0.8 million from BOR funding (Lake Powell water quality), and $0.7 million is unfunded.
- FY16 - $10.86 million (total GCDAMP request; $9.4 million recommended ($9.0 million GCDAMP funds available).
- FY17 - $10.71 million (total GCDAMP request) ($9.3 million GCDAMP funds available). FY16 and FY17 aren't balanced yet. A lot of research projects will be done by post-doctoral students and money will be brought in from other competitive resources because less will be available due to overhead costs.

Project 2. Stream Flow, Water Quality, and Sediment Transport ($1.34 million) – Dr. David Topping. This is a pretty straightforward project with no major changes. Arizona Water Science Center reduced $60K in overhead costs. This project will meet efforts to hold spring and fall HFEs.
Status: Approved by consensus.

Project 3. Sandbars and Sediment Storage Dynamics ($1.33 million) – Dr. Paul Grams (by phone). Project 3.1.3, is a new project at $42K to do surveying with a camera: rapid topographic surveys with digital images using structure-from-motion photogrammetry. The Hualapai Tribe has requested work in Western Grand Canyon and GCMRC is moving ahead on this. Without Project 3, Project 10 isn't possible. Concern was expressed about monitoring in Western Grand Canyon and is there room for monitoring archaeology sites as well.
Status: Dr. Schmidt will review the costs of this program tonight and report to TWG tomorrow.

Project 13. Socio-economic Monitoring and Research ($0.18 million) – Mr. Lucas Bair. Since a number of projects are unfunded, Mr. Ostler questioned the necessity for a new start and questioned how the information will be integrated under the LTEMP for next 20 years. Reclamation supports this proposal and feels it's an element that's been missing from the AMP for a long time. Lucas views 13.3 as broader than what LTEMP has addressed and from an economic viewpoint is more encompassing.
Comments:

- *Some elements can't have a dollar value. Further explanation would help us make comprehensive decisions and move us forward.*
- *Not convinced economics is the way to do it. The dollar benefit doesn't wash.*
- *Project 13.2 –the approach uses a capitalist perspective, how are tribes and the history of tribes considered in the tradeoffs that are of traditional importance? Did GCMRC use an internal review board for interviewing tribes? What recourse do tribes have if they do not approve of GCMRC use of the information? The research may not understand them or may be inappropriately used. Not sure if USGS has an IRP that is mainly used to protect the institution. (Helen: This is an OMB policy requirement and can do further checking.)*
- *Navajo Nation expressed concerns to Mr. Bair on 5/22 and we want a response from him.*
- *Not sure that, in many cases, our scientific knowledge of small, incremental changes and improvements on the resource is precise enough to be used effectively in an economic analysis. A good example is a .5° temperature increase at the LCR in June or HBC. What will the cost benefit be, what are the socio-economic parts, how will they be used? In theory, it would be nice information to have but is it going to get us there? There are unfunded projects to consider as well as a lack of research funding in the future. Where does this fit in?*

Don spoke offline to Dave and Lucas and reported back that he could approve this project.
Status: Approved by consensus with concerns noted.

Project 10. Mapping and Assessment of Aquatic Habitats Below Glen Canyon Dam ($0.15 million) – Dr. Ted Melis. This is a new project and will bring in several sets of information from several already pre-existing projects to address the question "Where does the Glen Canyon Dam rainbow trout tailwater

fishery end?" Most people assume it ends at the confluence with the Colorado and the Paria Rivers at Lees Ferry. Scott gave a PPT on "Not All Trout in Marble Canyon Originate from Lees Ferry: Evidence of Local Recruitment." There could be trout reproducing in the lower reach of the river and we don't want trout there. Ted said he was originally asked to think about a tailwater study for FY15 and beyond, mostly in Glen Canyon from questions on low flow operations and whether or not those affect the fishery through the food web. There are three elements to the project, the first takes place in 2015 and that is to complete work that's already been partially undertaken by Dan Buscombe. He used a fisherman's commercial side-scan sonar unit (Humminbird) to develop quantitative methods for creating scientific datasets. These can be compared and quantified for change detection of bed area coverage; sand vs. gravel. It is critical to complete this work in 2015 because the proposal for element 2 continues collecting bed data imagery to determine changes in the grain size and the NO project collects fish data in these four reaches. The data collection is scheduled to take place, if it's approved, in 2015 and 2016 utilizing the methods that hopefully will be completed. This is an inexpensive use of equipment that produces great bed imagery that can be used for scientific analysis. In 2017 a synthetic analysis in the context of a workshop will look at changes quantified in those reaches relative to the fish, RBT abundance and diet information and water quality.

This project is $54,000 unfunded. This could support a student for the first two years and get through the refinement of the methodology, continue collection, and process the data. Dr. Schmidt said he would like a clear statement from the TWG that is "super, high priority work and do the whole thing" or offer some other recommendation.

Comments:

- *Don't know whether I would prioritize these projects over something else. This may be another project that provides good information but not sure of tradeoff.*
- *Concern with funding this but might want to support other projects that haven't been discussed.*
- *Feel like some of these things (channel mapping) will be done anyway sooner or later so not sure all of it has to be done right now. Happy with the first year, 2015.*

Status: Approved by consensus with concerns noted.

Public Comments: None

Adjourned: 5 p.m.

Glen Canyon Dam Technical Work Group Meeting
June 24-25, 2014

Conducting: John Jordan, TWG Chair
Shane Capron, TWG Vice-Chair

Convened: 8:15 a.m.

Committee Members/Alternates Present:

Jan Balsom, NPS/GRCA
Cliff Barrett, UAMPS
Shane Capron, WAPA/TWG Vice-Chair
Jerry Lee Cox, Grand Canyon River Guides
Kevin Dahl, National Parks Conservation Assn.
Bill Davis, CREDA
Kurt Dongoske, Pueblo of Zuni
Craig Ellsworth, WAPA
Paul Harms, State of New Mexico
Loretta Jackson-Kelly, Hualapai Tribe
Tony Joe, Jr., Navajo Nation
Vineetha Kartha, State of Arizona
Robert King, State of Utah (phone)
Glen Knowles, Bureau of Reclamation
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Don Ostler, State of Wyoming
Larry Stevens, Grand Canyon Wildlands Council
Bill Stewart, Arizona Game & Fish Department
Jason Thiriot, State of Nevada
Mark Van Vlack, State of California
Michael Yeatts, Hopi Tribe
Kirk Young, FWS

Committee Members Absent:

Charley Bulletts, So. Paiute Consortium
Todd Chaudhry, NPS/GRCA
Kerry Christensen, Hualapai Tribe
Chris Harris, State of California
Chris Hughes, NPS/GLCA
VACANT, State of Wyoming

Grand Canyon Monitoring and Research Center:

Lucas Bair, Economist
Helen Fairley, Social Scientist
Kyrie Fry, Communications Coordinator
Ted Kennedy, Aquatic Biologist (phone)
Ted Melis, Sediment Resources Mgr. (phone)
Bill Persons, Biologist
Jack Schmidt, Center Director
Scott VanderKooi, Biology Program Manager
Charles Yackulic, Biologist
David Ward, Biologist

Interested Persons:

Mark Anderson, NPS/GCNRA
Peter Bungart, Hualapai Tribe
Marianne Crawford, Bureau of Reclamation
Evelyn Erlandsen, State of Arizona
Dave Garrett, M^{3}Research/Science Advisors
Katrina Grantz, Bureau of Reclamation (phone)
Lisa Meyer, WAPA (phone)
Sarah Rinkevich, Tribal Liaison DOI
Seth Shanahan, SNWA
Steve Wolff, State of Wyoming

Meeting Recorder: Linda Whetton

Welcome and Administrative: Mr. Jordan welcomed the members and the public. Introductions were made and a quorum determined.

TWG Chair and Vice Chair Elections – Mr. Knowles thanked Mr. Jordan for doing a fantastic job as TWG Chair for the past two years. The floor was opened for nominations for the next fiscal year (Oct 1, 2014 – Sept. 30, 2015). Mr. Stevens nominated Ms. Kartha as TWG Chair, seconded by Mr. Thiriot. Ms. Kartha was unanimously approved. Mr. Thiriot nominated Mr. Capron to continue serving as TWG Vice-Chair and he was also unanimously approved. Mr. Jordan said that one thing that's been very apparent in the time he's been associated with the AMP is the genuine, collegial goodwill that exists amongst all of the stakeholders. This also goes to the folks at GCMRC who he has found to be available, open, accessible, and eager to interact and be supportive of the program.

Basin Hydrology, Operations, and 2015 Hydrograph. (***Attachment 6a***) – Ms. Katrina Grantz (by phone). There was above average snowpack in most basins; the San Juan was the only sub-basin that was below average. Snowpack peak was 111% of median but nearly all measurable snow has melted. Inflow at Lake Powell came up around late May/early June at 64,000 cfs coming into the reservoir and is now down to 30,000 cfs. During peak times the reservoir was rising about a foot each day but now is coming up about half a foot a day. Lake Powell is operating under the Interim Guidelines based on the August 2013 projection of the January 1 elevation. We are in the mid-elevation release tier this water year and regardless of what the actual inflow is, the release will be 7.48 maf. In WY2015 the operating tier will be determined in August. The minimum probable and most probable projections are the upper elevation balancing tier release of 9.0 maf. Under the maximum probable inflow scenario the release is 11.4 maf with an April adjustment to the equalization tier.

GCD Maintenance: Maintenance will be arranged to have seven of eight units available for an HFE. The available capacity would be approximately 20,600 cfs through the powerplant plus an additional 15,000 cfs through the bypass tubes totaling 35,600 cfs. Under the maximum probable inflow scenario, annual release will be close to 11 maf. A typical 11.4 maf pattern would release 700,000 af but the capacity is 630,000. In Jun-Jul-Aug, the amount typically scheduled won't be available so water will be shifted to achieve the annual release.

DOI-DOE Hydrograph – Mr. Katrina Grantz. The 2015 hydrograph is based on a targeted approach with more volume released later in the year. The objective of the hydrograph is to retain sand inputs high in the system in anticipation of a potential fall HFE (Nov) 2015. Lower Aug-Oct releases will be targeted to avoid shifting "extra" water to June (which cools the temperature at the mouth of the LCR), and water from August will be moved to other equal value months for hydropower (Dec/Jan, Jul). Decreasing releases from 1,000kaf to 800kaf range can significantly decrease sand transport. The lower the release volume, the less impact there is on sand retention. The members reviewed the draft hydrograph motion (***Attachment 6b***) and offered minor changes and the following comments:

Comments:

- *Is the difference of 0.5°C temperature significant to HBC? Mr. VanderKooi: The effect would be minimal. The information we're getting suggests a lot of fish stay in the LCR until the monsoon season kicks in. Our sense is that it's important to be warmer earlier in summer than later.*
- *Is the 200 kaf in those two months sufficient justification? Glen: This ultimately began as a request from FWS, not moving water into June would help fish and is not that bad for hydropower as indicated by WAPA.*
- *We're constrained by water demands. The SDM process revealed that hydrology drives everything.*
- *The tribes have a stake in the river system and are sensitive to what happens with the flow regimes. The Bureau of Reclamation needs to consult with the tribes before the next AMWG meeting.*

Motion (Proposed by Ted Kowalski, seconded by Vineetha Kartha): TWG recommends the AMWG recommend to the Secretary of the Interior her approval of the DOI-DOE Proposed Hydrograph for Water Year 2015 as follows:

> **Annual Release Volumes will be determined by the 2007 Interim Guidelines and shall be reviewed and adopted through the normal annual operating plan process (in consultation with the Basin States as appropriate).**
>
> **Monthly Release Volumes are anticipated to shift depending upon: (1) the projected Annual Release Volume, (2) power plant capacity, and (3) the magnitude of a potential High Flow Experiment.**
>
> **Monthly Release Volumes may vary within the targets identified below. Any remaining monthly operational flexibility will be used for existing power production operations under the Modified Low Fluctuating Flow (MLFF) alternative selected by the 1996 ROD and contained in the 1995 FEIS and in compliance with all applicable NEPA compliance documents (HFE EA, NNFC EA, 2007 IG).Release objective for June is:**

600 to 650 kaf for annual releases below 9.0 maf
800 kaf for annual releases of 9.0 maf to less than 9.5 maf
900 kaf for annual releases of 9.5 maf to less than 10 maf
Greater than 900 kaf for annual releases 10 maf and greater

Release objective for August is 800 kaf

Release objective for September is:
600 kaf for annual releases below 9.0 maf
700 kaf for annual releases of 9.0 maf to less than 10.0 maf
800 kaf or greater for annual releases of 10.0 maf or greater; up to powerplant capacity for high equalization releases

Monthly Release Volumes will generally strive to maintain 600 kaf levels in the shoulder months (spring and fall) and 800 kaf in the December/January and July/August timeframe.

Additionally, the Bureau of Reclamation will continue to apply best professional judgment in conducting actual operations and in response to changing conditions throughout the water year. Such efforts will continue to be undertaken in coordination with the DOI/DOE agencies and in consultation with the Basin States as appropriate, to consider changing conditions and adjust projected operations in a manner consistent with the objectives of these parameters as stated above and pursuant to the Law of the River.

Status: Approved by consensus with follow-up consultation with the tribes.

FY 2015-17 Triennial Budget Discussion (Project PPT presentations = ***Attachment 7***) GCMRC's response to Arizona Game and Fish Department's concerns were provided by e-mail (***Attachment 8***).

Project 6. Main-stem Colorado River HBC Aggregations and Fish Community Dynamics ($.71 million) – Mr. Bill Persons (by phone). Dr. Rinkevich questioned why project 6.6 was being deferred. It's a good project. Bill said the funding isn't sufficient to pull experts together and detail the study plan. It's a placeholder in the FY17 budget. Project 6.5 is also being deferred. There is overlap in objectives between the otolith work GCMRC has been doing on BT and what is being collected as part of the Bright Angel non-native fish control efforts. It seemed best to let that one pan out first and see what the results are before moving forward on a second study on the same topic.
Comments:

- *The tribes don't support trout removal. The focus should be on HBC population growth.*
- *Tribes would support a project like this that shows a greater HBC population distribution.This would result in less ESA compliance pressure and allow future funding to be allocated to other ecological research projects. Tribal consultation shouldn't be considered a major stumbling block.*
- *Recreational fishing interests are very supportive of mainstem augmentation.*
- *System wide electrofishing will have reviews, some tied to evaluation. We need to take a hard look at the level of detail needed to make management decisions.*
- *Even though the electrofishing isn't geared towards killing fish, there is the potential for collateral loss of life to insects and other aquatic animals. That's a concern to Zuni. The tribal council has been alerted to these issues and they want consultation and negotiation with the decision-makers from Reclamation, GCMRC and NPS about loss of life.*
- *There's a lot of interest in this project and GCMRC is proposing to do a PEP panel to review what needs to be done because so many agencies have a stake in this work.*

Status: Approved by consensus with concerns noted.

Project 7. Population Ecology of HBC In and Around the Little Colorado River ($1.59 million) – Dr. Charles Yackulic (by phone). He reviewed the elements within the project.
Comments:

- *Have reservation funding for 7.5 and 7.9 with AMP funds. Projects 7.6 and 7.7 will provide good information, not sure what can be done from a management standpoint.*

- *It would be nice to have a way to prioritize some of these project elements.*
- *The NNFC fund (from the Experimental Flow Fund on yearly basis) is supporting non-native fish work.*
- *There has to be a lot of overlap within elements and potential funds could be saved each year.*

Status: Approved by consensus with concerns noted.

Project 8. Experimental Actions to Increase Abundance and Distribution of Native Fishes in Grand Canyon ($.19 million) – David Ward (phone). This project encompasses two ongoing experimental actions and two new projects that are all designed to increase survival of juvenile native fish. They are also proposing to convene a protocol evaluation panel (PEP) comprised of external experts to conduct a review of the fish research and monitoring that's occurring in Grand Canyon.

Comments:

- *Consultation needs to occur on removal of BT before the AMWG meeting.*
- *The AMP isn't a recovery program for the HBC so we need to understand the funding and be able to do things that fall outside of dam operations. The Hopi Tribe does support BT removal but concerned it doesn't become a de facto trout removal program*.
- *The need to explore the possibility of BAC as a suitable location for HBC by reducing or removing the trout population has moved into the mainstem and is looking like BT removal to reduce potential impacts of BT predation on HBC in the LCR.*

Status: Approved by consensus.

Project 9. Understanding Factors Determining Recruitment, Population Size, Growth, and Movement of Rainbow Trout in Glen and Marble Canyons ($0.87 million) – Mike Yard (phone). The reason for placing so much emphasis on RBT has a lot to do with the importance of the Lees Ferry Glen Canyon fishery but as well as the recent evidence that links RBT abundance to the decline of juvenile chub abundance around the LCR. One of the objectives of the NO project (9.2) identifies some of the uncertainty about the source and origin of the LCR population. This is a research project and it's going to sunset in 2016 so one of the reasons for these elements is to take advantage of this particular program and address some of the uncertainties under the present time schedule. The current elements remain unfunded: 9.4, 9.5, and 9.7.

Comments:

- *In the CFMP there are triggers related to 25-year dataset. Will the PEP change the course? Let's make sure we're fully aware of tradeoffs.*
- *We need an analytical conversion for the trigger points.*

Status: Approved by consensus with concerns noted.

Project 12. Dam-related Effects on the Distribution and Abundance of Selected Culturally-important Plants in the Colorado River Ecosystem – Dr. Helen Fairley. This is a 2-year project. It's a small project starting with a small subset of plants and exploring the possibility for a larger one in the future. The location hasn't been determined but will be in the river corridor. A workshop needs to be held with the tribes to determine what they want to work on. Dr. Garrett said the SA had concerns on: (1) Some implication that you do a fairly aggressive analysis that you relate to dam construction and presence, (2) Difficulty with photographing small plants, and (3) Limited budget may not result in producing good, effective products. Cliff asked if the entire $52K was needed because $7K is unfunded. Helen said that much of that covers her salary with a small amount being tacked onto a river trip to match for travel.

Comments:

- *Will funding continue in FY16-17? Can foresee integration into tribal monitoring in out years.*
- *Be aggressive to fully fund the project to enable a good start and do the literature research in order to have a successful workshop.*
- *Can approve project if Helen would ensure that the project documents plants that have improved in number and type and plants that have degraded in number and type, and eliminate the title of "dam-related effects" and just talk about effects "pre- or post-1964." Helen: Can't commit to any changes without talking with tribes. Am fine with changing the title.*

Status: Approved by consensus with concerns noted.

Project 5. Food Base Monitoring and Research ($0.56 million) – Dr. Ted Kennedy (phone). This project focuses on targeted monitoring of key food web linkages and some new research intended to better

understand the foodbase in Glen, Marble, and Grand Canyons. The AMP will not be asked to fund field work any place other than the Colorado River reach.

Comments:

- *WAPA is trying to figure out how to coordinate these studies with Ted. They want to work with some of the issues of EPT by looking at other locations where there are the right bugs. WAPA has a process to evaluate projects and will make a decision early this fall whether they will fund the work.*
- *The NPS work being done in BAC can inform work in these elements.*
- *The project should include looking at biological things that may be affecting distribution – chemical or water quality type issues.*
- *We've gotten too narrowly focused by looking at just one hypothesis. We need a broader scope.*

Status: The TWG couldn't reach consensus and felt more discussion was needed. The TWG will send questions/concerns to GCRMC and further discussion will be held on the next TWG webinar.

Public Comments: None.

Adjourned: 3 p.m.

Next Steps:

1. Will be sending out a "doodle" poll seeking availability for a webinar in mid-July. The purpose will be to discuss FY16 and FY17 budgets and develop a budget recommendation for the AMWG.
2. Reclamation needs to consult with the tribes on the proposed 2015 hydrograph before the August meeting.

Respectfully submitted,

Linda Whetton
Bureau of Reclamation
Upper Colorado Region

Key to Glen Canyon Dam Adaptive Management Program Acronyms

ADWR – Arizona Dept. of Water Resources
AF – Acre Feet
AGFD – Arizona Game and Fish Department
AIF – Agenda Information Form
AMP – Adaptive Management Program
AMWG – Adaptive Management Work Group
AOP – Annual Operating Plan
ASMR – Age-Structure Mark Recapture
BA – Biological Assessment
BAHG – Budget Ad Hoc Group
BCOM – Biological Conservation Measure
BE – Biological Evaluation
BHBF – Beach/Habitat-Building Flow
BHMF – Beach/Habitat Maintenance Flow
BHTF – Beach/Habitat Test Flow
BIA – Bureau of Indian Affairs
BO – Biological Opinion
BOR – Bureau of Reclamation
BWP – Budget and Work Plan
CAHG – Charter Ad Hoc Group
CAP – Central Arizona Project
GCT – Grand Canyon Trust
CESU – Cooperative Ecosystems Studies Unit
cfs – cubic feet per second
CFMP – Comprehensive Fisheries Management Plan
CMINS – Core Monitoring Information Needs
CMP – Core Monitoring Plan
CPI – Consumer Price Index
CRBC – Colorado River Board of California
CRAHG – Cultural Resources Ad Hoc Group
CRCN – Colorado River Commission of Nevada
CRE – Colorado River Ecosystem
CREDA – Colorado River Energy Distributors Assn.
CRSP – Colorado River Storage Project
CWCB – Colorado Water Conservation Board
DAHG – Desired Future Conditions Ad Hoc Group
DASA – Data Acquisition, Storage, and Analysis
DBMS – Data Base Management System
DOE – Department of Energy
DOI – Department of the Interior
DOIFF – Department of the Interior Federal Family
EA – Environmental Assessment
EIS – Environmental Impact Statement
ESA – Endangered Species Act
FACA – Federal Advisory Committee Act
FEIS – Final Environmental Impact Statement
FRN – Federal Register Notice
FWS – United States Fish & Wildlife Service
FY – Fiscal Year (October 1 – September 30)
GCD – Glen Canyon Dam
GCES – Glen Canyon Environmental Studies
GCT – Grand Canyon Trust
GCMRC – Grand Canyon Monitoring & Research Center
GCNP – Grand Canyon National Park
GCNRA – Glen Canyon Nat'l Recreation Area
GCPA – Grand Canyon Protection Act
GLCA – Glen Canyon Nat'l Recreation Area
GRCA – Grand Canyon National Park
GCRG – Grand Canyon River Guides
GCWC – Grand Canyon Wildlands Council
HBC – Humpback Chub (endangered native fish)
HFE – High Flow Experiment
HMF – Habitat Maintenance Flow
HPP – Historic Preservation Plan
IG – Interim Guidelines
INs – Information Needs
KA – Knowledge Assessment (workshop)
KAS – Kanab Ambersnail (endangered native snail)
LCR – Little Colorado River
LCRMCP – Lower Colorado River Multi-Species Conservation Program
LTEMP – Long-Term Experimental and Management Plan
LTEP – Long Term Experimental Plan
MAF – Million Acre Feet
MA – Management Action
MATA – Multi-Attribute Trade-Off Analysis
MLFF – Modified Low Fluctuating Flow
MO – Management Objective
MRP – Monitoring and Research Plan
NAU – Northern Arizona University (Flagstaff, AZ)
NEPA – National Environmental Policy Act
NHPA – National Historic Preservation Act
NNFC – Non-native Fish Control
NOI – Notice of Intent
NPCA – National Parks Conservation Association
NPS – National Park Service
NRC – National Research Council
O&M – Operations & Maintenance (USBR Funding)
PA – Programmatic Agreement
PBR – Paria to Badger Creek Reach
PEP – Protocol Evaluation Panel
POAHG – Public Outreach Ad Hoc Group
Powerplant Capacity = 31,000 cfs
R&D – Research and Development
RBT – Rainbow Trout
RFP – Request for Proposal
RINs – Research Information Needs
ROD Flows – Record of Decision Flows
RPA – Reasonable and Prudent Alternative
SA – Science Advisors
Secretary – Secretary of the Interior
SCORE – State of the Colorado River Ecosystem
SHPO – State Historic Preservation Office
SOW – Statement of Work
SPAHG – Strategic Plan Ad Hoc Group
SPG – Science Planning Group
SSQs – Strategic Science Questions
SWCA – Steven W. Carothers Associates
TCD – Temperature Control Device
TCP – Traditional Cultural Property
TEK – Traditional Ecological Knowledge
TES – Threatened and Endangered Species
TMC – Taxa of Management Concern
TWG – Technical Work Group
UCRC – Upper Colorado River Commission
UDWR – Utah Division of Water Resources
USBR – United States Bureau of Reclamation
USFWS – United States Fish & Wildlife Service
USGS – United States Geological Survey
WAPA – Western Area Power Administration
WY – Water Year

(Updated: 2/20/2014)

Glen Canyon Dam Technical Work Group WebEx/CC Meeting
July 15, 2014

Conducting: Shane Capron, TWG Vice-Chair **Convened:** 9:00 a.m.

Committee Members/Alternates Present:
Cliff Barrett, UAMPS
Charley Bulletts, So. Paiute Consortium
Todd Chaudhry, NPS/GRCA
Jerry Lee Cox, Grand Canyon River Guides
Kevin Dahl, National Parks Conservation Assn.
Craig Ellsworth, WAPA
Paul Harms, State of New Mexico
Chris Harris, State of California
Chris Hughes, NPS/GLCA
Loretta Jackson-Kelly, Hualapai Tribe
Leslie James, CREDA
Tony Joe, Jr., Navajo Nation
Vineetha Kartha, State of Arizona
Robert King, State of Utah
Glen Knowles, Bureau of Reclamation
Jerry Myers, Federation of Fly Fishers
Don Ostler, State of Wyoming
Dave Rogowski, Arizona Game & Fish Department
Jason Thiriot, State of Nevada
Michael Yeatts, Hopi Tribe
Kirk Young, FWS

Committee Members Absent:
Jan Balsom, NPS/GRCA
Kerry Christensen, Hualapai Tribe
Kurt Dongoske, Pueblo of Zuni
Ted Kowalski, Colo. Water Conservation Board
Larry Stevens, Grand Canyon Wildlands Council
Bill Stewart, Arizona Game and Fish Dept.
VACANT, State of Wyoming

Grand Canyon Monitoring and Research Center:
Helen Fairley, Social Scientist
Kyrie Fry, Communications Coordinator
Ted Kennedy, Research Aquatic Biologist
Ted Melis, Sediment Resources Mgr.
Barbara Ralston, Supervisory Biologist
Daniel Sarr, Research Ecologist
Joel Sankey, Research Geologist
Jack Schmidt, Center Director
Scott VanderKooi, Biology Program Manager

Interested Persons:
Mary Barger, Bureau of Reclamation
Peter Bungart, Hualapai Tribe
Evelyn Erlandsen, State of Arizona
Dave Garrett, M^3Research/Science Advisors
Lisa Meyer, WAPA (phone)
Seth Shanahan, SNWA
Mark Van Vlack, State of California

Meeting Recorder: Linda Whetton

Welcome and Administrative: Mr. Capron welcomed the members and the public. Roll call was taken and a quorum determined.

Science Advisor Report Update (attached) - Dr. Garrett provided a memo to Dr. Schmidt identifying the five critical areas that GCMRC needs to address in the budget:

1. Projects 4 and 12 do not demonstrate appropriate science standards in defining and justifying the science approach, presenting appropriate science design, and clarifying data development and assessments. These need to be rewritten.
2. After completion of the LTEMP EIS, the SAs recommend GCRMC merge the major planning documents (the Science and Monitoring Operations Plan, the Strategic Management and Science Plans, and a Core Monitoring Plan) into the 2015-17 Triennial plan.
3. GCRMC and AMWG should review general program and budget needs for 2015-20, and recommend new budget baselines.
4. A new management/science initiative should be developed by GCMRC in collaboration with BOR centered in collaborative work at Lake Powell. The design should be a basin wide monitoring and science effort including development of a system model for the basin that can relate management actions to resource effects. [Dr. Schmidt: GCMRC is proposing to do a science review panel for about $20K similar to a PEP panel that will include NPS, BOR, the states of Utah and Arizona , and academic sectors in order to develop a more rigorous Lake Powell water quality program.]

5. GCMRC needs to work with managers and stakeholders to reduce monitoring duplicity and cost savings.

Action Item: GCMRC and BOR will address the technical issues identified in the SA report. Jack and his staff will work with stakeholders to determine how to accomplish monitoring in FY17 due to budget shortfalls. A formal response will be provided to the TWG by August 1.

Action Item: The TWG will work with GCMRC and the SA in developing a "road map" to help inform the AMWG in preparation for the August AMWG meeting.

CRAHG Report to the TWG regarding FY2015-17 Budget and Workplan (attached) - Mary Barger. The CRAHG reviewed BOR's budget but didn't complete their review of all GCRMC projects:

- GRCA Mitigation and Monitoring. There was overall support but questions on how it will be integrated with the PA. This will be discussed at a later date. The CRAHG also requested the proposal from Glen Canyon.
- Zuni Associative Values. There were questions on this. In order to accommodate the changes, Glen proposed distributing money over next three years. However, Kurt said the work would be completed in FY16.
- Project 4. There were questions on how this would fit with the PA and if monitoring would be adequate for meeting GCPA. The proposed monitoring plan and Amy Draut's Aeolian processes for creating sandbars and doing some level of stabilization was discussed. There was overall support but inadequate funding to accommodate tribal review. They proposed an additional $30K.
- Tribal TEK. This is a preliminary project but supported. Not sure how to incorporate the Park Service
- Tribal Synthesis. A lot of conversation on how this would work. The group considered the success of international projects. They proposed interviews with indigenous people and managers. Phase 1 would include a summary of literature and interviews. Phase 2 would be developed based on results of Phase 1. The $50K in FY15 was moved into a FY16-17 effort.
- Tribal River Trip. All AMP members would be invited to attend.
- NN Removal Consultation. Some members questioned that if live removal is not being done why aren't we changing the MOA? Reclamation is proposing to do a Zuni consultation trip with GCMRC and NPS.
- Tribal NRHP Nomination. Two tribes (Hopi and Zuni) propose to do mitigation but three tribes are affected. Mary will work with Hualapai and Southern Paiute to determine what they intend to do. Funding was reduced due to overestimation.
- Zuni requested a meeting with BOR, GCMRC, and NPS on projects that could impact or kill fish or other water life. Other tribes haven't commented.
- Project 12. How does this fits with Hualapai TEK? The CRAHG would like a workshop to identify plants that are culturally important. As the SA suggested, blend projects 11 and 12 to make them as successful as possible. Peter added that there should be more than one workshop and longer than one day. Tighten up the Scope of Work.
- Project 13.2. GCMRC should discuss this project with tribes. It's a good idea to have downstream tribal values incorporated but uncomfortable with people talking to elders and getting information that determines what makes it important. Lucas was directed to talk with the tribes.

BOR Budget Update – Glen Knowles. Reclamation is proposing a change related to the HFEs under the protocol. Reclamation uses a rating curve that relates flows to develop an estimate of release. GCMRC and the Lees Ferry gage showed a discrepancy in recent HFEs of 2012 and 2013. The proposal is to install acoustic flow meters on the bypass tubes and would cost about $250K. Because this project is needed to measure the flow released during high flow experiments Reclamation is propose to use the Experimental Fund of Reclamation's AMP budget to pay for it. This would lead to a reduction of $250k from the NFCCF in FY16 and FY17 ($1,110,894 in FY 16 and $1,667,414 in FY17). This is an adequate amount for nonnative fish control based on the current status of native fish.

Update on SA Contract. Glen said they're hopeful that the new contract will be awarded by October 1, the start of FY15.

Status: Changes approved by consensus.

GCMRC Projects. Brief updates were given on the following projects:

- Project 5 Food Base Monitoring and Research - Dr. Ted Kennedy. This project is a new stand-alone effort designed to continue monitoring of the aquatic food base and conduct research to resolve questions about the current condition of the aquatic invertebrate community in Glen Canyon. It will synthesize published datasets to explore the factors affecting invertebrate productivity, diversity, and EPT abundance throughout tailwaters in the Intermountain West.
- Project 5.1- Identify the specific stressors that are limiting the diversity and productivity of the foodbase so managers will have a scientific basis for improving the foodbase. Additionally, it describes a flow experiment that might improve the food base be considered for implementation in FY15-17.
    - Leslie asked if approving the scientific work also meant approval of flows. [Glen: It wouldn't because additional NEPA compliance would be needed.]

Status: Approved by consensus with concerns noted on separation of scientific work and changing flows.

- Project 4 Connectivity along the fluvial-aeolian-hillslope continuum: quantifying the relative importance of river-related factors that influence upland geomorphology and archaeological site stability. This project is a continuation of what was previously Project J. It has been discussed with GCNP, the tribes, and with the CRAHG.
    - Project 4.1. - examines the connectivity of sand movement by wind from active channel sandbars to higher elevation sand landscapes. In order to evaluate the long-term changes, Helen proposes to work through a large set of photos that show the conditions of the river corridor and the archeology sites. Mary said it would be important to keep others involved in how the sites are ranked.
    - Don had concerns in long-term trends and seeing changes. Conclusions can't be drawn by looking at just one canyon. There are other sources of sand and one can't tell the difference from blowing sand or sand from an HFE. [Joel: 4.1.1 is designed to address that question. The rationale is to use a 5 class archeology process to rank sites by their proximity to sand and allow measurements to be made on the sites.]

Status: Approved by consensus.

- Project 11 Riparian Vegetation Monitoring and Analysis of Riparian Vegetation, Landform Change and Aquatic-Terrestrial Linkages to Faunal Communities – Barbara Ralston and Daniel Sarr. Research elements of this project utilize the monitoring data to explore the utility of plant response-guilds to probabilistically evaluate and assess wildlife habitat, and integrate the response guilds with a 22-year topographic survey record for retrospective analyses of topographic change of 20 sandbars. This project builds upon accomplishments associated with the FY13-14 work plan. In the next 3 years will continue the ground base sampling and collect more data this fall in terms of planned occurrences and how these plants in these guilds have changed or diminished in relation to annual hydrology.
- Project 11.3 – Utilizing vegetation response-guilds for integrated research of sandbars and riparian vegetation. A scoping workshop will be held with project principals and other scientists to decide the appropriate consumer taxa and field sampling locations for target studies. The workshop will likely be held in February and people from Dinosaur, GLCA, GRCA, Big Bend National Park, BLM, as well as tribal groups that have done some restoration.
- Project 11.5 – Will conduct a science panel to look at nonnative vegetation removal and vegetation management in Grand Canyon to inform a potential program to be developed as part of LTEMP.

Status: Approved by consensus.

Budget for FY2016-17 Concerns:

- There are still unfunded projects in FY15. [Jack: Appendix 2b is our request to the AMP and is our recommendation for how FY15 funds will be spent.]

- The CRAHG recommended that Project 12 be blended with Project 11. GCMRC will work on that.
- AGFD still has food base and SA questions. Not sure how Combining 11 and 12 will look.
- Another webinar may be needed to adequately prepare for presentation to the AMWG.

Dr. Schmidt will send a revised TWP to the TWG by August 1. The TWG will have a follow webinar on August 4.

Draft Motion (proposed by Kevin Dahl, seconded by Jerry Cox): The TWG recommends that the AMWG recommend for approval, the Glen Canyon Dam Adaptive Management Program Triennial Budget and Work Plan – Fiscal Years 2015-17 (Draft June 6, 2014) to the Secretary of the Interior. The revised work plan should include changes agreed to at the June and July TWG meetings as described in the TWG minutes.

Leslie provided an addition relative to the Project 5 flow proposal requiring additional NEPA ecause BOR stated such flows are not covered by the 1996 ROD and suggested language that the motion does not provide approval for the flows described in Project 5. Kevin said he objected to this addition. She further asked that analysis of the flow impacts to hydropower be included as part of the proposed experiment to assess the impacts to hydropower. After further discussion, all agreed that the motion does not provide approval or a recommendation of approval for the flows identified in Project 5. Glen Knowles stated that such flows would require additional NEPA compliance. There was general agreement on new motion language.

Final Motion (proposed by Kevin Dahl, seconded by Jerry Cox): The TWG recommends that the AMWG recommend for approval, the Glen Canyon Dam Adaptive Management Program Triennial Budget and Work Plan – Fiscal Years 2015-17 (Draft June 6, 2014) to the Secretary of the Interior, provided that such approval does not include approval of flows as described in GCMRC Project 5. The revised work plan should include changes agreed to at the June and July TWG meetings as described in the TWG minutes. Passed by consensus.

October 28-29 TWG Meeting. Noting there was a conflict with the Salinity Control Forum holding their meeting the same week, members involved recommended moving forward with the in-person TWG meeting on October 28-29 anyway. A webinar could be held, but the LTEMP EIS or the potential for a 2014 fall HFE may be good reasons for the TWG to meet and discuss in person.

Public Comments: None.

Adjourned: 1 p.m. (MDT)

Respectfully submitted,

Linda Whetton
Bureau of Reclamation
Upper Colorado Region

Review of Glen Canyon Dam Adaptive Management Program Triennial Budget and Work Plan – Fiscal Years 2015-2017

Prepared by

David Garrett, Executive Coordinator of Science Advisors, Economics, M3Research

Lance Gunderson, Adaptive Management & Policy, Emory University

James Kitchell, Fish Ecology, University of Wisconsin

John Loomis, Non-Market Economics, Colorado State University

Peter McIntyre, Riverine Ecology, University of Wisconsin

Barbara Mills, Anthropology and Archeology, University of Arizona

INTRODUCTION

This report summarizes reviews and comments on the Glen Canyon Dam Adaptive Management Program (GCDAMP or AMP) proposed budget and work plan for the period 2015-2017. The plan was prepared by staff of the Bureau of Reclamation and Grand Canyon Monitoring and Research Center (GCMRC), along with input and consultation from other groups of the GCDAMP. Aggressive collaborative work on the plan was initiated in February 2014 when staff from GCMRC presented a series of science findings from the previous year(s) programs to the AMP. This led to the draft plan being prepared in June 2014.

The plan presents a three year set of research and monitoring activities that will be reviewed by all groups of GCDAMP annually to assure continued effectiveness and efficiency. The Science Advisor Executive Coordinator and Science Advisors play active roles in the review and consultation process.

The procedure for Science Advisor input to the GCMRC 2015-17 monitoring and science planning process has permitted the following:

- Involvement of the SA Executive Coordinator to provide Science Advisor input in two discussions of the TWG, four discussions of the BAHG, multiple exchanges of information with TWG members including the Chair and Vice-chair, and with the GCMRC Chief during April, May and June, 2014.
- Request in May to the Science Advisor EC from the GCMRC Chief and TWG Chair and Vice-Chair to provide written comments on a Draft Prospectus of potential science plan projects, and follow-up participation in collaboration of the TWG and GCMRC on the most desirable projects to pursue.
- Participation of the Science Advisors in review of the Draft 2015-17 Monitoring and Research Tri-Annual Plan provided June 6, 2014, and development of this review report.

The Science Advisors appreciate the request for their involvement and participation in this plan development process. We believe the above noted interactions have permitted important exchange of information and collaboration for the TWG and GCMRC, and input of the Science Advisors.

PROCESS

While the collaborative process for development of the three year plan occurred over a five-month period, this review was done over two weeks in June. Once the plan was in draft form in early June, the SAs were asked to evaluate both the presented monitoring and science projects and their budgets for potential effectiveness and efficiency in meeting GCDAMP goals and desired future conditions for resources of concern. Each of the science specialists listed above as authors provided written comments which were collated into this report. The structure of this report is organized in three sections. The first section presents general comments that address the entire report in context of the overall adaptive management programs and processes. The second section provides comments on each of the enumerated projects. Finally, the report provides a set of recommendations for the Secretary, AMWG, TWG, and GCMRC to consider in their continued assessment of the most appropriate management and science programs to pursue in 2015-2017.

GENERAL COMMENTS ON TRIENNIAL WORK PLAN

Overall this is a well thought out research plan, and certainly the most thoroughly prepared plan we have ever reviewed. In particular, we like the context for the proposed research projects. The authors of the plan have responded to a variety of factors, such as the Assistant Secretary's direction (as provided in two memos), the Grand Canyon Protection Act, Strategic Science Questions (SSQ), desired future resource conditions (DFCs) Core Monitoring Information Needs (CMIN) and Research Information Needs (RIN). While not the only factors that should be influencing the direction of research for the next three years, they are certainly important factors. In addition, the research teams assembled have excellent track records of collaboration and research output in their areas of expertise.

All plans, like this one, present opportunities for improvements and the following comments by the Science Advisors should be taken in that vein. Each advisor takes this task seriously and looks deeply for areas where we can offer assistance in improving the plan. As will be borne out in our many review comments, GCMRCs leadership and staff have presented projects and proposed procedures that are extremely well designed and presented. As such the SAs find few significant faults with the plan and endorse all projects presented with changes proposed. Even then, we encourage the GCDAMP to consider all our comments as opportunities to improve the plan.

Our general comments are described more fully in the following paragraphs with these general headings.

- Program and budget plans.
- Budget suitability.
- Adaptive Management and collaborative processes.
- Systems assessment and systems models.

- Integration of science projects and integration of science and management.
- Revision of selected program administration.

Program and Budget Plans: The Glen Canyon Dam Adaptive Management Program, established in1996 by the Glen Canyon Dam EIS, was originally administratively structured around an annual science program and budget review process by stakeholders, agencies, and a research centers staff. The Adaptive Management Work Group (AMWG) led by the Secretary's Designee and with its Technical Work Group (TWG) for support, was responsible for collaboration with the Grand Canyon Monitoring and Research Center (GCMRC) in recommending to the Secretary management and science direction and required budgets. The first 5--7 years required extensive collaboration of stakeholders and scientists in development and refining the new adaptive management and science program direction required in the EIS. To provide longer term planning, a strategic science plan was developed and updated by GCMRC (1997/2007) and a management strategy was developed by the AMWG (2004). However, over this entire period the intense annual budget and project development process dominated planning and appeared to limit AMWG, TWG and GCMRC time to develop more focus on needed long-term science and management strategies. As noted both GCMRC and AMWG have developed strategic planning documents, but they are not living documents that are evaluated by management or science on even 5-7 year intervals. They are not used for continued reference to determine where the annual programs are in reference to where the Secretary would like them to be in 5-7 years. The new three year plan proposed for this review could be the opportunity for the AMP to accomplish improved short term (1-3 years) and longer term (5-7 years) planning. Three years provides sufficient time to implement a multi-year tiered program and gain some assessment of both its potential success and needs over a longer term. However, we note that bringing major lines of research to completion generally requires more than 3 years, hence there is an important role for both program review on a 3-year cycle and continued focus and funding on a set of core topics over multiple 3-year funding cycles. This proposed plan taken in two cycles could provide possibly an effective format for long term planning. However, to accomplish that end the AMP should consider several improvements and changes to the plan in the current cycle (2015-2017), including: improved integrated science planning; improved inclusion of BOR, other federal, state and tribal agency management and science programs explicitly connected to this program; incorporating and approving the complete elements of a core monitoring plan directly into this plan; and incorporating strategic management and science guidelines directly into this plan. Such a process, of course, is fully dependent on the policy direction to be laid out in the EIS/LTEMP. Once that policy direction is in place, perhaps AMWG/TWG/GCMRC could expand this instrument in 2016 or 2017 to include the above-discussed changes. It would be more effective as a short-term plan reviewed every three years if it had these components built into it. And, it could service as a long-term strategic plan that could be reviewed at six-year intervals. This approach would seem to be more effective and efficient than production of separate long-term plans that are not working documents.

An example of significant programs deserving more inclusion is cultural resources. They are not mentioned in some of the projects even though justification for data collection includes benefits for managing these resources. Projects that collect important time-series data, such as Project

3, should explicitly include some areas that are archaeological so that the very intensive data collection being done could also be used to benefit management and research of cultural resources. And, related to this is reviews. Independent research oversight panels that are convened should include cultural resource experts to help to ensure the integration of cultural and natural resources in both management and research goals.

A second example are is that the compartmentalization and possible redundancy of data collection for individual projects could be easily seen as needing improvement with a more systematic program strategy. More collaboration among the scientists to see what data collection strategies could be used across projects needs to be done. Many of the same data collection techniques will be used across projects and there could be more explicit discussion of collaborative methods (e.g., citizen science, remote sensing, LiDAR). There also could be more discussion of how research and management goals intersect across projects, not just within each project.

The organization and layout of the plan could be improved for communication to the GCDAMP stakeholders and a wider audience. It is a large document, just short of 500 pages. Its complexity and importance calls for a well designed and written executive summary that can stand as an independent document. As such all elements of this plan would be addressed in the executive summary. This would greatly extend its utility. The plan itself would also benefit from periodic guides in the text so that the reader would know what to expect and to provide logic for the overall report. Because of its complexity, there is limited indication to the uneducated as to how and why all projects fit together. Also, the level of detail varied across budget items. The overall budget never appears in the document, only as an appendix. As such, there was continued emphasis on outlining activities and costs for each program or project, rather than as a whole.

Budget suitability: In this plan, budgets are presented for program areas and projects, and the overall budget is placed as an appendix. A budget summary is needed in the introduction. Even though some new programs are costly, they may represent changes of less than 5% in overall activity, and none represent major departures from the general program direction. Budget in individual projects are addressed in a later section. Even then, the overall proposed budget allocations are somewhat similar to the approved 2013-14 program direction, which were determined satisfactory for maintaining science, and management direction toward the Secretary and stakeholder goals, lines of research, and questions being addressed. Regarding budget directed toward major science questions of concern to the AMP, several significant accomplishments regards long-term learning have occurred in the past decade along with launches of several new programs with significant associated findings. Clearly, some of the long-term projects have accomplished several of their objectives and, therefore, have been able to reduce the frequency and intensity of sampling effort. This also demonstrates budget suitability in maintaining progress toward important goals. Nonetheless, some concerns may exist regarding longer-term budget needs and potential commitments. With reference to the final five years of the GCES programs and the first five years of GCMRC programs, it would appear that GCMRC today at best has stable short term budgets. It is apparent that AMP scientists and managers may be required to address more challenging problems and questions in the next five years. GCMRC facility cost increases alone will challenge the ability of managers and scientists to maintain learning necessary to resolve issues in physical, biotic, and socio-cultural programs. And, although much has been learned about the biology in this system and its implications to

HBC survival and improvement, much uncertainty still exists regards impacts of food base, predation and habitat. The fish is improving but the science cannot clearly say why. Water temperature is considered a potential factor that could have negative effects in all of the above areas but, and even though a fund is maintained to at least respond to predation it may not be sufficient. SAs recommendations for development of capability (selective withdrawal device SWD) to cool downstream waters if future warm water projections occur is still under study. The Upper Colorado River Commission allocates over $2 million annually to non-native control compared to an annual average of less than $.3 million in the AMP. Many national and regional projections of climate change characterize the Southwest and Colorado River Basin to have more change relative to other U.S regions. Those changes reflect increases in ambient temperatures as well as water temperatures, reductions in precipitation, greater variance in weather patterns, and potentially more intense weather events. This system (GCD) currently has no management capability such as a SWD to mitigate increasing water temperature although it has been studied. Without this capability threats to HBC would seem to increase significantly. Regarding this three year plan, it would appear that the above noted issues and projections are of sufficient significance to this system to warrant a proposal for a new multifaceted science/management thrust in the GCMRC program and the associated required budget. This would be a strategic activity at this time and perhaps it is planned to be addressed in a separate strategic plan. However, as noted above, a strategic plan is not proposed. Even if that were the case it would seem that some proposed program activities and necessary funding would at least be evident in 2017 programs to address additional science and management needs. Some needed activities would include: closer formal collaboration of managers/scientists across the entire Colorado River Basin, development of a systematic and linked basin-wide approach to model, monitor and assess change in and impacts to key indicators, closer evaluation of a SWD, and at least projections of potential program and budget needs for these efforts. Since there is currently no other AM program on the Colorado River with the capabilities to monitor large riverine areas for effects of climate change on water temperature physical/biotic/social resources, one would assume such activities would occur in the AMP and be addressed in this plan. Their omission is a major oversight. It is our assumption that it does not appear here because of its development in the EIS/LTEMP, and that it will be incorporated in this document in 2016. That would in fact be more appropriate, and perhaps that could be noted in this document. Chapter 2 lists the criteria for development of the budget and these criteria lay a good foundation for understanding that process. However, there is no mention here of recommendations from the various Protocol Evaluation Panels (PEPs) that have been performed in the last few years, some of which include climate change impacts. Including these would be beneficial to ensure that all identified research themes and related budget needs have been incorporated. We suggest that a summary of overall budgets be included as part of the introduction, with the detailed document retained as an appendix**.** It is not clear why there is a need for two separate facilitator. We agree that there could be a healthy role for such a position, but it could surely be shared between AMWG and TWG and even then might not require full-time staff. It is not clear why overnight mail costs are considered for these meetings; it is far more cost-effective to email documents prior to the meeting, then provide hard copies on request as contributors arrive**.** NPS permitting costs for permitting the proposed projects seem excessive given that almost all project elements have 3-year time frames and hence should require labor-intensive permitting only in FY2014 or 2015. Given that the stated goal of the Native Fish Conservation Contingency Fund is non-native fish control, it is not clear why major spending commitments regard native fish studies (364k of 824k). If the balance of 460k is sufficient to cover all non-native fish control efforts, why is the budget so large in the first place?

We appreciate the need to have contingency funds available to act quickly if exotic species expand their range unexpectedly or trout densities rise enough to trigger removal efforts. However, it would be cleaner to keep these separate, so that ongoing research projects on native fishes would not be jeopardized by events that require non-native control, and likewise promises for native fish research do not have to compete with appropriate response to changes in non-native species status when allocation decisions must be made. Finally, the rationale for the enormous ramp-up of these funds for FY15-17 is needed. Proposing to spend that much money on an oral history seems like money that could be better spent on other efforts. There are a tremendous number of documents on AMWG, GCDAMP, etc. that are available on the web since the inception of these efforts, so the incremental gain from an oral history seems minimal compared to other opportunities available to the Public Outreach Program. The Web page development process could receive more support. It is a program that can provide real-time access to all the AMP completed and planned program activities for the general public.

Adaptive Management and Collaborative Processes: In reading the plan, several general program activities stand out to bolster ones confidence that active adaptive management processes are in place. Obvious improvements are occurring in research efforts directed toward implementing experimental manipulations, monitoring impacts, and revising management actions such as high flow events, non-native fish control, and HBC translocations. These examples of the adaptive management paradigm are commendable, as is enhancing the role of citizen science. Moreover, it is clear that collaboration between GCMRC and BOR is active in management actions and science with regard to high flow program implementation, modeling applications in Lake Powell, and funding critical fish ecology projects. We were also pleased to see that collaboration amongst GCMRC scientists and agency managers is expanding relative to the 2013-14 proposals, ranging from brown trout and RBT control to HBC translocations and assessments. It is difficult to determine how much adaptive management accomplishments are needed for the AM process to be considered successful in the AMP. One must first look at the evidence of AM processes being in place and also being actively pursued. A second is to determine if real outcomes are a product of using the AM processes. Although this is not a specific review of AM application in the AMP we believe that generally there is evidence that AM processes are being pursued, and that important accomplishment is and will continue to result from that pursuit. The GCDAMP has been in existence since 1996 and it has demonstrated accomplishment in the AM paradigm. As noted, it has implemented several complex adaptive management actions, including high flow releases, endangered fish translocation, non-native species control, etc., and modified these strategies through progressive science and monitoring learning processes. We also believe that any management direction such as AM has continued opportunity for improvement. The Asst. Sec. and AMWG determined in 2014 that revised management actions and programs could be important to the cultural resources program and the 2015-17 Plan proposes improvements in emphasis, funding, collaboration, monitoring, and research. We see these actions as important for improving AM effectiveness. Without an in depth assessment of AM application in the GCDAMP, it is difficult to determine if major changes are required. It might be important to actually make AM processes and accomplishments a formal part of the Tri-Annual Plan review process every three years. That is, AMWG and TWG and the AM processes they implement are critical elements to the AMP, but these elements are not reviewed and directly evaluated for accomplishment. After 18 years, perhaps the AM process itself needs revision in the AMP. Referred to “double loop learning” in application of AM processes, some programs have changed after formal assessments. We recognize that further assessment efforts would impose further costs on the overall GCDAMP process, and would

distract the scientific team from its core mission. Perhaps a brief lower cost review might be considered for direction by the SAs in 2015 in concert with the brief review of the 2016 program.

System Assessments and Systems Models: Arguments have been made consistently over the last two decades in multiple reviews that the complexity of the ecosystem under study and the science and management programs applied demand some type of ecosystem model to help guide most appropriate paths for management and science. Along with others, the SAs have proposed this direction in several reviews. Development of systems models and sub-systems models have occurred and several are being utilized to guide both science and management in this program. Both ecological system models to guide science and management system models to evaluate policies have been discussed. The SAs have strongly endorsed that an ecosystem science model be developed and used to guide strategic planning. GCMRCs past work led by Walters should be reviewed in this regard. The SAs have also encouraged that an overall systems model for the Colorado River Basin should also be developed. It would have to be an open model that at least permitted evaluation of potential impacts that are exogenous to the currently defined CRE for the GCDAMP, especially potential perturbations due to changes in climate and direct environmental alterations arising from new policy decisions. System models are very expensive. Should the stakeholders support development of a basin wide system model, the AMWG should define specifically what it must accomplish. Given future climate implications to the Colorado River as a whole, would it be best for AMWG to collaborate on a basin wide system model that would have greater focus on refined assessment of policy and management actions in the system and how they might affect critical habitat requirements, water availability for desired recreation and water development, energy production, etc.? That is, should the AMP be a partner in a basin wide model with other Colorado River programs? The approach could have greater focus on learning regarding impacts of basin wide impacts of management actions and natural phenomenon on general regional physical, biotic, and social resource needs rather than trying to refine the model to predict the specific impacts of marginal habitat changes on biotic species of concern and local social issues. GCMRCs and other basin programs science projects and associated ecosystem models could be tasked with this learning need. However, the SAs also recognize that such efforts can substantially dilute efforts away from specific needs of the ecosystem and social systems responding to Glen Canyon dam, and hence should receive significant planning.

Integration of science projects and integration of management and science: The AMP overall program has had one review since inception by the National Academy of Sciences that stressed the need for system-based science approaches, linkages and integration of differing resource science and monitoring projects and approaches, and greater integration of management and science approaches. The Science Advisors have stressed the importance of these approaches in several reviews including the 2013-14 Plan review, and the TWG and AMWG have also expressed the need for these efforts. This being said, there have been significant accomplishments in the last five years in all these areas as noted in this review, and the 2015-17 plan is demonstrating improved approaches and accomplishments in all areas. In reality, because of the complexity of this science and management program, and the detail that must

be provided at the project level, it is difficult to actually interpret all the integration that is occurring. Often plans of this complexity will devote an entire first chapter that presents a clear picture of the overarching aims of the program, its long term target outcomes, adaptive management and science methodologies to ensure critically needed science and management integration including system models and approaches for conflict resolution, application of results, addressing policy changes, etc. Such an approach could improve this plan. We believe that Project Element 13.3 Decision Support System (DSS) that is proposed is an important step in that direction. The development of the Decision Support System should be able to utilize information from numerous Project elements proposed in this Triennial Work Plan and point out any research gaps that need to be filled in the next Triennial Science Plan to enhance those linkages. We also applaud the fact that Project 10—a new initiative—is synthetic in its approach.

Revisions in selected program administration: Concerns by USGS over any potential perceived conflict of their administering the Science Advisor Program budget has resulted in transfer of this program administration to BOR. The Science Advisors do not see this as conflicting with the stated purpose of the program if its tasks and activities continue to be specified by the AMWG and independent unbiased reviews by a group of science specialists are permitted as prescribed in the operating procedures for the Science Advisor Program. It seems reasonable that BOR could administer the SA Program contract in an objective manner. However, for it to be effective as an independent review and service program, its services and outcomes should be available to all stakeholders and GCMRC as specified annually by the AMWG. It should also be permitted to provide some level of review and service input to AMP entities as specified in the SA Operating Procedures even if the level of budget support must be reduced due to budget constraints. These outputs should be provided independently by the SAs' representative(s) to the AMWG/TWG/GCMRC in open forum so as to prevent potential bias from any individual party in the AMP. Based on past requirements and expected future SA program requirements the proposed budget of $70-$80 K would seem to require AMWG to review the SA Operating Procedure and prescribe selected reductions in service/review activities for the necessary RFP. We are concerned that due to the timing of the program transfer and time requirements for contracting, the AMWG/TWG/GCMRC will not have access to an independent science group for an undetermined amount of time in FY 2015.

It is proposed that the Lake Powell program administration is also to be moved to BOR. The SAs have proposed in past reviews that if it is moved to another agency the general activities of this program should be retained. It also has been proposed in past SA reviews that this program needs to have an AMWG and agency review regarding how it can best contribute to specified AMP or agency goals, DFCs, critical questions, etc. in the future. For example, are the types of data collected and the intensity of sampling necessary to respond to agency needs? Should the analysis work continue on all the biological samples? Could an assessment be made of a subset of samples that have already been analyzed to determine if this data offers potential for learning beyond what would be expected given current existing knowledge from other western reservoirs? Certainly, the modeling capabilities cooperatively developed by BOR and GCMRC (CE-QUAL- W2) seem to be important current tools for agencies and would seem important to a basin wide management policy modeling approach should it ever be pursued.

COMMENTS ON SPECIFIC PORTIONS OF THE OVERALL TRIENNIAL WORK PLAN.

This Triennial Science Plan presented is the most comprehensive and complex plan ever presented to the AMP. It is a very professional presentation. A complement to both GCMRC and the TWG is that one has difficulty dismissing any project as not of important value to this program. The SAs find all projects to be worthy of pursuit and encourage their inclusion as possible with recommendations for change provided. In addition, the proposing scientists, program administrators, and reviewers alike would benefit from creating a more consistent template for each proposal element. We were impressed with the structure introduced in Project 5, where background information included key graphics summarizing existing data, and each element included coverage of both the scientific rationale and management implications.

Project 1, Lake Powell: The Lake Powell program and its importance to the AMP direction has been an [LG1]ongoing discussion since inception of the AMP. The AMWG In-and-Out Committee and the CRe definition of AMP boundaries downstream of GCD has created extensive discussions of how this particular program could best serve the AMP. It is now recommended in this plan that this program be shifted administratively to the BOR. How and where this program is administered is the purview of the Secretary and we believe it would not effect how its outcomes could support basin programs like the AMP. The SAs in past reviews have noted that a program in Lake Powell is critical to continued learning of how natural perturbations (climate) and human interventions (policy and management) will effect water quality and quantity variances in the CRe. As such the SAs have supported continuation of these programs. That being said the SA reviews have been critical of the fact that the program's budgets and productivity have been allocated to production of data without clear science plans as to how that data will be used to advance management and learning related to critical goals and resource questions of the AMP. Early reviews found that even data development was not properly automated, verified for accuracy, and timely reported. Although this has been corrected regarding physical parameters, extensive biological data assessments are still backlogged. Another primary criticism was the absence of effective plans for data analysis and interpretation, which appears in this plan to be in process. A very positive outcome has been the collaborative GCMRC/BOR effort on the CE-QUAL model, and this may in part provide good basis for transfer of administration. With recent issues of shortages, increased water demands in the basin, changing use and management policies, and the potential impacts of climate change, Lake Powell management and science programs will become more critical to all managers and users in the basin. We believe, therefore, that an effective Lake Powell program will be more critical to the AMP and basin in the future. There are many critical questions that will need to be addressed. What are the expected future water temperature changes in the CRe? We do not see the evidence of strong pursuit in this plan. What are the science analyses necessary for us to best predict temperature and other water quality changes, including biological parameters? Efforts to date on modeling are to determine short-term (1-2 years) outcomes of expected values. But climate change is now forecasted with greater certainty for the Southwest. Are not the climate change prospects and water level, volume, and water temperature changes critical to long-term management and science issues? Will not water released at the dam be drawn from somewhere closer to the thermocline? Will that not mean that water temperature will increase in the main-stem, as occurred last decade, with high likelihood of significant impacts to aquatic biology? Since a management tool is not in place to mitigate, is it or can it be planned.

And, are not GCD and Lake Powell critical water management tools in this basin? It would appear that the answer to most of these statements is yes. If so, the question raised in the general comments is then raised again here. The GCDAMP is currently the most capable program in the Colorado River Basin to plan and implement a program to address these issues, and seemingly a Lake Powell based collaborative initiative on systems analysis of the basin and mitigative management and science strategies would be planned. Yet, it is not in this plan. We conclude as above that it awaits policy direction from the EIS, which seems most appropriate.

Project 2: The monitoring of water quality and sediment transport is fundamental to evaluating changing riparian and aquatic habitats in many other projects. It appears that the proposing investigators have identified appropriate timescales, locations, and methods for profiling the water quality and sediment fluxes in the main river channel and select tributaries. Integration with other programs is demonstrated in collaborative work of these project scientists with other projects conducting interpretation of findings to biotic and cultural resources. Other major accomplishments are web-based efforts to continually create improved public real time access to data. Two questions always exist with costly monitoring programs. The first relates to stakeholder level of need for information as regards type and degree of specificity. The plan reviews in the last decade would indicate the program is responding to information desired and using several direct and indirect methods to provide the information to stakeholders and managers. The second question relates to methodologies used for data development, analysis and interpretation to managers and stakeholders. Again, reviews would indicate that ongoing assessments of improved science and methods are evaluated and implemented as proven more effective. New technologies are especially important to sediment transport and, perhaps, might be very useful in collecting sand budget data, which are critical to evaluating both sand storage and beach building and loss. What could possibly help at this juncture and especially on completion of the EIS is a reassessment of AMWG explicit information needs when cast against goals and critical questions being pursued. This process by AMWG/TWG would assure that only necessary information is being required of the GCMRC to assure future needed flexibility in science and management programs and budgets.

Overall, the proposal would be considerably more compelling if it focused more on evidence that continued monitoring and upgraded methods can change our perspectives. Even for strong supporters of monitoring, it is worrisome to perceive that the effort of monitoring itself takes precedent over creative use of the data to inform fundamental understanding and real-world management. That was the sense conveyed by the proposal; while 2 full pages of lists of relevant agency priorities/mandates was provided, only a single paragraph ("Recent research on the Colorado...") offered any specific indication of how the new data can boost understanding and improve management. How wrong were we with 60 minute time resolution instead of 15 minutes? How much change in sediments was observed during the ongoing drought compared to before? How might these data inform future climate change adaptation efforts? Just how are these data used to trigger and evaluate the High Flow Protocol? Tackling these kinds of issues with even a few sentences would go a long way toward justifying associated budgets. The work is really important, but it appears that funding success is taken for granted by the proposers (although SA sabers were rattled regarding the calamitous consequences of under-funding this monitoring).[p2]

The website is a great concept, though it took several minutes to create a figure of just 6 years of data (even requested in the early AM when server demand would be low). That suggests that the server is badly underpowered or overtaxed, and/or that the coding is far from optimized (e.g. using default bias settings, as most users would, should allow instantaneous generation of graphs because all values can be pre-calculated). The duration curve will indeed be a welcome addition, though the proposal makes it sound like a major technological feat when in fact every aspect of presenting such a graphic and allowing user-defined calculations is very easy to code and serve.

As noted in the introduction to this project, the data collected are used for a number of other investigations, including those related to socio-cultural resources (p. 55). This project would benefit from integration of archaeologically and culturally significant sites. It isn't clear how the important information that is being collected and will be collected is actually being used or could be used to monitor the impacts on cultural resources in the CRe. Thus, while it is stated that "Collaborations also exist between this project and every other funded physical-sciences and biology project at the Grand Canyon Monitoring and Research Center, mostly in a supporting role, and with researchers in academia" (p. 61) no mention is made of collaborations with archaeologists, or that the locations and physical attributes of archaeological sites are in any way being looked at as part of their work with the USGS Center for Integrated Data Analytics (CIDA). If it is, it should be mentioned how and what the results have been.

Project 3: This project has significant focus on the impacts of HFEs and intervening flows on riverine sediment abundance, movement, and storage. It also has focus on sandbar development and maintenance in the system, and modeling of sandbars in the system. It continues to address through both monitoring and research one of the most critical questions of the AMP, i.e., can appropriately managed high flow events and other required flows through time provide general stability to the number, location, and size of sandbars in the system. The program also provides critically needed inputs to understand flow regime impacts to riparian and aquatic habitats. Extensive funding is proposed for 2015/16 to evaluate differing data recovery methods and data quality to assess sediment and sandbar conditions. It is difficult to determine explicitly from the write-ups if duplicated effort exists. Most of this project effort, approximately $1.2M is directed at providing definitive assessments of the status of sediment and sandbar resources through multiple approaches. It was unclear whether the increased effort to gather higher resolution data will truly be more informative. Again the question addressed above might be posed. Would less data resolution serve managers well and also save costs?

Objective 3 proposes to utilize some of these data to develop and refine a model to predict sandbar development and variance in the system and how that variance is linked to operations management, including normal operations as well as event flows such as HFEs. Development and testing is to occur through the 2015-17 period at approximately $100 K per year. It is not made clear how this modeling effort will integrate in overall AMP and EIS program accomplishments, including Argonne's sandbar modeling efforts in the LTEMP. The two modeling approaches use different methods but seem to be addressing similar if not the same

questions. Although costly, this modeling project is addressing one of the most critical problems in the AMP. If in fact duplication exists by design it could be useful in moving more quickly to more effective monitoring methods and improved modeling in the three-year period. In total over $0.3 million may be expended in three years in this modeling effort, which seems cost effective if successful. Results from Project 3 should also provide useful information on the distribution and size of camping beaches, an important element in visitor satisfaction. On the surface it appears that parts of projects 2 and 3 could be integrated to reduce costs, and yet each project element provides critical elements to overall goals and objectives. Further, assessment of costs for each element does not reveal excessive expenditure.[p3] However, this should not preclude a closer look at potential cost savings from integration.

There were several more detailed issues that merit consideration. Element 3.1 focuses on sandbar dynamics, but seemed to treat each potential influence as being independent of others. An 'experimental design' perspective might be more informative, wherein sandbar growth and loss rates can be envisioned as integrating the effects of location in the river, bar configuration, local currents and sand inputs, event characteristics (HFEs, etc.), and interaction among these factors. Such an integrative way of thinking would be more powerful than treating each as an independent predictor. The work could then merge bathymetric and topographic perspectives by testing the spatial association between riverbed dynamics and sandbar dynamics. This merger would align with the overall geohydrological approach: is sand transport a local or long-distance phenomenon, and how does that scale with event size? By determining the scale at which sand exchange between bed and bar occurs, it would be easier to reconcile the interpretation of data from individual sandbars with the large-scale flux view of mass balance between tributary inputs and reservoir sink.

More generally, it was striking that no work was proposed on climate or other controls on sand loading from tributaries, or delivery of sand to the downstream reservoir. Those topics seem the logical way to tackle the sustainability context raised repeatedly in the background section. Figure 8 is fascinating, and prompts the question of whether it is coincidence that the one site where high-resolution data indicates major reductions in sand bar elevation is also the site where the validation of the RS approach is also very weak? It seems this could indicate that the RS approach works well for growing sandbars but poorly for shrinking ones. That has important direct implications, but could also point the way toward methodological refinements that enable better estimation of flattening sandbars using RS. The SFM approach is a nice addition as a high-risk, high-reward element, and it was good to see the precision will be quantified to pave the way for citizen science implementation. But why does the methods comparisons focus on down-sampled data to make high-res methods comparable in sample density to low-res methods, when the more salient comparisons would be comparing the gold-standard (LIDAR) to SFM and total-station without any down sampling? It seems the key aim is knowing how well each can perform in an absolute sense, which dictates which constitutes the minimum acceptable effort to achieve adequate accuracy. Similarly, under element 3.2, why not validate using new aerial imagery that could be directly compared the 3 methods proposed in the previous element (SFM approach). I understand that value of the historical perspective, but comparing against multiple methods in the present would provide richer validation and methods development possibilities.

As the 'long-reach' approach is discussed (p103), does the failure of the three small-scale sampling strategies to yield the larger-scale mass balance simply suggest that the wrong predictors are being used in sample site stratification? Apparently it is not enough to focus on large eddies, but it is not clear that the team has fully mined the 2000-2004 data by comparing depth changes to other mapped characteristics (depth, flow velocity and vectors, proximity to bars, nearest upstream or downstream riffle, etc.). It seems there must be some way to predict which places are most dynamic if the old data are mined more fully? Also, it was surprising that hyporheic issues were not mentioned. Perhaps some hydrological tracers of hyporheic exchange would help to predict locations where bed thickness is likely to be dynamic (by virtue of reflecting both substrate characteristics and hydraulic forcing). With regard to sonar application (p105), similar efforts are underway even with single-beam sonar in lake environments-- see lakemap.com for details. They use a standard Lowrance echo-sounder and can resolve macrophytes and hard vs soft substrates. To validate your methods (p107), will you collect grab samples of surface sediments and plant material. That is important since you are expanding the spatial scale of surveys enormously, and the identification of bryophytes and chlorophytes seems like a reach.

Finally, a few statistical comments. The test of predictors of sand bar change (p118) is a perfect application for boosted regression trees, which deal nicely with non-linear predictions and complex interactions. They also offer the capacity to predict unstudied areas from the suite of descriptors, though that is more complex than with multiple regression or other basic parametric approaches because there is no singular predictive equation. The idea of grouping sites is unlikely to be informative because groupings result in: a) reduced statistical power to detect and estimate influence of a particular predictor, b) losing the capacity to use small deviations in multiple predictors among broadly similar sites to inform fitting of each predictor (i.e. groups will still have modest heterogeneity, but that information is discarded in fitting), and c) lower large-scale predictive power over treating sites individually. In any case, that empirical descriptive statistical approach will be a nice complement to the mechanistic LES modeling approach. It is also admirable that the team will establish a control network to ensure consistent elevational standards for application to all types of data being collected for this and other Projects, but most readers would benefit from clear presentation of some what-if scenarios. How badly would the research mission be compromised if the control network did not exist (since it currently doesn't)? For instance, what would the consequences be of not having the RS and field observations of sand bar height on the same precise elevational benchmark?

According to the plan, the project has three research components, but as with Project 2, none of these explicitly addresses the integration of archaeological resources into the models. Nor do the "key monitoring and research questions addressed in this project" (pp. 81-82) specifically mention archaeological sites. Nonetheless, this is an important project and the monitoring portion could be extremely valuable for assessing impacts on archaeological sites, assuming that areas that are targeted for repeat photography, remote sensing, etc., are areas with archaeological sites or other culturally significant areas. However, there isn't anything in the plan that states that the sampling strategy included consideration of archaeological sites and/or culturally significant areas. Many of the cultural resources may not be directly affected by this

specific project because they are above the elevations being studied, but if they are in areas that overlap with sandbar areas and could be included in the studies then they should be explicitly part of the sampling design. The plan mentions that there is "a pressing need to develop a representative sandbar sampling design" (p. 97), so now would be the time to add areas with archaeological sites to the areas being sampled. The subproject (Project Element 3.5) to support the geodesic control network has important contributions to make to archaeological site monitoring as well as other research projects.

Project 4: Project 4 represents one of the main investigations into cultural resources during the next three years. The sub-plans to the project each tackle (1) mapping with remote sensing techniques areas of "active aeolian sand" and quantitative analyses to understand the sources and interactions with other elements such as barriers; and (2) analysis of historical photographs to more qualitatively assess landscape change associated with active erosion. The latter will result in the preparation of a long-term monitoring plan. The proposed components in the plan aim to determine rates of erosion that will contribute to the desired goal of preservation in place. So, understanding rates of erosion is extremely important for planning purposes, and especially for the Long-Term Experimental and Management Plan. However, we are concerned about effective specification of this project and it is difficult to connect directly the science effort in 4.1 and 4.2 to expressed stakeholder needs for mitigating impacts from dam operations to archeological sites. Research has been ongoing for multiple years to evaluate the relationship of fluvial processes below 45K CFS flows and geomorphic processes above 45K CFS flows. However, although establishing association, proofs are lacking to justify full entry into the proposed monitoring approach. The projects small sample size should be increased and TCPs added. It is not clear that the effort is a priority for Tribes. According to the Triennial Work Plan (p. 149), the research project is tied to suggestions in the prior Protocol Evaluation Panel (PEP) and addresses Strategic Science Questions (p. 151). A concern is that it is not clear if this would be considered the highest priority cultural resources research program to pursue for the next three years. For example, ongoing work involves the classification of archaeological sites in terms of the origin of sediments being deposited at archaeological sites, barriers to aeolian deposition, and prevailing wind directions. The result is a 5-category classification based on a small number of sites and the goal is to expand the number of sites classified (n=13). A larger sample is definitely needed and if the project is approved work should continue on this project to better understand the multivariate nature of deposition. Understanding why these sites are not receiving sufficient sediment deposit to stabilize the sites is a complex process, and variances related to assessments are high, at least in part to small sample size. It, therefore, may be unwise to launch a monitoring program of these processes in 4.2 at significant costs without stronger empirical support for the original stated hypothesis and increased sample sizes. As this sample is increased, it needs to include not just archaeological sites but also other TCPs. Identification of erosion to other kinds of cultural resources needs to be explicitly integrated into the project. This was a recommendation of the PEP report (Doelle 2000) and also brought out in the legacy monitoring review committee report by Kintigh and others.
The greatest concerns with the project are (1) understanding its potential contribution to Tribes or the NPS in assisting mitigation strategies for archeological sites affected by dam operations; (2) how the plan objectives will be achieved for all sites given the very small sample of sites that are included in 4.1; (3) how data from the quantitative and qualitative analyses will be

integrated; (4) how can changing weather patterns affect application of potential results, and how could it be mitigated? and (5) LiDAR seems to be an integral part of the project but funding for the technology has not been secured (see p. 44). Many of these issues relate to insufficient science effort in plan specification an interaction with Tribes and manager. Some of these concerns might be alleviated by inclusion of more detailed information in the plan. For example, how many of the total archeological sites that are determined to be impacted by flow operations in the canyon have attributes expressed in this research? Although not disclosed in the project description, we assume knowledge exists of this number and it is a significant percent of the total to support the need for this effort. If the entire approach, i.e. hypothesis testing and monitoring protocols, is successful how will they assist resource managers—i.e. NPS and the tribes in implementing mitigation strategies? Again unless improved science design can be presented, this seems an area where funds might better be used to pursue management actions. A goal for the project might best be to produce information to help anticipate worst-case scenarios and develop management actions to mitigate irreplaceable losses. Further documentation of site classification is perhaps helpful, but information on specific vulnerabilities and how management could mitigate them seems just as important. The use of LiDAR to answer the question of whether NPS use of check dams to reduce erosion gullies relative to areas without check dams is a part of the project that would follow this reasoning. In principle, this may be an extremely important project to conduct for the cultural resources if the methods and models could be implemented. The science presentation is not sufficient to produce confidence in these outcomes.

Project 5: This project presents new program thrusts related to EPT absence/low abundance in the Glen Canyon/Marble Canyon reaches; continuation of work on invertebrate drift in the river and primary productivity monitoring in the Glen and Marble Canyon reaches. The Colorado River below the dam exhibits a remarkable absence and rarity of insect groups found in other river systems. This group of investigators face an interesting set of problems owing to interactions of variable flow velocities and temperature effects as causes for the low diversity and low productivity observed in the river below the dam. The possible solutions are also complex and difficult to test. The issue presents a tough restoration problem. Answers will be importantly related to food web interactions. Comparative insect drift studies conducted in river reaches above Lake Powell and those in the canyon below the dam may offer important insight about what is possible vs. what simply won't work due to life history constraints within the realm of current management practices of flow variability and temperature effects. A parsimonious outcome may be very helpful in evaluation of management possibilities and priorities. I strongly suggest that this is a very worthwhile effort. Management needs to know if and how the challenges of evolutionary history can be accommodated and, therefore, what expectations are realistic. Developing a bottom-up modeling approach will be helpful in evaluation of the top-down constraints apparent in the productivity of higher trophic levels. Overall, the monitoring of invertebrate drift and associated budget is in major part a continuation of needed assessments of habitat quality for main-stem native fish and rainbow trout resources. The proposal for sampling work in the upper Colorado River to provide the context for ongoing assessments in the CRE would help validate methodologies. These benefits must be weighed against the $141 K cost by stakeholders. The proposed efforts on primary

productivity to develop approaches to derive algae production estimates from dissolved oxygen measurements present opportunities for more efficient assessments of aquatic biology metrics. The new effort on EPT discussed above follows on scientist and stakeholder discussions of general hypotheses. From the five presented hypotheses, the selected hypothesis recommended for testing is the impacts of hydro peaking on egg mortality. As noted the flow experiment portion of the research (34 weekend days of low steady flow from May to August) is not required to develop preliminary evaluations of the hypothesis. With the emphasis that was placed on the need to evaluate effects of low flows on biotic communities in the 1996 EIS it is disheartening to have had the 2000 and 2011 low flow experiments and not have had effective monitoring in place to evaluate aquatic insects. Project elements 5.11-5.17 propose evaluations of conditions in other riverine systems, literature reviews, citizen science assessments, and laboratory experiments to develop initial evaluations of the hypothesis. This engagement of publics in the research effort has been demonstrated effective in previous program efforts and adds important extensions to the AM collaborative process. Clearly a need exists to evaluate elements that could contribute to absence of EPT in the system and flow variance seems a reasonable hypothesis to test. Laboratory testing of water temperature effects also seems reasonable to evaluate even if a selective withdrawal device is not in current management planning. A management action such as translocation might have merit as well, but as noted would be difficult to assess in this system.

Overall, Project 5 encompasses an elegant set of observational, comparative, and experimental studies on insect ecology and algal productivity. Presenting management implications after scientific rationale was very persuasive, and the citizen science dimension is praiseworthy. However, much hinges on the validity of H5, and it is worrisome that the proposing team offers very little evidence in support of that hypothesis. Simply put, given that conditions below GC dam are lousy for most aquatic inverts (cold water year-round, low particulate organic matter from upstream, no substantial riparian organic inputs, hydro-peaking creating daily scouring and monthly hydrological instability, deep/wide channel that may lack microhabitats with algae and detritus accumulations), why would anything except small insects with rapid life cycles based on filter-feeding or collecting ever use such habitats? And given the extreme flow variation from hydro-peaking, it is perhaps not surprising that chiros and simulids (both of which are often pretty sedentary) are forced to drift, yet drift in low numbers due to the combination of low productivity (cold, no food) and behavioral tendencies against drift. By extension, it seems pretty unsurprising that EPT taxa would not do well below GC dam. It is quite interesting that they seem to do better in other tail-water areas, but the proposal does little to show that shoreline desiccation from water level fluctuations is likely to be the major cause of low EPT. The practical dimensions (readily manipulated without hitting hydropower or other interests very hard, weekly cycle over warm season, etc.) are great, but additional pilot data, direct observations, comparisons to hydro-peaking regime at other sites, etc should be offered in support of a costly proposal.

Another limitation of the approach is that it focuses on singular mechanisms that could explain the lack of EPT species below GC dam. Never did stressor synergies come up, despite the fact that GC dam clearly imposes three unnatural conditions: cold water, low turbidity, and large numbers of visually-oriented insectivorous fishes (trout). Is it really more likely that a single

stressor has extirpated sensitive insects than a synergistic combination of stressors (scour, low food resources, high predation, cold, and maybe also too few wetted oviposition sites)? Indeed, it was surprising that habitat limitation for larval insects was hardly mentioned. Many benthic insects require solid structure with interstitial spaces to thrive (sand and silt have more limited faunas), so it would be helpful to hear more about substrate patterns from the tailrace downward. Perhaps these concerns can be addressed by the proposing team by providing some details from the data that they already have in hand (e.g. dealing with temperature, substrate, and hydro-peaking amplitude in the comparisons indicated in Fig. 1), along with providing some additional details on drift netting to demonstrate that EPT are not just being missed by the nets.

Life history issues received less discussion that expected; midges and blackflies are small and develop quickly, and are talented filter feeders and collectors rather than scrapers (like many EPT taxa). So it seems there could be an important role for trophic ecology, as well as general habitat flexibility that is well known for small insects like midges and blackflies that are short-lived (whereas most EPT are likely to be uni- or bivoltine in rivers that are cold year-round) and often found in low quality streams. The oviposition site information presented in table also suggests that these flies may be more flexible than most EPT taxa in that regard.

Finally, despite the elegance of the proposed experimental manipulation of dam discharge (which is a great idea), it was difficult to assess whether May-August is a long enough window to see life-cycle completion (the basis for the multigenerational amplification argument offered in opposition to a favoring a longer low-fluctuation period) leading to a population-level response. Given the unnaturally cold temperatures below GC dam, the expected growth rates may be too low to allow much response. This could be calculated easily from existing knowledge of midge secondary production, generation times, and temperature dependent growth. Such an argument would strengthen the case for the potential for this novel manipulation to unequivocally resolve whether oviposition site limitation is the core problem.

Project 6: This project presents continued main-stem monitoring of HBC populations, RBT, and other native and non-native fishes represents maintenance of long term assessments of a resources considered critical to the AMP in understanding native and non-native fish dynamics in the system .It is unclear how monitoring is a conservation measure, but rather should be justified by reference to ESA or other administrative guidance. An extensive sampling effort has derived insights about distribution and abundance of humpback chub. Much the same is true of rainbow trout. Much less is known about many other non-native fishes and, more importantly, their interactions with native fishes. The SAs in their review of the 2013/14 Plan supported improved methodologies and assessments, many of which are continued in the 2015-17 Plan. An important factor in effective continued AMP science and management activities on both native and non-native fishes is the collaboration of GCMRC with federal and state agencies and tribal resource specialists, which is very evident in these projects. Regarding project element 6.8 on the Lees Ferry Creel Survey, we would encourage funding of this survey in 2015 if the recreational angler survey is to be performed that year, unless the recreational angler survey will collect that data. It would be extremely valuable to have creel census data in the same year as the angler survey so that an objective measure of catch per unit effort could be related to angler satisfaction and values. Another concern is whether $25,000 is sufficient for the creel survey. Seems unlikely. Also why is USGS charging burden on Cooperators non-USGS dollars? This seems counter productive to get cooperators to provide funding for these programs.

Overall this project is developing well in its major obligations and offering creative approaches for additional effectiveness. We suggest that the information from these assessments be integrated with other studies to help develop an understanding of multivariate factors that influence HBC .

A major shortcoming of the proposal document was the lack of concrete evidence from the abundance of past work provided to justify the approaches proposed for FY2015-2017. For instance, otolith chemistry is proposed without any clear statement of the scale and species for which it has been proven in this system (despite two citations that appear to provide exactly what would be needed). Oddly, otolith chemistry was not even mentioned in regard to brown trout tracking. Instead, a rather speculative analysis of color phenotypes is proposed, with little apparent evidence that existing observations suggest differences within the LCE. With regard to the SWEF effort and other monitoring, the background section makes passing reference to upstream movement from Lake Mead by non-native species, and increases in abundance of chubs, yet substantiating details of these patterns are not offered. This gives the reader the sense that monitoring is being conducted but rigorous analysis of the results is lacking. That sense, which hopefully is not accurate, raises questions about the value of monitoring even though the relevance is clear.

The PIT tracking at aggregations and extension of that approach to guides is a great idea, but it would be worthwhile to specify which parts of the river are assessed regularly by PIT reading and which are not. It is clear that the fishery biologists have an intuition for important areas than might be overlooked, but it is less clear whether that is based on a systematic assessment that could turn up additional target sites for the work. Will these data, and the new CPUE data (p217), be comparable enough to older datasets to rigorously test whether there are more chubs today than before, and how much they move?

With this and the other fish-tracking projects, it might be worth considering citizen science reporting based on distinct physical marks that anglers could recognize easily if they hook a chub while trout-fishing. For instance, a small V-notch in the dorsal fin crossing several soft rays heals rapidly yet leaves a long-term mark that is hard to miss, and could be applied only to translocated fish. That would facilitate angler reporting of translocated fish, since they will not have PIT-readers. The survey of exotics extending all the way to Lake Mead during spring is a worthwhile addition, since many of the invasive centrarchids and percids are quite mobile in the spring as they look for spawning habitat.

Project elements 7.1-7.5: These projects represent a very focused and complex assessment of adult and juvenile HBC population variance in the LCR and its confluence with the Colorado River. The multiple projects developed over time are attempting to both evaluate and confirm factors relating to habitat, competition, predation, etc. that contribute to population variance in HBC juvenile and adult fish. This is recognized as a critical element of the AMP. Results from this effort over the past three years have been extensive with abilities for modeling success greatly enhanced as referenced in the recent LTEMP efforts. Publication of new modeling approaches and their capabilities in contrast to existing and past modeling efforts will be important to maintaining confidence in all modeling efforts in the AMP. Continued work on the Asian

Tapeworm potential impacts to juvenile fish is important. The CO2 issue and other water quality dimensions in the LCR could become more extreme over the next two decades if projected dry warming trends persist. The studies to evaluate the effects of CO2 in LCR water, the role of water temperature on the extent of Asian fish tapeworm effects on juvenile humpback chub, and the potential for Bioelectrical Impedance Analysis as an evaluation of condition factors are laboratory studies designed to answer questions about physiological ecology of fish and may or may not pay a role in growth rates and population dynamics. The recent advances in modeling are associated somewhat with focused information needs of the LTEMP/EIS process with limited exchange with the AMP processes. Proposed capabilities of the model certainly seem to warrant proposed expenditures at the levels proposed. The approach creates a holistic picture of variability in humpback chub population dynamics and movements between the LCR and the main-stem of the Colorado River. As a result of both the laboratory studies and field monitoring, the work addresses interactions of young-of-the-year chubs and rainbow trout. However, it would be helpful to see some graphics of past results to demonstrate the inspirations for the next round of work proposed at $1.6M/yr. For instance, illustrating the documented variability in juvenile outmigration rates, fall survival rates in the main-stem, and shifts in population size structure, etc. would help connect the new work to intriguing patterns in the existing data.

In light of the patterns indicated in the opening of the Scientific Background (p240), structural equation modeling would be an ideal way to fit these data if the path diagram can be kept simple (which is necessary given the low number of years in the dataset). Jim Grace at USGS in Louisiana might be willing to help with such an analysis.

The advances in modeling are promising, but what are the quantitative consequences of the uncertainties in juvenile production and outmigration? Offering the reader something more concrete would help strengthen the case for further data collection and model development. For instance it was striking that temperature was rarely mentioned as a constraint on chub performance (only in 7.5 on p248), yet it would appear easy to look at water temperature records longitudinally and across years in LCR to test effects on chubs. Since water temperature is invoked as a key difference between the main-stem and LCR, digging into the LCR temperature data would be useful. Similarly, could inter-annual variation in water temperature be an important influence on tapeworm prevalence and impact on chubs? The potential effect of warming in the main-stem is noted, so presumably that could apply to LCR too.

The idea of spawning gravel limitation in LCR is interesting (p248), and worrisome in light of projected lower discharge in the future. Is there potential to use pumps to power-wash existing gravel beds, then use automated cameras to document whether chub preferentially use washed sites for spawning? The CO2 issue is also a nice element, but the background statement and approach appear to differ in indicating substrate vs respiration as the pathway of impact. Which is the case? Are there any field observations that suggest chub performance is compromised by high CO2 (e.g. during recovery after electrofishing)?

Finally, the proposal repeatedly mentions triggers for non-native species control, but never states the link between data collected and such triggers. What are the barriers to using new data to pull such triggers, and how will the proposed extension of basic monitoring help to

overcome those limitations? In other words, how bad would things need to get, and will the 2015-17 effort be certain of detection such a change?

Project 8: This project emphasizes AM processes related to implementing management actions, monitoring and revised actions to accelerate the learning process. These non-native fish control and native fish translocation management activities appear to be proving effective and should be duplicated in other science areas as possible. Proposals for expanded efforts on invasive species in the entire LCR watershed are critical. Invasive species transfer down the system would be expected to increase in importance in the future, especially if changes in climate and more intense weather events occur. Also recommended is citizen participation in evaluating LCR water quality changes related to land use practices. Extensive development is occurring in the upper drainages with increased expectations of pollution related to municipal water treatment, rural single-family housing, and small rural industry. The SAs proposed the expansion of collaborative adaptive management activities in the 2013-14 Plan as central to managers' success in understanding risks related to water quality in the upper LCR watersheds. The PEP scheduled for 2016 is most important and should incorporate questions related to system wide risks to water quality in the upper LCR watersheds.

While there is no question the non-native removal is a key tool, the proposal should make it more clear how many trout can be removed a year, and what kind of impact that would have on their overall abundance. Of the fish removed in the past, what proportion are big enough to eat small chubs? There is mention of relationships between removal needs and water temperature; what have the years of data since Coggins 2011 taught us about the strength of that relationship? It would be helpful to know whether chub (positive effect) or rainbow trout (negative effect) are more temperature sensitive, since that helps to frame how the future balance between trout fisheries and chub conservation can be struck under climate change. Is there potential to encourage recreational anglers to fish the Bright Angel area for brown trout, with a mandatory culling rule? That could potentially yield much higher removal rates, imposed year-round at low/no cost, as well as engaging citizens in the control effort.

There is also a need to be more clear about the success of past translocations. Does PIT monitoring indicate survival of all/most fish translocated since 2008? In terms of genetic assessments of chub aggregations, microsats may no longer be the best method; SNIPS or extensive sequencing is now within reach to gain very high resolution. These methods can now be outsourced at low cost, allowing investigators to focus on interpreting the data. If population sizes are small enough above Chute falls, detailed parentage analysis may even be possible for translocated and naturally-spawned fish.

Project 9: This project incorporates the ongoing monitoring efforts to evaluate status and trends of rainbow trout resources. Project 9 is aimed at filling a large and critical knowledge gap, which has significant implications for humpback chub and recreational angling. The hypotheses proposed on p. 281 seem reasonable and important to test. Overall the individual proposed projects within Project 9 seem to have some capability to address the key issues and hypotheses sufficient to warrant the amount of budgetary funds involved. It also proposes multiple new studies to evaluate and define key drivers that can impart change in RBT population size, movement, survival, reproduction, size, and condition. All of these factors are hypothesized to

have some effect on individuals and populations, and previous evaluations of varied scope have occurred in the program. Some assessments are extensions or add on analysis to evaluations approved in the 2013-14 Plan. To reiterate the point made in Project 6 we believe that discontinuing creel surveys may be ill advised in the short run. Presumably while the new mark-recapture methods for estimating trout populations are being developed the creel census will continue so that a relationship between the two can be established that will be useful for back-casting trout populations using the new method in order to have a consistent time series. Sport fishing for RBT in the Glen Canyon NRA is an important social benefit of the tail-water from GCD and brings with it many socio-economic issues. RBT growth rates have declined and abundances have become highly variable. Although downstream migrations and reproduction by migrants are still not well understood there should be continued effort to expand learning regarding relationships of Glen Canyon and Marble Canyon populations. Continued efforts are also recommended in providing better definition to HBC/RBT predation relationships. The capacity of this species to expand its habitat quickly on potential warming water should receive increased attention. Management of operations can affect this species and attention to water level management, experimental flows, and related food-base efforts need to continue. Although this premier sports fishery is a critical resource to maintain, it also could be a significant threat to HBC. Given that warmer water is probable for this river over the next two decades yet no management action is proposed regarding a selective withdrawal device, HBC at the LCR could receive threats from RBT and other predators in the river. It would be important for managers to understand how quickly RBT populations could expand in warmer water and their predation expectations.

Most of the specific project elements build on earlier work, and the proposal would be strengthened considerably by drawing more directly on evidence from previous data collection. For example, in element 9.4, what has been learned from all the past drift netting and stomach content analyses? If there is not strong evidence of selectivity, then the morphometric dimension of this study might be difficult to interpret.

In addition, is there a way to engage anglers as citizen scientists in the effort to understand trout movement patterns? Assuming that angler efforts range more freely in space and time than scientists can, then creating a physical mark (adipose clip or v-cut in dorsal) on trout caught in one place (e.g. tailrace of GC dam) could enable a small army to contribute to monitoring trout movement. Alternatively, can otolith chemistry approaches be used in the trout studies?

The lipid approach in element 9.3 could be powerful, but lipid storage probably is not the primary shift in resource allocation with trout size. Rather, the primary shift would likely be toward gametes rather than somatic growth (including lipids). Thus, the prediction of differential allometry of lipids in small v large trout may not be valid as proposed. The lab studies of turbidity effects in element 9.6 will be very useful, but under field conditions can differences in detection distance overcome density- dependent encounter rates and size-dependent detection rates? The literature values could provide a rough answer to that question prior to doing the work of lab manipulations. Similarly, for comparing different tailwaters, can all the other factors which differ be controlled for to allow strong inferences about the effects of temperature or other factors?

Project 10: The project focuses on Glen Canyon Dam rainbow trout tailwater fishery. This project nicely integrates information from other projects (2, 3, 9) together to address the issue of where does the trout tailwater fishery end. The project will evaluate select shoreline sites at flows below 8000 cfs in Glen and Marble Canyon to provide to ecologists evaluating food base definitive information of channel geometry and bed grain size. The project has been discussed by GCMRC at two TWG meetings and results from stakeholder requests for assessments. Introduction of rainbow trout in this system has been a huge success, which that now is sometimes expressed as a curse of riches. Biotic and socioeconomic issues surround management of the RBT. The project proposes a novel and potentially important approach to building a bridge between the detailed studies of river sediment particles and those that change habitats and productivity in support of desirable ecological conditions. Restated, this means that in developing the adaptive management approach at the GCe scale, there is need for more than sole attention to building beaches for campers. Before the dam, there was a very large annual flood. Now there are the realities of diurnal and seasonal flow fluctuations plus those of the weather, and the HFE's that have shoreline effects analogous to sending a tornado down the canyon. So how can things change in way that benefit food web interactions? In other words, what ecological benefits would develop if there were little or no HFEs for a significant period of time? This echoes the voice of conservationists in support of stable flow conditions and that recognizes climate change as an ominous reality. The scientists have the capacity to estimate hypo-symentric flow inundation effects. Unfortunately, I wonder if they have changed things with many HFE's in ways that do not provide a baseline condition. In ecosystem studies, these are known as reference or control systems that develop during time of the Holocene. It may take some time to build a reference condition that creates the habitat required to enhance like life histories of the invertebrates, etc. If they succeed, fishes will eventually find the prey resources. If gravel conditions develop to the point where fishes will spawn successfully, then monitoring efforts might provide evidence of success. The comparative study proposed by Project 9, and perhaps the drift study offered by Project 5, could offer some guidance in planning derived from tail-water sites where a regular pattern of seasonal or daily fluctuations has a history different from that of the GCe events and HFE effects. The SAs strongly endorse the potential learning from this unique project. If the project scientists implement strong collaboration in data gathering stages and design with Project 5, 9, 11 and especially 12 scientists, it would offer the type of opportunities in science and management integration that can advance science and learning at a much more rapid rate. Mother Nature has a time clock that is modified on an evolutionary scale with internal sensitivity to ecological interactions. That's how the GCe operated before the Anthropocene before when Glen Canyon Dam was constructed and the march of invasive species began.

Project 11: This is a continuation of the new vegetation monitoring and assessment programs supported by the SAs with proposed revisions in the 2013-14 Plan. River corridor vegetation dynamics associated with dam operations can affect physical, biotic, and cultural resources of concern to the AMP. The project uses the generally equivalent background evidence argued about Mother Natures' clock cited in Project 10. Stop the horrendous floods, remove the sediment, make the water cold and clear, and add in the invasion of tamarisk and its leaf beetle plus others that have come on regulated waters with human intervention at all watershed scales. The place was different then and it took millennia to set that clock. And, humans are constantly intervening in its current state in all the physical, biological, and social resources. That is where Mother Nature cast upon the system a more predictable slow changing set of

changes, humans invoke less predictable and much more rapid changes that the system must adjust to. Yet, it is the system we must understand if we plan to manage it while it continues to change toward some new equilibrium. An equilibrium that humans through our own actions keep in at least a moderate a state of flux. Several previously abundant native fish species are now gone. That's an indicative reality. While restoration to some state yet to be fully defined is applauded, it's difficult to imagine or forecast how successful those efforts can be. This is not to discourage the efforts, but the relative successes may offer some guidance to managing rates of change for the creatures and invasive species now known in the aquatic habitats. The experience with terrestrial life forms is an ongoing result of efforts by this group. In many places some but not all of the invaders become established, flourish to levels of strong negative effects on natives, then decline to lower and somewhat stable and lower levels as diseases, parasites, and consumers increase their effects. Battling the invaders is sometimes successful and sometimes not, while the invader persists at lesser levels. Many, many cases like that are known from the literature. The high priority research category shows direct attention to the interaction between hydrology, vegetation, and sediment dynamics. This should be highly relevant to the sedimentologists and the prospects for collaboration with Projects 9 and 10. The SAs support this effort as it has great potential for providing guidance in integrative science and management actions.

Project 12: This project evaluates dam effects on distribution of culturally important plants. This is an important step in science toward policy issues related to tribal traditions and culture, i.e. plants deemed important to Tribes for reasons related to religion, traditions, and culture. There does not seem to be a plant scientist on this team as one of the Investigators. That would seem be important given the basic science questions being asked. However, this project seems to reflect the interest of tribal members in understanding dam management impacts to plant resources of specific importance to tribal members. We are not convinced this project is specified effectively and there are several problems with this project that need to be addressed. First, one of the leading scientists is also working intensively on Project 4 and it difficult to see how effectively she will be able to do both especially since both projects seem to have critical design problems. Second, the project is severely under budgeted in terms of both time and funding. For example, in one day, the list of plants that are of significance to tribes will be identified. Even given the use of prior research this is impossible to do thoroughly in one day (and will condition everything that follows in terms of data collection and management recommendations). Third, there is little reference to the anthropological literature on TEK that could be used to help guide the research. Fourth, although the methods proposed include a mix of qualitative and semi-quantitative approaches it would seem possible for project members to collaborate closely with the collection of quantitative data to be collected in the vegetation assessment program (Project 11). This would further the goal of incorporating more TEK in all of the scientific projects, but would also provide explicit data sharing and discussion of plant community and individual plant distribution changes. The use of citizen scientists in documenting plants and their distribution, as used in Projects 3 and 5, for example, would be exemplary. There is a lost opportunity in this project to use multiple sources of data for analysis for what is an extremely important management issues. Cutting this project completely is unacceptable, however, because it is the only one that explicitly includes tribes in the research, and is one of only two that explicitly addresses cultural resources. However, concern exists that

appropriate science methodology are absent from both project 4 and 12 which are led by the same specialist.

We make several specific recommendations with respect to this plan to make it more doable as well as to ensure future duplication of effort. First, the project should take into account *both* plants and animals. Second, because the project is undoable at the level of funding requested ($35K), these funds should be used instead to fund the first phase of the project— a pilot project to convene a series of meetings to come up with the list of plant and animal resources identified as important to the tribes. This should also include discussion and planning for the implementation of the documentation phase of the plants and animals and their historic and contemporary distributions. That planning should include ways of taking incorporating citizen science and tribal members. In addition, that proposal should include ways of using existing and current data sources from other projects currently being conducted. Finally, this project will seemingly have significant difficulty establishing effect relationships, i.e. causation. In its rewrite perhaps a descriptive analysis should be considered instead.

Project 13: This project presents proposed socio-economic research programs provided through the leadership of GCMRCs newly placed economist. The proposed studies for 2015 for this project emanated in the SEAHG proposed and approved recommendations to the AMWG in 2011/12. Project 13.1, originally recommended by the SEAHG for 2012/13, was proposed for initiation by GCMRC in 2014 with carryover socio-economic funds from 2013-14 ($241K). The socio-economic research ties to GCDAMP goals (page 401), Strategic Science Questions (page 404-405), Core Monitoring Information Needs (CMIN page 405) and two Research Information Needs (RIN, page 405). This assessment of expenditures on recreational fishing and boating in the CRe will be accomplished from surveys originally proposed by NPS. Inclusion of several regional economic specialists in the analysis will assist the project. Project 13.3 represents a proposed SEAHG project for initiation in 2012/13 on tribal resource values in the CRe. It was recommended to the TWG by the SEAHG in 2013 as an originally approved program by the AMWG that is currently not being planned by any agency or group of the AMP. The approaches proposed by GCMRC are similar to general methods originally proposed by SEAHG. Use of focus groups for initial assessments and the Choice Experimental Method are recommended approaches for these types of assessments. Project 13.3 is a project proposed and approved in the SEAHG recommendations to assist in improved decision analysis by the TWG and AMWG. In all of these projects the approaches originally recommended by the SEAHG to the TWG are generally being proposed.

- Project 13.1. The trout fishing study is an achievable beginning and is targeted at a natural resource (trout) that has become more of a priority over the last few years. The whitewater boating study in GCNP provides a critical update to a very old economic study that past research suggests is sensitive to flow regimes. P. 403. We think the two recreation hypotheses put forward are foundational hypotheses that are critical to test. However, we would suggest it might be worth considering an additional hypothesis: that the value of angling Glen Canyon and whitewater boating in Grand Canyon NP will have increased over time due to changes in “improved” dam operations over the last two decades. Of course a one-year survey may have difficulty teasing this out from other events, but we think it would be worth at least considering. The recreation angling and

whitewater boating recreation economic studies used widely accepted methods and largely replicate earlier studies so as to provide comparable data so there should be a very high likelihood of success. The one concern is that the budget for Project Element 13.1, pages 413-414. We do not see funds for the actual printing and mailing of the surveys in this budget. Is AFGD or NPS picking up this cost?
The true merits of the recreation values assessment are revealed by an unfortunate history of very limited research and advisory efforts by socio-economists over the past three decades. In several past SA reviews concerns have been expressed regarding this program shortfall. In reality only flow event related hydropower financial impact assessments by Western Area Power have afforded any glimpse of this programs impacts on resource economic values. The economic surveys that will be used to determine regional expenditures, trip quality for anglers and tourists, direct recreational use values etc. are important to decision making on the Lees Ferry sport fishery. Relating these values to differing operations of GCD will also be valuable. What will be important is to differentiate short and long term operation effects on socioeconomic factors. General approaches proposed are common practice in economic assessments and related outcomes are needed for this program. Costs for the assessments appear reasonable given the diverse expertise of specialists proposed.

The SAs strongly agree that a formal program to assist the AMP in development and use of decision methods is needed. This has been proposed in several SA reviews and the subject of a brief white paper by the SAs on the subject, "Evaluating Decision Support Methods for the GCDAMP". As an outcome of this effort two attributes of preferred DSS by TWG were determined to be user friendly more simplistic models that are easily understood and models that can be readily used by a group in real time, i.e. meetings and workshops. There is an extensive base of literature to support this area, several of which are noted in the above mentioned SA report. It was a recommended area of pursuit proposed by the SEAHG and endorsed by the AMWG. GCMRC in discussions with the SEAHG/TWG has proposed this as a collaborative effort. The SAs encourage that approach as a collaborative effort with the TWG and SEAHG. The goal of the Decision Support System to integrate the physical and biological sciences with economics and address uncertainty using a dynamic model is an important one. (p. 402) However, Project Element team for 13.3 would benefit from seeing the ongoing work of Sandia Labs who are developing a much more general model of the Glen Canyon-Grand Canyon hydropower-natural resource system. It is proposed that this effort would benefit from discussions with Dr. Tom Lowry, systems analyst with Sandia Labs. . Framing (pages 408-410) of the DSS as a cost-effectiveness analysis of humpback chub recovery is a good choice that will increase its acceptability among AMWG and TWG. The reliance on cost-effectiveness in analyzing options for endangered species recovery have been used successfully in the past as well (e.g., spotted owl recovery).
Development of approaches for assessments of Tribal values is important. Although recommended by the SEAHG/ TWG and approved by AMWG, the activity has not been initiated by any entity of the AMP. As such this proposal is encouraged by the SAs. However, how it is accomplished, i.e. a necessity for full engagement of the Tribes in all project elements, is most critical. The manner in which the Tribes hold values must be

first determined through the focus groups proposed. Some resource values expressed by the Tribes may be wholly spiritual, making pursuit of economic values incongruent with Tribal desires. We suggest GCMRC evaluate the work by Failing and others on First Peoples of Canada for more insight into this issue (Failing et. al. 2007).

Project 14: This project overviews administrative costs for the Center, which generally tracks from costs in the 2013-14 programs supported by the SAs. An area of administration that has received some support in the past but appears to receive less support in this plan is the continued need for adaptive management assessments and planning. The EIS/LTEMP will be complete in the 2015 period and will have established significant new policy direction for the AMP. The AMP of necessity must develop new strategic and operational direction to respond effectively. All parties have struggled in this review in trying to sort out what of the total program is long term monitoring efforts that should not be changed in annual reviews, determining which science efforts need to be addressed with PEP assessments, and what alternative programs are best to pursue. We agree that trying to accomplish this without EIS policy guidance would be ineffective. On the other hand when the EIS is complete this will represent a significant administrative need. This is eluded to in several places but we do not see the needed budget emphasis on the effort in 2015 or 2016.

SCIENCE ADVISOR RECOMMENDATIONS

Without question this plan is the most comprehensive and well developed plan ever produced by the GCMRC, including presentation of science linkages to goals, response to Asst. Sec. direction, and stakeholder guidance in specified information needs and critical questions, as well as science review panel concerns. Over the years the stakeholders and managers have asked for increased inquiry based on challenges they face. The wealth of newly created knowledge is almost to the point of overwhelming stakeholders as to how best they can apply this knowledge. This program is about implementing management actions (dam operations, non-native fish control, habitat restoration, translocation of native fish, etc.), and following with iterations of science efforts (monitoring, research) to learn if outcomes can help us reach goals related to desired future conditions. Many iterations are necessary, some lasting 5-10 years, to accomplish desired knowledge and management outcomes. The management and science needs in this AM direction are very challenging with many surprises, and no absolute final independent answer for one resource or even several interacting resources will exist. Instead they are time-space- environment-bound with all factors in constant flux.
The proposed research and monitoring plans capture sufficient complexity of the CRe to be meaningful, and inordinately complex, demonstrating great progress toward integration of understanding across methods and disciplines. This is precisely what is needed to address the GDAMP needs. No plan that addresses this level of physical, biological and social science complexity can be perfect, and both the SAs and the stakeholders are in this process recommending improvements they feel might help the research center on development of future plans.

Many recommendations are mentioned throughout the review report. However, some points deserve second mention here and additional elaboration.

- The complexity, need for and quality of the information in this report is deserving of an executive summary that duplicates in summary form the primary report elements. Although a challenge, it should not exceed 25 pages, with significant dependence on figures and graphs.

- The introduction to the report should be modified, so that it provides a useful guide to the reader. The report is so massive that it needs to have the guide so that it can be easily followed. In chapter 2 we suggest that the authors present a summary of the overall budget either in the introduction or as a new chapter. This should be upfront in the report and consist of only one page. The detailed budget appendix should be retained. It would also be useful to present a short discussion about the collaborative budgeting process, and how decisions were made about allocations among projects, and costs within a program.

- The science advisors feel that significant improvements have occurred in interdisciplinary cooperation and integration of the monitoring and science across programs. Project 10 exemplifies this shift. However, we also note areas where it might be improved. Even where that collaborative process was not mentioned it is intuitive from the list of scientists involved in each project. We support this trend and encourage continuation in the future.
- The SAs feel that this plan although large needs to incorporate additional elements. Missing is an agreed to longer term management and science strategy, agreements on critical management actions and stakeholder AM actions as well as agreements on critical monitoring activities. The SAs propose consideration that in 2016 this plan be revised to incorporate agreements on all of these critical elements. In this manner the GCDAMP will have one major working plan that incorporates strategic and operational management/science/monitoring programs of all active entities. The SAs feel that this could be accomplished with one or two additional chapters to the existing plan.
- The SAs feel that the AM paradigm as applied in the AMP is working well. However, this belief does not therefore mean adaptive management in the GCDAMP does not need improvements. The GCDAMP has many accomplishments which far outweigh its inabilities to gain solutions. It has integrated science and management in ways that address key resource uncertainties and advances understanding about resource dynamics and interactions. However, this program has applied the AM paradigm for 18 years and AM processes should be reviewed and evaluated for change. This assessment of "double-loop" learning in AM programs , i.e. what do we now understand about the shortcomings of AM in this venue that should be modified, is critical to continued use of the management process.
- The plan does not describe well system level uncertainties nor how the management actions will address these uncertainties in a concerted and planned effort. These uncertainties fall into categories such as impacts of climate change and re-connecting to river system issues and opportunities upstream and downstream of the CRe in many biophysical and socioeconomic processes. Rather, the continuing emphasis is on monitoring and assessing actions that are in a constrained ecosystem definition largely derivative of political and legal mandates within that system. Perhaps the AMP is fully aware of this need and is developing both policy and strategic direction apart from this document. Some of this need is surely included in the EIS/LTEMP that is being developed external to the GCDAMP process. Some reference is made to the potential need for science and management revision to this plan once the EIS is completed. That being the case there should be both recognition of this need and budget placeholders to perform the needed work since it is known to be imminent. One potential approach to mitigating this expected need is collaboration with basin wide entities in evaluating threats and opportunities for the basin and

developing a system wide model that can adequately address policy, management and science planning needs.

- It is not clear that optional management treatments were considered in each of the projects. Due to the applied nature of GCMRC research, the SAs agree that it would benefit the proposal authors to create a project proposal template that includes separate sections for scientific rational and management implications under each element, much like that presented in the present proposal for Project 5. Making those linkages explicit would help to promote creative thinking about implementation as research projects are being designed. When such context was presented, in most cases only one management dilemma or scientific approach was presented for resolution. Obviously several options can exist which give more/or less benefit in learning and management resolution associated with greater or lesser costs. Overall, the entire AM cycle will move faster if science-based 'solutions' are always presented with their pros and cons, and alternative approaches to the same end are discussed more openly. In the guidance provided to proposers in the next funding cycle, we also feel there is a need to require more coverage of past results or other concrete context for requesting funding. There is mounting pressure for accountability, and some of the proposed projects with the largest budgets also offer the least rationales for further work. The SAs are not skeptical of the value of these efforts, but rather wish to encourage the proposers to make the most of their existing data in designing the next generation of studies.
- We would ask the AMP program and GCMRC to consider evaluating the social and organizational learning that is part of adaptive management. A few of the projects address this issue, such as the traditional ecological knowledge program for plants. But a more direct overview about modes of learning, repositories of learning (more than web available data or GIS files), would help facilitate the collective understanding and the adaptive management program. In the past, projects such as the State of the Colorado River Ecosystem (SCORE) report, knowledge assessment workshops, and integrative conceptual modeling have been very effective at fostering and facilitating institutional learning within the entire AMP. It is true that GCMRC produces an excellent workshop of its annual accomplishments and therein reflects somewhat on where they are related to uncertainties and learning as referenced to DFCs. Using that knowledge to specify and chart a future direction, i.e. strategic management with stakeholders and managers as noted above is critical.
- The overall budget in the 2013-14 plan seemed suitable from a short term perspective, but the SAs proposed that it might be insufficient in the longer term. The review of the 2015-17 budget creates more of an alarm for the long term for several reasons. These budgets have and are using up savings (carry-overs), base support from USGS, lower cost rents to maintain facilities, etc. to continue to respond to the very complex needs of the system as expressed by stakeholders and managers. Although excellent progress is being made in physical and biological sciences with promise in social sciences, much uncertainty still exists regarding very critical biological resources in the system. These science areas are also the most expensive to pursue. Already some critical areas of research cannot be sustained at desired levels and other potential needed research cannot be started or must be postponed. With the clear knowledge that administrative costs will rise significantly, and the threat that warming water temperatures could require new research efforts we believe the 2018-2020 management and science cycle will be significantly under-funded. Several strategies seem available; increase funding from internal or external sources, define lower requirements and reduce management and science activity, reprogram internally, and evaluate lower cost alternatives. The AMWG needs to consider a management review of the entire AMP management and science program to address future budget needs as well as the AM structure and process being used.
- The SAs support the program administration changes recommended, including the POAHG, Science Advisors and Lake Powell programs. A history of the GCDAMP is something that should be

accomplished at some point. However, we propose future opportunities to accomplish that task when currently limited energies and resources might be better focused on other AMP issues. In the meantime extensive documentation is and will be available to the task. Transfer of the Science Advisor program to BOR seems reasonable. It will be critical that the independence of the group remains inviolate, that its tasks continue to be directed from the full AMWG and that it accomplishes its tasks as defined in its operating procedures. Transfer of the Lake Powell Program to BOR seems appropriate as its future accomplishments lie more in applying its science findings directly to management needs. In major part BOR is currently leading these activities. It will be important that the Lake Powell reservoir and future implications of its management be considered for a new program initiative to evaluate impacts to the Colorado Basin from climate change.

Project 1: The Lake Powell Program, especially in its new administration by the BOR offers great potential for management application of accomplished science. The SAs propose that if the total time and cost of analyzing all biological samples is large, small subsamples should first be analyzed to determine the expected value of additional learning. If it is low perhaps energies and funding should be focused on more rapid application of physical data and analysis to enhance existing and needing modeling efforts. The SAs also propose that a new initiative should be undertaken by the BOR in collaboration with GCMRC and other basin entities. That initiative should focus on basin system assessment and modeling of management needs to mitigate predicted impacts of climate change in the basin.

Project 2: This monitoring project provides critical data and analysis to many other projects and should be considered as an ongoing need over multiple planning periods, i.e. a core monitoring need especially as relates to evaluating impacts of climate change on water temperature. Remote sensing technology continues to advance and as in the past this project should continue to test new technology for application. Although it is mentioned that this project collaborates with programs in cultural resources, it is not made clear how that occurs. This should be made more specific. It is also important that the AMWG evaluate the level of information resolution it needs from this project as it relates directly to increasing costs.

Project 3: The SAs see this as a critical monitoring project and should continue to provide important data and analysis inputs to other important resource areas, including riparian and aquatic habitats and recreation beaches. It provides the critical basis for enhancing modeling capability to both assess sediment balance in the system and predict flow implications to sandbar maintenance over time. Not emphasized is the potential capabilities of this project to integrate with data recovery and assessment related to archeological sites which needs to be included. Modeling efforts should proceed in collaboration with sandbar modeling efforts developed in the EIS/LTEMP process. Because of high sampling costs efforts should continue to adopt advanced remote sensing technology. High program costs dictate that AMWG continue to evaluate both the amount of information needed from this program and its resolution.

Project 4: The SAs feel this is an important project to consider even though it lacks effective science design and the small samples represented in empirical work have not fully validated approaches recommended. Several sets of information should appear in a revised project to help its full evaluation, including: How will it assist NPS and Tribes site mitigation approaches; improving sample size validate approaches; how will qualitative and quantitative data be integrated, etc.

Project 5: This program has developed critically needed understanding of food base in this system. In its ongoing efforts, management needs to know if and how the challenges of evolutionary history can be accommodated and what expectations in this system are realistic. Developing the bottom-up assessments and modeling approaches are helpful in evaluation of the top-down constraints apparent in higher trophic levels. The proposal for sampling work in the upper Colorado River to provide the context for ongoing assessments in the CRe would help validate methods. The mix of laboratory and in-stream experiments to probe basis for EPT existence/low abundance provides the type of science alternatives important to managers in their efforts to support broad based initiatives. Pursuing lab assessments initially to assist design elements of river based experimentation is applauded. Establishing proofs with river based experimentation will be difficult and longer term. The creative implementation of citizen science in these programs should be emulated as possible in other programs.

Project #6. The continued main-stem monitoring of HBC populations, RB, and other native and non-native fishes represents maintenance of needed long term assessments of resources considered critical to the AMP in understanding native and non-native dynamics in the system. Although continued assessments of new monitoring methods and enhancements of analysis modeling efforts are encouraged the project is most critical to advancing learning in this program. The SAs encourage funding of the creel survey in 2015 if the recreational angler survey is to be performed that year, unless the recreational angler survey will collect the creel census data as part of the recreation angler survey. It would be extremely valuable to have creel census data in the same year as the angler survey so that an objective measure of catch per unit effort could be related to angler satisfaction and values analysis. It will also be useful for back-casting trout populations to have consistent time series. Also, it is recommended to remove USGS burden on Cooperator dollars being provided to the GCMRC program. This discourages Cooperators from contributing to projects as it is essentially a tax on it.

Project 7: Elements 7.1-7.5 represent a very focused and complex assessment of adult and juvenile HBC population variance in the LCR and its confluence with the Colorado River. Due to the relative importance of the endangered HBC resource in the AMP program, LCR primary habitats for the species in this system and assumed predator interactions of RBT and juvenile HBC this program must continue to receive primary emphasis. Results over a short time span have yielded significant new understanding related to habitat, competition, predation, etc. Most important are the added values in enhanced modeling. Because of dependence on these modeling outcomes in several management applications it is recommended that publications in process contrast both improvements in model design and predictability of the new model to existing model. The studies to evaluate the effects of CO2 in LCR water and the role of water temperature on the extent of Asian tapeworm effects on juvenile humpback, may or may not play an strong role in HBC growth rates and population dynamics. Due to potential threats to water quality and non-native species introduction in the upper LCR system, a feasibility assessment of potential strategies to minimize impacts from these two factors should be evaluated. This project offers the greatest opportunity to evaluate predator interactions of the two species and should continue to be a significant element of this research.

Project 8: The success in more rapid learning noted for management actions in both non-native fish control and translocations of HBC should be continued in other resources and especially as

applied as collaborative efforts of science and management groups. Assessing most feasible approaches for management/science collaboration in EPT restoration, LCR water quality mitigation ,camping beach reclamation, gravel bed restoration, native vegetation restoration, archeological site restoration etc. could reveal different and more effective joint activities than are currently pursued.

Projects 9 and 10: These projects present the continued monitoring efforts and related research on factors that can induce variances in populations of this sports fishery resource and new investigations on implications of lower flows to critical reproduction habitats, and potentials for downriver migrations and establishment of new populations. This program is important to its contributions in maintaining a healthy sports fishery, but also to greater understanding of these populations ability to transition downstream and impose greater threats to native species in the system.

Project 11: This project proposed and supported by the SAs in the 2013-14 program represents new science in the river and offers promise to several other programs including camping beaches, aquatic habitat, food base, etc. It affords collaborative opportunities for NPS native plant restoration and camping beach reclamation projects.

Project 12. Concern exists regarding effective science design and specification of this project. There does not seem to be a plant scientist on this team as one of the Investigators. That would seem be important given the basic science questions being asked. If budget is a constraint, perhaps a specialist from the NPS could join the team in a collaborative capacity. Project 12 needs to be rethought because it lacks an effective design and is severely underfunded. It should be made more comprehensive with both more anthropological approaches to TEK included as well as integration with the data collection possibilities expressed through other projects with a much higher budget and/or use the funds requested for a pilot project instead. Citizen scientists could also be involved with the research to help with current and historical documentation. In the project rewrite perhaps the project should be specified as a descriptive analysis.

Project 13: Three important programs are presented in this project. All are recommended by the AMWG. Key elements are presented for each that support information needs sought by the AMWG. More emphasis on an initial pilot project to evaluate multiple decision analysis approaches with the TWG should be considered for 13.2 The socio-economics project team undertaking the Decisions Support Modeling (Project 13.3) should see the ongoing work of also consider collaboration with Sandia Labs which is developing a much more general model of the Glen Canyon-Grand Canyon Resource System. Perhaps both efforts would be needed, but collaboration would seem important. Dr. Tom Lowry, a system analyst with the Sandia Lab, is the leader on this project. As proposed 13.3 initial use of tribal focus groups to assist in program specification is critical. The SAs encourage continued engagement of tribal representatives in all stages of the project.

M E M O R A N D U M

To: John Jordan, TWG Chair
Vineetha Kartha, TWG Chair-elect
Shane Capron, Vice TWG Chair

From: Kurt Dongoske, CRAHG Chair

Date: 14 July 2014

RE: Cultural Resource Ad Hoc Group's Recommendations to the Technical Work Group Regarding the 2015-2017 Triennial Work Plan and Budget for the Glen Canyon Dam Adaptive Management Program

At the request of the Technical Work Group, the Cultural Resource Ad Hoc Group (CRAHG) met on 09 July 2014 to discuss the proposed 2015-2017 Triennial Work Plan (TWP) and budget for the Glen Canyon Dam Adaptive Management Program and to generate recommendations/comments back to the Technical Work Group. The meeting was held in a conference room at the United States Geological Survey's Flagstaff Field Station. CRAHG members in attendance were Mary Barger, Reclamation; Ellen Brennan and Jen Dierker, Grand Canyon National Park; Michael Yeatts, Hopi Tribe; Loretta Jackson and Pete Bungart, Hualapai Tribe; Kurt Dongoske, Pueblo of Zuni; Sarah Rinkevich, Tribal Liaison, DOI; Tony Joe, Navajo Nation (via teleconference); Rosemary Sucec, Glen Canyon National Recreation Area (via Teleconference); Diane Austin, Bureau of Applied Research in Anthropology, University of Arizona for the Southern Paiute Consortium (via teleconference), and Lisa Meyers, Western Area Power Administration (via teleconference). Grand Canyon Monitoring and Research personnel in attendance were Scott VanderKooi, Helen Fairley, Joel Sankey, and Daniel Sarr.

The following are the recommendations/comment of the CRAHG to the Technical Work Group:

<u>Bureau of Reclamation's Cultural Resources Work Plan (D.2):</u>

1. <u>Glen Canyon National Recreation Area Monitoring and Mitigation</u> – CRAHG wants to see the actual research design to understand how the proposed GCNRA's monitoring and mitigation would meet Reclamation's compliance responsibilities under the existing programmatic agreement and the proposed new programmatic agreement. Additionally, CRAHG is concerned that monitoring and mitigation approaches be consistent across the entire CRE and that GCNRA and GRCA are part of an overarching plan. CRAHG requested from Reclamation a timeline for activities accomplished for the draft of the new programmatic agreement, identify when the new programmatic agreement will be sent to the participating Tribes for review, and provide a copy of Reclamation's letter to the Arizona State Historic Preservation Officer (AZSHPO) regarding the definition of the new area of potential effects (APE) and any response from the AZSHPO.

2. Reclamation's Support for GCMRC's Project 4 & Project 4: The CRAHG supports GCMRC's project 4, including Reclamation's funding support, as a research effort to address the science questions being asked. However, project 4 does not meet Reclamation's full §106 compliance responsibilities as defined in the existing programmatic agreement. Specifically, project 4 does not adequately address Reclamation's monitoring responsibilities or the involvement of the participating Tribes in the development of a new monitoring plan. The Tribal involvement in the development of the monitoring plan associated with project 4 is not discussed and there are no provisions for funding meaningful Tribal participation in the development of the monitoring plan.
3. TEK Ecological Restoration Project: CRAHG supports this project and encourages a well coordinated effort with the Grand Canyon NPS vegetation program and personnel. The CRAHG also sees some potential for overlap between this project and GCMRC's project 12 and we encourage the project personnel to investigate the potential for integration.
4. Tribal Synthesis: CRAHG supports this project and believes that the request for proposal (RFP) needs to be very specifically worded so that the project's deliverable meets the needs of the adaptive management program. The CRAHG recommends a phased approach to this research effort with the first phase consisting of an overview of existing (national and international) collaborative ecosystem management programs involving Tribal and/or indigenous people. The overview would include identifying those programs which could be the focus of follow-up interviews with managers and indigenous representatives. Based on the information gathered during Phase I, Phase II would entail an analysis of the information and the generation of recommendations to the adaptive management program. CRAHG believes the phased approach would be less costly particularly in the first year and the findings from Phase I may determine that Phase II is not necessary.
5. Annual Integrated River Trip: CRAHG supports this project particularly because it fosters an important exchange of worldviews between Tribal representatives and representatives from the Department of the Interior within the appropriate contextual setting.
6. Non-native Fish Removal Consultation: The CRAHG supports continuing consultation by Reclamation, NPS, and GCMRC with the Tribes regarding any non-native fish removal or "incidental take" of natives or non-natives in any of the AMP programs. The CRAHG recommends that Reclamation consider amending/revising the existing non-native fish control Memorandum of Agreement in consultation with the Tribes because live fish removal does not appear to be a viable mitigative strategy now that whirling disease has been detected in Lees Ferry. This should be accomplished well in advance of the time when triggering criteria are anticipated to be met.
7. Tribal Preparation of Paperwork for DOE of Grand Canyon to the National Register: CRAHG supports this effort because it is viewed as a critical need of the program. Moreover, CRAHG recommends funding consideration for FY15 or 16 if possible.

8. Integrated Tribal Resources Monitoring: CRAHG supports this program.
9. Tribal Participation in GCDAMP: CRAHG supports the continuation of funding support for Tribal participation in the GCDAMP. CRAHG recommends that the DOI agencies investigate increasing the funding support for tribal participation because over the past fifteen years economic costs have dramatically increased by the tribal funding for participation has remained static.

Grand Canyon Monitoring and Research Center's Projects

10. Projects 6.2, 6.4, 8.1, 9.3 & 9.10: CRAHG strongly encourages Reclamation, National Park Service, and Grand Canyon Monitoring and Research Center to consult with the participating Tribes regarding these projects or any projects that involve the intentional euthanasia of non-native or native fish or the unintentional collateral loss of life (not just fish) associated with a research/monitoring project.
11. Project 12. Dam Related-Effects on the Distribution and Abundance of Selected Cultural-Important Plants in the Colorado River Ecosystem: CRAHG recommends moving forward with this project, but greatly expanding the role of the Tribes in identifying specific research avenues to be pursued. This will entail multiple Tribal workshops for the purposes of having the participating Tribes in collaboration with GCMRC design the structure of the research effort. The initial workshop would be followed by compilations and summarization of the data sources by GCMRC as envisioned in the FY 2015-2017 TWP. A second workshop would then be convened with the Tribes to utilize the results of the data compilation to revise and further refine the research effort designed by the Tribes. This project would be a pilot project with an emphasis on exploring the productivity of utilizing historic imagery in Tribal monitoring programs. The CRAHG recommends investigating the benefits of integrating this project with GCMRC's riparian program (Project 11).
12. Project 13.2. Tribal Perspectives for and Values of Resources Downstream of Glen Canyon Dam: CRAHG expressed concern about this research effort and the potential to reduce Tribal cultural values to Western capitalistic terms, a value system applied to this ecosystem that is not shared by the Tribes. CRAHG recommends that GCMRC researchers need to have more in-depth conversations with the Tribes regarding this project during 2014-2015 before it is implemented.

Glen Canyon Dam Technical Work Group WebEx/CC Meeting
August 4, 2014

Conducting: John Jordan, TWG Chair
Shane Capron, TWG Vice-Chair

Convened: 9 a.m. (MDT)

Committee Members/Alternates Present:
Cliff Barrett, UAMPS
Kerry Christensen, Hualapai Tribe
Craig Ellsworth, WAPA
Paul Harms, State of New Mexico
Chris Harris, State of California
Leslie James, CREDA
Vineetha Kartha, State of Arizona
Glen Knowles, Bureau of Reclamation
Ted Kowalski, Colo. Water Conservation Board
Jerry Myers, Federation of Fly Fishers
Don Ostler, State of Wyoming

Committee Members Absent:
Jan Balsom, NPS/GRCA
Charley Bulletts, Southern Paiute Consortium
Todd Chaudhry, NPS/GRCA
Jerry Lee Cox, Grand Canyon River Guides
Kevin Dahl, National Parks Conservation Assn.
Bill Davis, CREDA
Kurt Dongoske, Pueblo of Zuni
Chris Hughes, NPS/GLCA
Tony Joe, Jr., Navajo Nation
Robert King, State of Utah
Bill Stewart, Arizona Game and Fish Dept.
Larry Stevens, Grand Canyon Wildlands Council
Jason Thiriot, State of Nevada
Mark Van Vlack, State of California
Michael Yeatts, Hopi Tribe
Kirk Young, FWS
VACANT, State of Wyoming

Grand Canyon Monitoring and Research Center:
Lucas Bair, Economist
Helen Fairley, Social Scientist
Dave Lytle, SBSC Manager
Ted Melis, Sediment Resources Manager
Jack Schmidt, Center Director
Scott VanderKooi, Biology Program Manager

Interested Persons:
Mary Barger, Bureau of Reclamation
Evelyn Erlandsen, State of Arizona
Dave Garrett, M^{3}Research
Lisa Meyer, WAPA
Clayton Palmer, WAPA
Dr. Sarah Rinkevich, Tribal Liaison DOI
Seth Shanahan, SNWA

Meeting Recorder: Linda Whetton

Welcome and Administrative Mr. Capron. The purpose of today's call is to discuss additional concerns on the FY15-17 TWP revised on August 1, 2014 (posted 8/3/14). Comments will be captured and forwarded to the AMWG for their budget deliberation.

- Mr. Knowles said Reclamation received approval for expenditure of funds for Accusonic flowmeters on the bypass tubes at Glen Canyon Dam.
- Dr. Garrett asked if he could participate in today's call since the SA contract had ended. No funding was being sought from GCMRC so Dave was permitted to join the call.
- Ms. James suggested an update on the Colorado River Total Value Survey be added to the AMWG Agenda (https://www.federalregister.gov/articles/2014/07/09/2014-15987/proposed-information-collection-comment-request-colorado-river-total-value-survey).

Budget Discussion (***Attachment 1***) – Dr. Schmidt gave a PPT on "Final Draft GCMRC Work Plan and Budget FY15/16/17." He provided a breakdown for costs for FY13 and FY14 and presented changes to GCMRC's budget since mid-July. Referring to a pie chart, he said every category includes a 16% burden or indirect cost rate. At this point in time, GCMRC has balanced budgets for FY 15, 16, and 17:

Fiscal Year	Total Budget	GCDAMP Budget	GCMRC Carryover	Other/BOR
2015	$9,548,100	$8.7 million		$0.8 million
2016	9,859,600	$9.0 million	$0.1 million	$0.5 million
2017	$9,806,100	$9.3 million		$0.5 million

GCMRC's budget is broken down into the following categories by fiscal year and burden rate:

	FY15	FY16	FY17
Geophysical Sciences	35%	35%	38%
Aquatic & Fish Science	42%	41%	36%
Vegetation	6%	6%	5%
Socioeconomics	2%	2%	3%
Admin/Support	16%	16%	18%
Burden Rate	15.6%	11.3%	27.4%

He encouraged people to read the Chapter 2 introduction as it has undergone substantive revision. One of SA criticisms was that the program wasn't well connected to earlier documents, especially the Core Monitoring Plan. The staff did a great job linking the work being proposed to the CMP of February 2011, and also expanded the linkages with the DFCs. The SA had also suggested cycling back in the 3-year budget to revisit some of the important documents and continue to evaluate the present activities of GCMRC in relation to the earlier documents. He didn't want to wait on doing that so his staff re-evaluated those documents and placed this program in that framework.

Using the Desired Future Conditions Report he exerted some of the main DFC criteria just to remind people how diverse the range of issues are in the ecosystem. One way to think of the DFCs is to think of them as the active channel of the Colorado River. The active channel of a river is a very standard conceptual term and it's the part of the river that involves the active bare sandbars and channel beds and the edges of the river that are defined by the common floods. We have resources that occur above the active channel, resources within the active channel, and also keep in mind the concern of elevation of the riparian vegetation and the degree to which it continues to invade into the channel and make the active channel smaller. The active channel was much bigger prior to completion of Glen Canyon Dam and what is the response of riparian vegetation to that flood regime. They're learning the short duration HFEs (3 days) do not keep riparian vegetation from invading lower into the channel and the channel is shrinking. In chapter 2, they looked at which DFCs they think the TWP is responsive to and which ones less so or not at all. For instance, there is no part of this work plan that could be construed as evaluating the DFC to re-establish fishes extirpated from Grand Canyon. They explicitly why and don't believe there is TWG consensus for the program to marshal budget and resources at this time to study that.

He reviewed the principles in budget development and the guidelines for prioritization of projects and said staff were encouraged eliminate budget, particularly in aquatic and fish science monitoring. GCMRC, USFWS, and AGFD were subjected to a tremendous amount of pressure to look for duplicate efforts. All proposed monitoring took precedence over all proposed research. One thing that meant is that proposed monitoring in riparian vegetation, which is only tangentially mentioned in the HFE Protocol and NNFC EAs, took precedence over critical research to resolve some other issues of interactions that occur in the aquatic and fish communities.

In developing the FY16-17 budgets: (1) GCMRC prioritized the monitoring and research activities, (2) Made a number of research projects 2-year projects rather than 3-year projects, (3) Delayed the start times of other projects, and (4) removed some projects from proposed AMP funding. Jack said he got to a point where he wasn't comfortable cutting anymore projects. The AMP funding is going to require the principle investigators to reduce their overall budget requests in FY16 by 7% and in FY17 by 5%. They're proposing to do everything that is described. GCMRC was criticized by the TWG for not revealing how they were going to deal with the prioritization of projects in FY16 and 17 and for not presenting a *balanced budget* for those years. They revised Appendix 2a which reflects how each project stands in the 3-year cycle. In Appendices, 2c, 2d, and 2e, they have the "guts" of each project (salaries, logistics, etc.).

The following tables reflect changes and/or comments on the FY15-17 TWP:

Project 1: Reservoir Water Quality Program

FY	Proposed Budget	Comments

15		GCMRC is requesting $20K to fund a science review panel to evaluate past studies of reservoir physical limnology and ecology that have focused on Lakes Powell or Mead.
16		
17		

Project 2: Stream flow, water quality, and sediment transport

FY	Proposed Budget	Comments
15	$1.34 million	No significant changes.
16	$1.35 million	Funded at 95% of work to be done by David Topping.
17	$1.46 million	

Project 3: Sandbars and sediment storage dynamics…

FY	Proposed Budget	Comments
15	$1.33 million	No significant changes.
16	$1.27 million	GCMRC won't mettle in how work is being done by different PIs. All work will be funded at 93% but not sure of 7% or 5% cuts, or if some projects will be cut more or less. Will look for cost savings but not changes in work.
17	$1.37 million	

Project 4: Quantifying the relative importance of river-related factors that influence upland geomorphology and archaeological site stability

FY	Proposed Budget	Comments
15	$0.34 million	GCMRC took all of its carryover in FY14 and has allocated it to the purchase of a ground-based lidar to facilitate work in FY16-17 for this project. This amount of money was removed from FY15 budget because they're taking that money out of FY14 carryover. Work in Project 4.2 will be in the development of a monitoring plan in FY15.
16	$0.57 million	In Project 4.2, AMP the request in FY15 is $48K, but $174K was requested for purchase of equipment which was taken out of carryover money so it dropped out of FY15 budget. Yet, the budget is FY16 and 17 are substantial. Will also be receiving supplemental out of BOR cultural funds.
17	$0.59 million	

Project 5: Food base monitoring and research

FY	Proposed Budget	Comments
15	$0.52 million	There were small changes in the distribution in the food base project. Funding is not identified in Project 5.1.6. GCMRC is working with WAPA to seek funding ($180K) to support field work that allows comparison between ecosystem processes in Grand Canyon and those in Red Canyon downstream from Flaming Gorge that isn't part of this AMP project.
16	$0.55 million	Are proposing that projects 5.1.3, 5.1.4, and 5.1.5 be 2-year research projects rather than 3 years. The third year of support was dropped as the same in 5.2.3 and 5.3.1. Everything that is in **bold and italics** will be subject to a 7% cut in FY16 and a 5% cut in FY17. If it's not in bold, it's unfunded at this time. Items dropped in FY17 were efforts in synthesizing available information that could be done in 2 yrs.
17	$0.57 million	

Project 6: Main-stem Colorado River humpback chub aggregations and fish community dynamics

FY	Proposed Budget	Comments
15	$0.67 million	There aren't any major changes here. We had proposed to use some of the NNFCC to fund some NF projects to help balance the budget. Since we're out several years to trigger any management actions, they thought it would be worthwhile to use some of that funding to ensure they could conduct some of the research projects focused on native fish.
16	$0.65 million	Dropping funding in project 6.2. Everything else is subject to a 7% or 5% reduction. This is dropping support to sister agencies, such as 6.1 and 6.4. BOR committed to GCMRC in the budget cycle this time next year they would re-evaluate and could portray that those projects may be continued for funding from the NNFC. There are five projects that GCMRC would propose to be funded (6.2, 6.3, 7.6, 7.7, and 7.9). Currently, they are unfunded. Jack will put an * in those
17	$0.70 million	

		cells in the FY16 budget and note "contingent on approval from BOR." In the event that BOR doesn't approve the $300K, GCMRC will reprioritize because the program needs to find a way to fund those projects. These are HIGH priority items but unfunded at this time, but are expected to be funded and other lower priority projects will drop off even though they're not being identified now.

Project 7: Population ecology of humpback chub in and around the Little Colorado River

FY	Proposed Budget	Comments
15	$1.55 million	There are small differences of less than 5% on how funds were reallocated among these elements. There are no changes to the elements.
16	$1.60 million	Virtually every project except project 7.6 down will continue on because they think the work is very important.
17	$1.30 million	Will be using NNFC (from BOR) to support projects in 15. They're proposing a decrease of that fund in FY16. If in FY16 they hit the trigger and have to implement NNFC, then the FY16 budget will need to be revised as there will be about $300K of projects that can't be funded. BOR would be willing to consider using NNFC funds in the event the trigger and criteria are not met. If NNFC funds aren't available, then the budget will need to go through a prioritization process. BOR committed to GCMRC in the budget cycle this time next year they would re-evaluate and could portray that those projects may be continued for funding from the NNFC. There are five projects that GCMRC would propose to be funded (6.2, 6.3, 7.6, 7.7, and 7.9). Currently, they are unfunded. Jack will put an * in those cells in the FY16 budget and note "contingent on approval from BOR." In the event that BOR doesn't approve the $300K, GCMRC will reprioritize because the program needs to find a way to fund those projects. These are HIGH priority items but unfunded at this time, but are expected to be funded and other lower priority projects will drop off even though they're not being identified now.

Project 8: Experimental actions to increase abundance and distribution of native fishes in Grand Canyon

FY	Proposed Budget	Comments
15	$0.19 million	No significant changes.
16	$0.21 million	
17	$0.28 million	

Project 9: Understanding factors determining recruitment, population size, growth, and movement of rainbow trout in Glen and Marble Canyons

FY	Proposed Budget	Comments
15	$1.01 million	Scott reported there were some discussions with Bill Stewart about the monitoring of RBT in Lees Ferry. GCMRC's initial proposal was to end what they thought was duplicative sampling. There was concern about the loss of continuity of a long-term dataset. They came to an agreement to move funding assigned to AGFD from a couple of projects into project 9.1 so they could continue the Lees Ferry RBT electrofishing surveys in through FY15 and then are planning a PEP panel on the fisheries program to evaluate proposed changes. The natal origins and juvenile chub monitoring studies that GCMRC has been conducting with Dr. Korman ends in FY16 (end of 5-year agreement). There are some funding levels in FY17 related to the end of that project and based on the outcome of the PEP panel in early FY16, GCMRC and its cooperators need to decide on how the monitoring of trout in Glen Canyon and monitoring of juvenile chub in Marble Canyon changes in FY17 with the sunsetting of that project.
16	$1.02 million	
17	$0.74 million	Similar to what is proposed in FY15, there are a couple of projects that are being proposed to fund at a reduced level. Discussions with the PIs indicated they could make progress at a reduced level. These would be funded at half the original proposed level, FY15-17. Mike Yard had proposed a morphological study under feeding fish and they've decided to postpone that indefinitely. Another change is a study by Kim Dibble on lipid reserves in trout is only budgeted for FY15 and then ends. One other change is David Ward's laboratory studies evaluating turbidity

		and its effects on rainbow trout and their ability to feed on prey items including juvenile HBC – only proposing that work through FY16.

Project 10: Where does the Glen Canyon Dam rainbow trout tailwater fishery end? – integrating fish and channel mapping data below Glen Canyon Dam

FY	Proposed Budget	Comments
15	$0.15 million	Based on stakeholder feedback at the TWG meeting/webEx, they propose to fully fund this effort.
16	$0.15 million	Funded at 93% and 95% for 3 years.
17	$0.13 million	

Project 11: Riparian vegetation studies: ground-based and landscape-scale riparian vegetation monitoring and plant response-guild research associated with sandbar evolution and wildlife habitat analysis

FY	Proposed Budget	Comments
15	$0.49 million	No changes made.
16	$0.51 million	Funded at 93% and 95% for 3 years.
17	$0.48 million	Project 11.4 generated stakeholder concern (Yackulic) to look at changes in the active channel ecosystem related to the food base and emerging insections carries over into the terrestrial ecosystem. Funding is being reduced in FY15 and ramping up in FY16 and 17. Some stakeholders were skeptical about the value of this. GCMRC is trying to be responsive to other stakeholders particularly the tribes that keep emphasizing the need to understand the impacts to the upper elevation terrestrial ecosystem.

Project 12: Dam-related effects on the distribution and abundance of selected culturally-important plants in the Colorado River ecosystem

FY	Proposed Budget	Comments
15	$0.05 million	Based on feedback from stakeholders, particularly the tribes, there was a small amount of unfunded, but this project is now fully funded in FY15.
16	$0.08 million	Funded at 93%.
17		

Project 13: Socio-economic monitoring and research

FY	Proposed Budget	Comments
15	$0.18 million	Project 13.1. Clayton suggested the SEAHG and scientists hold an initial meeting to discuss the project in more detail and that any reference to SEAHG involvement needs to be stated in the BWP. Lucas concurred and said the BWP would be changed accordingly. Project 13.3. Leslie said in Chapter 2, top of page 64, the language just prior to this excerpt there is discussion about tradeoffs, which may not always be equal to "foregone hydropower." She believes that is sufficient to describe what is desired out of the model, as well as specifically citing the DFC language, which uses "consistent with," not "to meet other." She offered: ~~The analytical methods, predictive models in the decision support system, will provide a platform to identify the least cost approach (i.e., foregone hydropower) to meet other DFCs.~~ The research in TWP Project 13 is consistent with the goal and objective of the power DFC. ~~and~~ ~~with the Record of Decision's goal of not maximizing benefits but determining an operation at Glen Canyon Dam that limits impact to hydropower while meeting recovery and long-term sustainability of downstream resources~~.
16	$0.20 million	Tribal value assessments. This has been controversial and the subject of substantial angst and concern on the part of the tribes. In a world in which we're short on money and a world in which there is potential opposition on the part of the tribes or at least questions and concerns. This was moved to the "unfunded" category but is being proposed for funding in FY17 hoping that 2 years of dialogue with the tribes can build up enough trust and build up a revised arrangement for how that work carries forward.
17	$0.34 million	

Project 14: Geographic information systems, services, and support

FY	Proposed Budget	Comments
15	$0.22 million	No changes.
16	$0.22 million	
17	$0.24 million	

Project 15: Administration and Support

FY	Proposed Budget	Comments
15	$1.30 million	No changes.
16	$1.33 million	
17	$1.48 million	

Jack said that essentially every project was edited and revised in July to be responsive to the comments they heard from TWG, the SA, and other groups. They've tried to take on some bigger issues in explaining what they're doing in geomorphology. They developed a document to be released tomorrow called "Response to Reviewer Comments" (***Attachment 2***, with AFGD comments as it was accidentally omitted).

Additional Edits for the Final TWP:

- The project identifier "3" is a typo and shouldn't be in the budget tables.
- Asterisks (*) will be placed next to items that are non-AMP power revenues. For example, water quality that is supported with Reclamation funds and cultural resource work that is funded from BOR power revenues.

SA Contract. Since the SA contract has ended, Shane asked who would be giving the SA report at the AMWG meeting. Reclamation won't have the new SA contract in place until October. Glen deferred to Dave or Jack on how to secure funding for Dave's participation at the meeting. Shane felt strongly it would be important to have a funding mechanism in place that would allow Dave to provide the SA Report and also explain how the TWP was modified to address their comments.

Next Steps. GCMRC will develop an "addendum" page of edits captured at today's meeting and at the AMWG meeting and incorporate into the final version of the TWP.

Public Comments: None.

Adjourned: 12 noon

Respectfully submitted,

Linda Whetton
Bureau of Reclamation
Upper Colorado Region

Key to Glen Canyon Dam Adaptive Management Program Acronyms

ADWR – Arizona Dept. of Water Resources
AF – Acre Feet
AGFD – Arizona Game and Fish Department
AIF – Agenda Information Form
AMP – Adaptive Management Program
AMWG – Adaptive Management Work Group
AOP – Annual Operating Plan
ASMR – Age-Structure Mark Recapture
BA – Biological Assessment
BAHG – Budget Ad Hoc Group
BCOM – Biological Conservation Measure
BE – Biological Evaluation
BHBF – Beach/Habitat-Building Flow
BHMF – Beach/Habitat Maintenance Flow
BHTF – Beach/Habitat Test Flow
BIA – Bureau of Indian Affairs
BO – Biological Opinion
BOR – Bureau of Reclamation
BWP – Budget and Work Plan
CAHG – Charter Ad Hoc Group
CAP – Central Arizona Project
GCT – Grand Canyon Trust
CESU – Cooperative Ecosystems Studies Unit
cfs – cubic feet per second
CFMP – Comprehensive Fisheries Management Plan
CMINS – Core Monitoring Information Needs
CMP – Core Monitoring Plan
CPI – Consumer Price Index
CRBC – Colorado River Board of California
CRAHG – Cultural Resources Ad Hoc Group
CRCN – Colorado River Commission of Nevada
CRE – Colorado River Ecosystem
CREDA – Colorado River Energy Distributors Assn.
CRSP – Colorado River Storage Project
CWCB – Colorado Water Conservation Board
DAHG – Desired Future Conditions Ad Hoc Group
DASA – Data Acquisition, Storage, and Analysis
DBMS – Data Base Management System
DOE – Department of Energy
DOI – Department of the Interior
DOIFF – Department of the Interior Federal Family
EA – Environmental Assessment
EIS – Environmental Impact Statement
ESA – Endangered Species Act
FACA – Federal Advisory Committee Act
FEIS – Final Environmental Impact Statement
FRN – Federal Register Notice
FWS – United States Fish & Wildlife Service
FY – Fiscal Year (October 1 – September 30)
GCD – Glen Canyon Dam
GCES – Glen Canyon Environmental Studies
GCT – Grand Canyon Trust
GCMRC – Grand Canyon Monitoring & Research Center
GCNP – Grand Canyon National Park
GCNRA – Glen Canyon Nat'l Recreation Area
GCPA – Grand Canyon Protection Act
GLCA – Glen Canyon Nat'l Recreation Area
GRCA – Grand Canyon National Park
GCRG – Grand Canyon River Guides
GCWC – Grand Canyon Wildlands Council
HBC – Humpback Chub (endangered native fish)
HFE – High Flow Experiment
HMF – Habitat Maintenance Flow
HPP – Historic Preservation Plan
IG – Interim Guidelines
INs – Information Needs
KA – Knowledge Assessment (workshop)
KAS – Kanab Ambersnail (endangered native snail)
LCR – Little Colorado River
LCRMCP – Lower Colorado River Multi-Species Conservation Program
LTEMP – Long-Term Experimental and Management Plan
LTEP – Long Term Experimental Plan
MAF – Million Acre Feet
MA – Management Action
MATA – Multi-Attribute Trade-Off Analysis
MLFF – Modified Low Fluctuating Flow
MO – Management Objective
MRP – Monitoring and Research Plan
NAU – Northern Arizona University (Flagstaff, AZ)
NEPA – National Environmental Policy Act
NHPA – National Historic Preservation Act
NNFC – Non-native Fish Control
NOI – Notice of Intent
NPCA – National Parks Conservation Association
NPS – National Park Service
NRC – National Research Council
O&M – Operations & Maintenance (USBR Funding)
PA – Programmatic Agreement
PBR – Paria to Badger Creek Reach
PEP – Protocol Evaluation Panel
POAHG – Public Outreach Ad Hoc Group
Powerplant Capacity = 31,000 cfs
R&D – Research and Development
RBT – Rainbow Trout
RFP – Request for Proposal
RINs – Research Information Needs
ROD Flows – Record of Decision Flows
RPA – Reasonable and Prudent Alternative
SA – Science Advisors
Secretary – Secretary of the Interior
SCORE – State of the Colorado River Ecosystem
SHPO – State Historic Preservation Office
SOW – Statement of Work
SPAHG – Strategic Plan Ad Hoc Group
SPG – Science Planning Group
SSQs – Strategic Science Questions
SWCA – Steven W. Carothers Associates
TCD – Temperature Control Device
TCP – Traditional Cultural Property
TEK – Traditional Ecological Knowledge
TES – Threatened and Endangered Species
TMC – Taxa of Management Concern
TWG – Technical Work Group
UCRC – Upper Colorado River Commission
UDWR – Utah Division of Water Resources
USBR – United States Bureau of Reclamation
USFWS – United States Fish & Wildlife Service
USGS – United States Geological Survey
WAPA – Western Area Power Administration
WY – Water Year

(Updated: 2/20/2014)

Final Draft GCMRC Work Plan and Budget FY15/16/17

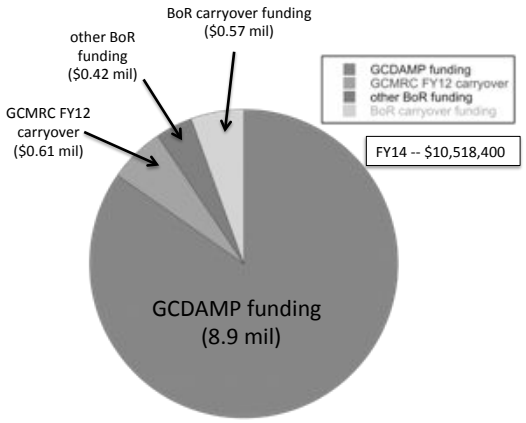
Grand Canyon Monitoring and Research Center
Southwest Biological Science Center
August 2014

FY 13: $10,441,000 total budget

GCDAMP funds = $8,546,000 (other sources GCDAMP carryover, BoR carryover, GCMRC carryover

FY14 -- $10,518,400

GCDAMP funds = $8,915,000 (other sources GCDAMP carryover, BoR carryover, GCMRC carryover)



FY15
$9,548,100 total budget

$8.7 million GCDAMP
$0.8 million (other BoR)

FY16
$9,859,600 total budget

$9.0 million GCDAMP
$0.1 million GCMRC carryover
$0.7 million (other BoR)

FY17
$9,806,100 total budget

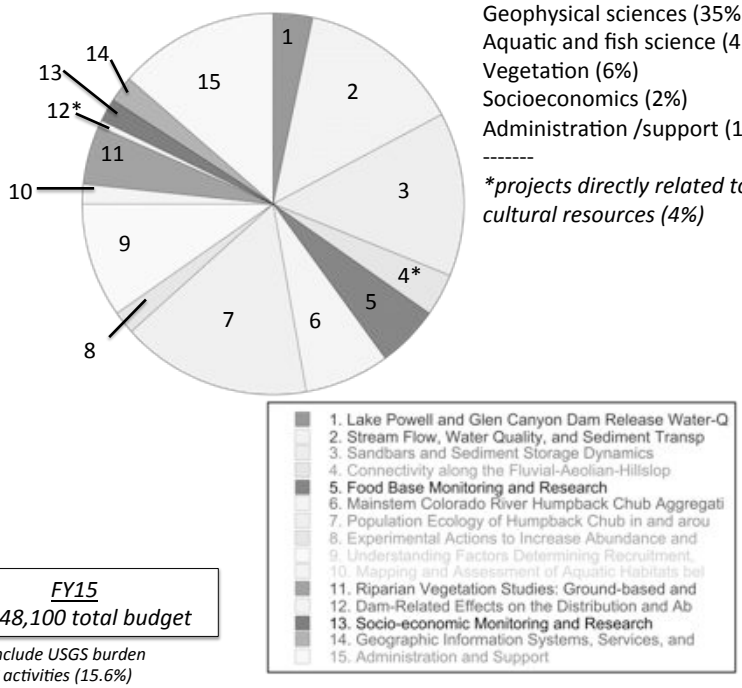
$9.3 million GCDAMP
$0.5 million (other BoR)

FY 13: $10,441,000 total budget

GCDAMP funds = $8,546,000 (other sources GCDAMP carryover, BoR carryover, GCMRC carryover

FY14 -- $10,518,400

GCDAMP funds = $8,915,000 (other sources GCDAMP carryover, BoR carryover, GCMRC carryover)

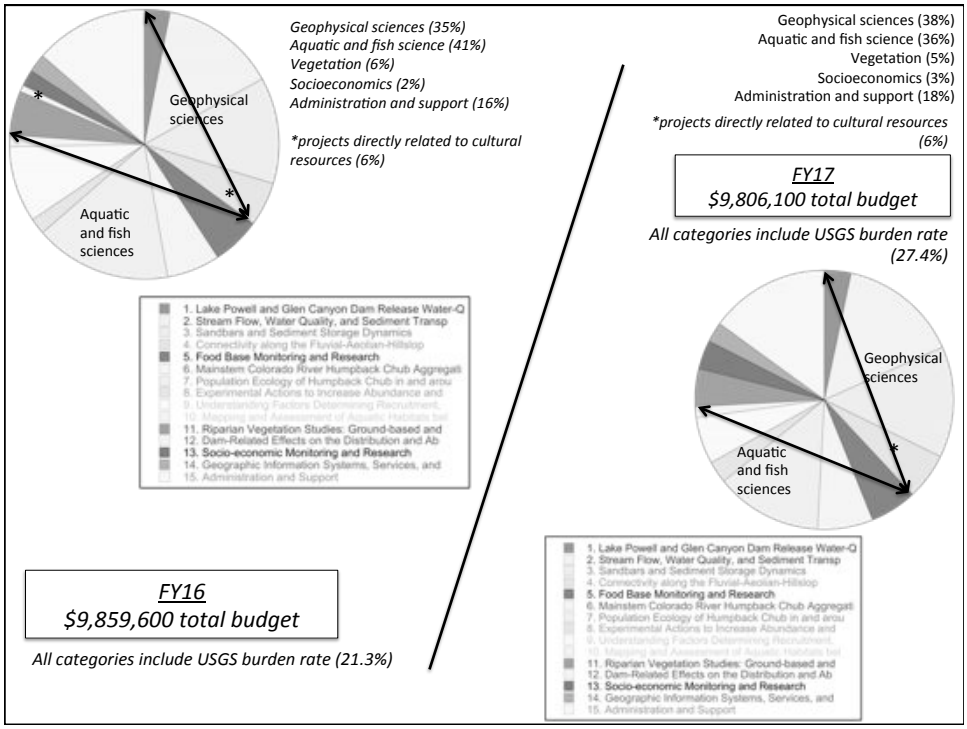


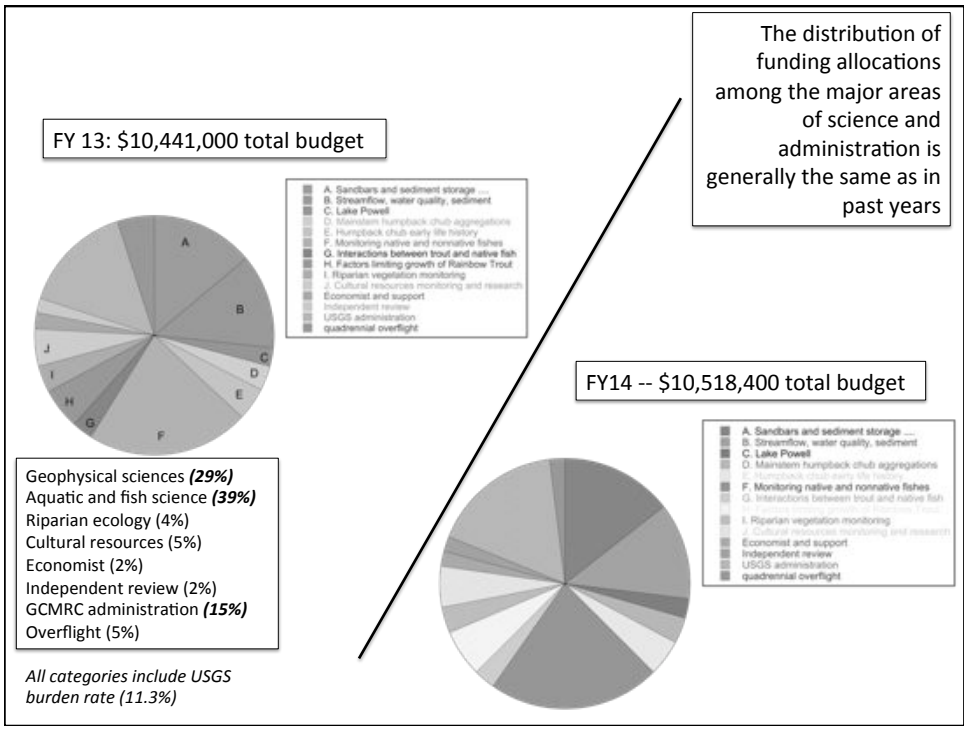
Geophysical sciences (35%)
Aquatic and fish science (42%)
Vegetation (6%)
Socioeconomics (2%)
Administration /support (16%)

**projects directly related to cultural resources (4%)*

FY15
$9,548,100 total budget

All categories include USGS burden rate on GCMRC activities (15.6%)


Geophysical sciences
Aquatic and fish sciences
*
*
Geophysical sciences (35%)
Aquatic and fish science (41%)
Vegetation (6%)
Socioeconomics (2%)
Administration and support (16%)
*projects directly related to cultural resources (6%)
1. Lake Powell and Glen Canyon Dam Release Water-Q
2. Stream Flow, Water Quality, and Sediment Transp
3. Sandbars and Sediment Storage Dynamics
4. Connectivity along the Fluvial-Aeolian-Hillslop
5. Food Base Monitoring and Research
6. Mainstem Colorado River Humpback Chub Aggregati
7. Population Ecology of Humpback Chub in and arou
8. Experimental Actions to Increase Abundance and
9. Understanding Factors Determining Recruitment,
10. Mapping and Assessment of Aquatic Habitats for
11. Riparian Vegetation Studies: Ground-based and
12. Dam-Related Effects on the Distribution and Ab
13. Socio-economic Monitoring and Research
14. Geographic Information Systems, Services, and
15. Administration and Support
FY16
$9,859,600 total budget
All categories include USGS burden rate (21.3%)
Geophysical sciences (38%)
Aquatic and fish science (36%)
Vegetation (5%)
Socioeconomics (3%)
Administration and support (18%)
*projects directly related to cultural resources (6%)
FY17
$9,806,100 total budget
All categories include USGS burden rate (27.4%)
Geophysical sciences
Aquatic and fish sciences
*
1. Lake Powell and Glen Canyon Dam Release Water-Q
2. Stream Flow, Water Quality, and Sediment Transp
3. Sandbars and Sediment Storage Dynamics
4. Connectivity along the Fluvial-Aeolian-Hillslop
5. Food Base Monitoring and Research
6. Mainstem Colorado River Humpback Chub Aggregati
7. Population Ecology of Humpback Chub in and arou
8. Experimental Actions to Increase Abundance and
9. Understanding Factors Determining Recruitment,
10. Mapping and Assessment of Aquatic Habitats for
11. Riparian Vegetation Studies: Ground-based and
12. Dam-Related Effects on the Distribution and Ab
13. Socio-economic Monitoring and Research
14. Geographic Information Systems, Services, and
15. Administration and Support


The distribution of funding allocations among the major areas of science and administration is generally the same as in past years
FY 13: $10,441,000 total budget
A
B
C
D
E
F
G
H
I
J
A. Sandbars and sediment storage ...
B. Streamflow, water quality, sediment
C. Lake Powell
D. Mainstem humpback chub aggregations
E. Humpback chub early life history
F. Monitoring native and nonnative fishes
G. Interactions between trout and native fish
H. Factors limiting growth of Rainbow Trout
I. Riparian vegetation monitoring
J. Cultural resources monitoring and research
Economist and support
Independent review
USGS administration
quadrennial overflight
Geophysical sciences (29%)
Aquatic and fish science (39%)
Riparian ecology (4%)
Cultural resources (5%)
Economist (2%)
Independent review (2%)
GCMRC administration (15%)
Overflight (5%)
All categories include USGS burden rate (11.3%)
FY14 -- $10,518,400 total budget
A. Sandbars and sediment storage ...
B. Streamflow, water quality, sediment
C. Lake Powell
D. Mainstem humpback chub aggregations
F. Monitoring native and nonnative fishes
G. Interactions between trout and native fish
I. Riparian vegetation monitoring
J. Cultural resources monitoring and research
Economist and support
Independent review
USGS administration
quadrennial overflight

Annual Reporting meeting and knowledge assessment
Technical Work Group meeting
TWG Budget Ad Hoc Group webinar
Adaptive Management Work Group meeting

Initial identification of potential projects (Mar)

Technical Work Group meeting
TWG Budget Ad Hoc Group webinar
GCMRC/tribes meeting

TWP Prospectus (May 9)

Budget Ad Hoc Group webinar *(May 20)*
GCMRC/tribes meeting *(May 22)*
Adaptive Management Work Group webinar *(May 27)*

First draft TWP (June 6)

Stakeholder and Science Advisors review *(June)*
Technical Work Group meetings *(June 24-25, July 15)*

Final draft TWP (August 1)

Important meetings that affected development of FY15/16/17 TWP

The Big Questions in Applied River Science …

What is the largest amount of fine sediment that can occur along the banks of the Colorado River, especially as eddy sandbars?

What flow regime, in relation to the natural supply of fine sediment from tributaries, results in the most widespread distribution of fine sediment along the channel banks and in eddies?

Do larger amounts of fine sediment along the channel banks and in eddies significantly change the amount and distribution of fine sediment that occurs above the active channel and that occurs at or near archaeological sites?

What management strategies should be employed to maintain a high quality rainbow trout fishery in Glen Canyon while protecting, and potentially recovering, the endangered humpback chub fish community in Marble and Grand Canyons?

Questions, Expectations, Concerns

Assistant Secretary's Guidance concerning research and monitoring priorities in GCMRC science planning (March 2011 and May 2014 memos)

2011 Desired Future Conditions Ad Hoc Group
(April 30, 2012: SoI directed AMWG "to utilize these DFCs to inform and guide the AMWG's future considerations")

Secretarial Directive concerning Environmental Assessments and related Science Plans for (1) High-flow Experimental Releases, and (2) Non-native Fish Control (May 23, 2012: "*I direct … USGS … to undertake coordinated implementation of the actions and commitments described and analyzed in the Environmental Assessments …*")

GCDAMP Documents and Guidance:

Core Monitoring Plan (February 2011, draft)
Strategic Science Plan (April 2009)
Monitoring and Research Plan (April 2009)
Priority Questions (5) and Program Goals (12) (August 2004)

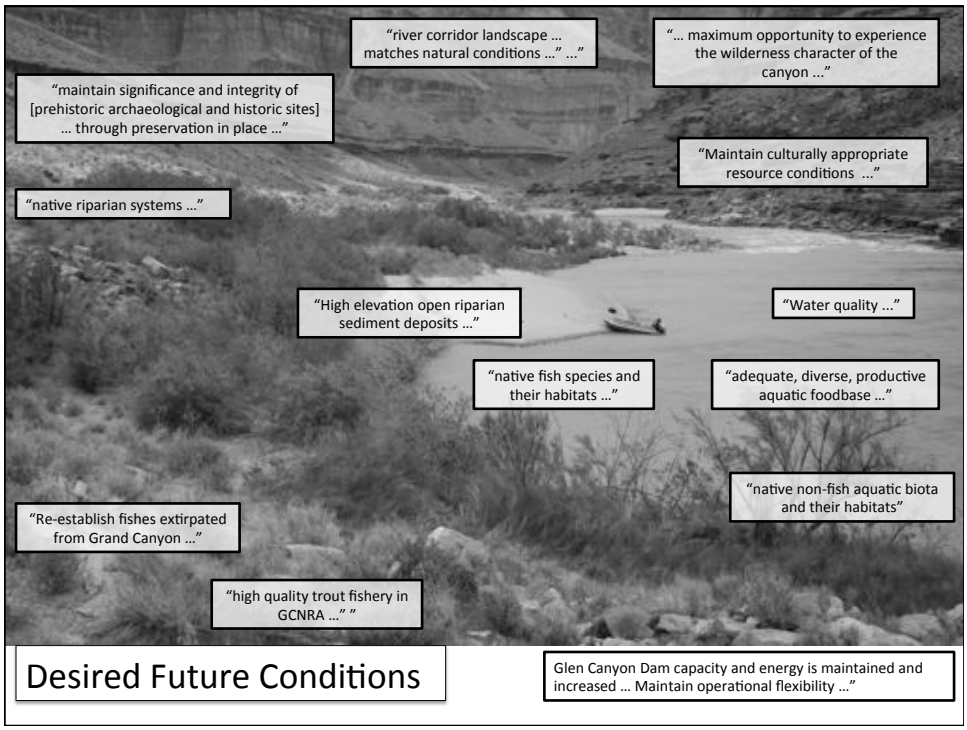
Recent Guidance from Secretary's Designee Regarding Triennial Budget Process and Science Planning Priorities

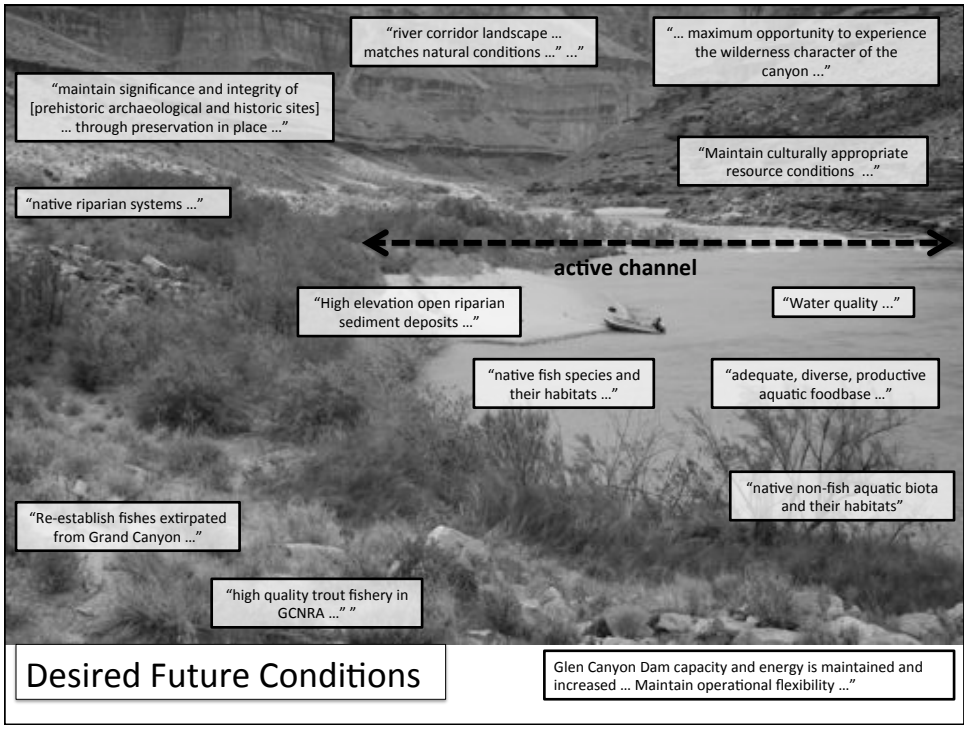
- "science relevant to compliance with Endangered Species Act, particularly relative to native fish and humpback chub"
- "science informing … compliance with the Grand Canyon Protection Act, especially the sediment resource"
- "science on non-native fish control and the recreational trout fishery"

science priorities originally described in March 2011 for which "the need for this science continues"

- "the evolving issue related to cultural/archaeological resources as linked to modern river processes"; "understanding … how cultural and archaeological sites are linked to modern river processes"
- "the role of Traditional Ecological Knowledge in contributing to scientific understanding and river operations"
- "other investigations for which there is "widespread support and further the purposes of the Adaptive Management Program"
- "continue … long-term monitoring of core ecosystem components"

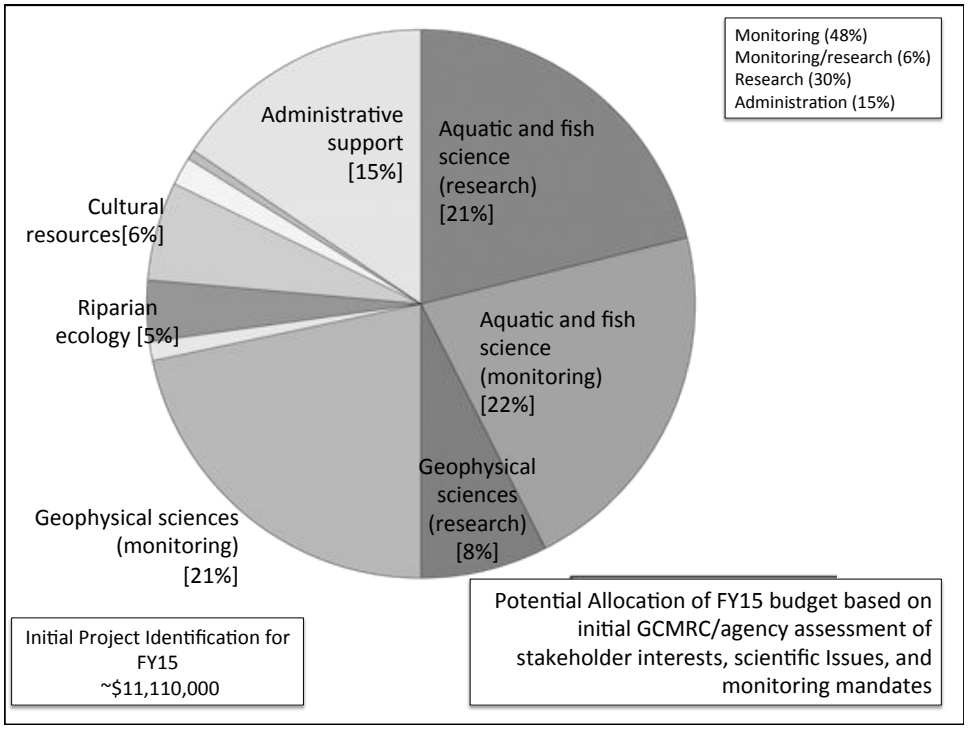
"within the relevant budget constraints"





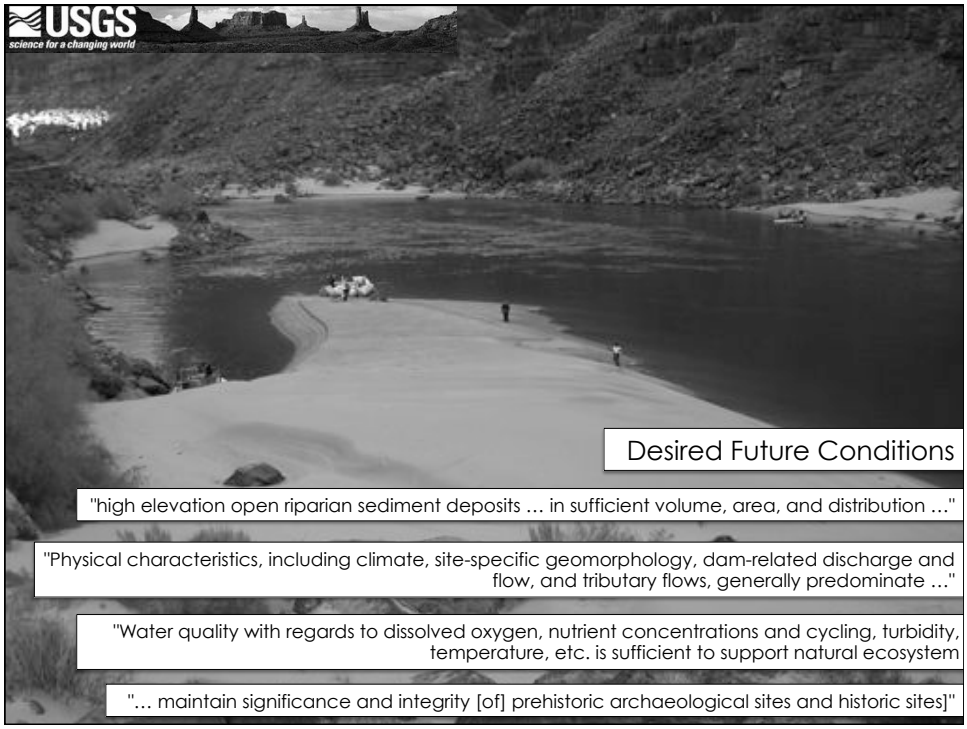
Principles in Budget Development

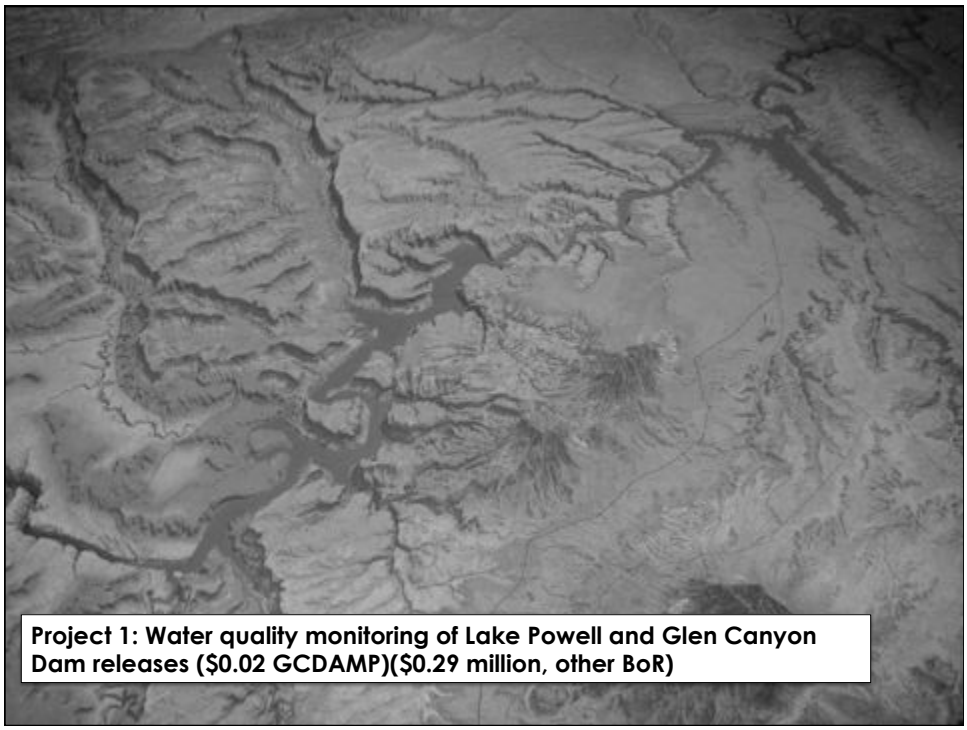
- Each project **comprehensively focus**es on a particular resource and/or specific questions; each project focuses on key monitoring activities and resolving key management uncertainties.
- To the degree possible, **projects should** reference each other and **be linked** with each other.
- Research projects should consider **cost effective strategies to resolve knowledge uncertainties**. Field-scale experiments should be avoided unless based on previous laboratory experiments, literature reviews, innovative data analysis, and/or comparative studies of other rivers
- **Collaborate** with land, species, and water management agencies. Pursue cost effective monitoring strategies.
- Report the **full cost** of each project (i.e., incorporate logistics and remote sensing/GIS costs in the associated science activity)



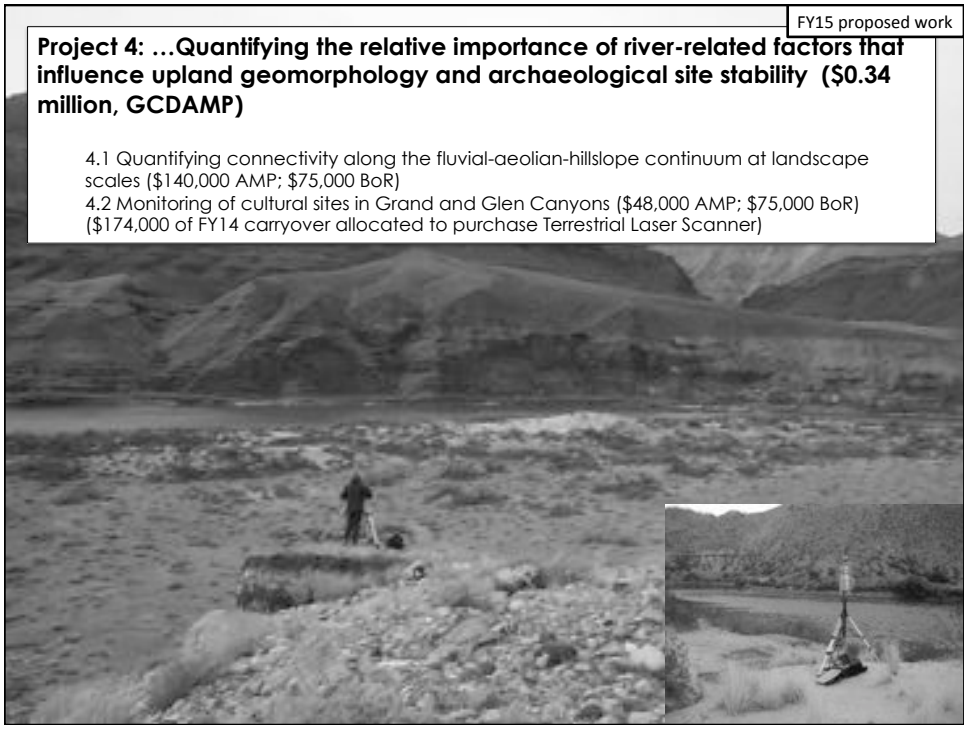
Guidelines for Prioritization of Projects

1. *Monitoring projects* that implement the HFE Protocol and NNFC EAs
2. *Monitoring projects* that evaluate the effectiveness of the HFE Protocol and NNFC EAs
3. Other core *monitoring activities*
4. Creating *independent science review panels* on critical issues
5. Advancing the *integration of tribal concerns* into monitoring and research
6. *Research* that advances monitoring techniques and analytical methods
7. *Research* that advances predictive modeling capabilities
8. *Research* to resolve critical scientific uncertainties.


USGS
science for a changing world
Desired Future Conditions
"high elevation open riparian sediment deposits … in sufficient volume, area, and distribution …"
"Physical characteristics, including climate, site-specific geomorphology, dam-related discharge and flow, and tributary flows, generally predominate …"
"Water quality with regards to dissolved oxygen, nutrient concentrations and cycling, turbidity, temperature, etc. is sufficient to support natural ecosystem
"… maintain significance and integrity [of] prehistoric archaeological sites and historic sites]"


Project 1: Water quality monitoring of Lake Powell and Glen Canyon Dam releases ($0.02 GCDAMP)($0.29 million, other BoR)


USGS
science for a changing world
FY15 proposed work
Project 2: Stream flow, water quality, and sediment transport … ($1.34 million, GCDAMP)
Project 3: Sandbars and sediment storage dynamics … ($1.32 million, GCDAMP)
3.1.1 Monitoring sandbars using topographic surveys and remote cameras ($370,000)
3.1.2 Monitoring sand bars and shorelines…by remote sensing ($120,000)
3.1.3 Surveying with a camera: rapid topographic surveys… ($42,000)
3.1.4 Analysis of historical images at selected monitoring sites ($89,000)
3.2 Sediment storage monitoring ($460,000)
3.3 Characterizing, and predictive modeling, of sand bar response… ($100,000)
3.4 Connecting bed material transport, bed morphodynamics… ($36,000)
3.5 Control network and survey support ($110,000)


FY15 proposed work
Project 4: …Quantifying the relative importance of river-related factors that influence upland geomorphology and archaeological site stability ($0.34 million, GCDAMP)
4.1 Quantifying connectivity along the fluvial-aeolian-hillslope continuum at landscape scales ($140,000 AMP; $75,000 BoR)
4.2 Monitoring of cultural sites in Grand and Glen Canyons ($48,000 AMP; $75,000 BoR)
($174,000 of FY14 carryover allocated to purchase Terrestrial Laser Scanner)

FY15 proposed work

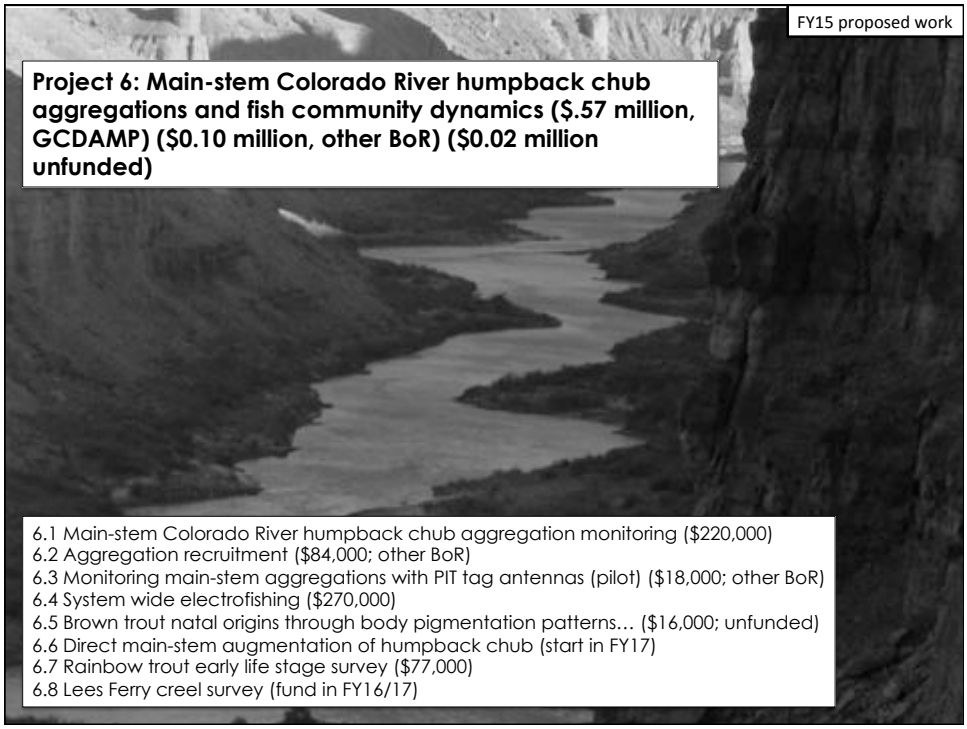
Project 5: Food base monitoring and research ($0.52 million, GCDAMP; $0.04 million unfunded; *$0.18 million request to WAPA for work beyond CRe*)

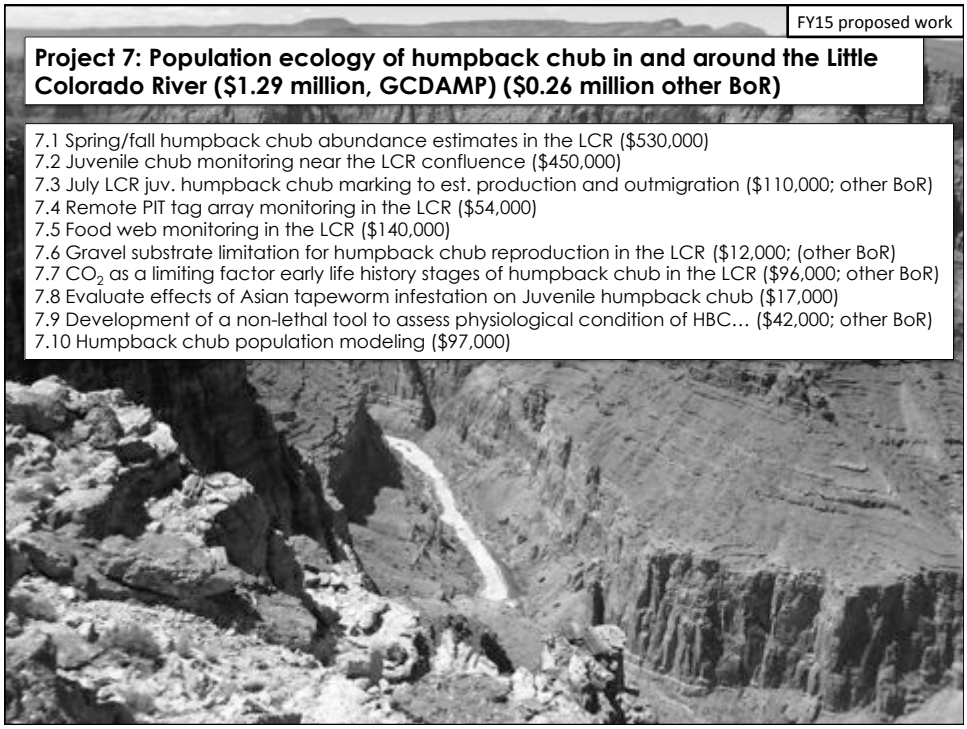
5.1 Are aquatic insect diversity and production recruitment limited?
- 5.1.1 Insect emergence in Grand Canyon via citizen science ($120,000)
- 5.1.2 Effects of hydropeaking on oviposition and egg mortality ($97,000)
- 5.1.3 Synthesis of stressors and controls on EPT distributions ($30,000)
- 5.1.4 Synthesis of the aquatic foodbase in western US tailwaters ($30,000)
- 5.1.5 Natural history of oviposition for species in Grand Canyon ($26,000)
- 5.1.6 Laboratory studies on insect oviposition and egg mortality ($37,000; unfunded)
- *5.1.7 Comparative emergence studies in Upper Basin ($59,000; WAPA)*
- *5.1.8 Natural history of oviposition for EPT in the Upper Basin ($25,000; WAPA)*

5.2 Patterns and controls of aquatic invertebrate drift in Colorado River tailwaters
- 5.2.1 Characterize and monitor drift, emergence in Glen Canyon ($52,000)
- 5.2.2 Drift monitoring in Glen, Marble, and Grand Canyons ($87,000)
- 5.2.3 Link drift to channel bed shear stress ($21,000)
- 5.2.4 Link drift patterns to substrate in Glen, Marble, Grand Canyons ($21,000)
- *5.2.5 Comparative drift in Upper and Lower Basin tailwaters ($94,000 ;WAPA)*

5.3 Primary Production Monitoring in Glen Marble and Grand Canyons
- 5.3.1 Synthesis and publication of Glen Canyon algae production ($26,000
- 5.3.2 Monitoring dissolved O_2 in Glen, Marble, and Grand Canyons ($15,000)
- *5.3.3 Developing automated tools for estimating algae production (outside funding)*

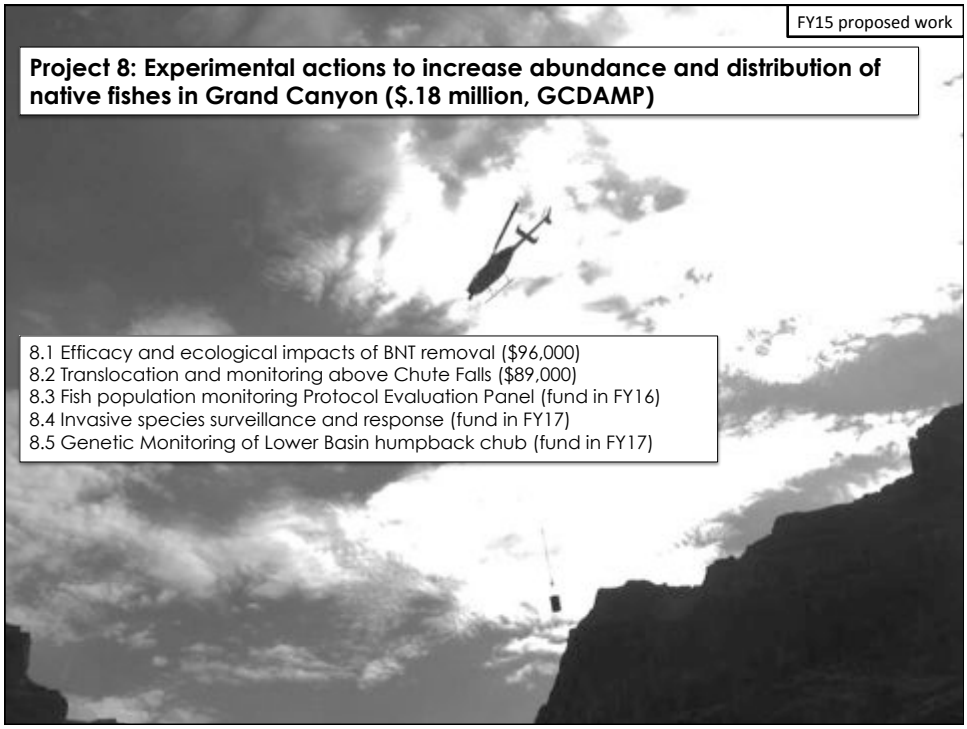
* WAPA: submitted to Western Area Power Administration for funding consideration


FY15 proposed work
Project 6: Main-stem Colorado River humpback chub aggregations and fish community dynamics ($.57 million, GCDAMP) ($0.10 million, other BoR) ($0.02 million unfunded)
6.1 Main-stem Colorado River humpback chub aggregation monitoring ($220,000)
6.2 Aggregation recruitment ($84,000; other BoR)
6.3 Monitoring main-stem aggregations with PIT tag antennas (pilot) ($18,000; other BoR)
6.4 System wide electrofishing ($270,000)
6.5 Brown trout natal origins through body pigmentation patterns… ($16,000; unfunded)
6.6 Direct main-stem augmentation of humpback chub (start in FY17)
6.7 Rainbow trout early life stage survey ($77,000)
6.8 Lees Ferry creel survey (fund in FY16/17)


FY15 proposed work
Project 7: Population ecology of humpback chub in and around the Little Colorado River ($1.29 million, GCDAMP) ($0.26 million other BoR)
7.1 Spring/fall humpback chub abundance estimates in the LCR ($530,000)
7.2 Juvenile chub monitoring near the LCR confluence ($450,000)
7.3 July LCR juv. humpback chub marking to est. production and outmigration ($110,000; other BoR)
7.4 Remote PIT tag array monitoring in the LCR ($54,000)
7.5 Food web monitoring in the LCR ($140,000)
7.6 Gravel substrate limitation for humpback chub reproduction in the LCR ($12,000; (other BoR)
7.7 CO_2 as a limiting factor early life history stages of humpback chub in the LCR ($96,000; other BoR)
7.8 Evaluate effects of Asian tapeworm infestation on Juvenile humpback chub ($17,000)
7.9 Development of a non-lethal tool to assess physiological condition of HBC… ($42,000; other BoR)
7.10 Humpback chub population modeling ($97,000)

FY15 proposed work

Project 8: Experimental actions to increase abundance and distribution of native fishes in Grand Canyon ($.18 million, GCDAMP)



8.1 Efficacy and ecological impacts of BNT removal ($96,000)
8.2 Translocation and monitoring above Chute Falls ($89,000)
8.3 Fish population monitoring Protocol Evaluation Panel (fund in FY16)
8.4 Invasive species surveillance and response (fund in FY17)
8.5 Genetic Monitoring of Lower Basin humpback chub (fund in FY17)

FY15 proposed work

Project 9: Understanding factors determining recruitment, population size, growth, and movement of rainbow trout in Glen and Marble Canyons ($0.92 million, GCDAMP; $0.14 million unfunded)

9.1 Lees Ferry RBT; monitoring, analysis, and study design ($180,000)
9.2 Detection of RBT movement from upper Colorado River below GCD ($350,000)
9.3 Exploring the mechanisms behind trout growth, reproduction, and movement in Glen and Marble Canyons using lipid (fat) reserves as an indicator of physiological condition ($100,000)
9.4 Comparative study on the feeding morphology of drift feeding fish ($86,000; unfunded)
9.5 Meta-analysis and development of reactive distance relationships… ($20,000; $18,000 unfunded)
9.6 Lab evaluation of turbidity as a management tool to constrain RBT populations and reduce predation/competition on juvenile humpback chub ($37,000)
9.7 Application of a bioenergetics model in a seasonally turbid river ($33,000; $33,000; unfunded)
9.8 Mechanisms that limit RBT and BNT growth in other western tailwater systems ($72,000)
9.9 Contingency planning for HFEs and subsequent RBT population management ($72,000)
9.10 Effects of HFEs on the physiological condition of RBT in Glen Canyon ($54,000)

FY15 proposed work

Project 10: Where does the Glen Canyon Dam rainbow trout tailwater fishery end? – Integrating fish and channel mapping data below Glen Canyon Dam ($0.15 million, GCDAMP)

FY15 proposed work

Project 11: Riparian vegetation studies: ground-based and landscape-scale riparian vegetation monitoring and plant response-guild research associated with sandbar evolution and wildlife habitat analysis (FY15: $0.49 million, GCDAMP)

11.1 Ground-based vegetation monitoring ($180,000)
11.2 Periodic landscape scale vegetation mapping and analysis using remotely sensed data ($150,000)
11.3 Influence of sediment and vegetation feedbacks on the evolution of sandbars in Grand Canyon ($100,000)
11.4 Linking dam operations to changes in terrestrial fauna ($24,000)
11.5 Science review panel of successes and challenges in non-native vegetation control in the Colorado River and Rio Grande watersheds ($33,000;)

FY15 proposed work

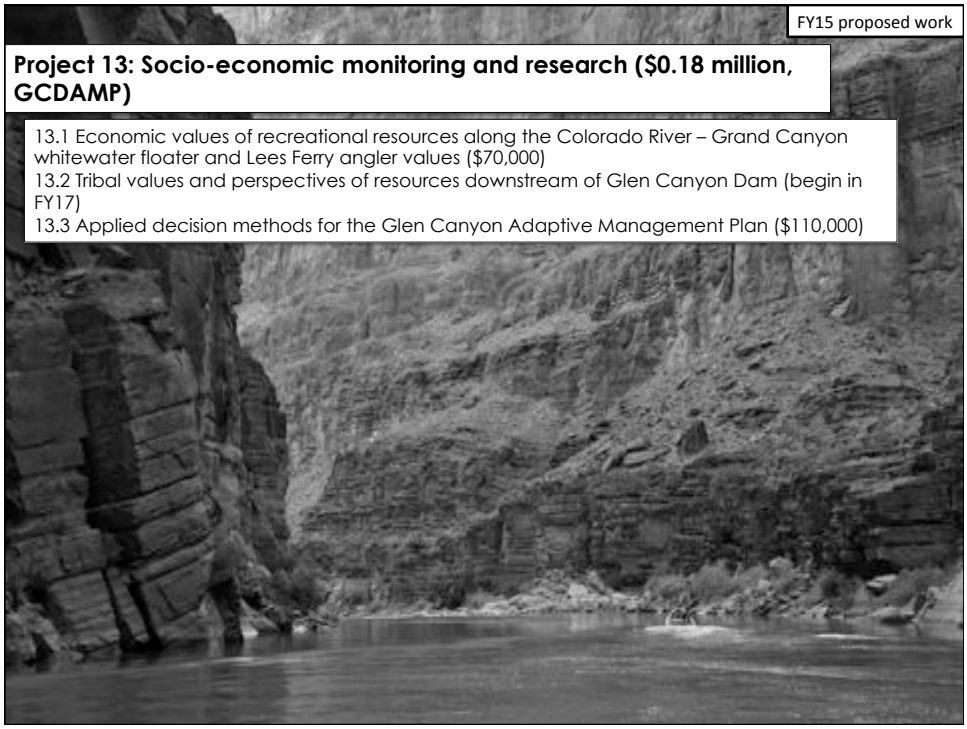
Project 12: Dam-related effects on the distribution and abundance of selected culturally-important plants in the Colorado River ecosystem ($0.05 million, GCDAMP)

12.1 Tribal workshop and analysis of cultural landscape change ($52,000)
12.2 Tribal evaluations of cultural landscape changes (begins in FY16)

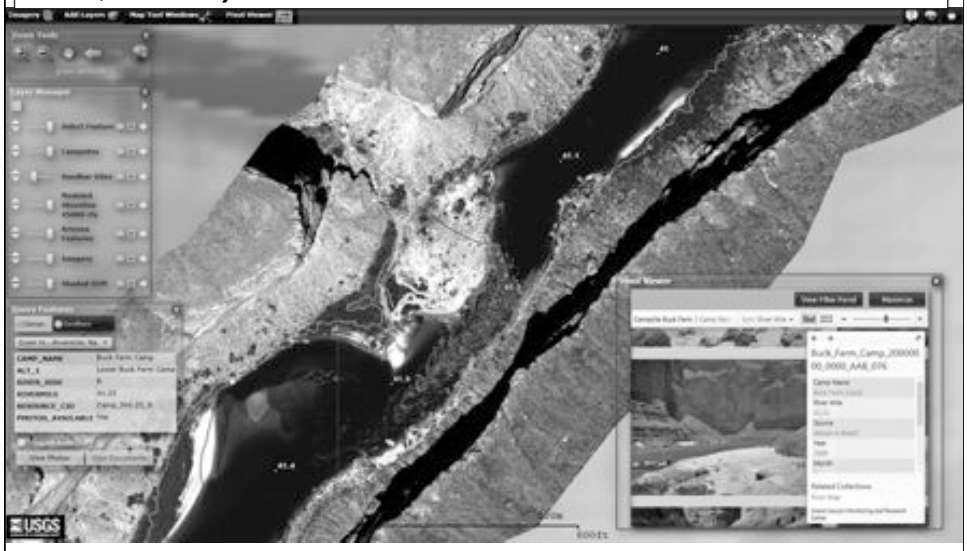
FY15 proposed work

Project 13: Socio-economic monitoring and research ($0.18 million, GCDAMP)

13.1 Economic values of recreational resources along the Colorado River – Grand Canyon whitewater floater and Lees Ferry angler values ($70,000)
13.2 Tribal values and perspectives of resources downstream of Glen Canyon Dam (begin in FY17)
13.3 Applied decision methods for the Glen Canyon Adaptive Management Plan ($110,000)



Project 14: Geographic information systems, services, and support (FY15: $0.23 million, GCDAMP)



Project 15: Administration and Support (FY15: $1.30 million, GCDAMP)

FY 16 and FY 17

Anticipated GCDAMP funding:
FY16 -- $9.0 million
FY 17 -- $9.3 million

USGS/SBSC/GCMRC indirect cost rates:
FY16 – 21.3%
FY17 – 27.x4%

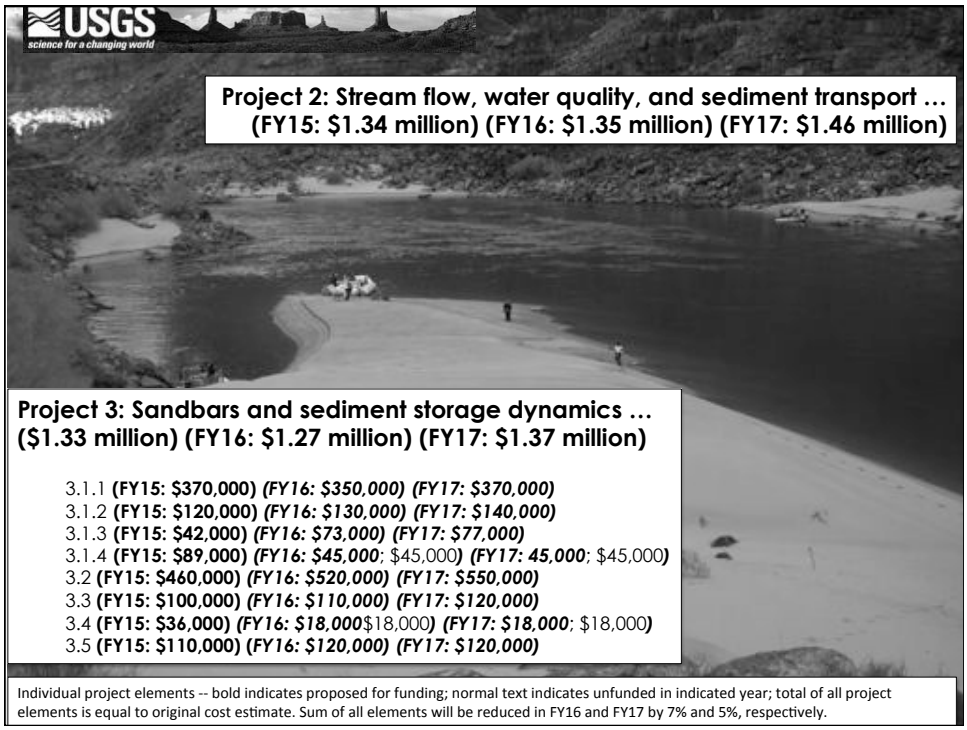
FY 16 and FY 17

Anticipated GCDAMP funding:
- FY16 -- $9.0 million
- FY 17 -- $9.3 million

USGS/SBSC/GCMRC indirect cost rates:
- FY16 – 21.3%
- FY17 – 27.4%

Prioritize monitoring and research activities
Shift research projects from 3 years to 2 years
Delay start times of some projects
Remove some projects from GCDAMP funding

Reduce GCDAMP funding and implement cost saving mandate:
- FY16 – GCDAMP funding at 93% of identified costs
- FY17 – GCDAMP funding at 95% of identified costs



Project 2: Stream flow, water quality, and sediment transport … (FY15: $1.34 million) (FY16: $1.35 million) (FY17: $1.46 million)

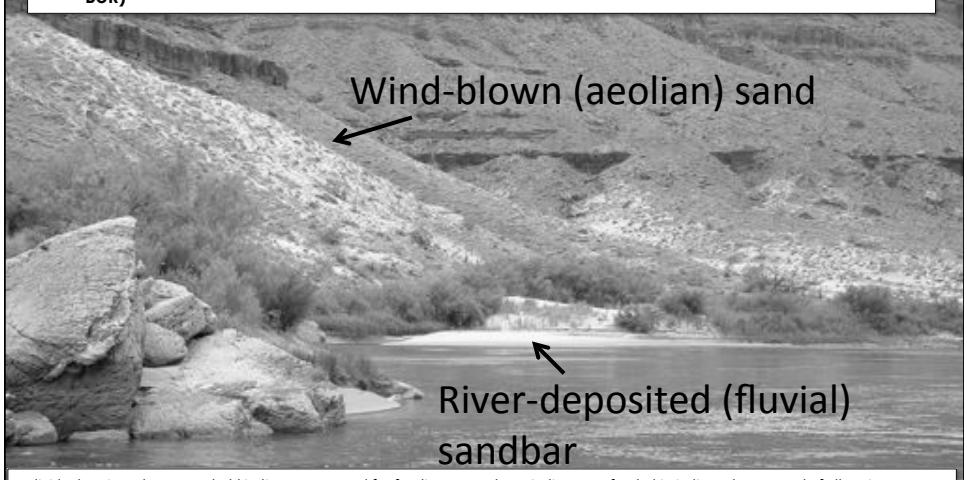
Project 3: Sandbars and sediment storage dynamics … ($1.33 million) (FY16: $1.27 million) (FY17: $1.37 million)

3.1.1 **(FY15: $370,000)** ***(FY16: $350,000) (FY17: $370,000)***
3.1.2 **(FY15: $120,000)** ***(FY16: $130,000) (FY17: $140,000)***
3.1.3 **(FY15: $42,000)** ***(FY16: $73,000) (FY17: $77,000)***
3.1.4 **(FY15: $89,000)** ***(FY16: $45,000***; $45,000***) (FY17: $45,000***; $45,000***)***
3.2 **(FY15: $460,000)** ***(FY16: $520,000) (FY17: $550,000)***
3.3 **(FY15: $100,000)** ***(FY16: $110,000) (FY17: $120,000)***
3.4 **(FY15: $36,000)** ***(FY16: $18,000***$18,000***) (FY17: $18,000***; $18,000***)***
3.5 **(FY15: $110,000)** ***(FY16: $120,000) (FY17: $120,000)***

Individual project elements -- bold indicates proposed for funding; normal text indicates unfunded in indicated year; total of all project elements is equal to original cost estimate. Sum of all elements will be reduced in FY16 and FY17 by 7% and 5%, respectively.

Project 4: …Quantifying the relative importance of river-related factors that influence upland geomorphology and archaeological site stability (FY15: $0.34 million) (FY16: $0.57 million) (FY17: $0.59 million)

4.1 **(FY15: $140,000; $75,000 BoR) (FY16: *$140,000*; $75,000 BoR) (FY17: *$160,000*; $93,000 BoR)**
4.2 **(FY15: $48,000 AMP; $75,000 BoR) (FY16: *$270,000*; $75,000 BoR) (FY17: *$250,000*; $93,000 BoR)**



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Project 5: Food base monitoring and research (FY15: $0.52 million; FY16: $0.55 million; FY17: $0.57 million)

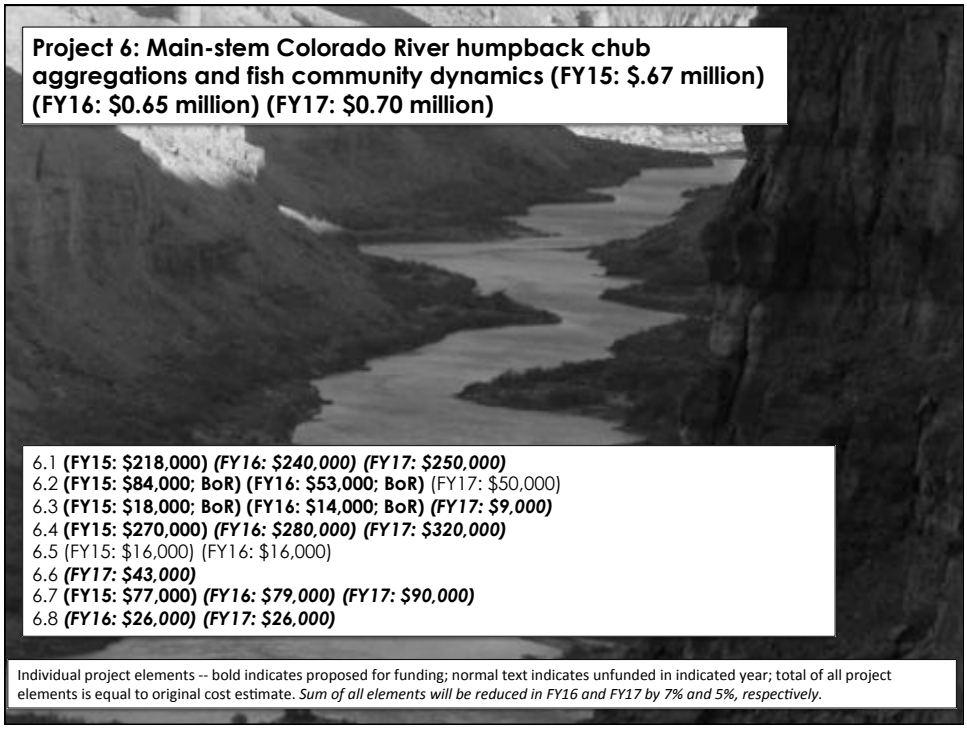
5.1 Are aquatic insect diversity and production recruitment limited?
- 5.1.1 **(FY15: $120,000) *(FY16: $120,000) (FY17: $140,000)***
- 5.1.2 **(FY15: $97,000) *(FY16: $110,000) (FY17: $120,000)***
- 5.1.3 **(FY15: $30,000) *(FY16: $30,000)*** (FY17: $38,000)
- 5.1.4 **(FY15: $30,000) *(FY16: $32,000)*** (FY17: $38,000)
- 5.1.5 **(FY15: $26,000) *(FY16: $28,000)*** (FY17: $31,000)
- 5.1.6 (FY15: $37,000) (FY16: $40,000) (FY17: $47,000)
- *5.1.7 (FY15: $59,000) (FY16: $64,000) (FY17: $75,000) (WAPA)*
- *5.1.8 (FY15: $25,000) (FY16: $27,000) (FY17: $31,000) (WAPA)*

5.2 Patterns and controls of aquatic invertebrate drift in Colorado River tailwaters
- 5.2.1 **(FY15: $52,000) *(FY16: $67,000) (FY17: $88,000)***
- 5.2.2 **(FY15: $87,000) *(FY16: $116,000) (FY17: $157,000)***
- 5.2.3 **(FY15: $21,000) *(FY16: $25,000)*** (FY17: $30,000)
- 5.2.4 **(FY15: $21,000) *(FY16: $25,000)* (FY17: $30,000)**
- *5.2.5 (FY15: $94,000) (FY16: $168,000) (FY17: $203,000) (WAPA)*

5.3 Primary Production Monitoring in Glen Marble and Grand Canyons
- 5.3.1 **(FY15: $26,000) *(FY16: $27,000)*** (FY17: $14,000)
- 5.3.2 **(FY15: $15,000) *(FY16: $17,000) (FY17: $18,000)***
- *5.3.3 (FY15-FY17: outside funding)*

Individual project elements -- bold indicates proposed for funding; normal text indicates unfunded in indicated year; total of all project elements is equal to original cost estimate. Sum of all elements will be reduced in FY16 and FY17 by 7% and 5%, respectively.

* WAPA: submitted to Western Area Power Administration for funding consideration



Project 6: Main-stem Colorado River humpback chub aggregations and fish community dynamics (FY15: $.67 million) (FY16: $0.65 million) (FY17: $0.70 million)

6.1 **(FY15: $218,000)** ***(FY16: $240,000) (FY17: $250,000)***
6.2 **(FY15: $84,000; BoR) (FY16: $53,000; BoR)** (FY17: $50,000)
6.3 **(FY15: $18,000; BoR) (FY16: $14,000; BoR)** ***(FY17: $9,000)***
6.4 **(FY15: $270,000)** ***(FY16: $280,000) (FY17: $320,000)***
6.5 (FY15: $16,000) (FY16: $16,000)
6.6 ***(FY17: $43,000)***
6.7 **(FY15: $77,000)** ***(FY16: $79,000) (FY17: $90,000)***
6.8 ***(FY16: $26,000) (FY17: $26,000)***

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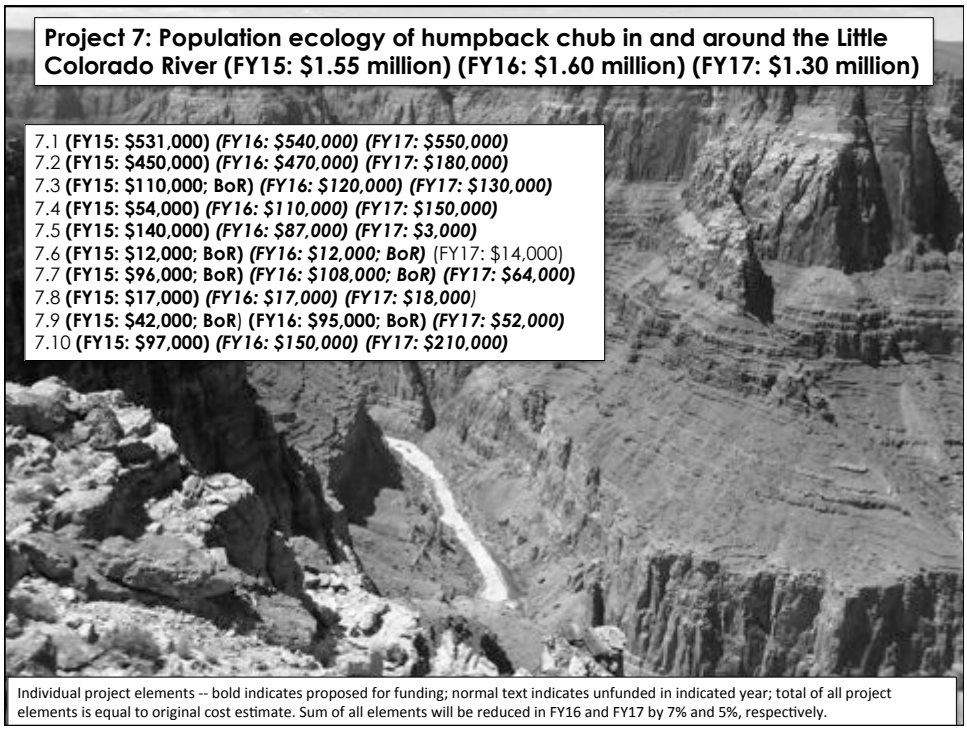
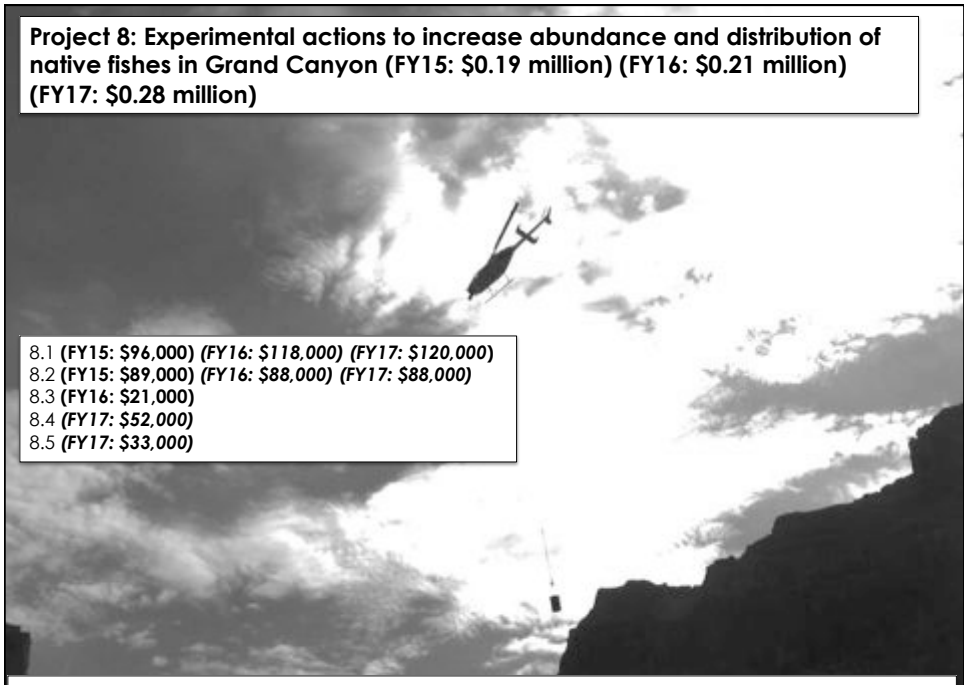


Project 7: Population ecology of humpback chub in and around the Little Colorado River (FY15: $1.55 million) (FY16: $1.60 million) (FY17: $1.30 million)

7.1 **(FY15: $531,000)** ***(FY16: $540,000) (FY17: $550,000)***
7.2 **(FY15: $450,000)** ***(FY16: $470,000) (FY17: $180,000)***
7.3 **(FY15: $110,000; BoR)** ***(FY16: $120,000) (FY17: $130,000)***
7.4 **(FY15: $54,000)** ***(FY16: $110,000) (FY17: $150,000)***
7.5 **(FY15: $140,000)** ***(FY16: $87,000) (FY17: $3,000)***
7.6 **(FY15: $12,000; BoR)** ***(FY16: $12,000; BoR)*** (FY17: $14,000)
7.7 **(FY15: $96,000; BoR)** ***(FY16: $108,000; BoR) (FY17: $64,000)***
7.8 **(FY15: $17,000)** ***(FY16: $17,000) (FY17: $18,000)***
7.9 **(FY15: $42,000; BoR)** **(FY16: $95,000; BoR)** ***(FY17: $52,000)***
7.10 **(FY15: $97,000)** ***(FY16: $150,000) (FY17: $210,000)***

Individual project elements -- bold indicates proposed for funding; normal text indicates unfunded in indicated year; total of all project elements is equal to original cost estimate. Sum of all elements will be reduced in FY16 and FY17 by 7% and 5%, respectively.

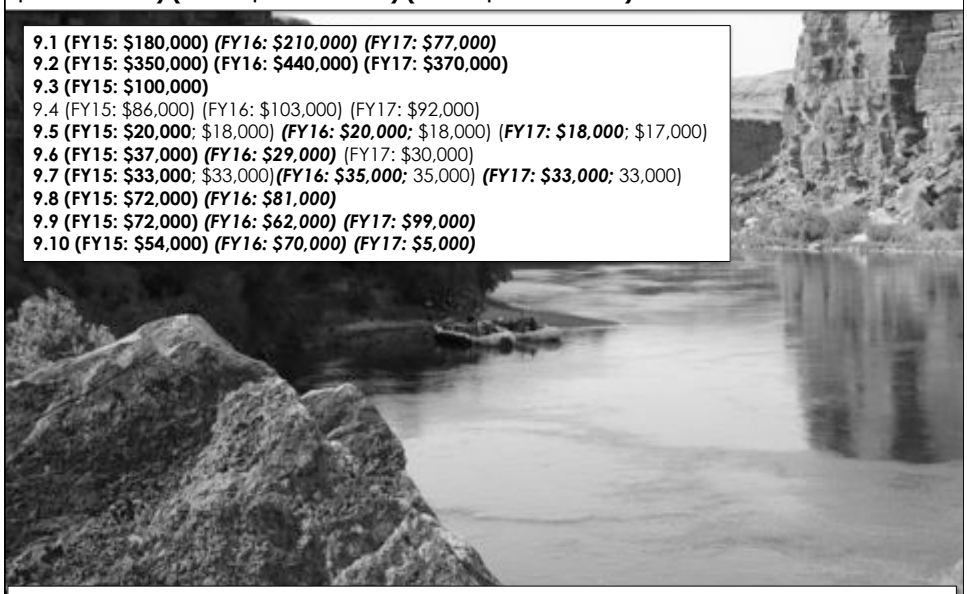
Project 8: Experimental actions to increase abundance and distribution of native fishes in Grand Canyon (FY15: $0.19 million) (FY16: $0.21 million) (FY17: $0.28 million)



8.1 **(FY15: $96,000)** ***(FY16: $118,000) (FY17: $120,000)***
8.2 **(FY15: $89,000)** ***(FY16: $88,000) (FY17: $88,000)***
8.3 **(FY16: $21,000)**
8.4 ***(FY17: $52,000)***
8.5 ***(FY17: $33,000)***

Individual project elements -- bold indicates proposed for funding; normal text indicates unfunded in indicated year; total of all project elements is equal to original cost estimate. Sum of all elements will be reduced in FY16 and FY17 by 7% and 5%, respectively.

Project 9: Understanding factors determining recruitment, population size, growth, and movement of rainbow trout in Glen and Marble Canyons (FY15: $1.01 million) (FY16: $1.02 million) (FY17: $0.74 million)



9.1 (FY15: $180,000) ***(FY16: $210,000) (FY17: $77,000)***
9.2 (FY15: $350,000) (FY16: $440,000) (FY17: $370,000)
9.3 (FY15: $100,000)
9.4 (FY15: $86,000) (FY16: $103,000) (FY17: $92,000)
9.5 (FY15: $20,000; $18,000) ***(FY16: $20,000;*** $18,000) (***FY17: $18,000***; $17,000)
9.6 (FY15: $37,000) ***(FY16: $29,000)*** (FY17: $30,000)
9.7 (FY15: $33,000; $33,000)***(FY16: $35,000;*** 35,000) ***(FY17: $33,000;*** 33,000)
9.8 (FY15: $72,000) ***(FY16: $81,000)***
9.9 (FY15: $72,000) ***(FY16: $62,000) (FY17: $99,000)***
9.10 (FY15: $54,000) ***(FY16: $70,000) (FY17: $5,000)***

Individual project elements -- bold indicates proposed for funding; normal text indicates unfunded in indicated year; total of all project elements is equal to original cost estimate. Sum of all elements will be reduced in FY16 and FY17 by 7% and 5%, respectively.

Project 10: Where does the Glen Canyon Dam rainbow trout tailwater fishery end? – integrating fish and channel mapping data below Glen Canyon Dam (FY15: $0.15 million) (FY16: $0.15 million) (FY17: $0.13 million)

Project 11: Riparian vegetation studies: ground-based and landscape-scale riparian vegetation monitoring and plant response-guild research associated with sandbar evolution and wildlife habitat analysis (FY15: $0.49 million) (FY16: $0.51 million) (FY17: $0.48 million)

11.1 **(FY15: $180,000)** ***(FY16: $190,000) (FY17: $210,000)***
11.2 **(FY15: $150,000)** ***(FY16: $130,000) (FY17: $130,000)***
11.3 **(FY15: $100,000)** ***(FY16: $98,000) (FY17: $50,000)***
11.4 **(FY15: $24,000)** ***(FY16: $136,000) (FY17: $110,000)***
11.5 **(FY15: $33,000)**

Individual project elements -- bold indicates proposed for funding; normal text indicates unfunded in indicated year; total of all project elements is equal to original cost estimate. Sum of all elements will be reduced in FY16 and FY17 by 7% and 5%, respectively.

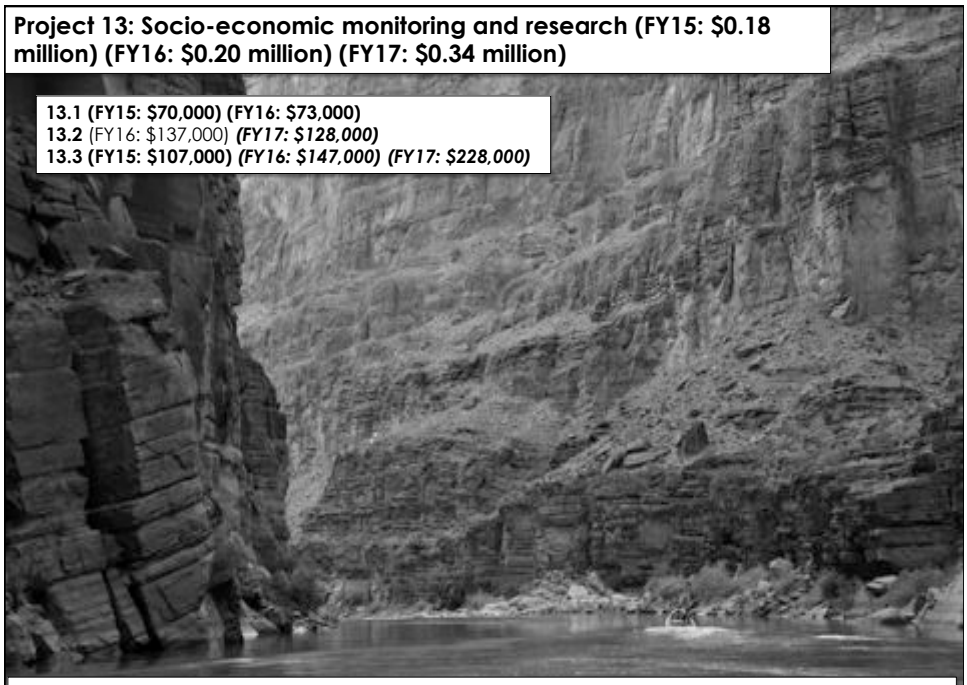
Project 12: Dam-related effects on the distribution and abundance of selected culturally-important plants in the Colorado River ecosystem (FY15: $0.05 million) (FY16: $0.08 million)

12.1 Tribal workshop and analysis of cultural landscape change (**FY15: $52,000**) ***(FY16: $80,000)***
12.2 Tribal evaluations of cultural landscape changes (FY16: $31,000)

Individual project elements -- bold indicates proposed for funding; normal text indicates unfunded in indicated year; total of all project elements is equal to original cost estimate. Sum of all elements will be reduced in FY16 and FY17 by 7% and 5%, respectively.

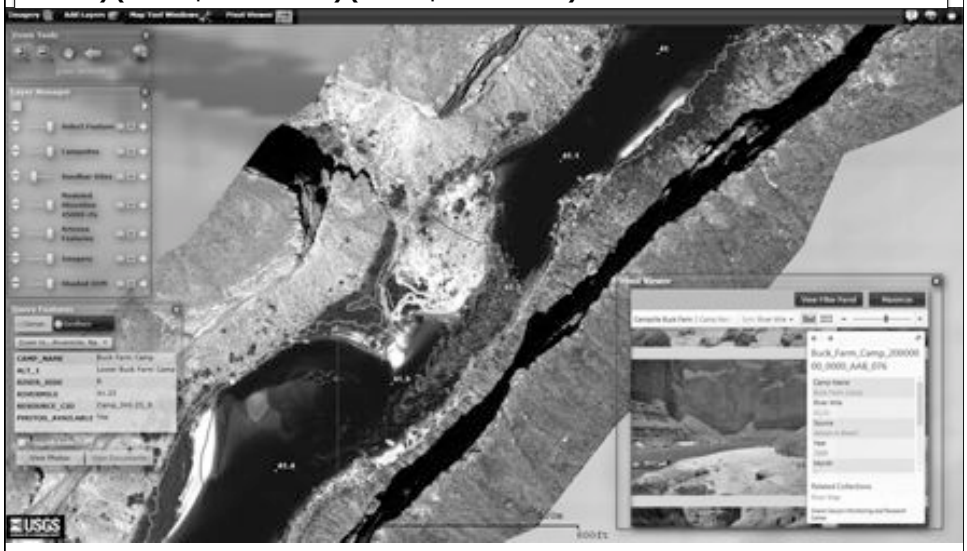
Project 13: Socio-economic monitoring and research (FY15: $0.18 million) (FY16: $0.20 million) (FY17: $0.34 million)

13.1 (FY15: $70,000) (FY16: $73,000)
13.2 (FY16: $137,000) ***(FY17: $128,000)***
13.3 (FY15: $107,000) ***(FY16: $147,000) (FY17: $228,000)***



Individual project elements -- bold indicates proposed for funding; normal text indicates unfunded in indicated year; total of all project elements is equal to original cost estimate. Sum of all elements will be reduced in FY16 and FY17 by 7% and 5%, respectively.

Project 14: Geographic information systems, services, and support (FY15: $0.22 million) (FY16: $0.22 million) (FY17: $0.24 million)



Project 15: Administration and Support (FY15: $1.30 million) (FY16: $1.33 million) (FY17: $1.48 million)

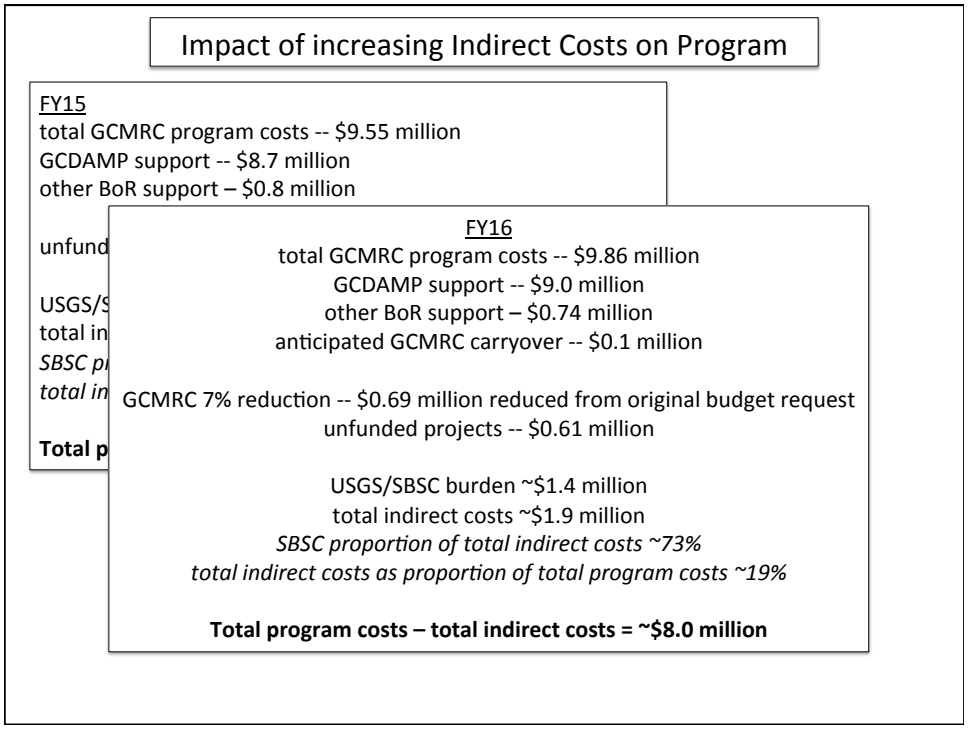
Impact of increasing Indirect Costs on Program

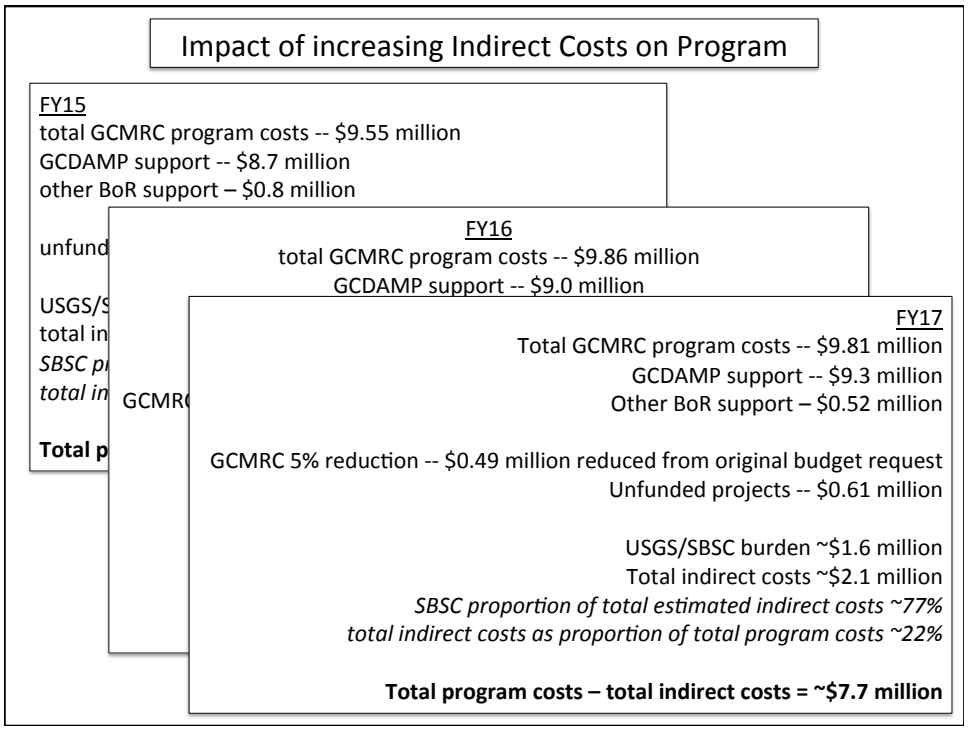
FY15
total GCMRC program costs -- $9.55 million
GCDAMP support -- $8.7 million
other BoR support – $0.8 million

unfunded projects -- $0.19 million

USGS/SBSC burden ~$1.0 million
total indirect costs ~$1.5 million
SBSC proportion of total indirect costs ~65%
total indirect costs as proportion of total program costs ~16%

Total program costs – total indirect costs = ~$8.0 million


Impact of increasing Indirect Costs on Program
FY15
total GCMRC program costs -- $9.55 million
GCDAMP support -- $8.7 million
other BoR support – $0.8 million
unfund
USGS/S
total in
SBSC pr
total in
Total p
FY16
total GCMRC program costs -- $9.86 million
GCDAMP support -- $9.0 million
other BoR support – $0.74 million
anticipated GCMRC carryover -- $0.1 million
GCMRC 7% reduction -- $0.69 million reduced from original budget request
unfunded projects -- $0.61 million
USGS/SBSC burden ~$1.4 million
total indirect costs ~$1.9 million
SBSC proportion of total indirect costs ~73%
total indirect costs as proportion of total program costs ~19%
Total program costs – total indirect costs = ~$8.0 million


Impact of increasing Indirect Costs on Program
FY15
total GCMRC program costs -- $9.55 million
GCDAMP support -- $8.7 million
other BoR support – $0.8 million
unfund
USGS/S
total in
SBSC pr
total in
GCMR
Total p
FY16
total GCMRC program costs -- $9.86 million
GCDAMP support -- $9.0 million
FY17
Total GCMRC program costs -- $9.81 million
GCDAMP support -- $9.3 million
Other BoR support – $0.52 million
GCMRC 5% reduction -- $0.49 million reduced from original budget request
Unfunded projects -- $0.61 million
USGS/SBSC burden ~$1.6 million
Total indirect costs ~$2.1 million
SBSC proportion of total estimated indirect costs ~77%
total indirect costs as proportion of total program costs ~22%
Total program costs – total indirect costs = ~$7.7 million

Whetton, Linda <lwhetton@usbr.gov>

AMWG Information and Review Document

1 message

Whetton, Linda <lwhetton@usbr.gov> Wed, Aug 6, 2014 at 12:22 PM

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I've started posting documents to the meeting page for the AMWG Meeting to be held on August 27-28, 2014 (link below). We anticipate finalizing the AMWG agenda and will send and post it as soon as it's available (hopefully tomorrow).

AMWG Aug Mtg Page

Attached is a GCMRC's response to reviewers on the FY2015-17 TWP. This document provides responses to comments received by the Grand Canyon Monitoring and Research Center (GCMRC) to its draft final Work Plan for FY15–17. This draft final Work Plan was made available on June 6. Comments were received from:
1) Science Advisors (Garrett et al., June 30);
2) Dr. Colden Baxter regarding Project 5;
3) Cultural Resources Ad Hoc Group comments;
4) Glen Canyon NRA staff; and,
5) Grand Canyon NP staff.
This document is organized by projects, and the specific comments related to each project and provided by each reviewer are included. A response to general comments is provided at the beginning of this document.

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GCMRC_Response.pdf
645K

Response to Reviewer Comments

Triennial Work Plan

Fiscal Years 2015-2017

Grand Canyon Monitoring and Research Center

August 5, 2014

This document provides responses to comments received by the Grand Canyon Monitoring and Research Center (GCMRC) to its draft final Work Plan for FY15–17. This draft final Work Plan was made available on June 6.

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Response to General Comments Provided by the Science Advisors

Comment: The new three year plan proposed for this review could be the opportunity for the AMP to accomplish improved short term (1-3 years) and longer term (5-7 years) planning. Three years provides sufficient time to implement a multi-year tiered program and gain some assessment of both its potential success and needs over a longer term. … This proposed plan taken in two cycles could provide possibly an effective format for long term planning. However, to accomplish that end the AMP should consider several improvements and changes to the plan in the current cycle (2015-2017), including: improved integrated science planning; improved inclusion of BOR, other federal, state and tribal agency management and science programs explicitly connected to this program; incorporating and approving the complete elements of a core monitoring plan directly into this plan; and incorporating strategic management and science guidelines directly into this plan.

Response: This comment is important. Although GCMRC is not in a position to adopt such a policy level recommendation, we recognize that the new three-year cycle provides an opportunity to focus, at times, on revising the planning guidance developed by the AMWG and TWG. Chapter Two of the Work Plan now includes a lengthy examination of the policy guidance that has been provided to GCMRC in the past few years. Clearly, this new guidance is sometimes at odds with past GCDAMP guidance in terms of which activities ought to be the focus of GCMRC's work. Re-evaluation of this guidance is in order.

Comment: An example of significant programs deserving more inclusion is cultural resources.

Response: This comment is a good suggestion. GCMRC continues to work towards improving ways to incorporate cultural resource concerns into the overall science program.

Comment: Compartmentalization and possible redundancy of data collection for individual projects could be easily seen as needing improvement with a more systematic program strategy

Response: This issue is an important one, and GCMRC has struggled to work within its own group of scientists and with collaborators to find ways to pursue a systematic program of study. We are excited by the many ways this plan has streamlined some activities, such as fish population measurements, but there is much more to do. We have convened science panels on a few key topics and look forward to collaborating with the stakeholders on this issue.

Comment: The organization and layout of the plan could be improved for communication to the GCDAMP stakeholders and a wider audience. It is a large document, just short of 500 pages. Its complexity and importance calls for a well-designed and written executive summary that can stand as an independent document.

Response: The Introductory pages of Chapter 2 were greatly expanded to provide this executive summary.

Comment: A budget summary is needed in the introduction.

Response: We reconfigured the Appendices to better reflect budget planning and expanded Chapter 2 to describe budget allocations.

Comment: It is proposed that the Lake Powell program administration is also to be moved to BOR.

Response: This is a miscommunication on our part. The Lake Powell program will continue to be housed within GCMRC although a science panel will be convened to explore alternative strategies for a comprehensive limnology and ecology monitoring program.

Project 1. Lake Powell and Glen Canyon Dam Release Water-Quality Monitoring

Response to Comments from Science Advisors for Project 1

Comment: Science Advisors support administrative transfer of the Lake Powell water-quality monitoring program to the Bureau of Reclamation (BOR); however, general activities should be retained.

Response: The Science Advisors review of the GCMRC Triennial Work Plan indicates concurrence with a recommendation to transfer the administration of the Lake Powell water-quality program to the (BOR). This may be the result of a misunderstanding of Jack Schmidt's statement that the Lake Powell program was external to the GCDAMP and not part of GCMRC's GCDAMP budget or its approval process. **It is not the intent of GCMRC, nor that of BOR, to transfer administration of the Lake Powell program.**

In 2000, based on an assessment of existing data relating to the linkage of Glen Canyon Dam operations with water quality in Lake Powell and Glen Canyon Dam releases, a decision was made to have BOR provide funding this program, and that it be administered and maintained by GCMRC. This was in part due to concerns raised by some stakeholders as to whether monitoring in Lake Powell was indeed part of the purview of the GCDAMP. Since 2000, BOR has directly funded the Lake Powell program under its Upper Colorado Water Quality program and has provided additional support with field assistance from BOR and NPS, sample analysis through BOR and contract laboratories, and the purchase of equipment such as the Seabird SBE-19plusV2 CTD profiling instrument. The Lake Powell monitoring program continues to be directed and administratively managed by GCMRC, with cooperation and sole funding on a calendar year basis provided by BOR under Interagency Agreement No. R13PG40028, effective through December 31, 2017.

Under GCMRC administration, the Lake Powell program accomplishes the needs of BOR's Upper Colorado Region in its effort to maintain current information on the status and trends of water quality in its many reservoirs, with primary focus on Lake Powell as the integration point for water in the Upper Colorado River basin. It also serves the GCDAMP, in its monitoring of internal processes and conditions in the reservoir and the resultant physical, chemical, and biological quality of water released from Glen Canyon Dam. Sampling is conducted from the GCMRC Uniflite limnology vessel. GCMRC's storage and logistics capabilities provide support for equipment storage and maintenance, and outfitting of multi-day reservoir surveys. More importantly, the administration of the Lake Powell program under GCMRC provides the scientific rigor and information dissemination requirement of a major USGS science center.

The Science Advisors state that administration by the BOR offers great potential for management application of accomplished science. However, it is deemed that management application of accomplished science can be effectively achieved if data on which management decisions are based are independent, reliable, readily available, and have undergone scientific review and scrutiny.

Comment: The Lake Powell program needs to have an AMWG and agency review regarding how it can best contribute to specified GCDAMP or agency goals, DFCs, critical questions, etc. in the future. There is a concern that the program's resources are allocated to the production of data without clear science plans related to critical goals and resource questions of the AMP.

Response: A Protocol Evaluation Panel (PEP) review of the Lake Powell program was scheduled to be performed in FY 2012; this was combined with the GCMRC Aquatic Foodbase program and was conducted in January 2012. However, most of the focus of this PEP was focused on downstream foodbase work and the ability of the Lake Powell and tailwater monitoring program to provide useful information for that program. As a result the Lake Powell program has not undergone scientific review from limnological standpoint since the initial Lake Powell PEP of 2002 and GCMRC supports a subsequent review panel process for this program. As stated in the Overview of the FY 15–17 Projects in Chapter 2 of the Triennial Work Plan, GCMRC proposes to fund a Science Review Panel to evaluate past studies of reservoir physical limnology and ecology that have focused on Lakes Powell or Mead. This Panel will be asked to make recommendations to the GCDAMP, Reclamation, and to other relevant agencies on how reservoir limnology and ecology ought to be monitored in the future and to make and to make recommendations about how existing and new modeling tools could be used to predict future conditions in Lake Powell. It is anticipated that the GCDAMP program will be closely involved with this process to ensure data collection and research efforts are aligned with the goals and needs of the GCDAMP.

The Science Advisors stated that early reviews of the program determined that data development was not properly automated, verified, and reported on a timely basis. It is acknowledged that this has been a shortcoming of the program is its effort to compile all previously collected data from Lake Powell in a common database while maintaining the monitoring program. Physical and chemical have now been published as Data Series Report DS-471and the process for annual revision with current data is now in place. A draft report of existing biological data through 2009 is in review. A backlog of biological samples since 2010 is now being processed under a contract administered by BOR. Analysis of this backlog is approximately 50% complete and final results are expected in 2014. After completion of this analysis, it is anticipated that the DS-471 physicochemical data report and biological data reports be combined into one comprehensive document, revised on an annual basis.

With the analysis of the current backlog of biological samples completed, the all historical data will be available in the WQDB database. In order to most effectively make these data available to a broad audience, the development of an enhanced web-based system for the serving of information is planned, which will provide improved access to management agencies, outside researchers, stakeholders and other users and will drive additional questions, collaborations, and focus scientific data collection efforts. This system of reservoir water-quality information has been designed to be applied to other reservoir monitoring programs. As such, it is broad and flexible enough to be capable of managing data and the generation of informational products from any number of reservoirs in the Colorado River Basin and could serve as a primary data repository for a basin-wide assessment of conditions and climate change impacts.

Another shortcoming of the Lake Powell program is the current lack of an integrated synthesis and interpretation of existing data. This synthesis would describe hydrodynamic, chemical, and biological processes in Lake Powell and the Glen Canyon Dam tailwater, based on previous observations and modeled data. In order to arrive at such a synthesis, the CE-QUAL-

W2 reservoir simulation model must be used to test hypotheses generated by the synthesis and explain observed processes. These processes include prediction of future climate scenarios and reservoir storage, the effects of reservoir drawdown, what conditions must be in place to achieve a winter underflow through the reservoir, quantification of sediment oxygen demand in resuspended deltaic sediments, and the effect of dam operations and high-flow operations on mixing and stratification patterns. The development of such a synthesis remains a goal of the program and is expected to be accomplished in the FY5-17 period.

Comment: An assessment of previously analyzed biological samples should be made before completing analysis for the current backlog of samples.

Response: The Science Advisors proposed that if the total time and cost of analyzing all biological sample is large, small subsamples should first be analyzed to determine the expected value of additional learning. The delay in the analysis of these samples stemmed in part from the desire to have BOR administer the plankton analysis contract so that other samples from the Upper Colorado basin could be included take advantage of volume discounts for a large number of samples. That contract has been issued and all samples have already been sent out for analysis.

Having all backlogged samples analyzed results in a more complete dataset, associated with other physical and chemical monitoring and contributes to a robust baseline of information on which to based future potential impacts of quagga mussel populations.

Comment: Modeling capabilities cooperatively developed by BOR and GCMRC are important tools and should be maintained as a collaborative project.

Response: The Science Advisors had favorable comments about the collaborative development between BOR and GCMRC of the CE-QUAL-W2 in providing short-term projections of temperature patterns from Glen Canyon Dam for its 24-month study and LTEMP projections. While BOR currently runs the model for these purposes, further development of the model would allow its use to facilitate the development of a Lake Powell data synthesis, answer various research questions, and provide more long-term predictive capabilities to evaluate potential climate change effects. Therefore, GCMRC proposes further collaboration with BOR, other USGS offices, and academic institutions so that the model could be run by a variety of users for multiple purposes, while keeping basic components such as meteorological and hydrological input files, reservoir bathymetry information, and other parameters with the portable model. As noted in the work plan, the installation of additional meteorological stations on the reservoir, resumption of inflow water-quality monitoring, and facilitation of data exchange between the model and WQDB database are expected to be accomplished within the next year.

Comment: A basin-wide systems assessment to predict and mitigate potential impacts of climate change should be undertaken by BOR in collaboration with GCMRC and other basin entities.

Response: The effects to Lake Powell of a changing climate are primarily the result of the amount and quality of water entering the reservoir from upstream sources. While extremes in discharge entering Lake Powell are mitigated to some extent by operation of upstream reservoirs, upper basin hydrological patterns, contrasted with release requirements from Glen Canyon Dam,

result in fluctuation of storage in Lake Powell and other reservoirs. This fluctuation in storage, therefore, is an integrated indicator of climate patterns in the entire Upper Colorado River basin.

GCMRC supports the idea of a basin system assessment and modeling of management needs to mitigate predicted impacts of climate change in the basin. This would involve multi-agency funding and cooperation. Sources of funding for this large initiative are yet to be determined. Under the current funding scenario, BOR's budget for Lake Powell is included in its water-quality monitoring program for other Upper Colorado basin reservoirs and is limited to the agency's basic needs for information to describe basin-wide conditions. More detailed research and increased funding for the Lake Powell program has not been supported at this point. Concerns continue with some stakeholders as to the inclusion and funding of Lake Powell work within the GCDAMP. Other outside funding may be available from grants, other agencies, or other undetermined sources. The Science Advisors stated that GCMRC is most capable program in The Colorado River basin to address these issues and wondered why a Lake Powell-based collaborative initiative on systems analysis of the basin had not been developed. It is felt that without broader agency cooperation, discussion, and funding, the development of such an initiative is premature at this time. However, much work could be accomplished to lay the groundwork for such an initiative, including the development of a web-based information delivery system for Lake Powell, which could be applied to all reservoirs in the Colorado River Basin and serve as an integrated source of information on which to base assessments of climate change, operational scenarios, and other management actions.

Project 2. Stream Flow, Water Quality, and Sediment Transport in the Colorado River Ecosystem

Comment: "Overall, the proposal would be considerably more compelling if it focused more on evidence that continued monitoring and upgraded methods can change our perspectives. Even for strong supporters of monitoring, it is worrisome to perceive that the effort of monitoring itself takes precedent over creative use of the data to inform fundamental understanding and real-world management. That was the sense conveyed by the proposal; while 2 full pages of lists of relevant agency priorities/mandates was provided, only a single paragraph ("Recent research on the Colorado...") offered any specific indication of how the new data can boost understanding and improve management. How wrong were we with 60-minute time resolution instead of 15 minutes? How much change in sediments was observed during the ongoing drought compared to before? How might these data inform future climate change adaptation efforts? Just how are these data used to trigger and evaluate the High Flow Protocol? Tackling these kinds of issues with even a few sentences would go a long way toward justifying associated budgets. The work is really important, but it appears that funding success is taken for granted by the proposers (although SA sabers were rattled regarding the calamitous consequences of under-funding this monitoring)."

Response : This comment shows a lack of knowledge on the part of the reviewer with respect to: (1) the published peer-reviewed scientific literature in the field of sediment transport, (2) the results published in the scientific literature by the PI of this proposal and his colleagues, (3) parameters listed as required in the DOI-approved DFC document, and (4) the decrease in random error with an increase in the number observations.

Of all of the projects at GCMRC, Project 2 has perhaps the best track record in the number of publications in the peer-reviewed scientific literature. Since 2000, Project 2 has published 64 papers in the scientific literature, at a rate of 4.3 papers per year. Many of these publications have had notable impact on the science of sediment transport and have resulted in changes in dam operations. Here are a few examples of papers that have not only had general impact but have resulted in changes in dam management. Topping and others (WRR, 2000a, 2000b) and Rubin and others (EOS, 2002) directly led to the 2004 and 2008 controlled-flood experiments, and ultimately to the DOI-approved 2012-2020 High Flow Protocol. Wright and others (WRR, 2010) describes the method we developed for modeling shifting sand rating curves in rivers where changes in the upstream sand supply partially regulate transport (Rubin and others, 2001, 2008; Topping and others, 2007, 2010). This shifting-rating-curve approach is used in combination with the data collected by Project 2 in the implementation of both the High Flow Protocol and in the LTEMP EIS. The most recent example of a publication from Project 2 that has had impact on the GCDAMP is Voichick and Wright (2014) where we show that turbidity in the pre-dam river greatly exceeded that in the modern river and never got as low as it does in the modern river.

In addition to having a good publication record with high impact, Project 2 has a history of being responsive to managers. The DFCs that were DOI-approved in 2012 require ongoing monitoring of stage, discharge, water temperature, sediment transport, turbidity, and dissolved oxygen. Because all of these parameters evolve through the CRe as dam releases move

downstream through Glen, Marble, and Grand Canyons and interact with local conditions, monitoring these parameters is required at more than one location along the CRe to adequately evaluate whether the DFCs are being met.

The "60-minute duration" part of this comment makes little sense. As is stated in the proposal "Collection of data at the 15-minute temporal resolution is required to accurately describe the changes in stage, discharge, water quality, and sediment transport in the CRe that have been documented to occur at intervals << 1 hour (for example, Topping and others, 2000b; Voichick, 2008; Voichick and Topping, 2010a). Months to years of data collected at this resolution easily fit on standard dataloggers, result in no additional processing time in the office, and result in no additional financial cost to the project. In addition, because random error is reduced as $1/\sqrt{n}$, data collection at >>15-minute intervals would not only hamper detection of systematic changes in stage, discharge, water quality, and sediment transport, but would substantially increase the error in the measurements provided by this project." In essence, collecting data at 60-minute intervals instead of 15-minute intervals not only would NOT change the cost of the project but would actually greatly increase the error in the measurements made by Project 2.

Finally, "how data collected by Project 2 are used in the High Flow Protocol" is well described in both the 2011 HFE EA and the 2012 High Flow Protocol documents approved by DOI.

Comment: "The website is a great concept, though it took several minutes to create a figure of just 6 years of data (even requested in the early AM when server demand would be low). That suggests that the server is badly underpowered or overtaxed, and/or that the coding is far from optimized (e.g. using default bias settings, as most users would, should allow instantaneous generation of graphs because all values can be pre-calculated). The duration curve will indeed be a welcome addition, though the proposal makes it sound like a major technological feat when in fact every aspect of presenting such a graphic and allowing user-defined calculations is very easy to code and serve."

Response: While the functionality offered to the public/users of the GCMRC application may appear to be simplistic to the naked eye, the front end application is actually powered by a very sophisticated set of tools dynamically producing graphs of data that are refreshed multiple times per day to include the most recent and authoritative calculations. The backend database supporting the application contains 57 sites and their data represents more than 86.3 million timeseries measurements and values as well as their metadata. In addition to these timeseries data, the database and web application serve up over 100,000 records representing physical samples also available through the application.

The server is neither underpowered nor overtaxed. The application resides on infrastructure in the EROS Data Center which provides ample network, processing and storage resources. The application benefits from sharing resources with many other successful USGS applications by being overseen by a group of professional System Administrators with expertise in providing stable infrastructure for web applications.

Your example taking minutes to provide six years of data is not an indication of an overtaxed system, but a system intended to be user-interactive. The browser requires all the data in separate pieces to allow the user to adjust percentages in real-time. That usually turns out to be five 15-minute timeseries that need to be transferred to the browser, which would turn out to be roughly

a million values in your specific six year example. However, in order to accommodate the spectrum of browser memory capacities and connection speeds, we filter the data to windowed local mins and maxes on requests of periods that long. The amount of values that make it to your browser for that example turns out to be closer to a couple hundred thousand. Your example was for six years but the application needs to be able to accommodate any request whether it be for a day or over 90 years. Because we attempt to serve the truest visual representation of the data, we scale the windowed filtering based on the amount of data the user requests.

Comment: "As noted in the introduction to this project, the data collected are used for a number of other investigations, including those related to socio-cultural resources (p. 55). This project would benefit from integration of archaeologically and culturally significant sites. It isn't clear how the important information that is being collected and will be collected is actually being used or could be used to monitor the impacts on cultural resources in the CRe. Thus, while it is stated that "Collaborations also exist between this project and every other funded physical-sciences and biology project at the Grand Canyon Monitoring and Research Center, mostly in a supporting role, and with researchers in academia" (p. 61) no mention is made of collaborations with archaeologists, or that the locations and physical attributes of archaeological sites are in any way being looked at as part of their work with the USGS Center for Integrated Data Analytics (CIDA). If it is, it should be mentioned how and what the results have been."

Response: Project 2 has a good history of working with archeologists in Grand Canyon. The following publications in the scientific literature provide documentation that this collaboration has occurred and illustrate how this collaboration has benefited archeologists.

Topping, D.J., J.C. Schmidt, and L.E. Vierra, Jr., 2003, Computation and Analysis of the Instantaneous-Discharge Record for the Colorado River at Lees Ferry, Arizona—May 8, 1921, through September 30, 2000: *U.S. Geological Survey Professional Paper* 1677, 118 p.

Draut, A.E., Rubin, D.M., Dierker, J.L., Fairley, H.C., Griffiths, R.E., Hazel, J.E., Jr., Hunter, R.E., Kohl, K., Leap, L.M., Nials, F.L., Topping, D.J., and Yeatts, M., 2005, Sedimentology and stratigraphy of the Palisades, Lower Comanche, and Arroyo Grande areas of the Colorado River corridor, Grand Canyon, Arizona: *U.S. Geological Survey Scientific Investigations Report* 2005-5072, 68 p.

Hazel, J.E., Jr., Kaplinski, M., Parnell, R., Kohl, K., and Topping, D.J., 2007, Stage-discharge relations for the Colorado River in Glen, Marble, and Grand Canyons, Arizona, 1990-2005: *U.S. Geological Survey Open-File Report* 2006-1243, 19 p.

Draut, A. E., Rubin, D. M., Dierker, J. L., Fairley, H. C., Griffiths, R. E., Hazel, J. E. Jr., Hunter, R. E., Kohl, K., Leap, L. M., Nials, F. L., Topping, D. J., and Yeatts, M., 2008, Application of sedimentary-structure interpretation to geoarchaeology in the Colorado River corridor, Grand Canyon, Arizona, USA: *Geomorphology*, v. 101, n. 3, p. 497-509, doi: 10.1016/j.geomorph.2007.04.032.

Knowledge of river stage during flood events and flood or stage frequency is fundamental to the interpretation of archaeological sites in the CRe. Project 2 measures both stage and discharge in the modern river, and has processed historical unit-values of these parameters and made them generally available (for the first time) through

http://www.gcmrc.gov/discharge_qw_sediment/stations/GCDAMP. In addition, Project 2 has published the stages and discharges associated with the largest known floods to have occurred in the CRe over the last several thousand years in Topping and others (2003).

These four papers together allow archeologists to determine the history of inundation in various parts of the CRe where archeological sites occur. For example, the driftwood surveys in Draut and others (2005) in combination with the flood frequency analyses in Topping an others (2003) allow inundation frequencies (and thus sediment deposition frequencies) to be determined for the large floods that have occurred over the last several thousand years. Some of these largest floods resulted in the burial of archeological sites (for example, on river left downstream from Tanner Rapid and the ruin on river right upstream from Bright Angel Creek).

Project 3. Sandbars and Sediment Storage Dynamics: Long-term Monitoring and Research at the Site, Reach, and Ecosystem Scales

July 29, 2014

Project 3 Reviewer Response
These comments include all of the text in the specific review of Project 3 by the science advisors. The text was broken out into individual comments of similar substance, and the associated responses follow immediately.

Comment: This project has significant focus on the impacts of HFEs and intervening flows on riverine sediment abundance, movement, and storage. It also has focus on sandbar development and maintenance in the system, and modeling of sandbars in the system. It continues to address through both monitoring and research one of the most critical questions of the AMP, i.e., can appropriately managed high flow events and other required flows through time provide general stability to the number, location, and size of sandbars in the system. The program also provides critically needed inputs to understand flow regime impacts to riparian and aquatic habitats. Extensive funding is proposed for 2015/16 to evaluate differing data recovery methods and data quality to assess sediment and sandbar conditions. It is difficult to determine explicitly from the write-ups if duplicated effort exists. Most of this project effort, approximately $1.2M is directed at providing definitive assessments of the status of sediment and sandbar resources through multiple approaches. It was unclear whether the increased effort to gather higher resolution data will truly be more informative. Again the question addressed above might be posed. Would less data resolution serve managers well and also save costs?

Response: As shown in Grams and others (2013), morphologic sediment budgets that use a sub-sampling scheme (channel cross sections at specified intervals) can be subject to large errors. Thus we propose that higher resolution data are necessary to appropriately assess sand resources canyon-wide. Furthermore, as discussed in more detail in the revised proposal, only full bathymetric and topographic maps of long reaches provide long-term assessments of sediment budgets over multi-year to decadal timescales. Part of the work proposed in Project 3, now

elaborated on in a new section D.1 describing the monitoring strategy, includes an assessment of how the different project elements will be used in a tiered monitoring approach. Part of the impetus to collect higher resolution, and more spatially exhaustive data sets, is to assess the degree to which different subsampling schemes are or are not representative of the wider system behavior. In the revision, we have outlined how each new data set will be incorporated into the analysis and evaluation of existing data in line with management objectives. The efforts of Project 3 are collaborative, and thus there is overlap between some project goals, but not duplicative, in that each element will provide a complimentary piece of the tiered monitoring strategy.

Comment: Objective 3 proposes to utilize some of these data to develop and refine a model to predict sandbar development and variance in the system and how that variance is linked to operations management, including normal operations as well as event flows such as HFEs. Development and testing is to occur through the 2015-17 period at approximately $100 K per year. It is not made clear how this modeling effort will integrate in overall AMP and EIS program accomplishments, including Argonne's sandbar modeling efforts in the LTEMP. The two modeling approaches use different methods but seem to be addressing similar if not the same questions. Although costly, this modeling project is addressing one of the most critical problems in the AMP. If in fact duplication exists by design it could be useful in moving more quickly to more effective monitoring methods and improved modeling in the three-year period. In total over $0.3 million may be expended in three years in this modeling effort, which seems cost effective if successful. Results from Project 3 should also provide useful information on the distribution and size of camping beaches, an important element in visitor satisfaction. On the surface it appears that parts of projects 2 and 3 could be integrated to reduce costs, and yet each project element provides critical elements to overall goals and objectives. Further, assessment of costs for each element does not reveal excessive expenditure. However, this should not preclude a closer look at potential cost savings from integration.

Response: We are collaborating with the Bureau of Reclamation, specifically David Varyu, on refinement of the LTEMP sandbar modeling effort. We intend to pursue refinements of the original model, as well as alternative modeling approaches such as re-application of the Wiele model. Multiple modeling approaches are required because they deal with different scales, different spatial and temporal resolutions, and different aspects of the physical processes contributing to the variances seen in the data. A deeper understanding at multiple scales is required to most effectively tackle the complex problem of being able to predict sandbar behavior. Projects 2 and 3 are complimentary, but integrating these projects would not affect the program budget or outcomes. On the comment about the distribution and size of camping beaches, as stated in Project Element 3.1.1., the collection and analysis of sandbar campsite data will continue.

Comment: There were several more detailed issues that merit consideration. Element 3.1 focuses on sandbar dynamics, but seemed to treat each potential influence as being independent of others. An 'experimental design' perspective might be more informative, wherein sandbar growth and loss rates can be envisioned as integrating the effects of location in the river, bar configuration, local currents and sand inputs, event characteristics (HFEs, etc.), and interaction among these factors. Such an integrative way of thinking would be more powerful than treating

each as an independent predictor. The work could then merge bathymetric and topographic perspectives by testing the spatial association between riverbed dynamics and sandbar dynamics. This merger would align with the overall geohydrological approach: is sand transport a local or long-distance phenomenon, and how does that scale with event size? By determining the scale at which sand exchange between bed and bar occurs, it would be easier to reconcile the interpretation of data from individual sandbars with the large-scale flux view of mass balance between tributary inputs and reservoir sink.

Response: Integrating data sources that include observations over different time scales is the subject of the modeling project element (3.3). Many of these suggestions are worth exploring, but are quite complicated, and require a detailed understanding of individual processes of flow and sediment transport from the grain-scale to the reach-scale. The effect of "local currents" and channel configuration is exactly what we are working on understanding in element 3.3 when we discuss the effects of local hydraulics on bar size and morphology. We tried to present complimentary questions in each project element that addresses some aspect of the overarching problem, but we certainly acknowledge that these factors are integrative; for example, in addition to project 3.3, the channel mapping project 3.2 is explicit in linking bathymetric and topographic data with measurements of sediment mass balance from Project 2.

Comment: More generally, it was striking that no work was proposed on climate or other controls on sand loading from tributaries, or delivery of sand to the downstream reservoir. Those topics seem the logical way to tackle the sustainability context raised repeatedly in the background section.

Response: It has not been convincingly demonstrated, using the historical record, that climate changes have in the past significantly altered the net sediment delivery to the entire mainstem. The emerging science of trying to predict sand delivery resulting from monsoons under various scenarios of climate change is not yet sufficiently mature to provide reliable insight such that we could readily incorporate it into our work on sandbar dynamics and channel storage. Project 2 is concerned with measuring sand flux in the mainstem and in tributaries. Sand transport into Lake Mead (transport past Diamond Creek) is also in Project 2. Until the foreseeable future, monitoring these fluxes into and out of the mainstem is the state of the art, in lieu of better and more consensual climate predictions.

Comment: Figure 8 is fascinating, and prompts the question of whether it is coincidence that the one site where high-resolution data indicates major reductions in sand bar elevation is also the site where the validation of the RS approach is also very weak? It seems this could indicate that the RS approach works well for growing sandbars but poorly for shrinking ones. That has important direct implications, but could also point the way toward methodological refinements that enable better estimation of flattening sandbars using RS. The SFM approach is a nice addition as a high-risk, high-reward element, and it was good to see the precision will be quantified to pave the way for citizen science implementation. But why does the methods comparisons focus on down-sampled data to make high-res methods comparable in sample density to low-res methods, when the more salient comparisons would be comparing the gold-standard (LIDAR) to SFM and total-station without any down sampling? It seems the key aim is knowing how well each can perform in an absolute sense, which dictates which constitutes the

minimum acceptable effort to achieve adequate accuracy. Similarly, under element 3.2, why not validate using new aerial imagery that could be directly compared the 3 methods proposed in the previous element (SFM approach). I understand that value of the historical perspective, but comparing against multiple methods in the present would provide richer validation and methods development possibilities.

Response: Sandbars are likely to increase in area above 8,000 cfs as they grow, and sandbars are likely to decrease in area above 8,000 cfs as they shrink. We can't detect sandbar area or elevation below 8,000 cfs in the remote sensing data, and because of the finite pixel resolution of the data we probably estimate larger areas (and elevations) above 8,000 cfs with greater certainty compared to very small areas above 8,000 cfs. This might result in the possibility suggested by the reviewer that the remote sensing approach works well for growing sandbars but poorly for shrinking ones. We would need to investigate this possibility for sandbar area and sandbar elevation and topography more thoroughly with a larger sample of growing and shrinking sandbars, however. The project does include assessments of "absolute" accuracy by comparison with LIDAR at a few sites. But the objective is sandbar monitoring, which does not require that level of resolution. We need to compare the SFM data with our regular monitoring data. A significant problem with any of the modern high-tech methods is "too much data." We have a monitoring data set that goes back to 1990 and we need to test the SFM data against those data. Modern imagery is completely different than the type of imagery used in the historical analysis. The purpose of the validation is to use the method on photos of similar quality to the 1984 photos, but for which we have independent measurements of the ground surface.

Comment: As the 'long-reach' approach is discussed (p103), does the failure of the three small-scale sampling strategies to yield the larger-scale mass balance simply suggest that the wrong predictors are being used in sample site stratification? Apparently it is not enough to focus on large eddies, but it is not clear that the team has fully mined the 2000-2004 data by comparing depth changes to other mapped characteristics (depth, flow velocity and vectors, proximity to bars, nearest upstream or downstream riffle, etc.). It seems there must be some way to predict which places are most dynamic if the old data are mined more fully?

Response: At some level, yes. Identifying the "correct" stratification is a major goal of this program. Much of the 2000-2004 data has been mined as suggested, but few if any relationships have been uncovered. Part of the goal of FY15-17 research is to better assess subsampling approaches, and the modeling project (3.3) will attempt to determine if different mapped characteristics can be correlated with different sandbar behaviors. Over long timescales, long-reach repeat channel mapping efforts are the most reliable (least error) indicators of sediment mass balance and changes in fine sediment storage.

Comment: Also, it was surprising that hyporheic issues were not mentioned. Perhaps some hydrological tracers of hyporheic exchange would help to predict locations where bed thickness is likely to be dynamic (by virtue of reflecting both substrate characteristics and hydraulic forcing). With regard to sonar application (p105), similar efforts are underway even with single-beam sonar in lake environments-- see lakemap.com for details. They use a standard Lowrance echo-sounder and can resolve macrophytes and hard vs soft substrates. To validate your methods (p107), will you collect grab samples of surface sediments and plant material. That is

important since you are expanding the spatial scale of surveys enormously, and the identification of bryophytes and chlorophytes seems like a reach.

Response: Previous coring efforts have shown that in general, sediment accumulations are not thick (<5m). Also, while some pre dam sediment contacts have been found, indicating a lack of bed dynamism, in most areas we predict that the layer of the bed exchanging with the flow is large and non-uniformally accreting or eroding. Measuring hyporheic exchanges is an interesting idea, however it would be extremely spatially limited. Acoustics are much more suited to mapping bed thicknesses continuously and at high resolution. Given observed heterogeneity in bed sediments and thickness, this is important. Single beam echo-sounders can be used to map vegetation and substrate type, but multibeam sounders do it better (they are typically higher frequency and soundings are more precise) and with greater coverage and resolution. Since we already use multibeam to map the channel, it makes more sense to use that technology for acoustic classifications. In the revision we state that bed and vegetation samples will be collected in association with any aquatic vegetation mapping efforts.

Comment: Finally, a few statistical comments. The test of predictors of sand bar change (p118) is a perfect application for boosted regression trees, which deal nicely with non-linear predictions and complex interactions. They also offer the capacity to predict unstudied areas from the suite of descriptors, though that is more complex than with multiple regression or other basic parametric approaches because there is no singular predictive equation.

Response: Given the unequal time intervals between sand bar measurements and that we are repeatedly measuring the same bars, BR is not an appropriate statistical technique.

Comment: The idea of grouping sites is unlikely to be informative because groupings result in: a) reduced statistical power to detect and estimate influence of a particular predictor, b) losing the capacity to use small deviations in multiple predictors among broadly similar sites to inform fitting of each predictor (i.e. groups will still have modest heterogeneity, but that information is discarded in fitting), and c) lower large-scale predictive power over treating sites individually. In any case, that empirical descriptive statistical approach will be a nice complement to the mechanistic LES modeling approach.

Response: This is a valid comment and one that we will consider in project execution. We recognize that any successful approach based on grouping would have to demonstrate that it captures more variability in the data than a non-grouping approach. Analysis of individual sandbar response would be a necessary first step in terms of grouping. Any successful approach based on grouping would have to demonstrate that it captures more variability in the data than a non-grouping approach. Using a simple multiple regression or principal components approach we could ascertain the variance in sandbar metric associated with each forcing variable. Also, part of the purpose of the groupings is to provide topographic test-cases for the LES modeling, so we want to know if we can stratify the generalized response (in the groupings) based on measured differences in topography that can then get fed into the LES model to elucidate real flow and sediment transport processes.

Comment: It is also admirable that the team will establish a control network to ensure consistent elevational standards for application to all types of data being collected for this and other Projects, but most readers would benefit from clear presentation of some what-if scenarios. How badly would the research mission be compromised if the control network did not exist (since it currently doesn't)? For instance, what would the consequences be of not having the RS and field observations of sand bar height on the same precise elevational benchmark?

Response: We are not proposing to establish a control network: it does currently exist. This project involves maintaining and improving the network with additional observations.

Comment: According to the plan, the project has three research components, but as with Project 2, none of these explicitly addresses the integration of archaeological resources into the models. Nor do the "key monitoring and research questions addressed in this project" (pp. 81-82) specifically mention archaeological sites. Nonetheless, this is an important project and the monitoring portion could be extremely valuable for assessing impacts on archaeological sites, assuming that areas that are targeted for repeat photography, remote sensing, etc., are areas with archaeological sites or other culturally significant areas. However, there isn't anything in the plan that states that the sampling strategy included consideration of archaeological sites and/or culturally significant areas. Many of the cultural resources may not be directly affected by this specific project because they are above the elevations being studied, but if they are in areas that overlap with sandbar areas and could be included in the studies then they should be explicitly part of the sampling design. The plan mentions that there is "a pressing need to develop a representative sandbar sampling design" (p. 97), so now would be the time to add areas with archaeological sites to the areas being sampled. The subproject (Project Element 3.5) to support the geodesic control network has important contributions to make to archaeological site monitoring as well as other research projects.

Response: The sandbar and in-channel sediment storage monitoring and the cultural/archeological site monitoring are treated separately because they occur in distinct locations and are affected by distinct processes. Sandbars are directly affected by daily flow regime, sediment inputs, and high flows. The cultural sites are in pre-dam deposits that are not inundated by normal dam operations or high flows. They are affected by hillslope processes and aeolian processes. We do now propose to integrate LiDAR based monitoring of cultural sites with the SfM project of rapid sandbar surveys, to better integrate these technologies across projects.

Project 4. Connectivity along the fluvial-aeolian-hillslope continuum: quantifying the relative importance of river-related factors that influence upland geomorphology and archaeological site stability

CRAHG Recommendations Prepared by Kurt Dongoske, CRAHG Chair
Project 4 Response Prepared by Joel B. Sankey, Research Geologist, GCMRC

Comment: The CRAHG supports GCMRC's project 4, including Reclamation's funding support, as a research effort to address the science questions being asked. However, project 4 does not meet Reclamation's full §106 compliance responsibilities as defined in the existing programmatic agreement. Specifically, project 4 does not adequately address Reclamation's monitoring responsibilities or the involvement of the participating Tribes in the development of a new monitoring plan. The Tribal involvement in the development of the monitoring plan associated with project 4 is not discussed and there are no provisions for funding meaningful Tribal participation in the development of the monitoring plan.

Response: We appreciate the CRAHG's support of the research we have proposed in project 4 (element 4.1). The perceived shortcoming of the lack of tribal involvement in the development of the monitoring plan (element 4.2) proposed for FY15 has been addressed in response to these comments. BOR has provided an additional $30,000 to the budget for element 4.2 to be used specifically to fund tribal participation in making recommendations for, and reviewing, the monitoring plan that will be developed in 2015.

GRCA Cultural Resources Comments on BOR/GCMRC Workplan
Response to comments on project 4 proposal prepared by Joel B. Sankey, Research Geologist, GCMRC

Desired future conditions for cultural sites: In our minds, this is the basis for the work under Project 4:

"The DFC specifically proposes that achievement of the goals for cultural resources be measured by:
Erosion or deposition rates of substrates in which cultural sites occur."

and

"Impacts at sites that affect eligibility to the National Register of Historic Places."

Comment: Page 148: "…and to demonstrate progress towards achieving federally-mandated goals for historic preservation under the Government Performance and Results Act. The NPS monitoring program also identified sites that may require excavation or other forms of "treatment" to preserve their cultural, historic, and scientific values."

We ask that you strike the reference to the Government Performance and Results Act (GPRA). The Grand Canyon Cultural Resource Program has developed monitoring protocols (Dierker 2011) and mitigation protocols (Dierker in draft) that guide monitoring and treatment activities in the park. Those protocols, which have been peer-reviewed, supersede and improve monitoring efforts as prescribed under the Archeological Sites Information System (ASMIS), not GPRA. GPRA is only an accounting (literally counts and percentages) of the number of archaeological sites that are in good, fair, or poor condition. There are no criteria under GPRA that defines condition status, no listing of disturbance mechanisms, and no treatment options. It is not what we use, or what we have ever used. The reference to a personal communications with E. Brennan in 2011 on this subject is clearly a misunderstanding.

Response: We appreciate these comments and have revised this section of the proposal as recommended by GRCA. We have removed the reference to GPRA, revised the previous text, and added the following statements to the revised proposal: "The current NPS monitoring approach, which was developed by the Grand Canyon Cultural Resource Program in 2011 (Dierker and Brennan, 2011), has peer-reviewed monitoring protocols and mitigation protocols that guide monitoring and treatment activities in the park. The current NPS protocols supersede and improve monitoring efforts as prescribed under the Archeological Sites Information System (ASMIS)."

Comment: Page 149: Regarding monitoring programs: We feel it is imperative to link monitoring activities to mitigation actions. The key purpose of the monitoring program, in our view, is to track resource condition, identify disturbance mechanisms, implement strategies, i.e., mitigations, to reduce adverse effects resulting from disturbance mechanisms, and evaluate the efficacy of treatment actions. There may be a tendency to describe research as monitoring.

Response: We appreciate that the GRCA has provided us with these and subsequent specific comments and suggestions regarding the purpose and protocol for the proposed monitoring program. In response to this and subsequent comments we have revised the proposal to include, and cite GRCA as the source of, these specific recommendations just as we did for the recommendations of BOR in the draft proposal. Please see our responses throughout this document that state "GRCA comment added to the revised proposal". Please see the recommendations for the monitoring plan from NPS Cultural Resources in the Project element 4.2 section of the revised proposal.

Comment: There are valid reasons to conduct research. Research will help inform us about the mechanisms of change and to develop and test hypotheses. These activities may affect treatment options or dam operations.

Response: We appreciate this statement of support from GRCA for the work we have proposed in the research element (4.1) of this proposal

Comment: Page 150: "A high-quality monitoring program.." What makes a monitoring program high quality? Expensive equipment, new technologies, consistently trained crews who repeat efforts year after year? A definition would help articulate expectations.

Response: We agree with this comment. We have concluded that our use of the term "high-quality" is not useful for more clearly defining or describing the nature of a monitoring program, and have deleted "high-quality" from the revised proposal. We now simply refer to "A monitoring program". Please see changes in revised proposal.

Comment: Page 152: Drafting a monitoring plan will definitely require close cooperation to negotiate issues related to requirements, management recommendations, and agency mission for example. We feel we need more information to develop the site sample, the time frame for monitoring sites, the variables that will be observed/collected and other specifics. It is imperative that a monitoring program be easily replicated and provide information to allow management decisions and treatments by the management entity.

Response: GRCA comment added to the revised proposal

Comment: Page 154: Evaluation of the proposed work plan would really benefit from review of aeolian sand maps generated from the 13-14 field activities. If those are available, we would very much appreciate seeing them.

Response: We have provided examples of these maps to BOR and NPS via the GCMRC Center Director, and at the discretion of these entities, we (project J and 4 scientists) would be happy to provide the entire dataset directly to GRCA Cultural Resources.

Comment: Page 155: We recommend adding a budget item to support NPS staff time to pull and scan photographs in our collections for the proposed analysis. Also note that currently, photographs from the work by Dr. Schwartz are currently housed at the School of Advanced Research. Photographs from Dr. Euler's work are housed at the Grand Canyon archaeological site files and museum collections.

Response: We appreciate that GRCA has alerted us to the fact that this work we proposed will necessitate an extra effort from NPS. Helen Fairley has offered to pull and scan photographs herself for the work proposed in sub-element 4.1.2 if the NPS would provide her access to the facilities and a small workspace for a short period of time. In return, we would be pleased to provide GRCA with copies of the scanned images that could potentially be used for other purposes by the park in the future.

Comment: Page 157: Will other stakeholder comments be included in the document or just BOR comments?

Response: Indeed! We appreciate these specific comments from GRCA regarding the proposed monitoring program and have revised the proposal to include them. We cite GRCA as the source of these recommendations just as we did for the recommendations of BOR in the draft proposal. Again, please see our responses throughout this document that state "Comment presented and attributed to GRCA in the revised Project 4 proposal"

Comment: Page 157: “Focus on sites that would benefit from HFE sand (types 1 and 2a, maybe 2b and 2c);”

We believe that a full understanding of effects is necessary properly manage and mitigate adverse effects from dam operation, not just those that have beneficial effects. Reports by Sankey and East (2014) and East (2014) suggests that deposition and erosion can change through time, even at Type 1 sites.

Response: GRCA comment added to revised proposal

Comment: Page 158: “For those sites identified in #1, describe a method to determine which sites could receive enough sand to make a difference e.g. the HFE sand bar is large enough, the vegetation barrier is not too dense or the topographic barrier is not too large”
We are not sure this direction is practicable as written. Does the comment really mean, describe a method to determine which sites could receive enough sand to stabilize them in-situ. Determine what HFE sand bar size is large enough, what density of vegetation is not too dense, and what topographic barrier is not too high to facilitate movement of sand to archaeological sites at a volume that will stabilize them in-situ.

Response: GRCA comment added to revised proposal

Comment: Reports by Sankey and East (2014) and East (2014) suggests that deposition and erosion can change through time, even at Type 1 sites and we need to recognize that “type” may change over time given changing field conditions.

Response: GRCA comment added to revised proposal

Comment: Page 158: “Define how much sand is needed to benefit a site that is eroding (this may be part of the methodology); “
We believe the answer to this question is going to be different for every site because it will relate to site type and features present, local topography and weather.

Response: GRCA comment added to revised proposal

Comment: Page 158: “Include criteria to determine where to focus the monitoring effort on such sites (gullies?);”
We believe monitoring activities have to look at an archaeological site within the landscape area where it exists. Tribes do not think of archaeological sites as only the physical manifestations of the past but the areas within which the sites are located. Perhaps something else is intended by the comment.

Response: GRCA comment added to revised proposal

Comment: Page 158: “Include the number of sites and schedule/interval of monitoring events that would be statistically significant;”

We may be misunderstanding the context of this statement. We know what the number of sites present in the APE. The sample should be based on geomorphic context and the potential for indirect effects (both adverse and beneficial).

Response: GRCA comment added to revised proposal

Comment: Page 158: "State criteria to be used in the evaluation of effectiveness that the HFE sand is making a difference for site erosion/stability;"
We think this statement may mean "State how you will quantify beneficial effects from HFE sand in making sites more stable. State how you will quantify adverse effects from HFE sand and site erosion."

Response: GRCA comment added to revised proposal

Comment: Page 158: "State criteria to determine if covering the site with HFE sand would be an adverse effect by changing the site's setting;" "State criteria to determine any other negative (adverse) effects from HFE sand on or across sites; "
We believe these are complex questions that can't be answered without tribal involvement and SHPO concurrence. We think it will depend on the type of site and how that site continues to be used by the traditionally associated tribes of the Grand Canyon (or Glen Canyon). The question really needs to address integrity of setting; the Colorado River setting has not changed, nor has the location of the archaeological sites. Evaluation of the aspects of integrity was performed a number of years ago and it might be worthwhile to incorporate previous evaluations into the component suggested in this project element.

Response: GRCA comment added to revised proposal

Comment: Page 158: "Precisely define all monitoring attributes that will be used (e.g. how will you use lidar?);"
We think the word "attributes" is referring to "methods" if the discussion is about field activities. If the discussion refers to analysis then the word for "attributes" might be "data."

Response: GRCA comment added to revised proposal

Comment: Page 158: "How you will determine if the archaeological assemblage is in situ or has been lowered to an erosional surface (mixing of components);"
We are not sure about what is intended here. In-situ deposits can be mixed chronologically as a result of site use from multiple occupations. Sheetwash would be evidence of movement. In any case archaeological sites are recorded in situ and monitoring information would indicate if creep and sheetwash are currently moving artifacts or features in the site context. We can't think of any archaeological sites that have been moved and whole redeposited elsewhere. If it were to occur, it would be obvious in the geomorphic context of the site. There would be no uniformity or human agency in the archeological deposits present in such cases. We are not sure this statement is relevant.

Response: GRCA comment added to revised proposal

Comment: Page 162: Deliverables

We would like to see an annual report, given to all participants that reports on the progress of the project, includes maps and graphics of findings to date,

Response: We agree with the recommendation that annual reports be included as deliverables and have included this in the revised proposal. Please see changes in the Deliverables section of the revised proposal.

Overall Project Comments:

Comment: We think there have been useful findings from efforts to understand aeolian transport and archaeological site stability. We think more work is needed to begin to answer some specific questions and conduct hypothesis testing.

Response: We appreciate these comments that are supportive and positive about our work to-date. We are also appreciative of this and other implicit statements of support from GRCA for the research we are currently doing, and we are proposing to test hypotheses that focus on improving understanding of how archaeological sites are linked to modern river processes.

Comment: We see beneficial effects from the use of lidar related directly to activities undertaken under Project J, specifically, using lidar to ascertain whether aeolian sand has been deposited on a site and has caused volumetric inflation of the ground surface and to determine how limited sand replenishment potential of a sandbar is for any given downwind landscapes. A well thought-out protocol and implementation plan including lidar may be the tool for documenting change such as overall deflation at a site that appears unchanged to the naked eye.

Response: We appreciate and agree with these comments. In the science background and project 4.2 element text of the proposal we attempted to concisely summarize the work that has been completed with lidar in the past decade to illustrate that it has generated a dataset that provides insight into the linkages between modern river processes and archaeological sites.

Project 4 Response to June 29, 2014 letter from L.D. Garrett (Executive Coordinator, Science Advisors) to Jack Schmidt (Chief, GCMRC) regarding "Comments on Science Advisors Review and Recommendations on 2015-17 Science Plan"

Project 4 Response Prepared by
Joel B. Sankey, Research Geologist, GCMRC

Comment: I appreciated our discussions at the TWG meeting. You requested I go over our review and recommendations and provide input to you and your staff on what we consider the five most critical areas for you to address in this plan. We have accomplished that task in the following text. However, we hope that your scientists will review all of our comments, because we believe they could assist the scientists in improving research methods, planned assessments, etc., in several areas.

The five areas we address are cast in general statements, because we have provided considerable detailed input on these issues in our general and specific comments and recommendations on the plan. Only one comment requests a major rewrite of project descriptions i.e. 4 and 12. Simply put, the projects mentioned do not present appropriate science standards in defining objectives, methods, assessment approach etc., and should be rewritten. The remaining four comments relate to what we feel are critical needs to insure future program stability and responsiveness.

Comment: In regards to past GCMRC plans that we have reviewed, this is clearly the most professional presentation of science projects. Of the project presentations, there are only two which we feel should be rewritten before you resubmit the Plan. The science ideals are supported by the SAs, but unfortunately Projects 4 and 12 simply do not demonstrate appropriate science standards in defining and justifying the science approach, presenting appropriate science design, and clarifying data development and assessments. Because of these issues some concern exists if expenditure of funds might best be directed at other cultural management needs or to other science projects.

Response: We appreciate the review provided by science advisors of project 4. Please see the remainder of this document which contains our detailed response to their specific review comments. We have revised the proposal for project 4 in response to specific science advisors comments, as well as a review provided by the GRCA Cultural Resources, and written recommendations from the CRAHG.

Project 4 Response to Review of Glen Canyon Dam Adaptive Management Program Triennial Budget and Work Plan – Fiscal Years 2015-2017

Review Prepared by
David Garrett, Executive Coordinator of Science Advisors, Economics, M3Research
Lance Gunderson, Adaptive Management & Policy, Emory University
James Kitchell, Fish Ecology, University of Wisconsin
John Loomis, Non-Market Economics, Colorado State University
Peter McIntyre, Riverine Ecology, University of Wisconsin
Barbara Mills, Anthropology and Archeology, University of Arizona

Project 4 Response Prepared by
Joel B. Sankey, Research Geologist, GCMRC

GENERAL COMMENTS ON TRIENNIAL WORK PLAN

Comment: An example of significant programs deserving more inclusion is cultural resources. They are not mentioned in some of the projects even though justification for data collection includes benefits for managing these resources. Projects that collect important time-series data, such as Project 3, should explicitly include some areas that are archaeological so that the very intensive data collection being done could also be used to benefit management and research of

cultural resources. And, related to this is reviews. Independent research oversight panels that are convened should include cultural resource experts to help to ensure the integration of cultural and natural resources in both management and research goals.

Response: Sankey is leading elements of Projects 3 and 11 that have been carefully designed to produce data that will not only be used for those projects but that will be used in the research proposed in project element 4.1.1. Specifically, sand bars mapped in the 2013 imagery in project 3.1.2 and vegetation classified in the 2013 imagery in project 11.1.2 will be used to quantify the relationships between aeolian sand, fluvial sandbar sources, and vegetation. In response to science advisor comments, the work proposed in project 3 to experiment with the novel and potentially more efficient topographic survey approach ("structure from motion") will be expanded to incorporate a proof of concept at two archaeological sites that were most recently surveyed with lidar in spring 2014.

We (the project 4 team) encourage the inclusion of independent review panels for our work. A key aspect of our work in FY15 will be to draft a monitoring plan that will be reviewed by all stakeholders. It seems appropriate that we seek independent reviews of the draft plan at that time.

Comment: "A second example are is that the compartmentalization and possible redundancy of data collection for individual projects could be easily seen as needing improvement with a more systematic program strategy. More collaboration among the scientists to see what data collection strategies could be used across projects needs to be done. Many of the same data collection techniques will be used across projects and there could be more explicit discussion of collaborative methods (e.g., citizen science, remote sensing, LiDAR). There also could be more discussion of how research and management goals intersect across projects, not just within each project. "

Response: Please see the response to the previous comment above that explains the intentional integration of remote sensing work in projects 3, 4, and 11 and also the recently revised plan to experiment with the "structure from motion" methods at archaeological sites in addition to sandbars.

COMMENTS ON SPECIFIC PORTIONS OF THE OVERALL TRIENNIAL WORK PLAN

Comment: "Project 4: Project 4 represents one of the main investigations into cultural resources during the next three years. The sub-plans to the project each tackle (1) mapping with remote sensing techniques areas of "active aeolian sand" and quantitative analyses to understand the sources and interactions with other elements such as barriers; and (2) analysis of historical photographs to more qualitatively assess landscape change associated with active erosion. The latter will result in the preparation of a long-term monitoring plan.

Response: These initial comments from the science advisors indicate substantial confusion about the structure of the project 4 proposal and the work proposed therein. In response, we have revised the Project Summary at the outset of the project 4 proposal to more clearly articulate the basic outline and structure of the proposal and proposed work. We clarify that project 4 consists of two elements. Element 4.1 is research. We present the research proposed in element 4.1 as 3

sub-elements (2 of which are incorrectly identified by the science advisor in this comment as the sub-plans of the entire project). It is not correct that the analysis of historical photographs will result in the preparation of a long-term monitoring plan. Element 4.2 is monitoring and we specifically state that the first year of the effort will be to draft, and develop the methodology for, a monitoring plan that will then be implemented in 2016 and 2017; we have proposed to invest a year drafting a monitoring plan in direct response to stakeholders who recommended that we adopt this strategy, and we intend to work closely with them throughout the entire process.

Comment: The proposed components in the plan aim to determine rates of erosion that will contribute to the desired goal of preservation in place. So, understanding rates of erosion is extremely important for planning purposes, and especially for the Long-Term Experimental and Management Plan. However, we are concerned about effective specification of this project and it is difficult to connect directly the science effort in 4.1 and 4.2 to expressed stakeholder needs for mitigating impacts from dam operations to archeological sites.

Response: Based on input from stakeholders that include BOR, NPS, and five tribes, we have designed a research element 4.1 that directly focuses on how cultural and archaeological sites are linked to modern river processes. The research of 4.1 will therefore directly investigate impacts from dam operations to archaeological sites. Based on input from stakeholders that include BOR, NPS, and the tribes, we have proposed a monitoring element 4.2 that aims to invest an entire year drafting a monitoring plan that focuses on impacts of dam operations to archaeological sites and that will benefit from the insights gleaned from our past and future research examining linkages between the modern river and archaeological sites. We have worked closely with stakeholders in developing this proposal and we propose to continue to do so throughout the life of the project. We have added text in the revised proposal to make it clear that stakeholders have weighed in on the proposal with respect to their needs and that the development of the monitoring plan during 2015 (Element 4.2) will be responsive to stakeholder recommendations and will necessarily be conducted with stakeholder involvement. Please see edits and clarifying text inserted in the Project Summary and Element 4.2 sections of the proposal.

Comment: Research has been ongoing for multiple years to evaluate the relationship of fluvial processes below 45K CFS flows and geomorphic processes above 45K CFS flows. However, although establishing association, proofs are lacking to justify full entry into the proposed monitoring approach. The projects small sample size should be increased and TCPs added.

Response: We agree with most of these suggestions and think that we duly identified these issues and potential limitations in our proposal. We have proposed a research component (element 4.1) specifically because we believe that the work completed to-date on linkages between modern river processes and archaeological sites has generated important hypotheses that we are now in a great position to test with our existing data. The research proposed in element 4.1 is not limited by sample size as we have proposed to conduct the analyses for the entire river corridor and therefore all archaeological sites. We have inserted brief text in the Project Element 4.1 section of the proposal to emphasize this point.

We explained in the monitoring element of the proposal 4.2 that the lidar-based monitoring that has been completed to-date has been limited by small sample sizes. Yet despite this limitation of sample size for the lidar-based monitoring we see that we are potentially close from

a statistical standpoint to being able to make inference from these measurements to the larger population of archaeological sites when we use the site classification system as a framework for doing so. We focus on the lidar work to-date and the site classification system in element 4.2 of the proposal because we feel that they provide a methodology and framework for future monitoring that will focus on how archaeological sites are linked to modern river processes. We have also explained, however, that when we draft the monitoring plan in 2015 we will certainly consider other methods and recommendations from stakeholders, and promote involvement from stakeholders who might like to participate in future monitoring using different tools and methodologies.

Comment: It is not clear that the effort is a priority for Tribes. According to the Triennial Work Plan (p. 149), the research project is tied to suggestions in the prior Protocol Evaluation Panel (PEP) and addresses Strategic Science Questions (p. 151). A concern is that it is not clear if this would be considered the highest priority cultural resources research program to pursue for the next three years.

Response: We have worked closely with stakeholders, including specifically BOR, NPS and the tribes, to develop a proposal that we feel is responsive to their individual and collective recommendations. Stakeholders can certainly state in more detail whether and to what degree this effort is or is not considered a priority.

Comment: For example, ongoing work involves the classification of archaeological sites in terms of the origin of sediments being deposited at archaeological sites, barriers to aeolian deposition, and prevailing wind directions. The result is a 5-category classification based on a small number of sites and the goal is to expand the number of sites classified (n=13). A larger sample is definitely needed and if the project is approved work should continue on this project to better understand the multivariate nature of deposition. Understanding why these sites are not receiving sufficient sediment deposit to stabilize the sites is a complex process, and variances related to assessments are high, at least in part to small sample size.

Response: We think it is very important that the science advisors understand that the research proposed in element 4.1 to better understand the "multivariate nature of deposition" will be completed with existing imagery and GIS data that encompass the entire river corridor and is not limited by small sample size. We specifically proposed to do the multi-temporal landscape scale analyses research of element 4.1.1 because we agree that a large sample size is necessary to understand the multivariate nature of deposition.

In our revision of the Project 4 proposal, we clarify that all river corridor sites (>350 sites) have been classified in Marble and Grand Canyon with the 5 class system, not just the 13 site where lidar measurements have been made, and that these results will be presented and summarized in the final report (currently in preparation) of project j from the 2013 and 2014 workplan. We have provided a new figure and text in the revised proposal to summarize the most current results of the site classification. The classification of all river corridor sites in Grand Canyon National Park will be summarized and presented in the "Project J" 2013 and 2014 biennial workplan final report. Please see revisions in the Scientific Background section of the proposal (section C.1) and in the Element 4.2 section of the proposal.

The lidar monitoring work that has been completed over the past decade has so far only included 13 of the river corridor sites that have been classified with the 5 class system. We propose to use the classification system as a way to make inference from an unavoidably smaller number of sites that are monitored with lidar to the more complete set of river corridor sites. We have tried to articulate in element 4.2 of the proposal that despite this limitation of sample size for the lidar-based monitoring we see that we are potentially close from a statistical standpoint to being able to make inference from these measurements to the larger population of archaeological sites when we use the site classification system as a framework for doing so. We also state that in 2015 when we draft the monitoring plan, we will explore using additional monitoring approaches and methods that might allow stakeholders such as the tribes to collect information about a larger number of sites.

It, therefore, may be unwise to launch a monitoring program of these processes in 4.2 at significant costs without stronger empirical support for the original stated hypothesis and increased sample sizes.

Response: At the recommendation of stakeholders, we have proposed to invest a year drafting a plan to monitor how archaeological sites are linked to, and impacted by, modern river processes. In the research element 4.1, we have identified important hypotheses that we believe can be tested with existing data. However, we believe that research completed over the past several decades has been comprehensive enough to guide the development of an adaptive monitoring plan that can focus on the key processes that have been identified to-date as most important linkages between the modern river and archaeological sites.

Comment: As this sample is increased, it needs to include not just archaeological sites but also other TCPs. Identification of erosion to other kinds of cultural resources needs to be explicitly integrated into the project. This was a recommendation of the PEP report (Doelle 2000) and also brought out in the legacy monitoring review committee report by Kintigh and others.

Response: To a large extent this is a policy issue that is out of our control as scientists. Stakeholders including the BOR, NPS and the tribes will need to collectively agree on the Programmatic Agreement and Area of Potential Effect to delineate the geographic boundaries and identify the collective set of locations at which we will focus our monitoring and research efforts. The tribes are currently working with BOR on how to identify their TCPs in Grand Canyon, but in the past, they have stated that the entire Grand Canyon from rim-to-rim constitutes their TCP interests. Project 4 incorporates a landscape approach in evaluating dam-related impacts and in that sense, it is partially responsive to the TCPs that have been identified to date, although we fully recognize that our study does not attempt to explicitly link changes to TCP-values. We expect to further refine our monitoring approach to be more responsive to tribal concerns through working with the tribes in developing the monitoring plan in FY15.

Comment: The greatest concerns with the project are:
(1) understanding its potential contribution to Tribes or the NPS in assisting mitigation strategies for archeological sites affected by dam operations;

Response: Again, we have worked closely with stakeholders including the BOR, NPS and the five tribes to develop a proposal that we feel is responsive to their individual and collective recommendations. Stakeholders can certainly state in further detail whether this effort is or is not a priority.

Comment: (2) how the plan objectives will be achieved for all sites given the very small sample of sites that are included in 4.1;

Response: This comment from the science advisors again indicates substantial confusion about the structure of the project 4 proposal and the work proposed therein. Project 4.1 is a research element that considers the entire river corridor, therefore it also includes all possible river corridor archaeological sites within that area. We have inserted text in the Project Element 4.1 section of the proposal to emphasize this point.

Comment: (3) how data from the quantitative and qualitative analyses will be integrated;

Response: It is not clear in this comment to what work the science advisors refer. All of the science proposed in project 4 is quantitative in that data will be collected to test hypotheses in a statistical framework. Sub-element 4.1.2 is the one portion of the project that is somewhat more qualitative, simply due to nature of the data (historical oblique photo matches). The results of this work will be naturally integrative with the other research proposed (e.g., 4.1.1) because they will provide a longer term perspective on linkages between river processes and archaeological sites.

Comment: (4) how can changing weather patterns affect application of potential results, and how could it be mitigated?

Response: We agree that this is an important question. Unfortunately, most of it is outside the scope of our present work. Our focus is to explain how archaeological sites are currently linked to modern river processes, and to the extent possible (i.e., based on availability of appropriate data) we have proposed to examine how these relationships have changed in recent history. We are not at the point where we can forecast into the future how these linkages might respond to future perturbations to weather and climate regimes. However, in Project J we are continuing to collect weather data at a small sample of sites where detailed measurements of change have been made, and these data are currently being applied in landscape evolution models that can help us better understand linkages between geomorphic attributes and weather conditions over longer time spans. Although additional modeling work is not proposed as part of Project 4 in FY15-17, data resulting from the research and monitoring elements of this proposal could potentially be used in future modeling efforts, including possibly predictive modeling. However, it is noteworthy that if such predictive modeling is undertaken by GCMRC in the future, even among the climate-science and atmospheric-science research community it is difficult to make detailed predictions for specific time scales and regional spatial scales

Comment: and (5) LiDAR seems to be an integral part of the project but funding for the technology has not been secured (see p. 44).

Response: We agree with this comment. We are working very hard to identify funding for the instrument and personnel to continue lidar surveys in the future. In fact, Sankey recently received external funding (from a nonAMP source) to experiment with more affordable and operationally autonomous lidar units that might be useful tools of the future (if you are interested in this effort, please see http://geography.wr.usgs.gov/ICES/opportunities.html).

Comment: Many of these issues relate to insufficient science effort in plan specification an interaction with Tribes and manager.

Response: We have worked very closely with stakeholders including the BOR, NPS and tribes to draft this proposal and have designed the monitoring element 4.2 to be specifically responsive to stakeholders' suggestion that we spend 2015 drafting a monitoring plan that will focus on how cultural and archaeological sites are linked to modern river processes. We have strived to provide insight and methodological detail into how the work that has been completed in the last decade of the cultural program at GCMRC is relevant to the future monitoring efforts. We have designed the research component 4.1 of the proposal to test key hypotheses that exist about linkages between the modern river and archaeological sites. Stakeholders can certainly state in further detail whether the proposed effort is or is not a priority and we will continue to attempt to make the science that we propose responsive to their individual and collective needs.

Comment: Some of these concerns might be alleviated by inclusion of more detailed information in the plan. For example, how many of the total archeological sites that are determined to be impacted by flow operations in the canyon have attributes expressed in this research? Although not disclosed in the project description, we assume knowledge exists of this number and it is a significant percent of the total to support the need for this effort.

Response: We appreciate this helpful suggestion. We have provided a new figure and text in the revised proposal to summarize the most current results of the site classification. We have also revised the proposal to clarify that all of the river corridor archaeological sites (>350 sites) in Marble and Grand Canyon have been classified and not just the 13 sites at which lidar monitoring has been previously conducted. The classification of all river corridor sites will be summarized and presented in the "Project J" 2013 and 2014 biennial workplan final report. Please see revisions in the Scientific Background section of the proposal (section C.1) and in the Element 4.2 section of the proposal .

Comment: If the entire approach, i.e. hypothesis testing and monitoring protocols, is successful how will they assist resource managers—i.e. NPS and the tribes in implementing mitigation strategies? Again unless improved science design can be presented, this seems an area where funds might better be used to pursue management actions. A goal for the project might best be to produce information to help anticipate worst-case scenarios and develop management actions to mitigate irreplaceable losses.

Response: We agree with the science advisors' articulation of a goal of our project in this comment. In fact, this is precisely why we suggest that a monitoring plan (which will be drafted in 2015 and implemented in 2016 and 2017) could focus on the site classification system. Classifications have been completed for all river corridor sites in Grand Canyon National Park

and provide us with a ranking of the current and past potential of sites to receive aeolian influx of river-derived sand. As the aeolian influx of river-derived sand is a key process by which archaeological sites are linked to modern river processes, this classification system provides us with a logical framework for identifying best and worst-case scenarios in terms of potential impacts of dam operations to archaeological sites. We suggest that results of measurements and monitoring conducted at a smaller sample of sites can be used to make inference to the larger population of sites based on the classification system.

Comment: Further documentation of site classification is perhaps helpful, but information on specific vulnerabilities and how management could mitigate them seems just as important.

Response: Work conducted over recent decades has indicated that a key linkage between modern river processes and archaeological sites might be that sites that receive more aeolian influx of river derived sand are somewhat less vulnerable to the longer term trajectory of degradation via hillslope and other erosion processes unrelated to modern river processes. The site classification system is critical because it allows us to make inference from observations at a small number of sites to the large population of sites throughout the corridor based on their degree of connectivity to modern river processes.

Comment: The use of LiDAR to answer the question of whether NPS use of check dams to reduce erosion gullies relative to areas without check dams is a part of the project that would follow this reasoning.

Response: We have suggested in the proposal that this work could consider interactions of aeolian sand and checkdams, because this would be an implicit interaction of modern river processes and management actions at archeological sites.

Comment: In principle, this may be an extremely important project to conduct for the cultural resources if the methods and models could be implemented. The science presentation is not sufficient to produce confidence in these outcomes.

Response: We appreciate the science advisors' review but are sorry to read that their interpretation is that our proposed science is not sound. We hope that our detailed comments, explanations, and revisions alleviate some of the apparent confusion that the science advisors had about the structure of the project 4 proposal and the work proposed therein. We think that we have proposed research and monitoring elements that incorporate the current state of the science and are very responsive to the needs and priorities of stakeholders who have recommended that we focus on how archaeological sites are linked to modern river processes.

SCIENCE ADVISOR RECOMMENDATIONS

Comment: " Project 4: The SAs feel this is an important project to consider even though it lacks effective science design and the small samples represented in empirical work have not fully validated approaches recommended. Several sets of information should appear in a revised project to help its full evaluation, including: How will it assist NPS and Tribes site mitigation

approaches; improving sample size validate approaches; how will qualitative and quantitative data be integrated, etc."

Response: Please see our detailed comments, explanations, and revisions to the proposal that we think will alleviate some of the apparent confusion that the science advisors had about the structure of the project 4 proposal and the work proposed therein. We would like to reiterate that we believe we have proposed research and monitoring elements that incorporate the current state of the science and that are very responsive to the needs and priorities of stakeholders who have recommended that we improve the state of knowledge on how archaeological sites are linked to modern river processes in the Colorado River ecosystem in Glen, Marble, and Grand Canyons.

Project 5. Foodbase Monitoring and Research

Project 5 Response to Science Advisor Comments

Prepared by Jeff Muehlbauer and Ted Kennedy, GCMRC

Comment: "Project 5 has created significant progressive accomplishments in a short time frame. New proposals 6.11-17 provide alternative options for laboratory studies, pilots and river experiments to initiate and test various hypothesis related to absence/low abundance of EPT. However, the science team does not provide strong supporting evidence for several hypothesis. It is understood that other southwest tail-waters support EPT, but the GCD environment may be sufficiently different to be hostile to these species. Contrasting key attributes of these different regimes might be helpful. An argument might be why would anything except small insects with rapid life cycles based on filter feeding or collecting use these habitats. A more thorough literature search and assessments could produce more focused hypothesis."

Response: The science advisors raise valid points here regarding potential differences between the GCD tailwater and Grand Canyon and other tailwaters in the Southwest, the need to contrast these systems, and the need to characterize the potentially hostile environment downstream of GCD for EPT taxa. This is precisely what we had in mind for Project Elements 5.1.3 and 5.1.4 ("Synthesis of stressors and controls on EPT distributions" and "Synthesis of the aquatic foodbase in western US tailwaters", respectively). In 5.1.3, one of our main objectives is to describe the life histories, habitat needs, etc. of EPT taxa that could be candidates for colonization of the Colorado River downstream of GCD, and to predict how EPT taxa are likely to respond to the conditions found in this ecosystem. In 5.1.4, our intent is to synthesize EPT (and other aquatic invertebrate) data for tailwaters throughout the Southwest in order to compare and contrast these ecosystems, their habitat conditions, and their respective aquatic invertebrate densities. The text in both of these sections has been modified to make these objectives clearer.

COMMENTS FROM TRIANNUAL PLAN REVIEW_6-22-14_V7 WORD DOCUMENT

Comment: "We were particular impressed with the structure introduced in Project 5, where background information included key graphics summarizing existing data, and each element included coverage of both the scientific rationale and management implications."

Response: We thank the science advisors for their support of this formatting approach, and have left it intact.

Comment: "**Project 5** presents new program thrusts related to EPT absence/low abundance in the Glen Canyon/Marble Canyon reaches; continuation of work on invertebrate drift in the river and primary productivity monitoring in the Glen and Marble Canyon reaches. The Colorado River below the dam exhibits a remarkable absence and rarity of insect groups found in other river systems. This group of investigators face an interesting set of problems owing to interactions of variable flow velocities and temperature effects as causes forthe low diversity and low productivity observed in the river below the dam. The possible solutions are also complex and difficult to test. The issue presents a tough restoration problem. Answers will be importantly related to food web interactions. Comparative insectinset drift studies conducted in river reaches above Lake Powell and those in the canyon below the dam may offer important insight about what is possible vs. what simply won't work due to life history constraints within the realm of current management practices of flow variability and temperature effects. A parsimonious outcome may be very helpful in evaluation of management possibilities and priorities. I strongly suggest that this is a very worthwhile effort. Management needs to know if and how the challenges of evolutionary history can be accommodated and, therefore, what expectations are realistic. Developing a bottom-up modeling approach will be helpful in evaluation of the top-down constraints apparent in the productivity of higher trophic levels. Overall, the monitoring of invertebrate drift and associated budget is in major part a continuation of needed assessments of habitat quality for main-stem native fish and rainbow trout resources.

Response: We thank the science advisors for their support of this project. We agree that the problems described are complex and will be difficult to answer. This is why Project 5 takes a multi-faceted approach to addressing this problem, from field studies in Grand Canyon, to lab studies, to data syntheses, to comparative research in other regional ecosystems and tailwaters**.**

Comment: "The proposal for sampling work in the upper Colorado River to provide the context for ongoing assessments in the CRE would help validate methodologies. These benefits must be weighed against the $141 K cost by stakeholders."

Response: The proposed research in the Upper and Lower Basins of the Colorado River (i.e., outside of the reach from GCD to Lake Mead) are proposed to be funded by non-GCDAMP sources. We nonetheless chose to include these sections in this GCDAMP project proposal because they help provide a more well-rounded description of all the work we are proposing over the next three years, and they provide complementary and supporting information for the remainder of the work that is proposed for GCDAMP funding. The project text has been modified to clarify which project sub-elements are proposed for GCDAMP funding, and which are proposed to be funded from non-GCDAMP sources.

Comment: "The proposed efforts on primary productivity to develop approaches to derive algae production estimates from dissolved oxygen measurements present opportunities for more efficient assessments of aquatic biology metrics."

Response: We thank the science advisors for their support of this project element.

Comment: The new effort on EPT discussed above follows on scientist and stakeholder discussions of general hypotheses. From the five presented hypotheses, the selected hypothesis recommended for testing is the impacts of hydro peaking on egg mortality. As noted the flow experiment portion of the research (34 weekend days of low steady flow from May to August) is not required to develop preliminary evaluations of the hypothesis. With the emphasis that was placed on the need to evaluate effects of low flows on biotic communities in the 1996 EIS it is disheartening to have had the 2000 and 2011 low flow experiments and not have had effective monitoring in place to evaluate aquatic insects. Project elements 5.11-5.17 propose evaluations of conditions in other riverine systems, literature reviews, citizen science assessments, and laboratory experiments to develop initial evaluations of the hypothesis. This engagement of publics in the research effort has been demonstrated effective in previous program efforts and adds important extensions to the AM collaborative process. Clearly a need exists to evaluate elements that could contribute to absence of EPT in the system and flow variance seems a reasonable hypothesis to test. Laboratory testing of water temperature effects also seems reasonable to evaluate even if a selective withdrawal device is not in current management planning. A management action such as translocation might have merit as well, but as noted would be difficult to assess in this system.

Response: We thank the science advisors for their support of this project, and their assessment that our proposed focal hypotheses seem reasonable candidates to test.

Comment: Overall, Project 5 encompasses an elegant set of observational, comparative, and experimental studies on insect ecology and algal productivity. Presenting management implications after scientific rationale was very persuasive, and the citizen science dimension is praiseworthy. However, much hinges on the validity of H5, and it is worrisome that the proposing team offers very little evidence in support of that hypothesis. Simply put, given that conditions below GC dam are lousy for most aquatic inverts (cold water year-round, low particulate organic matter from upstream, no substantial riparian organic inputs, hydropeaking creating daily scouring and monthly hydrological instability, deep/wide channel that may lack microhabitats with algae and detritus accumulations), why would anything except small insects with rapid life cycles based on filter-feeding or collecting ever use such habitats? And given the extreme flow variation from hydropeaking, it is perhaps not surprising that chiros and simulids (both of which are often pretty sedentary) are forced to drift, yet drift in low numbers due to the combination of low productivity (cold, no food) and behavioral tendencies against drift. By extension, it seems pretty unsurprising that EPT taxa would not do well below GC dam. It is quite interesting that they seem to do better in other tailwater areas, but the proposal does little to show that shoreline desiccation from water level fluctuations is likely to be THE major cause of low EPT. The practical dimensions (readily manipulated without hitting hydropower or other interests very hard, weekly cycle over warm season, etc.) are great, but additional pilot data,

direct observations, comparisons to hydropeaking regime at other sites, etc should be offered in support of a $3M proposal.

Response: The Science Advisors note that the proposal would have been more compelling if it also included pilot data, direct observations, or comparisons to hydropeaking regimes on other rivers in support of Hypothesis 5. We certainly agree with this sentiment, but note that the Science Advisors did not identify any flaws in the logic that we used to ultimately focus our proposed investigations on Hypothesis 5; in fact, this logical structure was praised throughout their review comments. The Science Advisors also make the case that the ecosystem is generally inhospitable to aquatic insects, because there is a combination of stressors that might be interacting and preventing EPT from inhabiting the river. We do not disagree; however, based on the data presented in Fig. 1 of this proposal, EPT nonetheless make a living in other regional tailwaters that are also likely to be relatively "lousy," and many even seem to do quite well in these other tailwaters. Clearly, EPT downstream of GCD are anomalously low, even by the relatively inhospitable standards found in other tailwaters. Although the physical and biotic conditions that are identified in this passage undoubtedly represent a filter that prevents some EPT taxa from inhabiting the River downstream of GCD, it is our expert opinion that only one of these filters (i.e., high egg mortality because of hydropeaking) can explain the zero EPT condition of the Glen Canyon tailwater. We have thus not modified the proposal based on these comments, and look forward to the opportunity to conduct syntheses and collect new field data that will evaluate the validity of Hypothesis 5.

Comment: Another limitation of the approach is that it focuses on singular mechanisms could explain the lack of EPT species below GC dam. Never did stressor synergies come up, despite the fact that GC dam clearly imposes three unnatural conditions: cold water, low turbidity, and large numbers of visually-oriented insectivorous fishes (trout). Is it really more likely that a single stressor has extirpated sensitive insects than a synergistic combination of stressors (scour, low food resources, high predation, cold, and maybe also too few wetted oviposition sites)?

Response: We agree that the multiple stressors have likely acted synergistically to extirpate EPT taxa downstream of GCD. In fact, we state this explicitly in the first paragraph of our "Support for Hypothesis 5" section within section C.4. We go on to devote two full paragraphs to the discussion of significant interactions, or synergies from multiple stressors acting as filters that combine to extirpate and prevent recolonization of these taxa. However, our contention is that identification and amelioration of the primary, or limiting, stressor has the potential to improve conditions enough—even in the continued presence of other filters—to allow many candidate taxa to recolonize. This "filtering" concept has support from the literature, as noted by the references cited within that section. In light of the breadth of the discussion already devoted to the topic of multiple stressors in the project proposal, we have not modified the text in this instance.

Comment: Indeed, it was surprising that habitat limitation for larval insects was hardly mentioned. Many benthic insects require solid structure with interstitial spaces to thrive (sand and silt have more limited faunas), so it would be helpful to hear more about substrate patterns from the tailrace downward. Perhaps these concerns can be addressed by the proposing team by

providing some details from the data that they already have in hand (e.g. dealing with temperature, substrate, and hydropeaking amplitude in the comparisons indicated in Fig. 1), along with providing some additional details on drift netting to demonstrate that EPT are not just being missed by the nets.

Response: The Science Advisors note that sand and silt habitats have limited invertebrate faunas compared to hard substrates, and imply that a new habitat-related Hypothesis could be included in the proposal. We chose not to include a habitat-related hypothesis in the proposal because ongoing sediment studies clearly demonstrate that the river has a limited sand supply, and the hard substrates that support diverse invertebrate faunas are abundant (see Projects 2 and 3). Simply put, substrate conditions in the post-dam river are similar or, in many cases, even more hospitable to EPT than in other large river ecosystems. Thus, substrate cannot explain the zero EPT condition in Glen Canyon, or the rarity of EPT in Marble and Grand Canyon. Further, we are confident that our estimates of EPT abundance are accurate, and that EPT were not missed by our sampling nets. Recent food web investigations led by Kennedy sampled invertebrates throughout the Colorado River from the drift and all habitat types (i.e., cobble, sandy, cliff, talus) using habitat-specific sampling devices equipped with 250 micron mesh netting, which are capable of retaining even the smallest macroinvertebrates. These studies are cited throughout the proposal, and the methods we allude to here are described in much greater detail therein. Thus, the data on EPT abundance that were presented in the proposal come from exhaustive drift and benthic sampling. Additionally, invertebrate studies in the River have been conducted by several different groups/institutions intermittently for more than three decades, and these prior studies also noted the absence/rarity of EPT.

Comment: Life history issues received less discussion that expected; midges and blackflies are small and develop quickly, and are talented filter feeders and collectors rather than scrapers (like many EPT taxa). So it seems there could be an important role for trophic ecology, as well as general habitat flexibility that is well known for small insects like midges and blackflies that are short-lived (whereas most EPT are likely to be uni- or bivoltine in rivers that are cold year-round) and often found in low quality streams. The oviposition site information presented in table also suggests that these flies may be more flexible than most EPT taxa in that regard.

Response: We agree that midges and blackflies have more flexible life history attributes than most EPT taxa; indeed, this is why EPT are generally more sensitive to perturbation and are used as bioindicators, while midges and blackflies are among the most tolerant species on the planet. As discussed in a comment at the beginning of this document, project element 5.1.3 proposes to address life history differences between these organisms explicitly, with one outcome being a richer understanding of how and why EPT may have been extirpated from downstream of GCD and which species are likely to be the best candidates for re-colonization. Nonetheless, it remains surprising just how few EPT taxa are found downstream of GCD, particularly in the first 50 or so river miles, when EPT richness is 0. The mayfly genus *Baetis*, for instance, is globally ubiquitous, physically adapted to swift water, and—like midges—is a collector-gatherer. One of the project's authors (Muehlbauer) has personally collected *Baetis* (albeit sometimes at low densities) in ecosystems ranging from acid drainages, to urban stormwater outlets, to blackwater,

brackish coastal plain streams, to large, heavily regulated rivers in Europe such as the Danube. The absence even of EPT groups such as *Baetis* from downstream of GCD is thus surprising, and exploring the reasons for this related to species life histories, habitat conditions, trophic levels, etc. is a major objective of many of the project elements we propose. We have modified the project elements throughout (as described in responses to earlier comments) to make this clearer.

Comment: Finally, despite the elegance of the proposed experimental manipulation of dam discharge (which is a great idea), it was difficult to assess whether May-August is a long enough window to see life-cycle completion (the basis for the multigenerational amplification argument offered in opposition to a favoring a longer low-fluctuation period) leading to a population-level response. Given the unnaturally cold temperatures below GC dam, the expected growth rates may be too low to allow much response. This could be calculated easily from existing knowledge of midge secondary production, generation times, and temperature dependent growth. Such an argument would strengthen the case for the potential for this novel manipulation to unequivocally resolve whether oviposition site limitation is the core problem."

Response: The Science Advisors suggest that the proposed flow experiment may not be of sufficient duration to elicit a population-level response in invertebrates. To this point, we note that preliminary citizen science data indicate that midge populations can respond to environmental manipulations on the scale of 30 days or less (see Fig. 2). The summer timing of the proposed flow experiment is also designed to coincide with the time when the vast majority of insect emergence and egg-laying occurs, and therefore to have the greatest potential for effecting population-level improvements to the foodbase. However, as with the first HFEs, we acknowledge that uncertainty regarding the long-term efficacy of a summer flow experiment remains, much of which is unlikely to be resolved prior to attempting such an experiment. The proposed May-August timeframe for the experiment, and more significantly, the proposed weekends-off and weekdays-on approach, were informed by the overall importance of minimizing negative impacts to other GCDAMP resource goals. Our intent here was to describe a mitigation strategy that would likely benefit the target resource (based on preliminary data from monthly flow changes and the May 2013 steady flow, see Fig. 2), facilitate and increase learning, and minimally impact other resources. Adaptive management experimentation is an interactive process, and stakeholders are encouraged to view the proposed experiment as a first-step in this interactive process.

We also acknowledge that other significant flow experiments are further along in their planning and development, and testing invertebrate flow experiments may not be a high priority at this time. For example, Trout Management Flows (TMFs) have been undergoing testing and refinement for more than a decade (e.g., Trout Suppression Flows were first implemented in 2003-2005), and further testing and refinement of TMFs is a significant component of many EIS alternatives. Current plans for TMFs would involve stable and high discharges for a period of days to weeks, followed by a rapid decrease in discharge intended to strand and kill juvenile trout that have moved to high elevation edge habitats. TMFs represent a unique opportunity to study the processes of insect egg-laying and egg-mortality under two different stable flow conditions (high stable discharge followed by low stable discharge). We will capitalize on this

and any other learning opportunities that present themselves. However, TMFs are unlikely to benefit EPT because mortality of insect eggs would likely occur when flows are reduced. It is our belief that flow management actions more specifically geared toward improving the productivity of the foodbase and promoting colonization of EPT, such as the flow experiment proposed in this project, are likely to have much more notable, positive effects on this resource. We look forward to the opportunity to revise and refine the invertebrate mitigation flow experiment in collaboration with stakeholders and other scientists as part of the LTEMP EIS process.

Comment: "**Project 5:** This program has developed critically needed understanding of food base in this system. In its ongoing efforts, management needs to know if and how the challenges of evolutionary history can be accommodated and what expectations in this system are realistic. Developing the bottom-up assessments and modeling approaches are helpful in evaluation of the top-down constraints apparent in higher trophic levels. The proposal for sampling work in the upper Colorado River to provide the context for ongoing assessments in the CRe would help validate methods. The mix of laboratory and in-stream experiments to probe basis for EPT existence/low abundance provides the type of science alternatives important to managers in their efforts to support broad based initiatives. Pursuing lab assessments initially to assist design elements of river based experimentation is applauded. Establishing proofs with river based experimentation will be difficult and longer term. The creative implementation of citizen science in these programs should be emulated as possible in other programs."

Response: We thank the science advisors for their support of this project.

Project 5 Response to Colden Baxter's Comments

Prepared by Ted Kennedy and Jeff Muehlbauer, GCMRC

Comment: I begin with assessment of two of the key premises, which are clearly stated in the opening sentences of the project summary: "The absence of mayflies, stoneflies, and caddisflies from the Colorado River in Glen Canyon, and the rarity of these insect groups in Marble and Grand Canyon, indicates this segment of river is unhealthy. The stressors that prevent mayflies, stoneflies, and caddisflies (i.e., EPT) from re-colonizing the Colorado River may also be contributing to low overall production of midges and blackflies (i.e., the foodbase that supports key fish populations)." Fundamentally, I judge that the scientific reasoning behind both of these statements is sound. There is a history of controversy surrounding the use of terms like "health" and "integrity" to describe ecosystems (e.g., Costanza et al. 1992, Suter 1993, Wicklum and Davies 1995). On the other hand, the concept of ecosystem health has gone through several decades of refinement and is now consistently used in ecosystem management applications (Rapport et al. 2009). There is a strong precedent for its use in the context of riverine ecosystems, there is a well-established body of work that links assessment of river ecosystem health to the community structure of benthic macroinvertebrates (e.g., Carlisle et al. 2013), and such assessments frequently rely upon so-called "EPT" taxa (insects belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera) as principal indicators (e.g., Reynoldson and Metcalfe-Smith 1992, Rosenberg and Resh 1993, Rosenberg, Resh and King 2008). EPT taxa are key components of the "reference condition" of most temperate rivers of the world, including the Colorado River, as pointed out by the proposal authors in proposal section 5.2C. Therefore, the

authors' first statement seems a well substantiated claim, and they are justified in outlining a series of hypotheses to be investigated so as to better understand the factors limiting these taxa. The second statement, that stressors presently constraining EPT taxa in the Colorado River may also be contributing to low production of midges and blackflies (which currently contribute disproportionately to sustaining fish production), seems to me an additional plausible hypothesis, as indeed it is treated in the balance of the proposal.

The proposal authors then link the first two statements analyzed in the previous paragraph to Goal 1 of the strategic plan of the Glen Canyon Dam Adaptive Management (GCDAMP) Program: to "Protect or improve the aquatic foodbase so that it will support viable populations of desired species at high trophic levels." Though there might be other reasons to manage for a more diverse insect assemblage in the Colorado River (e.g., maintenance of native biodiversity is an important mission of the National Park Service), as I understand it, at present this Goal 1 of the GCDAMP strategic plan seems to be the principal policy basis for justifying a science focus on factors limiting diversity and productivity of insects in the river. It also seems to me there are two key assumptions essential to making the link as the proposal authors have done. First, it is assumed that populations of desired species at higher trophic levels (e.g., fishes) are limited by food, an assumption that is solidly rooted in the results of recent detailed food web studies, in which I have participated (e.g., Cross et al. 2013, Kennedy et al. 2013). Second, it is assumed that the goal could be met by increasing midge and blackfly production and/or by restoring a more diverse insect assemblage (including EPT taxa). Whereas the former seems like a straightforward inference from the evidence that fishes are food limited, the latter requires closer examination.

I can think of two basic means by which a more diverse insect assemblage (including EPT taxa) in the Colorado River might be expected to improve the capacity of the aquatic foodbase to "…support viable populations of desired species at higher trophic levels." First, reasoning from a "niche-based" perspective, a more diverse assemblage of river insects might be expected to make more efficient use of food and space, yielding greater total insect production. However, relationships between diversity and productivity in plant and animal communities have been the subject of both empirical and theoretical investigation for decades, and the results vary greatly with organism groups, context, and scale of investigation (e.g., Mittlebach et al. 2001, Chase and Leibold 2002, Hillebrand and Cadinale 2010, Cardinale et al. 2012). There have been surprisingly few investigations of the relationship when it comes to river insects, mostly because there have been relatively few whole-assemblage estimates of secondary invertebrate production in streams and rivers. Those few studies have typically revealed positive associations between insect diversity and secondary production (e.g., Benke et al. 1985, Benke and Huryn 2010), and related studies suggest this relationship may be most consistently positive in settings subject to the frequent hydrologic disturbance (e.g., Cardinale et al. 2005, Whiles and Goldowitz 2010). In addition, diversity-productivity relationships are frequently "hump-shaped," such that positive associations occur at low levels of diversity. For both of these reasons, it seems likely that an increase in diversity of the Colorado River in Glen, Marble or Grand canyons (where hydrologic disturbance—at least in the form of peaking—is frequent, and insect diversity is extremely low) would result in an increase in invertebrate production. In turn, if food is limiting fishes, then an increase in total insect production might be expected to fuel increases in fish populations as well. However, under any future line of research and monitoring these should be treated as hypotheses to be investigated.

A second mechanism by which an increase in the diversity of the insect assemblage might translate into positive consequences for the viability of fish populations (or, indeed, populations of other insectivores that depend on river-derived prey) is perhaps best expressed in terms of the "stock portfolio" analogy. Indeed, Dr. Kennedy, one of the lead investigators of the proposed work, has used this analogy several times in presentations and discussions on this topic, though it was not explicitly articulated in the proposal text (but see proposal section 5.2C). In brief, the idea is that diversifying the insect assemblage would improve the reliability of its performance as the food base for insectivores like many fishes, much as modern economic theory predicts optimal long term performance of a stock portfolio with diversification of investments. The improved "reliability" of the insect assemblage as a food base could take several forms. Productivity of a more diverse insect assemblage might prove more resistant (or resilient) to changes in the river resulting in the reduction or loss of individual species. Similarly, because increased insect diversity would lead to more diverse insect life histories, the timing of life cycles might be more complex, resulting in more consistent availability of insect resources across seasons or among years. Specifically, an increase in insect diversity might mean favorable feeding conditions for fish in the Colorado River would become less dependent upon whether conditions had been good for growing blackflies or midges. In turn, this might lead to a more consistently favorable state for sustaining healthy fish populations, buffering against changes in insect production that might otherwise translate into dramatic swings in fish populations (e.g., as we have observed for the Glen Canyon trout population in response to changes in midge and blackfly production following high flow experiments; Cross et al. 2011, 2013). The portfolio analogy is a powerful and intuitive one. However, it also represents a hypothesis, rather than a principal that can be assumed.

To me the array of activities proposed by the authors seem predicated on the assumptions and the two additional hypotheses on which I have focused in the preceding paragraphs. This means that though I judge the work proposed here to be necessary, I would point out that it may not be altogether sufficient to make the key connection between the work and Goal 1 of the GCAMP strategic plan. Let me elaborate. The authors outline a set of five hypotheses regarding mechanisms that might limit EPT taxa and productivity of midges and blackflies. These are well-reasoned and articulated. They then proceed to limit the scope of the proposed investigations (proposals 5.1 and 5.2) to addressing hypotheses 4 and 5, respectively. The reasons for this focus also seem well justified to me in the pragmatic context of adaptive management—though I leave it to others to evaluate whether the authors' assumptions about management practicalities are accurate. Hypotheses 4 and 5 posit that EPT taxa are limited by hydro-peaking activities because it causes catastrophic drift and high mortality of EPT larvae (H4) and/or because it caused high egg mortality (i.e., limiting recruitment, H5). Addressing these hypotheses seems necessary, and I judge that the proposed combination of studies would accomplish this (but see below for relatively minor technical comments). However, in light of my general comments above, I'd suggest that there are perhaps two additional elements that should be considered that would address each of the two hypotheses I outlined above.

First, I think that the proposed emergence and drift studies involving comparisons between Glen/Grand Canyon and other sites in the upper basin (or entailed in the proposed synthesis across tailwaters) would benefit from a more explicit plan to evaluate the relationship between insect diversity and productivity. For the purposes of such analyses, measures of drift and/or emergence rates might be used in lieu of benthic production estimates, which I think would be

fine. On the other hand, I suspect an array of benthic invertebrate data exist for the suite of tailwaters the investigators propose to study (and especially for Glen Canyon and Flaming Gorge), which may mean the relationship could be evaluated using a combination of data types. In any case, the point is that under the proposed activities the data would be collected to investigate the relationship, so it should be tested rather than assumed. In turn, this would help managers determine "where on the diversity-productivity curve" each of the tailwaters resides, and hence, what gains in productivity might be expected with improvements in diversity at these respective locations."

Response: The reviewer 'unpacks' the Problem Statement and Management Background sections of the proposal, and suggests that assumptions that are implicit in these sections could actually be treated as hypotheses to be evaluated during the course of our studies. Describing the relationship between invertebrate diversity and invertebrate productivity in other tailwaters is an interesting idea, and could easily be folded into the proposed synthesis of the foodbase for western tailwaters (project element 5.1.4). We have updated the proposal and now include description of the diversity-productivity relationship for tailwaters as an explicit goal of this project element.

Comment: Second, I would recommend more explicit investigation of the link between insect diversity itself (i.e., not productivity alone) and the capacity of the foodbase to sustain viable populations of fishes. This is necessary if the proposed activities are to make the direct link to the desire outcome articulated in Goal 1 of the GCDAMP. Again, I suspect this is the kind of analysis that could only be accomplished by comparison across tailwaters and/or between Glen/Grand Canyon and upper basin sites. Ideally, such an investigation would amount to a test of several predictions derived from the "portfolio hypothesis" described above. I will outline a few of these. For instance, if the invertebrate portfolio hypothesis is correct, then one expectation would be that tailwaters with more diverse insect assemblages should host fish populations that have diets that are more diverse over time (across a hierarchy of time scales from days to seasons to years) than those of fishes in tailwaters with lower insect diversity, reflecting the ability of fishes to track resource availability and switch from one prey type to another. Following from this, another important expectation would be that fish populations in tailwaters with higher insect diversity should also exhibit less dramatic swings in numbers and/or population size structure—reflecting the presumed "buffering" effect of the diverse insect portfolio. I suspect that there are quite a lot of existing data that could be brought to bear to test these predictions. Testing the first of the two predictions regarding fish diet diversity might involve making use of existing and published data for fishes from some tailwaters, but could require some sleuthing and new analysis for other sites. Many fishery monitoring programs regularly collect gut content samples of their populations. These samples do not always get processed (but may be archived and available), and if they are analyzed they may be published infrequently. In addition, fisheries monitoring often involves sacrificing and preserving fish for other reasons (including museum collections), and some of these specimens may be available for use in testing this prediction. Similarly, I suspect the second prediction regarding buffering of longer-term dynamics in fish populations could be tested using existing fisheries monitoring datasets. Though few tailwaters have the same intensity of fish population monitoring as Glen Canyon and Flaming Gorge, I suspect that several others that encompass the needed gradients in insect diversity could be identified that also have the needed fisheries data. Indeed, the "tailwater synthesis" currently being conducted by GCMRC (led by Kim Dibble) should set the stage wonderfully for such an

analysis because it has focused on trout population data, and the new analysis might be included as part of the "food base" synthesis of western tailwaters proposed here."

Response: The reviewer identifies approaches for explicitly linking the studies we propose to the GCDAMP's Goal 1 for foodbase. Specifically, the reviewer suggests that direct links between proposed invertebrate studies and fish populations could be accomplished by 1) quantifying diet diversity of trout populations in other tailwaters to see if diet diversity increases with invertebrate diversity, and 2) evaluating whether trout populations in tailwaters that have more diverse invertebrate assemblages tend to exhibit less dramatic swings in abundance. Incorporating these types of investigations into Project 5 would serve to identify what might be expected in terms of trout population dynamics if a more diverse invertebrate assemblage was present downstream of Glen Canyon Dam. The reviewer identifies that pre-existing fish diet and long-term population abundance data for other tailwaters might allow these types of investigations to be accomplished without the need for additional field data collections. These are all excellent and practical suggestions for explicitly linking our proposed invertebrate studies to important fisheries questions that are relevant to the AMP. However, acquiring museum specimens or other fish samples needed to rigorously quantify diet diversity would require considerable time and effort, and is beyond the scope of our proposed budget. We have updated the synthesis of the foodbase in other western tailwaters section (Project element 5.1.4), and now describe how we will collaborate with Dibble on the larger tailwater synthesis and identify whether trout population dynamics (e.g., population stability) in tailwaters are related to invertebrate diversity. Additional funding would be required to support the description of diet diversity in other tailwaters.

Technical comments

Comment: First, a number of the proposed activities link to the possibility that oviposition conditions and/or egg mortality constrain the productivity of existing insect taxa (midges and blackflies) in the mainstem Colorado in Glen and Grand Canyons and/or limit to potential for maintaining EPT taxa. These are plausible hypotheses, and given the lack of our understanding regarding such crucial life cycle stages it seems likely we stand to learn very useful lessons via such investigations. In all of the years that invertebrate sampling has been done in places like Grand Canyon and Flaming Gorge, it is striking that we remain so "blind" when it comes to these stages. This blindness stems, in part, from the traditional means by which we sample and monitor benthic insects, which themselves shed little light on these processes. Such methods are so entrenched that it hardly requires more than a sentence or two to convey to scientists (and indeed many managers as well) how studies that employ these techniques will be conducted. On the other hand, the methods used to survey egg-laying behavior of a wide range of taxa, or the techniques to be used to quantify mortality rates of insect eggs across a spectrum of taxa, locations and time periods—both of which are proposed here—are much less standardized. The investigators did not include any methodological detail that might help the audience to understand how such investigations are to be performed with confidence and success. With the suite of experts that are involved, I suspect that the methods have been thought out in rigorous fashion. Yet, in many cases studies of insect egg laying and egg development/mortality have been conducted at small scales and/or to pursue questions much different from those this team proposes to investigate—typically to get at life cycle questions rather than evaluating population level implications. However, there has been a recent shift toward the latter, and associated methods are becoming more commonplace (see, for example, studies of the mayfly *Baetis* by Lancaster et al. 2010, Encalada and Peckarsky 2011). Anyway, I think it would be helpful to

know more about how the investigators plan to conduct these components of their planned work, and I expect this would help to a) justify the focus on egg laying and development stages and b) help managers envision how the work would be accomplished. This technical issue seems especially critical because a major flow manipulation experiment is proposed whose key mechanistic response metrics include egg-laying and egg mortality. Nevertheless, the group has a history of developing and applying new techniques with success, and (see my next comment) I myself am confident they will tackle these challenges with similar outcomes.

Response: The methods and techniques used to quantify insect egg-laying and egg mortality, two of the key processes that we will study as part of Project 5, are not well developed. However, the reviewer identifies several recent studies, some of which are already cited in the proposal, that provide examples of methods that have been successfully used to study these processes in small streams. We have updated relevant sections of the proposal, and now explicitly describe some of the approaches we will attempt to use to study these important processes. We also note that innovation and new methods will likely be required to successfully study these processes in the Colorado River.

Comment: Rather than raising any other methodological "issues" I'd next like to make a supporting point to help emphasize an opportunity represented in the proposed work. For almost 15 years I have studied the emergence of adult insects from streams and rivers as part of a wide variety of food web investigations. These investigators are using novel techniques and what I think is an unprecedented citizen science program to measure the process of insect emergence in a way that has not before been accomplished. I see this as a real strength of the proposed activities. The use of the citizen science approach is allowing the team to amass a dataset that has a spatial and temporal extent and resolution that is rather unheard of when it comes to the study of riverine insects. Together, these two measures, extent and resolution, determine the "scope" of a method to detect patterns at multiple scales in space and time (see Wiens 1989, Schneider 2001). I am aware of no study of river insects that has ever collected data with such high scope as are presently being accomplished by this team. It is exactly these kinds of inventive efforts that I think are most likely to reveal new patterns not previously detected during the decades of repeated applications of traditional techniques with much more limited scope. In turn, I think that detection of these patterns and the novel hypotheses they generate (like those articulated in this proposal) are what will fuel the creative feedback needed between science and management in the context of adaptive management.

Response: We thank the reviewer for these supportive comments.

Project 6. Mainstem Colorado River Humpback Chub Aggregations and Fish Community Dynamics

Response to Review of Glen Canyon Dam Adaptive Management Program Triennial Budget and Work Plan – Fiscal Years 2015-2017

Page 17. Reviewers questioned why monitoring is a conservation measure. We used the meaning of "conservation measure" as described on page 32 of the 2011 U.S. Fish and Wildlife Service Biological Opinion on the Operation of Glen Canyon Dam:

"Reclamation has committed to expand the information and understanding of mainstem aggregations through improved monitoring to support humpback chub distribution throughout the action area as a new conservation measure. Monitoring will be expanded beyond the small NSE study area to better understand the population dynamics of the mainstem aggregations of humpback chub, including yearly trips to try and generate population estimates for these aggregations."

Page 17. Reviewers commented that project element 6.8 on the Lees Ferry Creel Survey should be funded. We agree and consider the creel survey to be a very important data collection effort. We clarified the text to state that creel surveys during FY2015 would be conducted and funded by Arizona Game and Fish Department (AGFD) with funding outside of the Glen Canyon Dam Adaptive Management Program (GCDAMP). USGS GCMRC will continue to fund the project during FY2016 and FY2017, with the expectation that AGFD will fund the project every third year. USGS does charge GCMRC burden on the project during FY2016 and FY2017 when funds are transferred to AGFD, but the rate is very low (3%). We do not charge burden on projects not funded by the AMP such as the Creel Survey in FY2015.

Page 18. Reviewers point out that a major shortcoming of the proposal document was the lack of concrete evidence from past work to justify approaches proposed for FY2015-2017. We added text, tables and figures to the Scientific Background Section to clarify and provide more background on monitoring work that has taken place during the past three decades.

Page 18. Reviewers asked about specific locations where PIT tracking at aggregations was employed, and asked if data would be comparable to CPUE data and older datasets to test whether there are more chubs today than before, and how much they move. PIT tag antennas, although successfully deployed in the LCR, have been used in the mainstem Colorado River only during brief pilot testing. We plan to temporarily deploy antennas from boats while they are moored at campsites, and then move the antenna to the next campsite with the boat. Locations where detections are attempted will therefore be restricted largely to established campsites, but should encompass most of the length of the river. Data derived from these efforts may help identify additional locations occupied by PIT tagged chub and may inform us regarding movement of PIT tagged fish within Grand Canyon. At present we do not think the data from these efforts can be used to estimate chub abundances, although if we can establish permanent deployment locations, they might be used to generate survival estimates.

Page 18. Reviewers suggestion that anglers mark chub while trout fishing, while appealing, is likely not feasible because there is very little angling in Grand Canyon except in the tailwater trout fishery and in Bright Angel Creek. We also want anglers to release any humpback chub captured immediately without mutilating the fish.

Project 7. Population Ecology of Humpback Chub in and around the Little Colorado River

Response to Reviewer Comments

In response to reviewer comments we provide estimates of the variability in juvenile abundance and outmigration rates in the text as well as provide figures previously reported in presentations showing estimates of juvenile chub survival with respect to trout abundance estimates, comparisons of a simulation model with historical trends, and a figure illustrating how temperature, trout abundance and LCR recruitment interact to determine minimum population sizes over twenty-year simulations for the LTEMP process.

It was also suggested that we dig into the LCR temperature data. An in-review manuscript by Dzul et al., somewhat addresses this suggestion by looking at seasonal and spatial variation in growth, survival and abundance, however there are a number of complications in a simple comparison to temperature. For example, within-day variation in temperature in the LCR is substantial and may be more important than average temperatures, not to mention early evidence that food availability is likely to vary systematically within the LCR. The reviewer also suggests looking at inter-annual variation in water temperature, however, LCR temperatures are remarkably constant when compared between years owing to the constant temperature coming out of Blue and others springs and the relatively short travel time between Blue Springs and the confluence. While it is true that inputs above base flow can change the temperature, they also change the turbidity and food availability. Juvenile chub density is likely to play a bigger role in differences in inter-annual growth and tapeworm prevalence than temperature differences.

While the experimental approach to washing gravel beds is a very interesting, it may be premature and given budget constraints we suggest focusing on cheaper observational studies in the short-term.

With regards to science advisor comments regarding recovery after electrofishing in the Little Colorado River there are no such observations because electrofishing in the LCR is not practiced owing to the high conductivity. There are field observations of juvenile chub losing equilibrium when held in water entering the LCR from side springs that are higher in CO_2 than the water in the main channel. Humpback chub that are translocated from the lower portion of the Little Colorado River to areas above Chute falls also must undergo extensive tempering to prevent loss as a result of the CO_2 change.

Other comments suggest some confusion about triggers related to non-native species control. Data collected through project elements 7.1 and 7.2 are directly linked to current triggers.

Survival and abundance estimates to inform triggers are calculated as part of project element 7.10. These projects are the basic monitoring program for the LCR aggregation of humpback chub (not extensions as suggested) and there are no barriers. Given the way the biological opinion was written it is unlikely that removals will be triggered in the next 3 years even though chub will likely be declining (under the most probably scenario that trout abundances remain high near the confluence in the short to mid-term). This has nothing to do with monitoring or research, but rather with the policy metrics and triggers chosen. The research projects suggested are designed to help rule out competing hypotheses about causes of decline/recovery so managers will have the necessary tools and understanding to act when it is deemed necessary.

Project 8. Management Actions to Increase Abundance and Distribution of Native Fishes in Grand Canyon

Response to Reviewers Comments

While there is no question that non-native removal is a key tool, the proposal should make it more clear how many trout can be removed a year, and what kind of impact that would have on their overall abundance.

Response: Brown trout removal in the Mainstem Colorado River near Bright Angel Creek has only been conducted once as of this date, so the amount of information available on effectiveness and potential impacts are very limited at this point. In 2013, 1,851 nonnative fish were removed with a majority of those being rainbow trout (1370) and brown trout (336) (Nelson and others 2014, Bright Angel Creek infow trout reduction Study trip report). Conditions in 2013 were not ideal for electrofishing because of the High Flow Event and subsequent storm events that caused the water to be very turbid during the removal effort. The number of fish that were removed was far less than what was anticipated could be removed with this 5-pass effort. Estimates of the cumulative percent of trout removed, based on capture probability, indicate that in 2013 less than 50 % of the trout population in the area was removed with this effort. Unless conditions improve in future years and significantly more fish can be removed, it is unlikely that the removal effort will impact overall abundance of trout in the mainstem near the Bright Angel inflow. For this reason additional years of effort are needed to evaluate effectiveness under better environmental conditions. If significantly more fish are not able to be removed in future years then the project will likely be discontinued, and the scheduled protocol evaluation panel in FY 16 or 17 will assist with making the recommendation to continue or discontinue this effort.

Of the fish removed in the past, what proportion are big enough to eat small chubs?

Response: Predation vulnerability of small chubs to rainbow and brown trout depends on the size of the trout, the size of the chub, and the species of trout, so the specific answer to this question is complex, but in general, most of the fish that are removed via electrofishing in this area are adult fish (>300 mm TL) which are capable of preying on small juvenile chub (<60 mm Total length).

There is mention of relationships between removal needs and water temperature; what have the years of data since Coggins 2011 taught us about the strength of that relationship? It would be

helpful to know whether chub (positive effect) or rainbow trout (negative effect) are more temperature sensitive, since that helps to frame how the future balance between trout fisheries and chub conservation can be struck under climate change.

Response: Water temperature does affect predation vulnerability of small chub. Most of this information comes from ongoing laboratory studies. Preliminary results indicate that for every 1 °C increase in water temperature (from 10 °C to 20 °C) there is a corresponding decrease in predation vulnerability of small chub to rainbow trout by about 5% (Ward et al. 2014 Annual Reporting Meeting, Poster Session). In reference to climate change and water temperature, effects of a large hydroelectric dam on water temperatures will always likely have a much larger impact on water temperatures than climate change effects. Significant nearshore warming was not observed, under current release volumes, for much of Grand Canyon (Ross and Vernieu 2013, Nearshore temperature findings for the Colorado River in Grand Canyon, Arizona- Possible implications for native fish). The Colorado River in Grand Canyon will likely remain below the thermal optimum of humpback chub in much of Grand Canyon even under projected conditions of global warming.

Is there potential to encourage recreational anglers to fish the Bright Angel area for brown trout, with a mandatory culling rule? That could potentially yield much higher removal rates, imposed year-round at low/no cost, as well as engaging citizens in the control effort.

Response: It is unlikely that angling pressure on Bright Angel could be sufficient to remove enough fish to have a population level impact even with increased encouragement. Over 14,000 fish were removed by the Park Service using backpack elecrofishing in Bright Angel Creek from Jan- Feb of 2013 (Healy et al. 2013, Bright Angel Creek Trout control project, trip report). That magnitude of removal is just not possible in such a remote area with the amount of angler use that Bright Angel Creek receives.

There is also a need to be more clear about the success of past translocations.

Response: This is a good question. One reason that the success of translocations is unclear is that there is no consensus on how we measure success of a translocation? If we measure success in terms of growth rates because we know that increased growth rates equate to higher survival then we have good data to suggest that translocating fish has been successful. If we measure success in terms of how many fish survive then the answer is unknown because we do not have good survival data for most of the translocated fish. If we measure success in terms of establishing self-sustaining populations of humpback chub in new areas, then we have not been successful yet because we do not have documented reproduction in these areas. The protocol evaluation pane scheduled to take place in FY16 or 17 will hopefully assist with answering these questions about success of translocation efforts and whether or not translocations should continue.

Does PIT monitoring indicate survival of all/most fish translocated since 2008?

Response: Pit tag monitoring does detect a few of the translocated humpback chub at the downstream fixed antenna near the confluence, but those data do not tell us anything about

survival of fish that remained upstream. Fish and Wildlife Service annual monitoring does give some information about survival of translocated fish that remained upstream, and the following paragraph pasted from the 2014 FWS trip report summarizes that information, "…in the two reaches above Lower Atomizer Falls between the summer 2009, 890 unique Humpback Chub were captured, and the summer 2010, only 13 unique chub were captured. However, the Humpback Chub juveniles (68-136 mm) that were translocated after this event have shown relatively high retention and growth rates above Lower Atomizer Falls through this May. For example, this May we recaptured (A) eight of the 109 chub (7.3%) translocated in 2010 (277-413 mm at recapture); (B) 34 of the 96 chub (35.4%) translocated in 2011 (233-334 mm); (C) 40 of the 212 chub (18.9%) translocated in 2012 (183-303 mm); and (D) 113 of the 303 chub translocated (37.3%) last November (111-210 mm). (Stone, 2014 trip report. Spring Monitoring of Humbpack chub above Lower Atomizer Falls in the Little Colorado River.)

In terms of genetic assessments of chub aggregations, microsats may no longer be the best method; SNIPS or extensive sequencing is now within reach to gain very high resolution. These methods can now be outsourced at low cost, allowing investigators to focus on interpreting the data. If population sizes are small enough above Chute falls, detailed parentage analysis may even be possible for translocated and naturally-spawned fish.

Response: These are all great suggestions that we will pass along to those who will be contracted to do the genetic analysis. We have removed the specific reference to microsatellite genotyping within the work plan. Instead we have been more general and have indicated that DNA samples from Humpback chub fin clips will be genotyped to establish baseline data. The specific methods for the genetic analysis will be developed in collaboration with Wade Wilson, Geneticist at the Southwest Native Aquatic Resources Research and Recovery Center.

Project 9. Understanding the Factors Determining Recruitment, Population Size, Growth, and Movement of Rainbow Trout in Glen and Marble Canyons

Response to Reviewers Comments

Project 9 incorporates the ongoing monitoring efforts to evaluate status and trends of rainbow trout resources. Project 9 is aimed at filling a large and critical knowledge gap, which has significant implications for humpback chub and recreational angling. The hypotheses proposed on p. 281 seem reasonable and important to test. Overall the individual proposed projects within Project 9 seem to have some capability to address the key issues and hypotheses sufficient to warrant the amount of budgetary funds involved. It also proposes multiple new studies to evaluate and define key drivers that can impart change in RBT population size, movement, survival, reproduction, size, and condition. All of these factors are hypothesized to have some effect on individuals and populations, and previous evaluations of varied scope have occurred in the program. Some assessments are extensions or add on analysis to evaluations approved in the 2013-14 Plan. To reiterate the point made in Project 6 *we believe that discontinuing creel surveys*

may be ill advised in the short run. Presumably while the new mark-recapture methods for estimating trout populations are being *developed the creel census will continue so that a relationship between the two can be established that will be useful for back- casting trout populations using the new method in order to have a consistent time series*. Sport fishing for RBT in the Glen Canyon NRA is an important social benefit of the tail-water from GCD and brings with it many socio-economic issues.

Response to review comment concerning creel surveys (Project 6)

Workplan FY2015-17 has been structurally organized around three primary resource programs, physical, biological, and cultural, and these programs have been further partitioned into multiple projects that make distinctions between monitoring and research. For this reason, the creel survey is not part of Project 9. Clearly, there are numerous linkages that exist between the different project elements and a reliance on the consistent flow of data coming from baseline monitoring (6.4, 6.7 & 6.8). Therefore, these monitoring data are essential to the management of the Lees Ferry trout fishery because they provide an indication of the influence of Glen Canyon Dam operations and other naturally occurring disturbances in the Colorado River ecosystem (CRe) on the health of the rainbow trout fishery. Inferences from these data have fueled the types of questions that are being addressed by these research activities, but are temporary in scope. Secondly, project element 9.1 (Rainbow Trout Population Dynamics – Ongoing Modelling and Future Monitoring) is to evaluate monitoring protocols to determine if these meet current management needs, and transition from a research focused approach (Natal Origin Research project) to a better more appropriate monitoring plan for the future, and that is collaboratively develop by GCMRC and its cooperators, and technically reviewed.

RBT growth rates have declined and abundances have become highly variable. Although downstream migrations and reproduction by migrants are still not well understood there should be continued effort to expand learning regarding relationships of Glen Canyon and Marble Canyon populations. Continued efforts are also recommended in providing better definition to HBC/RBT predation relationships. The capacity of this species to expand its habitat quickly on potential warming water should receive increased attention. Management of operations can affect this species and attention to water level management, experimental flows, and related food-base efforts need to continue. Although this premier sports fishery is a critical resource to maintain, it also could be a significant threat to HBC. Given that warmer water is probable for this river over the next two decades yet no management action is proposed regarding a selective withdrawal device, HBC at the LCR could receive threats from RBT and other predators in the river. *It would be important for managers to understand how quickly RBT populations could expand in warmer water and their predation expectations.*

Response to review comment concerning regarding potential warming

There are a number of uncertainties regarding fish community response in the CRe to changes from geomorphic, hydrologic, and climatic factors. Clearly, changes in the thermal regime have and are more likely to occur in the future. Although not explicitly stated in this workplan

(FY2015-17) temperature is recognized as a major ecological driver that is likely to affect not only the native and nonnative fish communities but the aquatic foodbase resources of this system. For this reason, this and other physio-chemical parameters are being monitored (Project 2) by an array of stations robustly distributed throughout this system. Also, we are reevaluating the monitoring protocols (6.4, 6.7 & 6.8) to determine if these meet current management needs for measuring fishery responses accurately. As identified by Yackulic (unpublished data) the increased information from mark-capture data over CPU data has increased our understanding of the roles of temperature and trout in the dynamics of juvenile humpback chub through NSE and then JCM sampling (see Project Element 7.2). The impetus for evaluating current monitoring protocols is to make sure that the sampling design and type of fish metric will be informative enough to make inferences on fish community responses throughout the CRe regardless of the causal mechanism.

Most of the specific project elements build on earlier work, and the proposal would be strengthened considerably by drawing more directly on *evidence from previous data collection*. For example, in *element 9.4, what has been learned from all the past drift netting and stomach content analyses?* If there is not strong evidence of selectivity, then the morphometric dimension of this study might be difficult to interpret.

Response to review comment concerning morphometric analysis

We agree with the reviewers regarding the need to include additional evidence to support this proposed scope of work. We inserted another paragraph into the document, project element 9.4 –

Inserted paragraph - Results from detailed diet analysis from mechanical removal (2003-2004) on rainbow trout (n=1,391) and brown trout (n = 401) (Yard, unpublished) suggest that invertebrate prey availability and prey size; as well as predator size strongly influences feeding success. Aquatic prey items found in the CRe lack taxonomic diversity, these invertebrates consist primarily of a Nearctic dipteran assemblage of small midges and black flies, and a large lentic species of amphipod (*Gammarus lacustris*). Diet for both trout species indicates a high electivity for larger rather than smaller prey items. (An electivity index [E] is based on a scale of 1 to -1, and represents the relative proportion of a diet item to its availability in the drift.) Rainbow trout consume prey like *G. lacustris* (E = 0.87; size range 1-12 mm) and black flies (E = 0.55; size range 0.7-5 mm) in higher proportion than their availability; however, midges (E = -0.79; size range 0.5-2 mm) and zooplankton (E = -1; size range 0.35-0.7 mm) were consumed less than their availability. Although suspended sediment appears to negatively affect prey detection for visual sight feeders by reducing food intake (high frequency of empty stomachs during increased turbidity) (unpublished data) (project 9.5 & 9.6), trout size was also negatively correlated with prey food intake (weight of gut contents). Essentially, the difference between observed and expected food intake based on size suggests that daily rations for trout become limiting for larger sized trout (> 250 mm TL), unless prey availability is limitless. Budy and others (2005) and Langeland and Nost (1995) analyses of branchial arch/gill-raker morphology

for rainbow and brown trout, respectively, strongly suggest that prey size and its availability may be a limiting factor on trout growth because of feeding inefficiencies with increasing trout size.

Due to and earlier revision that changed the availability of funding available to complete these analyses we excluded any effort to evaluate humpback chub, and have limited our analyses to only rainbow trout and brown trout.

In addition, is there a *way to engage anglers as citizen scientists in the effort to understand trout movement patterns?* Assuming that angler efforts range more freely in space and time than scientists can, then creating a physical mark (adipose clip or v-cut in dorsal) on trout caught in one place (e.g. tailrace of GC dam) could enable a small army of to contribute to monitoring trout movement. Alternatively, *can otolith chemistry approaches be used in the trout studies?*

Response to review comment concerning using citizen science to resolve trout movement

Citizen science has been an effective means for documenting and collecting secondary information on specific resource responses (e.g., repeat photography as per Adopt a Beach Program, and use of invertebrate light traps as per Aquatic Foodbase Program). Unfortunately, angler use in this river system is primarily centered in the Glen Canyon reach. Although, recreational angling occurs downstream in the Marble Canyon reaches, it is seasonally and spatially limited in scale to upstream as well as unpredictable across years. The lack of a broader spatial distribution in anglers and the inability to quantify the distribution of their effort throughout the area of interest (Glen Canyon to below the LCR) has a potential to create spatial and sampling bias. The use of external marks or tags necessary for detection by anglers has a higher shed rate than passive integrated transponders. Additionally, without inducing differential mortality by size the application of external tags (e.g., floy or Carlin tags) is limited to larger sized animals. Engaging anglers has some scientific value (e.g., creel study); however, altering the current sampling design for NO is unlikely to benefit our understanding of trout movement patterns.

Response to review comment concerning using otolith chemistry to resolve trout movement

Otolith microchemistry has been useful for resolving some questions about native fish, particularly humpback chub's providence and movement between river and tributary systems (Limburg et al. 2013). Water chemistry for certain tributaries differs sufficiently from the Colorado River; unfortunately, the suite of major, minor, and trace elements (Se, Pb, Zn, Ca, Ba, Cu, Fe, K, Mg, Mn, Rb, and SrSr) analyzed to date do not differ enough longitudinally along the water course to discriminate between water samples collected within the Colorado River mainstem itself (~ 400 km). Rainbow trout and the area of interest where this species resides is found between Glen Canyon Dam and downstream of the Little Colorado River.

The lipid approach in element 9.3 could be powerful, *but lipid storage probably is not the primary shift in resource allocation with trout size*. Rather, the *primary shift would like be*

toward gametes rather than somatic growth (including lipids). Thus, the prediction of differential allometry of lipids in small v large trout may not be valid as proposed.

Response to review comment concerning using lipid analysis to resolve short-term growth

Energy allocation strategies in teleost fish are complex and often include tradeoffs among somatic growth and reproduction, which can differ among fish species. For trout and other salmonid species, research has shown that adults do invest a significant amount of energy into reproduction as they grow larger (Jonsson and Jonsson 2003, Manor et al. 2012); however, the allometric relationship between lipid mass and body size in rainbow trout remains, even though body protein, water, and ash exhibit isometric growth as a fish gains body mass (Dumas et al. 2007). This allometric pattern in lipid deposition occurs in rainbow trout to a body mass of ~400g, after which lipid mass continues to increase allometrically, albeit at a slower rate (Dumas et al. 2007). For context, a 400g fish in Lees Ferry would measure approximately 362mm (14.2 inches); over the past two decades, the average size of rainbow trout in Lees Ferry was 257mm and 218g. Other researchers have verified that this allometric relationship exists for rainbow trout and other salmonid species such as brown trout and Atlantic salmon at various life history stages (Weatherley and Gill 1983, Jonsson and Jonsson 1998, Post and Parkinson 2001, Simpkins et al. 2003).

Further, investment of energy reserves into gametes would not result in a decrease in total body lipid mass until after the reproductive season in mature adults. We hypothesize that post-reproductive energy stores in adult rainbow trout will be lower relative to juveniles or mature trout that skip spawn. Nonetheless, rapid energy accumulation post-reproduction should occur due to high densities of drifting invertebrates in early summer that coincide with clear water conditions. Therefore, we would expect to see a natural decline in adult lipid reserves in the spring (post-reproduction) followed by a rapid accumulation of fat stores in summer and fall coincident with higher primary and secondary production, which is a phenomenon shared by many temperate fishes in preparation for winter survival.

The lab studies of turbidity effects in element 9.6 will be very useful, but under *field conditions can differences in detection distance overcome density- dependent encounter rates and size-dependent detection rates?* The literature values could provide a rough answer to that question prior to doing the work of lab manipulations.

Response to review comment concerning using lab studies to evaluate turbidity effects

The reviewer is correct that biotic factors like fish density and size structure are likely to influence encounter rates between fish. However it remains uncertain whether or not changes in physical factors like turbidity interact to reduce or increase individual detection rates under varying fish densities or size-class distributions. Although this is an interesting ecological question, it still remains uncertain and is beyond the scope of this study. Under the current structure of our sampling design we will attempt where possible to address some of these

questions. However, environmental conditions in the field are often more variable than what can be simulated in a laboratory setting and sometimes by inducing levels of complexity similar to field conditions compromises the capabilities of a lab because of the number trials, time, and monies available to complete these studies.

The conception of project element 9.5 was proposed to act as a companion study for 9.6 to evaluate the literature by conducting an extensive metadata analysis on published detection (reactive) distance relationships (refer to 9.5). Preliminary analysis would indicate that most of the past laboratory studies have used turbidity as a surrogate metric for light intensity levels because of its light attenuating characteristics. Because turbidity is directly influenced by particle size, shape, and concentration, equivalent turbidity levels between different river systems does not equate to similar sediment or light attenuating characteristics (Davies-Colley and others, 2003). Unlike most laboratory studies, other physical variables (light, NTU, concentration levels) are to be concurrently collected and the relationships developed will be specific for this system.

Similarly, for comparing different tailwaters, can all the other factors which differ be controlled for to allow strong inferences about the effects of temperature or other factors?

Response to review comment concerning tailwater synthesis

The first analysis associated with the tailwater synthesis project identified hydrologic and density-dependent factors that influence the size of rainbow and brown trout in regulated rivers across the West. However, this analysis was limited by the availability of high-quality temperature data because many federal and state water gages do not have the capability to measure temperature on a subdaily basis. Further, we were only able to establish correlations between fish size and the other factors across a large number of dams by using mixed effects models and a multi-level R2 analysis. In the FY15-17 workplan, we plan to take this analysis further by using only data from systems with long-term fish, flow, foodbase, and temperature data. This next set of analyses will apply to a smaller population of tailwaters, but will be more rigorous…"Stronger inferences" will require controlled experiments.

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Project 10. Where does the Glen Canyon Dam rainbow trout tailwater fishery end? - Integrating Fish and Channel Mapping Data below Glen Canyon Dam

Responses to reviewer comments

Science Advisor Review Comments:

Comment Project 10: The project focuses on Glen Canyon Dam rainbow trout tailwater fishery. This project nicely integrates information from other projects (2, 3, 9) together to address the issue of where does the trout tailwater fishery end. The project will evaluate select shoreline sites at flows below 8000 cfs in Glen and Marble Canyon to provide to ecologists evaluating food base definitive information of channel geometry and bed grain size. The project has been discussed by GCMRC at two TWG meetings and results from stakeholder requests for assessments. Introduction of rainbow trout in this system has been a huge success, which now is sometimes expressed as a curse of riches. Biotic and socioeconomic issues surround management of the RBT. The project proposes a novel and potentially important approach to building a bridge between the detailed studies of river sediment particles and those that change habitats and productivity in support of desirable ecological conditions. Restated, this means that in developing the adaptive management approach at the GCe scale, there is need for more than sole attention to building beaches for campers. Before the dam, there was a very large annual flood. Now there are the realities of diurnal and seasonal flow fluctuations plus those of the weather, and the HFE's that have shoreline effects analogous to sending a tornado down the canyon. So how can things change in ways that benefit food web interactions? In other words, what ecological benefits would develop if there were little or no HFEs for a significant period of time? This echoes the voice of conservationists in support of stable flow conditions and that recognizes climate change as an ominous reality. The scientists have the capacity to estimate hypsometric flow inundation effects. Unfortunately, I wonder if they have changed things with many HFE's in ways that do not provide a baseline condition. In ecosystem studies, these are known as reference or control systems that develop during time of the Holocene. It may take some time to build a reference condition that creates the habitat required to enhance life histories of the invertebrates, etc. If they succeed, fishes will eventually find the prey resources. If gravel

conditions develop to the point where fishes will spawn successfully, then monitoring efforts might provide evidence of success. The comparative study proposed by Project 9, and perhaps the drift study offered by Project 5, could offer some guidance in planning derived from tail-water sites where a regular pattern of seasonal or daily fluctuations has a history different from that of the GCe events and HFE effects. The SAs strongly endorse the potential learning from this unique project. If the project scientists implement strong collaboration in data gathering stages and design with Project 5, 9, 11 and especially 12 scientists, it would offer the type of opportunities in science and management integration that can advance science and learning at a much more rapid rate. Mother Nature has a time clock that is modified on an evolutionary scale with internal sensitivity to ecological interactions. That's how the GCe operated before the Anthropocene before when Glen Canyon Dam was constructed and the march of invasive species began.

Response: The support and encouragement of the Science Advisors for this new proposed project is appreciated greatly. In their comments, they make several points and raise a few questions that are quite important. Regarding the reviewer concerns about the desire/need for establishing a "reference" condition for the channel, one possibility for establishing a "baseline condition" for assessing the 2012-16 trout abundance/distribution in Glen, Marble and Grand Canyon segments – the issue that the reviewer appears to be concerned about - could be addressed by using the available SEP 2000 towed sidescan sonar imagery within the Natal Origin (Project 9) study reaches. These imagery data are included in Table 1 of the project description and may provide some relative context for bed sediment grain size conditions. Earlier imagery may also still be available that was collected in fall 1984, but both of these imagery data sets were collected following periods of high-flow releases that likely significantly altered the distribution of finer sediment on the channel bed, so that a true "reference" condition for the deeper channel habitats may not be possible except in the Glen Canyon segment where topography and bed-sediment grain size conditions were documented by Reclamation in the 1950s. The information from those early studies prior to dam construction were documented by Pemberton and others, and have fortunately been compiled and published by Grams and others (2007), at least for the Glen Canyon tailwater segment between the dam and Lees Ferry. We intend to use those data as the project's baseline condition in NO reach #1, where most trout production has been occurring and has been documented since dam operations were modified in the 1990s.

Reviewer Recommendations

Comment Projects 9 and 10: These projects present the continued monitoring efforts and related research on factors that can induce variances in populations of the sports fishery resource and new investigations on implications of lower flows to critical reproduction habitats, and potentials for downriver migrations and establishment of new populations. This program is important to its contributions in maintaining a healthy sports fishery, but also to greater understanding of these populations ability to transition downstream and impose greater threats to native species in the system. The science advisors feel that significant improvements have occurred in interdisciplinary cooperation and integration of the monitoring and science across programs. Project 10 exemplifies this shift. However, we also note areas where it might be improved. Even where that collaborative process was not mentioned it is intuitive from the list

of scientists involved in each project. We support this trend and encourage continuation in the future.

Response: Every attempt will be made to coordinate closely with the researchers leading elements of Project 9, as well as others working on Project 5. Although no specific collaborations are included in the project description with Projects 11 and 12, the outcomes of those research efforts will be considered in planning the proposed 2017 synthesis workshop and results from those projects will be included in syntheses as possible and appropriate.

Project 11. Riparian Vegetation Monitoring and Analysis of Riparian Vegetation, Landform Change and Aquatic-Terrestrial linkages to Faunal Communities

John Spence, Glen Canyon NRA

9 June 2014

I have focused my review on the vegetation and wildlife sections under Project No. 11, based on my educational background and field experience. In general, I think the sections I have reviewed would benefit from objective reviews by outside plant community ecologists and ecological statisticians, including appropriate academic researchers. I am reviewing this under the assumption that this is either happening or will be happening prior to finalizing the long-term plan. Thus my review is general in nature and raises general issues about sampling design, scale, and other monitoring-related concerns.

Project 11.

Comment: The Introduction talks about using 20 pre-selected sand bar complexes as the basis for the proposed vegetation work. However, later in PE 11.1 other settings (channel margins, randomly placed sites) are mentioned. This is a little confusing. It would be useful to have a table indicating which work will be done at which types of sites to help organize the section.

Response: In the revised project description, we attempts to clarify the sampling sites and the approach for plot sampling in relation to river stage.

Most of my review comments are on the ground-based vegetation sampling and avian projects.

<u>Project Element 11.1</u>

Comment: P. 106: Sand bars represent only a small portion of the river system and are not necessarily representative of much of the river corridor. Especially in the lower canyon much of the riparian vegetation and associated avifauna is not connected to sand bars. To the extent that work is focused on sand bars, inferences will not be possible for much of the system. There is some confusion for the reader as other geomorphic settings are also mentioned in the vegetation

project, so it would help to better articulate the sampling framework and project elements vis-à-vis specific geomorphological settings.

Response: When the reviewer refers to the sand bars on p. 106, we assume that he is referring to the retrospective analysis – element 1.3. We agree that sand bars are only a small portion of the river systems, but these are sites that are the most dynamic and where the greatest amount of physical and image data are available to permit a retrospective analysis of vegetation change relative to annual hydrology, stage discharge and changes in elevation. Though they are a minor component of the river corridor, sand bars play a large role in campsite availability and the recreational experience. In the revised project description for 11.1., we provide a table that attempts to clarify the sampling sites and clarified the language describing the framework within the descriptive paragraphs.

Comment: P 107: The response guild approach is interesting, but the concept is still somewhat theoretical and may be difficult to apply at the scale of the river corridor and with the mix of riparian species present. Although draft "guilds" can likely be developed, there is always the potential problem that species respond individualistically to various environmental predictors. Further, the same species may be classified in different types of guilds depending on whether one is looking at limiting factors, disturbances, resources, etc. I would like to see a much better articulation of how the theory is going to be used with ground-based vegetation data – in the TWP it is all pretty vague. This especially becomes a problem when polygons may have mixes of species with differing guild adaptations (see below).

Response: We agree with the comment that delineation of guilds is very dependent on the variables chosen as well as the quantitative information available associated with the variable. With the recent addition of Daniel Sarr and Emily Palmquist to the group, positions that remained vacant for 2/3rds of the previous work plan we a making great advances associated with applying species values to chosen variables and documenting the process associated with variable selection and subsequent analytical steps that were used. We are currently working on a draft manuscript that describes this process and reviews the limitations and applicability of this approach.

Comment: P. 109 (at the end of the section on fixed site sampling and also random sampling): The most serious concern I have is how the ground-based vegetation sampling will be done. The two chosen measures seem to be canopy cover and species presence. There are several issues that need to be better resolved in the TWP in order to answer concerns about repeatability, accuracy, precision, scale and appropriate performance measures. These are reviewed below.

1. Repeatability, accuracy and precision: canopy cover and richness can be measured in a variety of ways, but most are extremely subjective and sensitive to observer errors. Canopy cover visual estimation in particular is extremely difficult to collect in an objective manner, and is not very repeatable. There are many ways around this, such as using point counts along transects, frames with pins, intercept sampling, etc. yet there is no mention of how canopy cover data is going to be collected, and how this problem is going to be resolved. Without understanding the quality of

the data collected it begs the question as to whether the data can be used to make informed management decisions.

Response: In the revised project description we provide a table that attempts to clarify the sampling sites and we provide more detail about the approach for plot sampling in relation to inundation frequency and repeatability. In FY15 we will be developing a written protocol for subsequent review that discusses minimum sample size, scale, and accuracy and precision as it pertains to monitoring and informing resource managers.

Comment: 2. Scale: Scale issues are critical to both sampling and to species diversity (including presence/absence). The use of 1-meter quadrats is fraught with problems of scale. Originally, in the European schools of vegetation ecology this size was recommended primarily for low-growing herbaceous vegetation, not for riparian shrubs. Species richness in particular is strongly affected by sampling pattern and size (quadrats, plots, shape of plot, etc.). In general, the larger the plant species, the larger the plot size required for sampling. For tall shrubs a typical size would be 25-100 m^2. The modified Whittaker plot approach is one available method, but is somewhat time intensive. Simpler circular or rectangular plots scaled for different growth forms would be appropriate. Use of a 1-meter quadrat for anything larger than low shrubs should not be done when sampling vegetation. Part of the issue with scale relates also to the pattern in the vegetation, i.e., how individuals are spaced with respect to each other. An excellent discussion of the issues around these concepts and various tests and solutions can be found in Grieg-Smith (1983: Quantitative Plant Ecology, 3rd Ed.). A clear analysis and articulation of the sampling methodology, the pros and cons of the selected methods, repeatability, precision, accuracy and scale are critical to development of any long-term vegetation monitoring program.

Response: We agree that estimating canopy cover for taller woody species is problematic. We are exploring other options to estimate this value. A majority of the riparian species encountered along the river corridor are forbs, grasses and shrubs for which a 1-meter square plot is sufficient. Further, the 1-meter plot samples is effective in sampling seedlings and samplings of woody species while taller/older woody species above a meter tall would be captured in the landscape scale vegetation mapping effort. In FY15 we will develop a written protocol for subsequent review that discusses minimum sample size, scale, and accuracy and precision as it pertains to monitoring and informing resource managers.

Comment: 3. Performance measure: the most commonly used measure of taller (>2 m) woody species performance is not canopy cover, rather it is stem density and DBH, usually in plots that are appropriately scaled to the stature of the species (larger trees = bigger plots), as well as the individual plant spacing. Canopy cover cannot be accurately measured using subjective ocular estimation. Other methods are preferable based on logistical constraints. These include use of a light meter or other device to capture leaf interception (e.g., spherical densitometer; the idea being calculation of some type of eaf area against the sky background), the Total Vegetation Volume (TVV) method, or sampling stem density and size in belt transects or other plots.

Response: We agree that estimating canopy cover for taller woody species is problematic. We are exploring other options to estimate this value. We also supplement the ground-based

sampling with vegetation mapping at approximately a 5-year interval. The landscape scale vegetation mapping provides information about changes in tall woody species to compensate for the short-comings of plot sampling. The 1-meter plot samples is effective in sampling seedlings and samplings of woody species while taller/older individuals above a meter tall would be captured in the landscape scale vegetation mapping effort.

Comment: P. 110: Table 2 – what does PI stand for?

Response: This is a typo, we have removed it.

Comment: P. 111: Collection of species richness, and in general presence/absence is affected by scale and phenological considerations. Using small quadrats (randomly or fixed) will miss many species. Some analysis of scale dependency and sampling intensity should be included based on already collected pilot data that can be used to determine when sites are adequately sampled. PC-ORD has a method that uses jackknife estimation that is easy to implement.

Response: We agree that this is a matter that needs to be discussed in a monitoring document that details the methods and discusses the ability to detect change. In FY15 we will develop a written protocol for subsequent review that discusses minimum sample size, scale, and accuracy and precision as it pertains to monitoring and informing resource managers.

Comment: P. 113-114: for response guilds, the following comments are relevant to all project elements.

1. Presumably polygons are composed of several species, sometimes in mixture and sometimes as mostly single dominants. In the former I think it might be difficult to assign a single guild designation if several species are present and common. For example, *Salix exigua* is not likely to be in the same response guild as tamarisk on many settings, yet they often co-occur. *Phragmites* and *Typha* are very different in their adaptations to hydrologic variables, but also often co-occur.

Response: We agree that individuals from separate guilds can co-occur on a location on the landscape. They represent individual species responses to hydrologic events or other factors that might promote species recruitment. The intent of the guild is to determine which species within a guild may occur more frequently within a particular hydrologic setting. For example, if the frequency of *Phragmites* (from plot data) occurring along the channel just above the stage of daily inundation is greater than the frequency of occurrence of *Typha* at time X +1 and that frequency has increases since X then one might infer reduced hydrology or increased disturbance. The frequency of other species associated with particular guilds can assist in identifying vegetation response as a whole as well as single species responses.

Comment: 2. Given that we are looking at complex variations (gradients) in several hydrologic responses across different scales (individual, population, etc. – see Merritt et al. Table 1), it becomes extremely important that the appropriate variables (water potential, leaf size, root architecture, etc.) are selected as well as the response variables, whether flooding disturbance, sediment grain size, resource limitations, etc. It is highly likely that a single species may respond very differently depending on what variable is being studied. I think that this aspect of the TWP needs to be carefully analyzed with working hypotheses and conceptual models of predicted

responses to be developed, reviewed and refined. Currently, nothing is explained in the TWP on how this approach is going to be used to benefit long-term monitoring and understanding of riparian vegetation and wildlife habitat. However, I think that making the attempt is worthwhile as it could provide a valuable test of the approach in a large-scale complex system.

Response: We agree with the comment that delineation of guilds is very dependent on the variables chosen as well as the quantitative information available associated with the variable. With the recent addition of Daniel Sarr and Emily Palmquist to the group, positions that remained vacant for 2/3rds of the previous work plan, we are making great advances associated with applying species values to chosen variables and documenting the process associated with variable selection and subsequent analytical steps that were used. We are currently working on a draft manuscript that describes this process as well as reviews the limitations and applicability of this approach along other stretches of the Colorado River and its tributaries. Within the TWP we had added more detail regarding the variables chosen that analyses used to address the concerns of the review's comments.

Project Element 11.2

This element looks appropriate, methodology and objectives seem reasonable.

Comment: P. 113: for some riparian vegetation I think that a one species-one image pixel (polygon) will not work very well. This needs to be tested with pilot data. There are ways to get around potential problems using some combination of species correlation analysis, such as pair-wise approaches, to develop species combinations (or perhaps more species) that co-occur. However, this issue may be less of a problem with respect to response guilds, as these tend to integrate several species in a pixel showing presumably similar adaptations. However, with multi-canopy vegetation there will still be some cross-walk issues to solve.

Response: We agree that the one-species –one image pixel does not work very well for 4-band imagery. The approach for final analysis is elaborated here for the benefit of the reviewer. We did not change the text in the workplan. Once total vegetation is segregated in the 2013 image data set (anticipated by or before summer 2016), a most-likely vegetation species will be assigned to each image pixel based on reflectance angle. Spectral un-mixing of individual pixels is not a priority for final analysis. Given that pixel reflectance will likely represent multiple species in densely vegetated areas, mapping will focus on the response guild and association levels (categories of classification within the National Vegetation Classification Standard (FGDC, 2008)). The spectral band quality of the 2013 imagery are different from previous overflight acquisitions in terms of dynamic range, consistency, and accuracy and, therefore, the level of the final vegetation map for this database will not be known until the species classification is completed. Species classification will be accomplished using the following information, in order of preference: (1) ground observations that were collected in August and September 2013; (2) ground-truth site observations that occurred during other image acquisitions, where it is determined by visual examination of the periodic images that certain vegetation is the same in the image data being analyzed; and (3) our previously collected ground-reflectance database for the common vegetation species within the canyon. Image classification

will proceed in 8-km increments progressing downstream in the river corridor from Glen Canyon Dam, because vegetation composition and the spectral properties of species gradually change downstream."

Project Element 11.3

Comment: Some of the same issues found in sampling in 11.1 are relevant in this project. Also, the methodology seems to make the assumption that response guilds for riparian woody vegetation will be used as they form the basis of the sampling approach. But what if they don't work?

Response: We are confident that from the plot data collected on sandbars in 2012, 2013, and 2014 and stage-discharge information for the sandbars, we can create exceedance probability curves subsequently create probability of occurrence surfaces for guilds. This approach was used to project vegetation response under future flow scenario (Merritt and others, 2010; Merritt and Bateman, 2012). We would be taking a similar approach to validate hypotheses about species and guild response to changes in annual hydrology.

Project Element 11.4

Comment: In general, bird species respond to a variety of factors including those on wintering grounds, migratory corridors and breeding grounds. Thus changes in riparian habitat for breeding riparian species is only one aspect of a larger complex story of change. Previous power analysis has shown that most species cannot be monitored in this system without significant expenditures and timeframes.

Short of intensive sampling, there seem to be several ways these issues could be resolved. These include presence/absence (occupancy theory), guild approaches, or using selected *common* permanent residents that are restricted to riparian vegetation. Occupancy theory is a promising new way to look at changes in bird distributions, and is generally easier to do than sampling using intensive point count and distance estimation methods. However, this approach would best be done using a relatively large subset of the river corridor, and sample sizes approaching 40-50 or more. To use the Glen Canyon reach, as suggested in the methods, is simply too limited for this approach, as there are at best 10-15 independent locations that could be used.

Another issue is what exactly do bird species respond to in their habitat? This will likely vary, from responses based on available nest cavities (ash-throated flycatcher) to canopy volume and cover/density (many insectivores), to particular food items (phainopeplas). However, bird populations are usually not controlled by canopy cover per se, rather vegetation structure, volume and in some cases particular plant species are important. In the 1996-2000 program Total Vegetation Volume was used as a measure of habitat structure/complexity. Something like this will need to be repeated if contrasts with those data sets are going to be made.

I would encourage the use of occupancy methods for looking at changes in distribution for riparian bird and other selected animals species, focusing on those restricted to the riparian zones.

Response: We agree with many of the comments and insights provided by the reviewer. The initial phase of this project is the development of a conceptual framework as well as sampling design development to develop the best approach for sampling to detect trends.

Literature cited.

Merritt, D.M., Bateman, H.L., Peltz, C.D., 2010, Instream flow requirements for maintenance of wildlife habitat and riparian vegetation: Cherry Creek, Tonto National Forest, Arizona. US Forest Service report Arizona. Report to Arizona Division of Water Resources. 87pp.

Merritt, D.M., Bateman, H.L., 2012. Linking stream flow and groundwater to avian habitat in a desert riparian stream. Ecological Applications, 22: 1973-1988.

Project 12. Dam-Related Effects on the Distribution and Abundance of Selected Culturally-Important Plants in the Colorado River Ecosystem

Responses to comments re: Project 12

Comments from L.D. Garret (Executive Coordinator, Science Advisors) to Jack Schmidt (Chief, GCMRC) in a letter dated June 29, 2014,

Comments from Grand Canyon National Park Staff to Jack Schmidt in an attachment to an email dated July 7, 2014 and

Comments from K. Dongoske (Chair of the Cultural Resources Ad Hoc Committee) to the TWG dated July 14, 2014

Responses Prepared by H. Fairley, Sociocultural Program Manager, GCMRC

SCIENCE ADVISOR COMMENTS

Comment: In regards to past GCMRC plans that we have reviewed, this is clearly the most professional presentation of science projects. Of the project presentations, there are only two which we feel should be rewritten before you resubmit the Plan. The science ideals are supported by the SAs, but unfortunately Projects 4 and 12 simply do not demonstrate appropriate science standards in defining and justifying the science approach, presenting appropriate science design, and clarifying data development and assessments. Because of these issues some concern exists if expenditure of funds might best be directed at other cultural management needs or to other science projects.

Response: We appreciate the review provided by Science Advisors of Project 12. Please see the remainder of this document which contains our detailed response to specific review comments. We have revised the proposal for Project 12 in response to Science Advisor comments, as well as a review from the GRCA Cultural Resources staff, and written recommendations from the CRAHG.

Comment: This project evaluates dam effects on distribution of culturally important plants. This is an important step in science toward policy issues related to tribal traditions and culture, i.e. plants deemed important to Tribes for reasons related to religion, traditions, and culture.

Response: We agree that this is an important topic and appreciate the recognition from the Science Advisors that this project constitutes an important step in science toward policy issues related to tribal traditions and culture.

Comment: There does not seem to be a plant scientist on this team as one of the Investigators. That would seem be important given the basic science questions being asked. However, this project seems to reflect the interest of tribal members in understanding dam management impacts to plant resources of specific importance to tribal members.

Response: Although the Project PI is not a plant expert, plant identification has always been part of her field work, and she has taken courses in the subject, including a Native Plants of the Southwest identification course. Nonetheless, we agree that having additional riparian plant expertise on this project would be beneficial; therefore, we have added a riparian ecologist to the team, and we have also added a biostatistician, in response to this and similar comments received from the Cultural Resource Ad Hoc Committee.

Comment: We are not convinced this project is specified effectively and there are several problems with this project that need to be addressed. First, one of the leading scientists is also working intensively on Project 4 and it difficult to see how effectively she will be able to do both especially since both projects seem to have critical design problems.

Response: We appreciate the Science Advisors concern with the project lead's time been spread over more than just one project. With a reduced scope of work now proposed for Project 12, and with the addition of a riparian ecologist and biostatistician to the project team, we believe the first issue has been satisfactorily addressed. With regards to the issue of "project specification", in the May draft of the project proposal, we deliberately avoided being specific about methodologies because we anticipated a need to have further discussions with tribal participants to refine methods prior to initiating in-depth research involving tribal members; therefore we did not want to be perceived as having made these decisions in advance of discussing and refining these details with the tribal participants. During recent discussions with CRAHG members. Tribal participants reconfirmed their desire to discuss and review the results of the workshops and initial data compilation and synthesis prior to determining final methods for eliciting tribal value information in Part 12.2 Therefore, in the revised proposal, we are more explicit about this plan and the need for further discussion with tribal stakeholders before specifying methods more precisely. We have also added some more details about some ***possible*** approaches that may be used to elicit tribal values information in the future.

Comment: Second, the project is severely under budgeted in terms of both time and funding. For example, in one day, the list of plants that are of significance to tribes will be identified. Even given the use of prior research this is impossible to do thoroughly in one day (and will condition everything that follows in terms of data collection and management recommendations).

Response: In the original proposal we did not include sufficient background detail which, in retrospect, might have alleviated this, and some other, Science Advisors concerns. For example, several of the tribes who are participating in this project previously were funded through the GCDAMP to develop comprehensive ethno-botanical inventories. These inventories have already documented the majority of plants in the river corridor that are of cultural interest to each tribe. Therefore, there is already a solid foundation for developing a list of species of mutual interest to multiple tribes. A part of the proposal that was not explicitly described in the first draft was the plan to compile existing ethnobotanical information in advance of the workshop and use these existing ethnobotanical inventories as a starting point for the workshop discussions. Nonetheless, we agree that a one-day workshop is less than ideal and therefore, in the revised proposal we have expanded the scope of the first workshop to include one extra day and have added a second workshop for follow up on the results of the first year of data compilation and analysis.

Comment: Third, there is little reference to the anthropological literature on TEK that could be used to help guide the research.

Response: In the revised proposal, we have substantially expanded the background discussion to include more information about ethnoecology, TEK, and landscape ecology, and we describe how these various sub-disciplines can and do inform the current project proposal.

Comment: Fourth, although the methods proposed include a mix of qualitative and semi-quantitative approaches it would seem possible for project members to collaborate closely with the collection of quantitative data to be collected in the vegetation assessment program (Project 11). This would further the goal of incorporating more TEK in all of the scientific projects, but would also provide explicit data sharing and discussion of plant community and individual plant distribution changes. The use of citizen scientists in documenting plants and their distribution, as used in Projects 3 and 5, for example, would be exemplary. There is a lost opportunity in this project to use multiple sources of data for analysis for what is an extremely important management issues.

Response: As briefly stated in the original Project 12 proposal (but now more thoroughly and clearly described in the revised proposal), we intend to glean and synthesize as much information as possible from as many available sources as possible, including previous GCES-era research projects, past and current GCMRC research and monitoring data (including specifically Project 11 data), tribal monitoring data, previous ethnoobotantical surveys, the Hualapai Tribes' current pilot TEK project, and historical imagery. We are unclear as to what the Science Advisors might be thinking in terms of using citizen scientists in this project, beyond the tribal participants already included. Certainly reliable plant identification is not something that can easily handed-off to someone who does not have some previous background in plant identification. Nevertheless, we are open to suggestions for using citizen scientists in this and other GCMRC projects, as appropriate, and will include a discussion of the potential for using citizen science information during the first workshop.

Comment: Cutting this project completely is unacceptable, however, because it is the only one that explicitly includes tribes in the research, and is one of only two that explicitly addresses cultural resources. However, concern exists that appropriate science methodology are absent from both project 4 and 12 which are led by the same specialist.

Response: The Science Advisors are misinformed concerning who is leading Projects 4 and 12. Joel Sankey is designated as the lead scientist for Project 4, while Fairley is leading Project 12. With regards to concerns about the science methodology proposed for Project 4, please refer to Sankey's responses re: Project 4. See responses above and below concerning methodological comments re: Project 12.

Comment: We make several specific recommendations with respect to this plan to make it more doable as well as to ensure future duplication of effort.

First, the project should take into account both plants and animals.

Response: We disagree with this recommendation, not because animals are not an important and highly valued component of Tribal TCPs and the riparian ecosystems but because including animals is beyond the current scope and budget of Project 12. With the exception of fish, and increasingly aquatic insects, data on the historical distributions/abundances of animals in the river corridor is patchy and more variable than the available plant information; furthermore, the available animal data does not lend itself to the types of analyses and assessments proposed for Project 12. A discussion of animals and how to approach this topic from a tribal-values perspective in the future may be included during the second workshop.

Comment: Second, because the project is undoable at the level of funding requested ($35K), these funds should be used instead to fund the first phase of the project— a pilot project to convene a series of meetings to come up with the list of plant and animal resources identified as important to the tribes. This should also include discussion and planning for the implementation of the documentation phase of the plants and animals and their historic and contemporary distributions. That planning should include ways of taking incorporating citizen science and tribal members.

Response: We are concerned that the Science Advisors did not have the most up-to-date budget information when formulating their review comments. The $35,000 figure was first proposed for FY15 in the April work plan "prospectus", but it was subsequently adjusted upward in the May version of the draft TWP. Nonetheless, we agree that the project has a very limited budget to accomplish a considerable amount of proposed work. Therefore, we have scaled back the project to be more of an exploratory pilot project, per recommendations of the SAs, although we still plan of conducting some analyses of available data in addition to hosting two workshops.

Comment: In addition, that proposal should include ways of using existing and current data sources from other projects currently being conducted.

Response: The use of existing data sources was part of the original proposal for this Project, although apparently this point was not emphasized sufficiently in the original proposal. The use of existing data from multiple sources is a central component of this project. This component is now more heavily emphasized in the revised proposal.

Comment: Finally, this project will seemingly have significant difficulty establishing effect relationships, i.e. causation. In its rewrite perhaps a descriptive analysis should be considered instead.

Response: The Science Advisors apparently misinterpreted the focus of Project 12 to be an effects analysis. This was never the intent of this project, and we have revised the proposal to make this point more explicit. A descriptive analysis of available information is emphasized in the revised proposal.

GRCA Comments

Comment: This project proposal looks interesting and solidly designed. The proposal states that " The biological changes resulting from Glen Canyon Dam's alteration of river hydrology (Topping and others, 2003) have not only affected individual species and habitats; they have also affected culturally-valued attributes of the landscape." Have the culturally-valued attributes of the landscape been previously identified to a point where there will be a nexus between the findings of this research and that statement? The research questions are quite good but the research focuses on areas around archaeological sites and TCPs. Are areas adjacent to beaches or other locations included? If not, it would be good to have an explanation of why specific sites have been or will be selected.
Response: We appreciate these positive and helpful comments from GRCA staff. We believe that this project will help to further elucidate some of the tribally-valued cultural attributes of the river corridor landscape. The proposal has been revised to make this point more explicit. Project 12 does not focus on areas around archaeological sites but rather will focus on plants growing adjacent to the active river channel (past and present), so as to emphasize potential linkages between river hydrology and effects to cultural (tribal) values associated with the riparian landscape and ecosystem. We hope that this project will contribute to improving understanding of how landscape attributes, and specifically culturally-important plant species, contribute to tribal TCP values, and how those values may be affected by changes in vegetation that are potentially due, at least in part, to Glen Canyon Dam operations.

CRAHG Comments

Comment: CRAHG recommends moving forward with this project, but greatly expanding the role of the Tribes in identifying specific research avenues to be pursued. This will entail multiple Tribal workshops for the purposes of having the participating Tribes in collaboration with GCMRC design the structure of the research effort. The initial workshop would be followed by compilations and summarization of the data sources by GCMRC as envisioned in the FY 2015-2017 TWP. A second workshop would then be convened with the Tribes to utilize the results of the data compilation to revise and further refine the research effort designed by the Tribes. This project would be a pilot project with an emphasis on exploring the productivity of utilizing historic imagery in Tribal monitoring programs. The CRAHG recommends investigating the benefits of integrating this project with GCMRC's riparian program (Project 11)

Response: The project12 proposal has been substantially revised in response to these comments from the CRAHG. The proposal now includes an expanded (two day) initial workshop, plus a second two day workshop that will follow after the first year of data compilation, analysis and synthesis. We have also revised the project description to further emphasize the point (which was included in the original draft but was not sufficiently emphasized) that there will be opportunities for additional tribal input prior to finalizing the methods to be used in part 12.2, and that the collection of data from tribal members will be led by tribal participants.

Project 13. Socioeconomic Monitoring and Research

Project 13 Response to Cultural Resource Ad Hoc Group's Recommendations to the Technical Work Group Regarding the 2015-2017 Triennial Work Plan and Budget for the Glen Canyon Dam Adaptive Management Program

CRAHG Recommendations Prepared by Kurt Dongoske, CRAHG Chair

Response Prepared by Lucas Bair, Economist, GCMRC

Comment: Project 13.2. Tribal Perspectives for and Values of Resources Downstream of Glen Canyon Dam: CRAHG expressed concern about this research effort and the potential to reduce Tribal cultural values to Western capitalistic terms, a value system applied to this ecosystem that is not shared by the Tribes. CRAHG recommends that GCMRC researchers need to have more in-depth conversations with the Tribes regarding this project during 2014-2015 before it is implemented.

Response: GCMRC staff appreciate the recommendation of the Cultural Resource ad hoc Group and recognize the importance of research within the GCDAMP that distinguishes Tribal preferences for and economic value of resource management decisions from Tribal cultural values associated with Glen and Grand Canyons. To clearly develop methods identifying preference for and economic value of resource management decisions, and not inappropriately reduce non-economic Tribal cultural values to economic terms, the project team will have continued in-depth conversations with the Tribes regarding this project during FY 2015 and work closely with the Tribes in FY 2016-17 to implement the project and 1) review relevant previous studies and tribal programs; and 2) identify focus group participants and develop and pretest focus group survey content to ensure culturally appropriate methodology.

Response to National Park Service's Review of Project 13.2 of the 2015-2017 Triennial Work Plan and Budget for the Glen Canyon Dam Adaptive Management Program

Comments prepared by Martha Hahn and Janet Balsom, NPS

Response Prepared by Lucas Bair, Economist, GCMRC

Comment: It would be useful to clearly articulate the direct benefit of this project overall; you heard some concerns voiced at the TWG meeting a making a direct correlation of the benefits you envision would help with project support; it is interesting to me that this project is one from the SEAHG yet garnered little support at the meeting.

Response: The benefit of Project 13.2 would be realized through improving decision processes in the GCDAMP. This is stated in section D.1, 'Project Elements', of the TBW. Additional text has been added to the TBW to further emphasize this point (added text <u>underlined</u>).

> The objective of this project element is to identify tribal preferences and values associated with management of resources downstream of GCD in order to inform

> decision making processes in the GCDAMP. Defining individual tribe's preferred actions or constraints associated with management of downstream resources is important when evaluating potential actions and associated trade-offs.
>
> …
>
> Information gained through this research is necessary for evaluation of management decisions and development of applied decision methods that accommodate tribal preferences for and values of downstream resources (see FY15–17 Workplan, Project Element 13.3).

For example, recognizing potential objections to economic valuation of humpback chub (i.e., stakeholder constraint), specific methods to evaluate the economic efficiency of management actions are proposed in Project 13.3.

> Cost-effectiveness analysis…identifies the least cost alternative, when faced with competing or complimentary management actions, to reach a defined objective. This…is important because it…removes the onerous, or in some cases contentious, identification of economic value of downstream resources. The focus is shifted from establishing the benefit of the objective to identifying the most cost-effective way to meet the objective (Sagoff, 2009). This is an important distinction when stakeholders may fundamentally reject attempts to economically value aspect of ecosystem resources.

This is one example, and further understanding of Tribal preferences for and value of management actions (or outright objections to) only improve the framing of decision process within the GCDAMP.

Comment: The project personnel may not be well suited to conducting the tribal focus groups; there needs to be considerable coordination with the tribal groups in order to design a program that will meet the needs expressed.

Response: Project personnel have several decades experience working with tribes and choice experiments. The project personnel from University of Montana have worked with the Penobscot , Hopi, Salish Kootenai, Kalispell, Spokane, Yuma, Elem Pomo, Klamath, Blackfeet, Ute Mountain Ute, and Metis Tribes on a variety of natural resource economics studies.

Considerable coordination with tribal groups will occur in order to design a program that will meet the needs expressed. As mentioned in the TBW, the project team will "cooperate with GCDAMP Tribal representatives and Tribal members to review previous studies and tribal programs relating to tribal preferences for and values of resources downstream of GCD; conduct initial meetings with individual tribes to identify focus group participants and develop and pretest focus group survey content to ensure culturally appropriate methodology; and conduct focus group meetings with individual Tribal members to explore preferences for and values of downstream resources.

Comment: At a minimum this project should include a tribal representative on the research team.

Response: The project team will coordinate project development with Tribal representatives, councils, and staff. The coordination will provide overall project direction and review with minimal workload requirements from Tribal representatives, councils, or staff.

Comment: #2 of the Individual Project Elements is to "Conduct initial meetings with individual tribes to obtain permission and gauge interest in participation, identify focus group participants, and develop and pretest focus group survey content to ensure culturally appropriate methodology. What if tribes don't give permission or are not interested? These are things that should be pursued BEFORE a project like this is submitted or approved. #3 talks about the focus groups strategy but there is not a good discussion or rationale for this methodology. Again, a tribal partner could and should help design this project.

Response: Tribal council permission for the proposed project will require prior coordination with tribal representatives and staff. This coordination will include review of previous studies and tribal programs to establish the tribal specific methods of the research. Therefore, the project must be approved by the Glen Canyon Dam Adaptive Management Program (GCDAMP) prior to formal approval from each tribe.

Final survey methods will be determined following coordination with individual tribes. Text has been added to section D.1, 'Project Elements' to clarify that other methods used to implement surveys may be employed following coordination with the tribes.

> Focus groups provide an open forum for clarifying survey methods and participant questions. However, in-person, mail or alternative survey methods will be used if individual tribes discourage the use of focus groups.

The project team will coordinate research with Tribal representatives, councils, and staff. The coordination will provide overall project direction and review with minimal workload requirements from Tribal representatives, councils, and staff.

Comment: The proposal references 'partnership with the tribes' but they are clearly not partners but rather research subjects.

Response: The project team will coordinate research with Tribal representatives, councils, and staff. The coordination will provide overall project direction and review with minimal workload requirements from Tribal representatives, councils, or staff. The language in the TBW has been changed, from "in partnership with" to "in coordination with", to reflect this.

Comment: There is not a clear indication of what 'downstream resources' are being discussed or if those are resources the tribes will specifically identify.

Response: Resources will be identified with the cooperation of the Tribes. This is clarified in section D.1, 'Project Elements', of the TBW (<u>added text underlined</u>).

> For the choice experiment methods, <u>downstream</u> resource attributes of tribal importance (e.g., hydropower, humpback chub) and their potential variation with

> different future management actions will be defined in task 2 and will shape the experimental design.

Comment: There is not a clear method to achieve the objective to " identify tribal preferences and values' some of which seem to be predetermined in the hypotheses

Response: The objective of the project is to identify statistically significant differences in the relative preferences or economic values placed on resources of importance, when trade-offs occur due to operations at Glen Canyon Dam. The hypothesis, as written, are standard format when proposing such statistical analysis.

Choice experiment methods will be used to achieve the research objective. This is stated in section D.1, 'Project Elements' in the TBW.

> The assessment of tribal preferences and values will be achieved through focus group meetings with individual tribes, where choice experiment methods will be conducted to explicitly evaluate resource attributes tradeoffs that occur from management of GCD.
>
> The meetings will use choice experiment methods (Breffle and Rowe, 2002; Harpman, 2008), which are commonly applied in marketing and resource economics studies, to identify these preferences and values.

See Harpman (2008) for a detailed explanation of choice experiments (i.e., conjoint analysis).

Harpman, David A. 2008. Introduction to Conjoint Analysis for Valuing Ecosystem Amenities. Bureau of Reclamation Technical Memorandum Number EC-2008-03. U.S. Department of the Interior, Bureau of Reclamation. Denver, Colorado. February 2008. 46 pages.

Comment: There is nothing that I can identify in the budget to compensate tribal participants for any of their participation.

Response: The line item "operating expenses" in the 2016 fiscal year totals $10,250. Of this, $10,000 is set aside for nominal compensations of Tribal focus group participants. The following text has been added to the TBW, "When appropriate, nominal compensation will be provided to Tribal members for their participation in focus groups."

The project team will coordinate research with Tribal representatives, councils, and staff. The coordination will provide overall project direction and review with minimal workload requirements from Tribal representatives, councils, or staff.

Comment: The deliverables should, but do not identify any products directed at the tribes.

Response: Discussion of Tribal specific deliverables has been added to the 2015-2017 Triennial Work Plan and Budget for the Glen Canyon Dam Adaptive Management Program.

"Reports and presentations specific to the research methods and results of Project 13.2 will be provided to individual Tribes as requested."

Project 13 Response to Review of Glen Canyon Dam Adaptive Management Program Triennial Budget and Work Plan – Fiscal Years 2015-2017

Review Prepared by
David Garrett, Executive Coordinator of Science Advisors, Economics, M3Research
Lance Gunderson, Adaptive Management & Policy, Emory University
James Kitchell, Fish Ecology, University of Wisconsin
John Loomis, Non-Market Economics, Colorado State University
Peter McIntyre, Riverine Ecology, University of Wisconsin
Barbara Mills, Anthropology and Archeology, University of Arizona

Project 13 Response Prepared by
Lucas Bair, Economist, GCMRC

Comment: We think the two recreation hypotheses put forward are foundational hypotheses that are critical to test. However, we would suggest it might be worth considering an additional hypothesis: that the value of angling Glen Canyon and whitewater boating in Grand Canyon NP will have increased over time due to changes in "improved" dam operations over the last two decades. Of course a one-year survey may have difficulty teasing this out from other events, but we think it would be worth at least considering.

Response: The additional hypotheses have been formally added to the draft text of section 'C.1 Scientific Background', Project 13.

Comment: The one concern is that the budget for Project Element 13.1, pages 413-414. We do not see funds for the actual printing and mailing of the surveys in this budget. Is AFGD or NPS picking up this cost?

Response: The printing and mailing costs of the surveys was included in the carryover socio-economic funds from 2013-14 ($241K) used to implement the project. Therefore, these costs are not included in the Triennial Budget and Workplan – Fiscal Years 2015-2017 (TBW). Text has been added to the TBW to clarify this point.

Comment: What will be important is to differentiate short and long term operation effects on socioeconomic factors.

Response: The research proposed in Project 13.1 will result in information that is useful in determining the short and long-term socioeconomic effects of dam operation. Information, such as the marginal value of recreational activities, as related to dam operation, can be utilized in short and long-term economic analysis to inform management decisions. Text has been added to the TBW stating that Project 13.1 'information is important when conducting short and long-term impact, and other policy related analysis.'

Comment: The SAs strongly agree that a formal program to assist the AMP in development and use of decision methods is needed. This has been proposed in several SA reviews and the subject

of a brief white paper by the SAs on the subject, "Evaluating Decision Support Methods for the GCDAMP".

Response: The Science Advisor's December 2010 document, ' Prospectus for Evaluating Tradeoff and Decision Support Methods for the GCDAMP' and June 2010 document, 'Evaluation of Criteria Guiding Transition of Science Management Actions in Adaptive Management Programs' will be referenced during in the development of Project 13.3.

Comment: …Project Element team for 13.3 would benefit from seeing the ongoing work of Sandia Labs who are developing a much more general model of the Glen Canyon-Grand Canyon hydropower-natural resource system. It is proposed that this effort would benefit from discussions with Dr. Tom Lowry, systems analyst with Sandia Labs.

Response: Dr. Tom Lowry of Sandia National Laboratory was contacted on 7/8/2014. Dr. Lowery agreed that continued discussion and collaboration between Sandia National Laboratory (SNL) and GCMRC would benefit SNL, Project 13.3 and the GCDAMP.

Comment: However, how it is accomplished, i.e. a necessity for full engagement of the Tribes in all project elements, is most critical. The manner in which the Tribes hold values must be first determined through the focus groups proposed. Some resource values expressed by the Tribes may be wholly spiritual, making pursuit of economic values incongruent with Tribal desires. We suggest GCMRC evaluate the work by Failing and others on First Peoples of Canada for more insight into this issue (Failing et. al. 2007).

Response: As discussed in the TBW, each stage of Project 13.2 will be conducted with the cooperation of the Tribes. The project team will 1) cooperate with GCDAMP Tribal representatives and Tribal members to review relevant previous studies and tribal programs; 2) conduct initial meetings with individual tribes to identify focus group participants and develop and pretest focus group survey content to ensure culturally appropriate methodology; and 3) conduct focus group meetings with individual Tribal members to explore preferences for and values of downstream resources.

The work of Failing et al. (2007), 'Integrating science and local knowledge in environmental risk management: A decision-focused approach', along with other relevant literature, will be referenced during the development of the Project 13.2 to avoid misrepresentation of non-economic Tribal cultural values associated with Glen and Grand Canyons when considering preferences for and economic values of resource management decisions.

GCMRC thanks AZG&F for taking the time to review the FY15-17 workplan. We appreciate the feedback, comments, and questions and have responded to each below. AZG&F comments are given in italics with responses provided below each question in regular text.

Project 5.1. *This is a very expense and comprehensive food base project (FY15 = $421,452, FY16 = $449,969, FY17 = $517,973) Can GCMRC please provide a prioritized list of the project elements? I would like to know what would be lost if each element is not funded. I feel that there are many questions surrounding the impact of flows on food base, but not all need to be answered during the work plan.*

GCMRC response: We agree that this is a comprehensive project, but believe that we have proposed a cost-effective group of studies that will enhance our understanding of the aquatic foodbase and provide critical information in support of management of the Colorado River ecosystem and the fish that rely on the aquatic foodbase. The proposed funding from the GCDAMP for foodbase research and monitoring in FY15 is actually slightly less than was received in FY14; FY15 Project 5 + Project Element 7.5 = $664,000 vs. FY14 Project Elements E.2 + F.7 + H.2 = $672,000. Our initial prioritization, in the form of the FY15 recommended budget released June 6, 2014, would delay proposed laboratory experiments related to insect oviposition until more field data is available to help guide these experiments.

5.1.1 (Insect emergence in Grand Canyon via citizen science; Recommended for funding $117,920)
Is the data collected via citizen science robust enough to evaluate changes in species diversity and density over time? In other words, if there was a core monitoring program for foodbase, would this be it? What is lost if we discontinue this work or reduced frequency of collection?

GCMRC response: This is a very robust data set that provides an unprecedented level of geographic and temporal coverage characterizing aquatic insect emergence throughout the Grand Canyon ecosystem. This project provides near continuous coverage during the motor season (April – September) and is being expanded to involve private river trips in hopes of improving coverage during other times of the year. This is an ideal, cost-effective tool to evaluate changes in species diversity and density over time. On a per sample basis, this is almost certainly the most cost-effective biology or aquatic ecology project conducted by GCMRC or its cooperators. Ending or reducing this work would only return relatively small savings to the program at the cost of one of our most informative data streams that is helping inform scientists and managers on the spatial and temporal dynamics of insect populations in the Colorado River ecosystem. Cutting funding to this project would also eliminate a powerful and effective outreach tool that currently involves the guiding community and the whitewater rafting public as active participants in the overall effort of gathering relevant scientific information in support of the GCDAMP.

5.1.2 (Quantifying the effects of hydropeaking on oviposition and egg mortality; Recommended for funding $97,236)
It's difficult to assess the feasibility of this project element if details are lacking. How is this study going to be carried out? Is this river wide? Can funding be reduced if focus is at Lees Ferry where hydropeaking will likely have the greatest effect?

GCMRC response: Monitoring sites will be selected based on flow characteristics which will produce the greatest contrasts. Sites with wide and narrow varial zones will be selected to allow for comparisons of the effects of drying and warming on invertebrate production in areas where minimal proportions of the shoreline are exposed due to daily flow changes vs. areas where large proportions of the shoreline are exposed daily. Similarly, sites where minimum flows occur during the day will be selected for study and

compare with areas where minimums occur at night. More details on the proposed methods will be forthcoming once the study PIs return from conducting field work.

5.1.3 and 5.1.4 (Synthesis projects; Recommended for funding $29,672 and $29,672)
With restricted budgets I am concerned about the extent and cost of this project. I am not convinced that conducting a synthesis stressors and controls on EPT distributions and synthesis of foodbase in western tail waters takes 3 years and $200,160 to complete. I would suggest reducing costs and time frame (ex $75,000-$100,000 for 2-years) and putting this out for competitive bid.

GCMRC response: We believe that any future management actions should be fully informed by the best available science. A thorough understanding of species-specific traits and stressors will be essential to designing potential mitigation strategies and target species and ensuring that they have the best chance for success. Further, we believe that it will be very helpful to our understanding of the current condition of the aquatic foodbase in Glen Canyon to compare it with tailwaters elsewhere in the Colorado River basin and the western United States. Placing Glen Canyon in the context of other tailwaters may provide insight as to how the current invertebrate assemblage became established and suggest approaches for management actions to develop a more diverse assemblage in the future. GCMRC will review the proposed budgets for FY16 and FY17 and re-evaluate the need to continue these Project elements for all three years of the workplan.

5.1.5 (Natural history of oviposition for species present in Grand Canyon; Recommended for funding $25,878)
It's difficult to assess the feasibility of this project element if details are lacking. This project element is not clear to me. Please explain what actually will be taking place under this element.

GCMRC response: Similar to Project element 5.1.3, we believe that understanding the current state of the aquatic foodbase in Glen and Grand Canyons should be fully informed by the best available science. A thorough understanding of species-specific traits and stressors for species currently inhabiting the Colorado River ecosystem will be essential to determine what support, or lack thereof, exists for the five hypotheses described for Project 5. GCMRC will review the proposed budgets for FY16 and FY17 and re-evaluate the need to continue these Project elements for all three years of the workplan.

5.1.8 (Natural history of oviposition for EPT via studies in the Upper Basin; Submitted for non-AMP funding $25,878)
It's difficult to assess the feasibility of this project element if details are lacking. This project element is not clear to me. Please explain what actually will be taking place under this element. If this does not get funded will that impact project 5.1.5?

GCMRC response: GCMRC is not requesting GCDAMP funding for this project. We believe, however, that it will be very helpful to our understanding of the current condition of the aquatic foodbase in Glen Canyon to conduct comparative studies with tailwaters elsewhere in the Colorado River basin. Placing Glen Canyon in the context of other tailwaters may provide insight as to how the current invertebrate assemblage became established and suggest approaches for management actions to develop a more diverse assemblage in the future. If the study isn't funded, we believe learning will be considerably slower as will the development of potential management approaches to improving conditions in Glen Canyon.

5.2.2 (Continue Natal Origins drift monitoring in Glen, Marble, and Grand Canyons; Recommended for funding $87,365)

Is the information we gather from this work in terms of changes in species diversity and density over time different from that of project 5.1.1 (citizen science)? What is lost if we discontinue this work or reduced frequency collection (ex. discontinue January NO trip)?

GCMRC response: Yes, this study is different is several key ways. This effort is focused on sampling invertebrates in the drift so provides information on food directly available to fish. It also includes sampling that occurs concurrently with sampling of fish at specific sites. Paired data will allow linkage of fish diets with abundance and distribution data collected concurrently with quarterly trout sampling. This data will also be used to parameterize rainbow trout bioenergetics models for Glen, Marble, and Grand Canyons.

5.2.3 (Link drift at Natal Orgigins project transects to channel bd shear stress; Recommended for funding $20,619)
Why is this funding through FY17. The project states that this work can be done over the course of one NO trip.

GCMRC response: Data collection would occur in the first year with analyses and modeling occurring in the second and third years. GCMRC will review the proposed budgets for FY16 and FY17 and re-evaluate the need to continue these Project elements for all three years of the workplan.

6.2 (Humpback chub aggregation recruitment studies; Recommended for funding; $83,750)
I support this project as determining the natal origins of humpback chub is important in understanding the areas we need to focus monitoring and management efforts. A similar project was budgeted for in the FY13/14 work plan ($85,000) and as I understand it was not completed due to tribal concerns of the taking of life of humpback chub.

1. *If the project proposed in FY13/14 was not completed, what happened to the $85,000 from FY13/14 and why is another ~$84k in FY15, ~$54k in FY 16, and ~$50k in FY17 being spent on this project?*

2. *This question might be more appropriate for the tribe(s) that were concerned, but will the taking of life of the surrogate species be a problem?*

GCMRC response: 1. A portion of this funding went to Dr. Karin Limburg, our cooperator at SUNY, to purchase equipment and support a graduate student. Unspent funds will be carried forward into FY15. The extra funding in FY15-17 is to support GCMRC staff in efforts to sample YOY humpback chub from backwaters near aggregations, something that has not been done recently. Part of the sampling program will involve tagging YOY and juvenile fish (as small as 80 mm) as well as looking for VIE tags that are being applied to YOY humpback chub in the Little Colorado River during July sampling. We hope that over time some of these tagged fish will be captured and will help shed light on recruitment at downstream aggregations.

2. We can collect surrogate species with NPS samples from Shinumo and Havasu Creeks taken as part of trout removal activities that were covered in the NPS fish management plan. Bio/West and NPS have agreed to use ethanol to preserve samples (preserves otolith structures unike other preservatives)

collected as part of their razorback sucker seining surveys (monthly samples through the summer downstream of Lava Falls). They can then provide specimens to us for Dr. Limburg to examine. We anticipate that they will likely have humpback chub incidental mortalities as a result of their sampling.

6.4 (System Wide Electrofishing; Recommended for funding; $283,722)

I appreciate GCMRC for incorporating the comments we provided on an earlier draft of this project. The system wide electrofishing program has been the cornerstone of long term monitoring of native and non native fish species in the Colorado River through Marble and Grand Canyons. Species interaction, habitat availability, food availability, and water quality dictate the presence and distribution of fish species throughout the CRE. The standardized collection of relative fish abundance and distribution collected from the long term monitoring is important as it is very difficult to conduct biological experiments in a largely uncontrolled environment. While we agree that a reduced effort and duplication of effort is warranted we have not been convinced that a focus on abundance measures instead of CPUE is warranted nor has it been shown that this is feasible, or an acceptable alternative to the long term monitoring currently occurring. While we agree that abundance estimates at certain locations of high interest (e.g. at the confluence of Bright Angel Creel and the Little Colorado River) should be pursued the standard monitoring program should not be abandoned for short term goals, that may or may not be achievable. Changes to this program must be done with caution.

GCMRC response: GCRMRC is not proposing to reduce the overall effort applied by the SWEF project, but have in fact proposed to expand this work by adding a second survey downstream of Diamond Creek. For the sake of efficiency, we have proposed coordination between this project and the Natal Origins of rainbow trout study (9.2) to avoid duplicate sampling of the same sites in Marble Canyon. We have proposed to add experimental mark-recapture efforts at one or more sites to be selected in conjunction with cooperating agencies, but not at the expense of maintaining continuity of this important long-term monitoring project.

6.5 (Brown trout natal origins through body pigmentation patterns in the Colorado River; Unfunded, moderate priority $16,146)

Not sure I would consider this a moderate priority project in the context of other projects that are listed as funded. Identifying the source of brown trout and other high risk nonnatives has been identified as an information need in the NPS comprehensive fish management plan.

GCMRC response: Dr. Limburg (SUNY) has agreed to examine YOY brown trout and other salmonids collected from Bright Angel Creek to determine if there are markers that can be used to identify fish that originate in BA Creek. The idea of using pigment patterns to evaluate natal origins of brown trout is appealing, but we believe it would be better to wait to determine if the ongoing approach with otoliths will be successful before funding a second study on the same topic.

6.6 (Mainstem translocations of humpback chub; Recommended for funding $9,790)

This project might be more appropriate in under project 8. Also is there adequate funding for this project (FY15 = $9,790)? This is much less for what appears to be similar work in project 8.2 (FY=15 $88,600)

GCMRC response: This was included to provide some staff time to examine the feasibility of this project and to begin initial NEPA compliance efforts that would be required. The USFWS also indicted this level of funding was inadequate so GCMRC will withdraw the request to fund this element.

6.7 (Rainbow Trout Early Life Stage Survey; Recommended for funding $77,024)

This might be more appropriate under project 9.

2009 PEP recommended:

> *Monitoring age-0 trout habitat use and movement is not routinely needed because the electrofishing survey provides a direct index of pre-recruit trout density. Similarly, redd counts are not needed because the electrofishing survey provides a direct index of adult trout density. This program's strength is in evaluating the impacts of flow manipulations on early life history, and it should be part of the evaluation of future flow tests.*

The need to conduct annual RTELLS work should be considered when evaluating a standardized monitoring program for Lees Ferry as proposed in project 9.1.

GCMRC response: For the current workplan, we decided to include ongoing monitoring of native and nonnative fish in the mainstem in a single project. We believe that annual RTELSS surveys are needed given that frequent flow manipulations are already being conducted as part of the HFE protocol and operations like equalization and other release levels. In addition, it seems likely that Trout Management Flows (TMF) will be included the final LTEMP EIS. These RTELLS data will inform those experiments and operations and provide more resolution than other studies which would include only fall electrofishing surveys of juvenile trout. While fall electrofishing of juvenile trout may provide good information on the strength of a cohort, it will not provide information on possible mechanisms that affect cohort strength (redd deposition, early juvenile survival, survival through the summer). Understanding these mechanisms will be key to understanding the potential for compensation and tailoring the exact design of TMFs. Key questions in the design of TMFs include how many cycles, how should they be spread out over the summer, and what will each cycle look like. Relying on fall catch alone would likely answer these questions eventually; however, the slow rate of learning, possibly on the order of decades, makes this approach undesirable.

7.3 (July Little Colorado River juvenile humpback chub marking to estimate production and outmigration; Recommended for funding $112,172)

What will be lost if this work is not conducted? I have a concern about costs ($112,000), additional helicopter flights, handling of chub in summer for this project. I am not sure if the benefits of this project outweigh the costs. There will always be some level of uncertainty around the actual population of HBC. I think at some point we just need to accept it and focus more on the population over the long term. Is it going up or is it going down. At some point ASMR became unacceptable yet we were able to make decisions based on the population estimates that came from that model. This project is planned for an additional three years why is that necessary?

GCMRC response: Although the information gathered as part of this study will help generate more accurate and less biased estimates of humpback chub population (see Project element 7.10), the main objective is to help resolve uncertainties about the drivers of humpback chub population dynamics by testing hypotheses. Understanding humpback chub production and outmigration rates are significant for managers for two key reasons: 1) it's practically impossible to determine what levels of trout abundance and temperatures can be tolerated while meeting humpback chub population and/or recovery goals without a better understanding of these rates and 2) understanding how and why the values vary may allow managers to improve the timing of certain management actions. For example, managers would not want to implement expensive actions like LSSF or trout removal if it was known that a humpback

chub recruitment year like those observed in 2000, 2002, or 2006 was likely (we think these years were poor recruitment years based on fall catches of YOY in the Little Colorado River, but it's possible outmigration was unusually high). Others have noted the importance of understanding humpback chub production and outmigration in the Little Colorado River. As part of the LTEMP process, modelers conducted simulations to predict the consequences of alternative management strategies. The order of importance of various factors in introducing uncertainty in predictions were: 1) humpback chub production and outmigration rates, 2) Hydrologic trace, 3) Trout flow-recruitment and outmigration, 4) HBC vital rates, and 5) uncertainty in trout-temperature-chub interactions. This study will provide information on the degree to which production and outmigration vary inter-annually and will allow us to test some of the assumption of the multistate models (e.g., is it true that ~20% of juvenile outmigrants end up in the JCM reach or does this rate vary between years). Once we have a reasonable set of replicates, potentially by the end of this workplan, we can likely discontinue this research project and rely on the Juvenile Chub Monitoring and fall sampling. Another advantage of this project is that we hope to leverage the large number of marks being put out prior to dispersal to determine what proportion of recruitment at different aggregations is attributable to the Little Colorado River. Since directed take of otoliths is not currently allowed, we hope that comparison of recapture rates of marked humpback chub at mainstem aggregations from fish marked in the Little Colorado River will allow us to make formal inferences.

Concerning the comment about ASMR, this model assumed that all individuals in the population had similar growth and survival rates. It's now clear that this assumption was grossly violated (see Yackulic et al., 2014 plus January 2013 and 2014 annual reporting meeting presentations) which could have misled informal inferences in the past and thus decisions. In addition, most of the information to inform population estimates was from fish caught in the Little Colorado River, but fish are not available in this tributary in all years because of skip spawning. This creates heterogeneity in capture probability which leads to biased low estimates of adult population size. Finally, ASMR is not a predictive tool so it does not help formal decision making. In past instances when predictive information for was needed for managament documents like EAs and EISs, modelers would develop simulation models that were entirely separate from ASMR. As part of the LTEMP EIS for example, Charles Yackulic worked with Lew Coggins and Josh Korman to develop such a model which would more closely link estimation and predictive tools with the goal that predictions can eventually be updated based on new learning. Moreover, review of the published papers on ASMR will make it clear that the developers tried to fit models that differentiated the Colorado River and Little Colorado River. They were unsuccessful, however, because they lacked critical data on young fish now available due to successful implementation of projects like Near Shore Ecology, Juvenile Chub Monitoring, and this project.

7.6 (Potential for gravel substrate limitation for humpback chub reproduction in the LCR; Recommended for funding $11,600)

I have a hard time understanding how this will apply to management decisions. With budget restraints I do not see this as a high priority project and do not recommend this project element for additional funding at this time. I would suggest seeking outside funding or propose this during the next workplan.

GCMRC response: If humpback chub reproduction is limited by gravel substrate, this would allow us to predict future years when reproduction would be low and could lead to relatively cheap management interventions. Additionally, if this is an important process for humpback chub production and climate change predictions are accurate, then this may actually be more important than any other intervention for avoiding extirpation. A long-term decline in production in the LCR would be a much more

detrimental than anything occurring in the mainstem. GCMRC had this project identified as unfunded in the May 9 prospectus, but moved this to recommend for funding at the suggestion of the BAHG.

7.7(Evaluate CO2 as a limiting factor early life history stages of humpback chub in the LCR; Recommended for funding $86,420)

I have a hard time understanding how this will apply to management decisions. This project is expensive (FY15 = $86,420, FY16 = $98,210, FY17 $118,272). With budget restraints I do not see this as a high priority project and do not recommend funding for this project element. I would suggest seeking outside funding or propose this during the next work plan.

GCMRC response: It will be difficult to assess the effects of dam operations (or other management actions) on humpback chub without understanding the factors that really limit fish populations within the Little Colorado River. Carbon Dioxide has the potential to completely structure fish communities within the Little Colorado River and if we are not accurately accounting for CO_2 effects, it is likely to confound interpretations of any management actions. The laboratory work to evaluate CO_2 tolerances of Little Colorado River native and nonnative fishes, relative to the published literature, should be complete within one year. Field assessments of CO_2, however, will need to take place over three years (which adds cost) to account for differences in hydrology that will affect the timing and duration of high CO_2 levels in the Little Colorado River and its effects on early life history stages of fish.

7.9 (Development of a Non-Lethal tool to assess the physiological condition of humpback chub in the Colorado and Little Colorado Rivers; Recommended for funding $41,876)

I have a hard time understanding how this will apply to management decisions. This project is expensive (FY15 = $41,876, FY16 = $95,526 FY17 $103,808). With budget restraints I do not see this as a high priority project and do not recommend this project element for additional funding at this time. I would suggest seeking outside funding or propose this during the next work plan.

GCMRC response: The hope is that new technology may provide an alternative to weighing humpback chub to calculate condition factor and monitor growth. We have generally discontinued weighing humpback chub because of the extra time and stress on the fish, and our inability to find tools to provide accurate weights under windy conditions or on a moving boat. Moreover, preliminary data from ultrasound work suggests that humpback chub in the field have considerably fewer eggs than humpback chub held at the USFWS Southwestern Native Aquatic Resources and Recovery Center in Dexter, NM. If this holds, it suggests that humpback chub in Grand Canyon may be chronically in poor condition. This is not accurately measured by traditional fish condition indices and warrants further evaluation of the proposed approach.

8.1 (Efficacy and Ecological Impact of Brown Trout Removal at Bright Angel Creek; Recommended for funding $96,396)

As I understand it, this project was cut in half due to the HFE this past fall. If another HFE is planned in the fall can we expect a similar impact? I suggest using funding from project 9.9 (FY15 = $72,616), which is designed as contingency during HFE years, to fund this project during non HFE years? In other words in HFE years spend money on project 9.9 and in non HFE years spend money on project 8.1 and not try to do both at the same time especially if the HFE is going to affect data collection for project 8.1.

GCMRC response: The timing of last year's HFE did interfere somewhat with planned mainstem trout removal near the confluence of Bright Angel Creek and resulted in less effort in the mainstem. GCMRC staff instead helped NPS crews conduct removals by backpack electrofishing in Bright Angel Creek itself

during and immediately following the HFE. Mainstem removals were planned to coincide with the timing of brown trout spawning with the goal of removing fish as they staged near the creek mouth to move upstream so rescheduling this effort may reduce the effectiveness of this project. We are open to discussion about this project, but it should be noted that this project is identified as a conservation measure in the USFWS 2011 Biological Opinion and is also part of an overall effort described in the NPS Comprehensive Fish Management Plan to control nonnative fish in and near Bright Angel Creek in an effort to benefit native fishes. One option could be to utilize the HFE's to target those brown trout that move into the creek out of the turbid mainstem (where they can be caught much more effectively) and limit electrofishing in the mainstem, but this would need to discussed with NPS to determine if they could support this change. Alternating funding between this project and project element 9.9 might be a feasible solution if HFEs were infrequent, but note that HFEs have been triggered in two of two years since the HFE EA was implemented. This change would also have to be reconciled with the USFWS and NPS given the recommendations described in the management documents mentioned above.

8.3 (Glen Canyon Dam Adaptive Management Program Fisheries Research, Monitoring, and Management Actions Protocol Evaluation Panel; Recommended for funding $0)
I fully support funding a Fish PEP to evaluate the fish program. I would suggest this occurs in FY16 and not FY17 so there is time to work PEP recommendations into the FY18-20 work plan.

GCMRC response: We agree that a PEP will be valuable. There are advantages to conducting the review in both the proposed years. Convening a panel in FY16 could bring a relatively quick resolution to outstanding issues. On the other hand, it would limit the amount of time available to collect and analyze data from some projects as compared to postposing the review until FY17.

Project 9.1 (Rainbow Trout Population Dynamics – ongoing modeling and future monitoring; Recommended for funding $37,120)
Maybe I am missing something here, but this is a dramatic shift from the long term monitoring program that has been in place since 1991. This long term monitoring project has done a good job of monitoring trends and as one of the primary stakeholders for this fishery do not feel like we are missing population changes to the fishery. The NPS comprehensive fish management plan outlines stocking triggers based on this long term monitoring, which will no longer be valid under the proposed changes. There are certainly tradeoffs with doing mark/recapture vs CPUE and those tradeoffs should be evaluated by the stakeholders.

1. *Is this replacing the standardized trout monitoring at Lees Ferry? If so I do not agree with this project as proposed. Lees Ferry standard monitoring should be funded. Funding for this project in FY13/14 was $217,000/yr.*

2. *Similar to what is proposed in project 6.4, AZGFD in coordination with GCMRC, would like an evaluation of the standardized sampling at Lees Ferry with what is proposed in project 9.1. However, before this is done we should not change the standard sampling at Lees Ferry as proposed.*

GCMRC response: 1. During the proposed 2-yearr hiatus (2015-2016), the NO sampling will provide data that is more robust spatially and temporally, as well as include other additional population metrics besides CPUE. These metrics include actual abundance and vital rates like survival, growth and movement (which are not currently estimated by the AZG&F long-term monitoring program). Secondly, because CPUE data are also measured as part of the NO program, reducing other efforts will not affect

how managers use CPUE metrics for assessing stocking triggers, however, these other metrics will provide the additional information mentioned above. We believe this information is critical to providing a full understanding of the effects of past and ongoing dam operations including HFEs, equalization, and steady flows on rainbow trout population dynamics and movement in Glen and Marble Canyons. It should be noted that our proposal would in fact only be a partial hiatus since we have proposed to retain the fall electrofishing survey in 2015 to maintain continuity and provide trigger information identified in the NPS Comprehensive Fish Management plan and provide an additional year of overlap of different approaches. 2. We agree that an evaluation of sampling approaches would be worthwhile and some preliminary analyses have already been conducted. There are multiple years of overlap for the two data sets such that comparisons should be relatively straight forward. In addition, this project along with all other GCDAMP supported fisheries projects will be evaluated in the PEP proposed in Project Element 8.3.

9.2 (Detection of Rainbow Trout Movement from the upper Reaches of the Colorado River below Glen Canyon Dam/Natal Origins; Recommended for funding $440,512)

1. *What information is lost if we eliminate the January NO trip?*
2. *How much money will be saved if we eliminate the January NO trip?*

GCMRC response: 1. The types of data that would be lost include rainbow trout abundance and vital rates like survival, growth and movement in Lees Ferry, Marble Canyon, and the Little Colorado River confluence area during January. Additionally, if trout movement is episodic (e.g., as occurred in the winter of 2011-2012) and occurs primarily in winter for age-0 fish, we are likely to miss the event. Additionally, we will lose the same information for humpback chub during the winter, which will make the humpback chub state model less precise in its estimation of juvenile humpback chub survival in the Colorado River mainstem. 2. There would be approximately $50,000 in savings if the January 2015 NO/JCM trip is cancelled.

9.3, 9.4 and 9.5 (Multiple projects)
9.3 is recommended for funding, 9.4 is unfunded and 9.5 if partially funded. I have a difficult time seeing the ties to management of each of these projects and do not feel that these projects are high priority. What information is lost if we do not conduct each of these projects?

GCMRC response: These different studies are attempting to understand the mechanisms that control demographic states and rates of rainbow trout. Currently, the GCMRC program has demonstrated that there is a negative relationship between rainbow trout abundance and humpback chub survival at the Little Colorado River confluence area. Understanding the mechanisms that regulate abundance levels at the Little Colorado River has considerable bearing on whether or not the Lees Ferry fishery is actively managed, or the Little Colorado River confluence area is actively managed or if trout numbers can be controlled by other physical factors such as flow or sediment. Knowing the mechanisms that drive rainbow trout populations allows managers to act in a cost effective manner, make informative decisions in selecting management actions, and make future predictions regarding resources of concern based on monitoring data.

9.7 (Application of bioenergetics model in a seasonally turbid river; Recommended funding $33,234, Unfunded High Priority $33,234)
Maybe I missed something here, but I do not recall seeing result from FY13/14 work plan. Half of the funding for this project is recommended. Can this project be completed if only half funded?

GCMRC response: This project would help us better understand through modeling physical and biological factors how certain management actions or environmental conditions outside of our control might influence the demographic characteristics of rainbow trout in Marble Canyon. This modeling approach allows for us to evaluate the different mechanisms that are potentially regulating population parameters for the species of concern. This type of information allows managers to be proactive rather than reactive. A preliminary poster for this project was presented at the January 2014 Annual Reporting Meeting and a presentation was given in May 2014 at the Joint Aquatic Sciences Meeting. If there is interest, the May presentation can be presented to the TWG via webinar. A manuscript is currently in development with a draft scheduled to be completed later this year. While partial funding is not ideal, we believe progress can be made on this project and useful information can be provided at a reduced funding level albeit on a longer timeline.

9.9 (Effects of High Experimental Flows on Rainbow Trout Population Dynamics; Recommended for funding $72,616)
See comment for project 8.1

GCMRC response: Evaluating the effects of HFEs on rainbow trout was identified as a needed activity in the HFE and Nonnative Fish Control EAs. GCRMC needs to be prepared to implement this work in the event of HFEs being triggered during the course of the FY15-17 workplan.

Project 10.
Will this project provide a comprehensive fish habitat assessment? I would like to see system wide assessment of physical habitat suitability for fish species of interest in the CRE and not just rainbow trout. For example I would like to know where and how many miles of suitable (physical) habitat exist for adult Humpback Chub. I like and support the concept of this project and would like to see it fully funded.

GCMRC response: No, this study is focused on assisting project 5 researchers in determining what effects lower flows like those seen in 2014 might have on key components of the aquatic foodbase by disproportionately dewatering shoreline areas that may be critical to these organisms. In addition, we are proposing to evaluate the effects of high-flow dam operation on channel-bed sediment conditions in Glen, Marble and eastern Grand Canyons that might be contributing to local rainbow trout production downstream of Lees Ferry. We believe the habitat assessment proposed by AZG&F would require an extensive muti-year effort considerably larger than what is proposed here.

Project 13.1 (Economic Values of Recreational Resources along the Coloraod River-Grand Canyon Wiewater Floater and Glen Canyon Angler Values; Recommended for funding $69,801)
We suggest collaborating on the interviews and experimental design to make use of AGFD expertise in angler surveys at Lees Ferry.

GCMRC response: This is a good suggestion and should be evaluated. Initial discussions about collaboration with AZG&F have already occurred.