

**GLEN CANYON NATIONAL RECREATION AREA
REVIEW OF DRAFT
GRAND CANYON MONITORING AND RESEARCH CENTER
INTEGRATED WATER QUALITY MONITORING PLAN (5/10/99)
(comments by Norm Henderson, NPS)
June 3, 1999**

The overall style and organization of the plan is good. The writing style was easy to follow. It was obvious the authors put a great deal of time into the refinement of the April draft. This effort is much appreciated at least by this reader. Further, it is clear within the plan that the authors are extremely knowledgeable about the general character of the Lake Powell aquatic system and have been instrumental in retrieving past data and organizing a rather large and complex data set. Notwithstanding the great strides that have been made, there are several points of concern that must be addressed to improve the proposed program and the current document to make it more usable and responsive to AMWG/TWG needs. These points are the following:

1. General -

- a. The purpose and scope of the plan itself was somewhat unclear and should be specified early in the document, i.e., what is this plan intended to accomplish? Is the plan a long-range strategic plan or an annual plan? It should be more than just what INs will be addressed. For example, a detailed budget summary and justification must accompany the FY-2000 annual work plan (including contracts, equipment, salaries etc.) in order for the plan to be meaningful to TWG. A generalized budget summary is also needed for the out-years. The budget summary should include the various funding sources to be used, i.e., AMP/O&M, O&M, appropriated etc.

Response: A short narrative is included below each water quality-related information need in Chapter 1. This includes a statement of whether the IWQP will fully support this information need through its research and monitoring or partially support the information need by providing necessary water quality information for separate studies specifically answering the information need.

A budget summary is included at the end of Chapter 2.

- b. The objectives and goals of the program (IWQP) are stated and paraphrased at various locations throughout the plan but each description is, somewhat, different. I suggest that the program goals and objectives be stated once and then either used by reference or stated verbatim throughout the remainder of the plan. Better yet, use the INs verbatim.

Response: Information Needs are stated verbatim in Chapter 1 with a brief paragraph describing how the IWQP addresses each IN. Each IN is categorized into an overall priority category, based on voting by TWG members on April 28, 1998. A statement of whether information from the program fully addresses the Information Need or partially supports it by supplying basic long-term water quality information for use by other investigators is also included. This information is summarized in a table at the end of Chapter 1.

Response: The introduction to Chapter 2 has been rewritten to clarify the primary goal of the IWQP and its linkage to the Management Objectives and Information Needs of the AMP. It specifies general objectives of the four monitoring program components, which aid in guiding monitoring activities. The specific objective of each program component is listed separately under the description of each component

- c. Two authors are listed on the proposal. One person should be designated as the Principal Investigator for the project. Only in this way can the responsibility for the program be adequately tracked.

Response: The plan as written has been co-authored by the GCMRC staff members. The plan will be implemented by the co-authors in a collegial manner with each co-author having defined responsibilities.

- d. Subheading and heading characteristics (font size and bolding) are so similar as to be mostly indistinguishable to the reader. As a result it is difficult to follow the outline format of the plan.

Response: Document style has been reformatted to enhance readability.

- e. Very important and missing from the proposal/plan is a deliverable section detailing the reports to be provided and on what schedule.

Response: Deliverables include annual status reports, publications addressing specific research or information needs, updating of web site/SCORE report, data accessibility, and public presentations.

- f. The terms "characterization," "monitoring," and "basic-level monitoring" are variously used throughout the plan but are never really defined. As a consequence, it is unclear just how such characterization and monitoring addresses the specific INs. Each of these terms suggests the acquisition of general data about a system rather than the acquisition of specific information designed to answer scientific questions. At this point, almost 30 years of baseline data exist to "characterize" Lake Powell. It is now time to address specific hypotheses.

Response: The primary goal of the IWQP will be met by maintaining a long-term program of basic water quality monitoring, defined as the periodic measurement of a consistent, repeatable set of common water quality parameters from an integrated network of sites from Lake Powell through the Grand Canyon. The information will be collected according to standardized monitoring and maintained in a common location. To fully address specific Information Needs, form linkages with other resource components, and evaluate protocols and methodology, necessary research will be also be conducted based on specific hypotheses.

- g. As required for all other research proposals to GCMRC, this proposal should include a vitae or qualifications summary for each of the authors.

Response: This is included as Appendix C.

- h. A data analysis section must be included to indicate how the acquired data will be assessed to address the specified objectives. This section should specify the statistical methods employed as well as the parameter comparisons to be made.

Response: A brief description of data analysis techniques is given in Chapter 4. These focus mainly on summarization and graphic representation of the data. Analytical methods specific to answering a given Information Need or hypothesis will be specified in the plan for that specific research project.

2. Page 2, purpose and scope - This section implies that the GMCRC IWQP addresses both AMP and BOR-specific information needs [outside the AMP]. It is unclear whether BOR needs are in addition to AMP requirements or are included. Any new responsibilities separate from AMP requirements must be identified as such with a specific funding source also identified, and included in the long-term program only if GMCRC personnel are able. Since it is obvious that the GMCRC limnology staff is stretched pretty thin, it seems unreasonable to add responsibilities without providing additional staff and/or funding.

Response: This section has been revised so that only AMP needs are addressed in this plan. As needs from other agencies with associated funding sources are identified, it is possible that the IWQP can be modified to accommodate these needs. These activities will be accomplished by GMCRC staff or outside contract, as appropriate.

3. Page 2, water quality monitoring and adaptive management information needs - It is not at all clear how the INs are utilized in this section. Certain INs, mostly related to downstream resources (white area) are not addressed directly within this plan. Other INs, mostly related to Lake Powell, are more specifically addressed. It is important to make this distinction clear to the reader since one could legitimately expect specific results for the entire suite of downstream INs.

Response: The narrative below each IN in Chapter 1 states whether the IWQP addresses the IN directly or provides supporting information.

4. Page 3-6 - The description of black, white and gray areas is unnecessary and confuses the reader not familiar with the process. All that is necessary is to list the INs to be addressed within the plan.

Response: The confusion over which activities address upstream or downstream resources has been ongoing and continues to be misunderstood. The black, white, and gray concept was introduced by an AMWG member to resolve this confusion. The definitions of these categories are based on where the activities are conducted and whether they address upstream or downstream resource effects. Sources of funding are based on these definitions. This concept was adopted by the TWG, which drafted the definitions, identified funding sources, and instructed GMCRC to separate activities and develop a plan to accomplish this work. It is felt that the inclusion of this discussion as necessary to provide clarification and common definitions.

5. Page 7, Introduction, paragraph 1 - As in 2 above, the latter part of this paragraph specifies that the GMCRC IWQP is being developed for other agencies. As stated above, the GMCRC

program specifically addresses only the INs of concern to the AMWG. Other agencies are free to contract with GCMRC but only if GCMRC has sufficient resources to devote to these additional responsibilities. The GCMRC plan is "coordinated" with BOR and others to ensure that there is no duplication of effort, not to meet the needs of those agencies.

Response: This sentence has been revised to remove references to the needs of other agencies.

6. Page 7, Introduction, paragraph 2 - I recommend not including specific dates or a chronology within this section since changes are likely that will quickly date the plan.

Response: Reference to the July 1999 AMWG meeting and FY2000 will be removed.

The statement that this plan proposes a "basic-level" long-term water quality monitoring program is confusing. What is meant by basic level? I was under the impression that the plan was not "basic-level" at all but was intended to specifically address one or more of the INs specified in Chapter 1.

Response: This definition is provided at the beginning of Chapter 2 and states how the IWQP consists of a basic long-term monitoring program and specific research. It is not the intent of the IWQP to fully address all INs specified in Chapter 1. A primary function of the IWQP is to provide consistent high-quality information on water quality resources to the entire Adaptive Management Program.

The final sentence is confusing as well. How do these "main objectives" pertain to the INs presented in Chapter 1?

Response: The general and specific objectives of the four components of the water quality monitoring program have been developed to guide specific monitoring activities and methodologies. The goal of the program is to meet the overall needs of the AMP in understanding the effects of dam operations on water quality by providing consistent data to a broad range of research interests. To fully address specific Information Need additional targeted research activities may be required.

7. Page 7, last paragraph - The detailed methodology is found in Appendix D not Appendix A as stated.

Response: This change has been made.

8. Page 7-9, Proposed monitoring activities - It is not at all clear how the proposed four general monitoring activities described here (and in Appendix D) will specifically address the information needs presented in Chapter 1. For example, to address IN 1.1d, I would have expected a very detailed study plan to study a couple of side channels to assess water movement at various layers (refreshment rates), influence of tributary inputs, nitrification rates, differences between side channels and main channel, dam operational effects etc.

I suggest that each of the INs to be addressed have a specific hypothesis to be tested and a methodology (including data analysis) to address each hypothesis. Without this nexus between the INs and a standard scientific protocol, it is difficult for me to see how the INs will be

specifically addressed by the generalized sampling scheme proposed. An example showing the process might be the following for hydrogen sulfide:

- a. Testable hypothesis: hydrogen sulfide concentrations in the hypolimnion are undetectable and not affected by dam operations. (This is a very simplistic hypothesis. Given an expert limnologist's understanding of the system, more complex hypotheses would be likely and more meaningful. To me this is the hardest step in developing a research/monitoring program)
- b. Methods: Take water samples from the water column of the forebay, main channel, and a specified number of side channels at 1 meter intervals from the hypolimnion/thermocline boundary to the bottom. Sample at monthly intervals under routine operating conditions. Take additional samples just before major changes in dam operations (specify).
- c. Data analysis: Utilize standard analysis of variance statistics to determine differences in time and space within Lake Powell and between different operational criteria.

Response: It is beyond the scope of the IWQP to fully address each water quality related Information Need. However, the IWQP will have separate research items to address specific questions. Before research to address a specific Information Need is implemented, a detailed study plan will be developed.

It just seems incredulous to me that the past monitoring program, where no objectives were stated, is so robust that it immediately incorporates this new set of specific objectives.

Response: The previous program was developed as a basic long-term monitoring program. The data required for the INs identified by the AMWG were developed. These were compared against the previous program and changes were made as required. Protocol evaluation will be conducted in FY2001.

The relationship between the proposed monitoring plan and the downstream INs specified in the plan is even more fuzzy. The authors seem to be arguing that general monitoring of the tailwater and thermal monitoring through the canyon are all that is necessary to specifically address almost 20 biological INs related to water quality. At this point, general INs and specific INs are being mixed which entirely confuses this reader.

Response: The IWQP does not propose that the data from this program will completely address all the downstream INs. The program would, however, provide basic water quality information required by other projects in support of addressing a particular IN. The INs listed in Chapter 1 are organized in the order they appear in the Management Objectives and Information Needs document. The table at the end of Chapter 1 addresses whether the program directly meets or generally supports a particular IN.

The authors argue that a consistent long-term monitoring program provides supporting data to a variety of disparate programs and reduces the need for individual studies to initiate their own water quality monitoring. Difficulties with different methodologies, data management techniques, quality assurance protocols, inconsistency, and redundant resource expenditures can result when individual projects are left to collect common parameters that are also applicable to other studies.

9. **Page 10, Proposed Activities for FY2000** - The relevance of this section is unclear since the overall purpose and scope of the plan has not really been made clear or described (see above). It is not clear whether the authors are proposing that yearly changes be made with no plan amendments, a yearly work plan be produced with anticipated changes, a revision to this plan be made each year etc.

Response: Once the IWQP program is approved, the annual planning process of GCMRC would also include annual planning for water quality. This yearly work plan would contain a plan for continuation of long-term monitoring, with changes made that address changing information needs and protocol evaluation, and a plan for specific necessary research to be conducted that year. The proposed FY 2000 activities are listed in Chapter 2.

10. **Page 10-11, hydrodynamic modeling** - This section does not explain what GCMRC intends to accomplish within the timeframe of the plan regarding hydrodynamic modeling. More, it implies that GCMRC will work generally with BOR in their modeling efforts. It would seem that an explanation as to modeling needs should be explained in a little more detail including how the BOR effort will meet those needs.

Response: Development of a hydrodynamic model is anticipated with BOR collaboration. Modeling needs of each entity may vary but basic input data gathering, reservoir geometry, meteorological inputs, and initial calibration would be common to all further uses of the model. A more detailed explanation of GCMRC modeling needs are provided in Chapter 2.

11. **Page 11, data management** - Data management is very different from data analysis. This section describes only how data will be stored not how data will be utilized and analyzed to answer specific INs or hypotheses. I recommend that a section entitled "data analysis and management" replace the current section with detailed data analysis included for each of the hypotheses.

Response: Current methods for analyzing water quality data are briefly explained in this chapter. The chapter does not exclusively address data management, although the importance of adequate data management protocols cannot be de-emphasized. Without an effective data management system for basic long-term monitoring, the data are of little use for broader purposes. Analysis is closely tied with data management and ranges from graphical representations and statistical summaries to more rigorous hypotheses testing. Details of specific data analysis are more appropriate to a specific research study plan.

12. **Page 12, paragraph 1** - Research or monitoring projects outside the scope of the specified INs do not seem appropriate. For example, a project regarding seiche effects does not seem to be responding to any particular IN specified by AMWG/TWG.

Response: The research projects listed here can be directly related to specified IN's. Research regarding the nature of seiches, or internal oscillations within Lake Powell is related to all INs addressing water quality in downstream releases. Understanding and defining the nature of these seiches aids in prediction of discharge water quality and the separation of these effects from operational effects.

13. **Page 12-13, Temperature Control Modifications** - The IWQP should address TCD objectives and information needs. The TCD EA, input from stakeholders, and the expert panel

on TCD all have provided input on these needs. Further, the GCMRC FY-2001 budget has already made projections on needs. If the needs are known for 2001 they should be known for other years.

Response: The IWQP plan was developed without specific consideration for TCD. Research and monitoring specific to a TCD will be developed and funded separately from the IWQP. Data would be collected under the IWQP that, while not specific to the evaluation of a TCD, would provide valuable baseline information for such an evaluation.

14. Page 13, conceptual modeling - The 1998 Lake Powell program (approved by AMWG) included a conceptual model for Lake Powell. If the model can be included and funded as part of the Grand Canyon conceptual model now being developed then describe it clearly that way. As now described, it is a little fuzzy about whether adequate funding is available for this effort from that source. I recommend that a timetable for development of the conceptual model be included in the plan.

Response: At the July 1998 AMWG meeting, the Lake Powell program was approved provided that activities be separated into the "Black, Gray, and White" category and appropriate funding mechanisms established. Since that time the previously proposed Lake Powell conceptual model has been identified as belonging to the "black" category and no further attention has been given to it. In order to focus primarily on downstream effects, the linkages between data from the IWQP or other hydrodynamic models are proposed. A time table for development of a Lake Powell conceptual model is currently inappropriate until other needs and funding sources are identified.

15. Page 14, Resource Requirements - A budget is referenced here but is not included in the plan.

Response: A budget for the IWQP is included in Chapter 2.

16. Page 14, equipment/staffing - This section briefly summarizes the proposed major equipment and staffing required to implement the program. However, a clear justification for these needs is not made along with the funding requirements. It seems that the authors assume continuance of what has occurred in the past for both items. They should justify why it is necessary and/or cost effective to maintain the proposed monitoring platform (Uniflite) for the sampling effort rather than renting or leasing such equipment. Further, they should explain why it is necessary and/or cost effective for data collection to be carried out by internal staff rather than contracted, and why two staff members are needed to implement the program. It would seem that a well-tailored contract could eliminate or greatly reduce the field time needed by the authors leaving more time to them for analysis and study. A contract would eliminate or greatly reduce the time required to maintain complex field equipment and even the monitoring platform itself on Lake Powell again allowing more time to the authors to analyze and report on the results.

Response: A goal of the IWQP is to conduct and maintain a consistent long-term monitoring program for water quality. One means of achieving this goal in the past has been to utilize the expertise, experience, equipment, and methodology currently existing in the GCMRC. A substantial investment has been made in all areas. Another way would be initiate a contract for all or part of this work. Adequate staff would need to be maintained for contract administration, data integration, and quality assurance in addition to analyzing and reporting results.

It is the view of GCMRC that this high quality work can be continued with the resources and budget outlined in Chapter 2. If the proposed program is approved, several monitoring and research aspects of the program could be contracted where appropriate. The proposed program would continue to remain under the direction of GCMRC.

Execution of the program would be accomplished with the two existing GCMRC staff members and two additional technical positions. These could be GCMRC staff positions, student positions, contract positions, or details from other agencies.

The Uniflite vessel used as a monitoring platform is a 32 foot twin-engine sedan capable housing a sampling crew for a weeklong reservoir survey. It is equipped with sampling winches, cable reels, depth sounder radio and other equipment that have been customized for this particular vessel. In short, it works very well for supporting reservoir water quality monitoring on a lake the size of Lake Powell. No equipment with similar capability has been found to be available by rental or lease.

17. Page 15-25, Chapter 3 (Appendix D) - This chapter and appendix describes the current sampling program and history. The relevance of this ongoing program (whatever the history) to the proposed new program is not really made clear except for the unstated implication that the current program exactly meets the needs of the new one. On the other hand, a summary of results of these past efforts would have been highly useful to determine the needs of the current program proposal. In my view, the "history" of the existing program is somewhat irrelevant. Describing the proposed program in terms of the ongoing program and continually in the past tense can cause some to question the authors independence, and does, at a minimum, confuse the reader who is trying to determine what is being proposed within the plan.

Response: The historical description of water quality monitoring in Lake Powell is given to give context to the current level of monitoring in Lake Powell. The history of the program must be evaluated in order to interpret the results of past data collection efforts. Methods are improved, and the monitoring locations and frequency have been modified to represent a balanced and more efficient restructuring compared with past phases of the program. As understanding of the system improves, new methodology and tools such as hydrodynamic modeling become available, and further direction is received from the AMP, it is expected that the program will be refined further.

With implementation of the data management efforts described in Chapter 2 more information and increased understanding can continue to be gleaned from past efforts. It is expected that findings or the previous Lake Powell assessment will be enhanced by further synthesis work with past data.

18. Page 15, paragraph 3 - Reference to Appendix B is incorrect.

Response: This reference has been corrected.

19. Page 18, paragraph 1 - The objective of the biological program is stated to be the "characterization" of the lake and tailwater. However, this objective seems at odds with other statements of objectives and goals in the plan, and the INs specified by TWG.

Response: This objective meets with the goal of basic long-term monitoring program of the biological resource as the effects of releasing this biological component to the downstream ecosystem.

20. **Page 24** - A specific section devoted to site coding and geo-referencing is unnecessary.

Response: The section was moved to Appendix B

21. **Page 26-30, Chapter 4** - Although interesting, I question the need for a lengthy discussion about data management history in this plan. Further, a description of the current data management features, design, techniques, protocols, and structure is not really necessary in any great detail, and is more a subject for the GCMRC information management program than for the IWQP. I recommend that such lengthy discussions be reserved for a complete presentation of hypotheses to be tested and descriptions of the specific data analysis techniques used.

Response: We have left chapter 4 as it stands, with a little simplification.

Comments from Cliff Barrett:

-----Original Message-----

From: cliff barrett <barrett@trilobyte.net>

To: bgold@flagmail.wr.usgs.gov <bgold@flagmail.wr.usgs.gov>

Date: Tuesday, June 01, 1999 1:32 PM

Subject: IWQP

Barry,

I've not reviewed the entire draft document in detail, but here are some initial reactions.

Appendix A - page 50 should make the definition for the Black area the same as in the AMWG approved paper. Replace the term "solely within Lake Powell" with the same wording as used on pg. 52 - i.e. "not directly related to downstream effects". I think there is a major difference in these two terms.

Response: This correction has been made.

Chapter 1 - the discussion of IN's beginning on pg. 3:

White area - several are related to the TCD. They are probably still a part of the IWQP, but should be funded separately as part of the total TCD program. Examples are Bio Res 5.1, 5.2, 5.3c, 5.4, and 5.5.

Response: Research and monitoring specific to a TCD will be developed and funded separately from the IWQP. The basic long-term monitoring specified in this plan provides information to establish baseline patterns on which the operation of a TCD could be evaluated as well as addressing Information Needs not directly related to the TCD. In other words, IWQP temperature monitoring does not exclusively address TCD needs and therefore should be funded as other White area activities.

- Some are listed in White that seem to me to be Gray (Phys Res 2.1b) or Black (Bio Res 5.4)

Response: See narrative for each information need. Bio Res 5.4 addresses affects to both reservoir and downstream resources. It is hoped that the narrative below this information need makes clear that the focus is on "characterizing water...available for withdrawal under a TCD scenario" and that addressing effects to Lake Mead is NOT proposed as part of the IWQP.

- What is the location of the activities and the effects of Phys Res 2.1b and Rec Res 1.5?

Response: IWQP activities that respond to Phys Res 2.1b occur at sampling locations on Lake Powell, below Glen Canyon Dam, and Lees Ferry where chemical samples for nutrients and major ions are collected. There are NO IWQP sampling activities that address Rec Res 1.5. Information on metals concentrations to support this IN is provided by USGS NASQAN sampling at Lees Ferry and Diamond Creek.

Grey Area - I have questions about the inclusion of any of the MO/INs referred to on pg.5 in the Grey area. Probably they should be in the Black area. Please see the introduction to the Lake Powell section of the Mgmt Obj Document adopted by AMWG, which clearly states that all of these are related to "upstream effects only".

Response: Reservoir monitoring provides a longer-term view of future release water quality and describes how dam operations and other factors affect water quality patterns in the reservoir and eventual downstream releases. Water in Lake Powell is affected by dam operations and is available for withdrawal to the downstream ecosystem downstream. An ad hoc group of the TWG developed the breakdown of information needs and definitions of the White, Grey, Black Categories listed in the plan and instructed GCMRC to develop a water quality monitoring and research program from that effort.

Chapt. 2 - This is short on the type of details needed to evaluate a program for FY2000 and 2001. I would like to see:

- A direct link between the work items proposed and the particular IN being met.

Response: A short narrative has been added to each water quality-related information need discussing how the IWQP meets or supports that information need.

- An indication that the top priority INs are given priority in the proposed program.

Response: Based on the TWG prioritization of 4/28/98, each information need was assigned a priority, High, Medium, or Low, based on the number of votes out of fourteen. This ranking is given in the text of each information need.

- Costs for each element of the monitoring program, with a breakdown between the White and Grey areas.

Response: A budget for the IWQP is presented at the end of Chapter 2.

- Some assurance that no Black area work is included in the GCMRC/AMP program.

Response: It is stated under the listing of Information Needs in Chapter 1 that no support is provided by the IWQP in this area and no activities are proposed in this plan to address these information needs.

DATE: July 19, 1999
TO: Barry Gold
FROM: William Davis
Richard Meyerhoff
RE: Comments on *GCMRC: Integrated Water Quality Plan*

Thank you for the opportunity to review the above-referenced draft document. Please find our comments attached. If you have any questions, please contact us at (480) 831-8780.
Attachment

cc: Leslie James, CREDA
Cliff Barrett, CREDA
Robert Lynch
Ted Rampton, UAMPS

Comments on GCMRC: Integrated Water Quality Monitoring Plan

We have summarized our comments into three key points:

1. The proposed monitoring activities are not clearly linked to the management objectives and information needs, the stated purpose for the development of the plan. Consequently, it is difficult to follow a clear path from a given information need to the monitoring activity designed to meet that need. The attached table lists the information needs (white, gray, black) and our attempt at evaluating whether the appropriate data would be collected by the proposed monitoring activities. While it is understood that resources may limit what can be researched, it appears from our evaluation that many of the information needs will not be met by the proposed monitoring plan.

Response: A short narrative is included below each water quality-related information need in Chapter 1. This includes a statement of whether the IWQP will fully support this information need through its research and monitoring or partially support the information need by providing necessary water quality information for separate studies specifically answering the information need.

The table attached to the comments from Bill Davis has been modified and incorporated into the IWQP plan.

2. The monitoring plan lists three main objectives (Chapter 2, Introduction), a primary goal and "four main components of monitoring activities" (Chapter 2, Proposed Monitoring Activities). However, the relationship among objectives, the goal and the monitoring components is not clear. It is also not clear how these various objectives and components support the need "to evaluate the effects of the Secretary's actions and refine management approaches."

Response: The introduction to Chapter 2 has been rewritten to clarify the primary goal of the IWQP its linkage to the Management Objectives and Information Needs of the AMP. It specifies general objectives of the four monitoring program components, which aid in guiding monitoring

activities. The specific objective of each program component is listed separately under the description of each component.

3. The monitoring plan emphasizes water quality monitoring in Lake Powell. However, many of the information needs involve the area downstream of the dam. The tailwater site is within the dam and while it will provide important baseline data, it will not provide data about what happens to water quality below the dam as a result of river processes. There is only one downstream site for water quality monitoring (other than thermal data) - Lee's Ferry. How data from Lee's Ferry alone can be used to address the information needs downstream of Glen Canyon dam needs clarification.

Response: Conditions in Lake Powell are monitored because water withdrawn from the reservoir can be affected by various aspects of dam operation and is eventually exported to the downstream environment. Future release water quality can be predicted by monitoring conditions and understanding processes in the reservoir. The physical, chemical, and biological components of dam releases directly affect the aquatic ecosystem below the dam. These biological processes, in turn, affect the water quality of the river, especially in the Glen Canyon Reach above the Paria River. Below this point, primary productivity becomes limited by light availability and biological oxygen dynamics are masked by aeration from rapids in Grand Canyon. Other water quality data are collected downstream by USGS at gauging stations (conductance, temperature, stage level, DO, DOC, N, P, bacteria) and this is a part of the water quality plan as part of these data collection efforts are funded by GCMRC. Data collection at Lees Ferry and Diamond Creek Gauges include DO, DOC, N, P, and bacteria as a part of the NASQAN Program. These data are available from USGS. Thermal monitoring is maintained because of the importance of temperature to the aquatic ecosystem and the effect of dam operations on release temperatures and warming patterns in Grand Canyon.

Recommendations

- Revise the plan to clearly show how the proposed monitoring activities will yield data needed for the information needs developed by the TWG and evaluate the effects of the ROD. For example, the first information need, IN 1.1, which involves the aquatic food base downstream of the dam, should be linked to the proposed monitoring activities to show how these activities will provide appropriate data to address this particular need. This type of analysis and presentation for each information need would demonstrate how the monitoring plan is designed to meet the research needs for Glen Canyon.

Response: See Chapter 1 for a narrative of how the IWQP addresses each information need.

- Reevaluate the number of sampling stations below Glen Canyon Dam. It is not clear how reliance on one sampling station, Lee's Ferry, to provide the kinds of data needed to research complex issues such as the aquatic food base below Glen Canyon Dam, will meet the objectives of the monitoring plan.

Response: The number of sampling stations are maintained in the current proposal based on the reasons given above. This could be reevaluated based on the need for this information by the TWG or other researchers.

-----Original Message-----

From: Gary Burton <BURTON@wapa.gov> [SMTP:Gary Burton BURTON@wapa.gov]
Sent: Monday, June 14, 1999 3:39 PM
To: B PERSONS@GCES@PHX
Cc: SMTP@AZGF_PHX1@Servers["CLAYTON PALMER" CSPALMER@wapa.gov]
Subject: WAPA Comments on IWQP

Bill,

Our concise comments are included below. I apologize that they did not make it out to you last Friday.

Western is glad to see the draft plan come out and appreciates the opportunity to provide comments. The Introduction to Chapter 2 states the draft has been sent out for independent technical review by a panel of experts. Please note we would like to receive a copy of the panel's comments when available.

1. The direction given by the ad hoc group was to create a plan that describes what is required and how water quality monitoring should be accomplished in Lake Powell and downstream. The draft plan does propose what should be done to effectively monitor water quality in these areas. It also gives the appearance of an implementation plan to begin the proposed (continue current) monitoring. While efficient, implementation is a step beyond the task given.

Response: The TWG instructed GCMRC to develop a monitoring plan, addressing the split of upstream and downstream activities for recommendation by the AMWG in July 1999. This plan incorporates the funding mechanism, proposed for FY2000 for Lake Powell work and is part of the GCMRC FY2000 Annual Plan.

2. Western is pleased to see the Temperature Control Device monitoring issue separated from IWQP thermal monitoring and believes this to be the appropriate approach. Only when the TCD is authorized would monitoring needs develop. If the TCD is authorized for construction, an experiment-specific monitoring plan, as proposed, would then be developed. Depending on the results of the experiment, if authorized, a long-term, TCD monitoring plan could be integrated with the IWQP.

Response: This philosophy is incorporated in the plan. The IWQP would continue to provide baseline water quality information, not specific to, but in support of, the evaluation of the operation of a TCD.

3. It is a positive aspect of the document to have the background and developmental history of the water quality monitoring issue included in Appendix B. The monitoring activity and funding source separations are accurate and clarify those portions that are presented in the body of the document. However, it is inappropriate at this point to include a justification for GCMRC staff to conduct the program for the Adaptive Management Program and Reclamation in the canyon reaches below Glen Canyon Dam and in Lake Powell. Once the "what is required and how" of the plan are finalized, the "who" can be determined. AMP and Reclamation have some separate, but related monitoring responsibilities. Some of the AMP responsibilities may need to be accomplished through the competitive bid process. This is a determination to be made after the IWQP is final.

Response: Pending approval by the AMWG, implementation of the IWQP will begin October 1, 1999. While there may be many ways to accomplish this task, the in-house efforts of GCMRC are currently providing a cost-efficient and effective solution. It is also felt that this approach is of benefit over the long-term in terms of quality, consistency, and central data management. For these reasons, the justification for an in-house program was included.

Robert S. Lynch
Attorney at Law

340 E. Palm Lane
Office: (602) 254-5908
Suite 140
Fax: (602) 257-9542
Phoenix, Arizona 85004-4529
Email: RSLynchAty@aol.com

Emailed only

MEMORANDUM

TO: Barry Gold (bgold@flagmail.wr.usgs.gov)
FROM: Robert S. Lynch
DATE: June 7, 1999
SUBJECT: Draft GCMRC Integrated Water Quality Monitoring Plan

I have briefly reviewed the draft Plan. I am concerned that most of the activity is centered on Lake Powell and too little of it is centered on the Colorado River below Glen Canyon Dam. Given the limited financial resources that Reclamation can apply to this effort, I am concerned that water quality studies in Lake Powell will divert resources from data gathering below Glen Canyon Dam that is essential to building a proper data base about the effects of the current dam operating criteria for power generation on downstream resources.

Response: The concern that efforts are centered on Lake Powell was shared by other reviewers (see Bill Davis, Item 3). This has been addressed through a plan to assess past downstream activities and develop a research plan for monitoring downstream (Grand Canyon) water quality resources. Additionally, other data are collected downstream by USGS at gaging stations (conductance, temperature, stage level, DO, DOC, N, P, bacteria) and this is a part of the water quality plan as part of these data collection efforts are funded by GCMRC.

The peer review of the draft environmental analysis of the proposed temperature control device pointed out substantial gaps in baseline data that made impact predictions from the facility problematic at best. I viewed that peer review as a wake-up call about the focus of ongoing studies.

Response: Most of the TCD-EA comments were focussed on fisheries monitoring gaps. The point is taken, as addressed above. The TCD is a separate proposal and a monitoring and research plan focussed on the TCD is being developed.

Regardless of the source of funding, there are only so many people and so many hours in a day. Even if studies are contracted out, Reclamation personnel must supervise and manage those efforts. Ultimately, the Center is going to have to answer the question: What are the impacts of the use that has been made of the operating criteria? Without proper baseline data of downstream impacts, neither the Center nor Reclamation will be able to do so credibly. Launching into a wide array of water quality studies in Lake Powell will likely shortchange the monitoring program the 1992 Act directed be done. This ambitious Plan needs to be measured against the scientific deficiencies in the database below Glen Canyon Dam.

Response: Some GCMRC contractors have and are doing water quality collections downstream. Specifically, USGS, NAU Aquatic Food Base, NAU geology, and most fisheries researchers perform some water quality monitoring. These are not comprehensive and are difficult given logistics and timing issues for the transient nature of the fluvial environment. A PEP will be used to evaluate past data, determine exact water quality monitoring needs, and develop research to guide the implementation of a downstream water quality plan.

RSL:psr

Reviewer 1:

GRAND CANYON MONITORING AND RESEARCH CENTER
2255 N. Gemini Dr., Room 341, Flagstaff, AZ 86001 (520) 556-7094
PROPOSAL EVALUATION FORM

PRINCIPAL INVESTIGATOR(S) (Name & Address: last name first; show first name and/or initials as shown in manuscript)

INSTITUTION

Vernieu, W.S. and S.J. Hueftle,
Grand Canyon Monitoring and Research Center

PROPOSAL TITLE

P.O. Box 22459, Flagstaff, AZ 86002-2459
Integrated Water Quality Monitoring Plan

PROGRAM :

A. UTILITY OR RELEVANCE OF THE MONITORING/RESEARCH PROPOSAL - LIKELIHOOD THAT RESEARCH WILL CONTRIBUTE TO PROGRAMMATIC GOAL OR PROVIDE KNOWLEDGE THAT WILL SERVE AS THE BASIS FOR IMPROVED UNDERSTANDING AND MANAGEMENT OF COLORADO RIVER ECOSYSTEM.

The proposed monitoring work should be very useful and contribute to understanding both Lake Powell and the export of nutrients, plankton and water of specific temperatures into the Grand Canyon. Due to the proposed penstock changes the detailed monitoring in the forebay would appear to be the most pragmatic aspect of the study, but since the forebay is "fed" by the entire reservoir, the monitoring of the entire system is warranted. Removal of warmer surface water that is more nutrient deficient will likely influence the productivity of the lotic system below the dam, as well as the productivity of the reservoir itself, and the monitoring will be necessary to anticipate what changes will occur. It is not clear how tightly-linked the temperature, nutrient and plankton work in the reservoir is to the studies of production in the lotic areas. The two groups responsible for these different aspects should be working closely together to facilitate the most appropriate data gathering.

Response: Integration of downstream work is in a developmental stage and ongoing. Linkages are continuing to be found and explored. The monitoring plan intends to provide long-term data that can reflect operational changes including epilimnetic releases, whether they result from spillway operation or a TCD. The nature of the epilimnion has been demonstrated to influence the water quality of the releases (Hueftle & Vernieu, in review).

A very important aspect of the proposed work is that it will continue the long-term data base that is established. This will allow investigators and managers to determine how dam-modifications are impacting the reservoir and, in turn, how those changes in the reservoir will influence the Grand Canyon. With the long-term data base in hand, it is unfortunate that the program is not planning on integrating a reservoir model with the model being constructed for the Grand Canyon. Although a hydrological model will be implemented, it would be much more productive to integrate a hydrological-chemical-biological model such as DYRESM (Imberger and Patterson, 1981). This would provide a model not only of the hydrological functions of the reservoir and linkage with the Grand Canyon, but it would allow the prediction of nutrient and organic carbon export. It would also facilitate understanding of how biological aspects of the reservoir would function with modified withdrawal scenarios.

Response: Concerns for collection of nutrient and organic carbon are being evaluated as a part of an ongoing effort to refine the current monitoring plan.

B. INTRINSIC MERIT OF THE MONITORING/RESEARCH PROPOSAL - LIKELIHOOD THAT RESEARCH WILL :
-LEAD TO NEW DISCOVERIES OR FUNDAMENTAL ADVANCES WITH REGARD TO PROGRAMMATIC GOALS; PROMOTE TECHNICAL ADVANCES IN THE SUBJECT AREA;
-PROVIDE RESOURCE MANAGEMENT ALTERNATIVES NOT PRESENTLY AVAILABLE; IMPROVE UNDERSTANDING OF THE LINKAGES BETWEEN RESOURCES; ANTICIPATED PARTNERSHIPS/LINKAGES WITH OTHER FACILITIES.

The research is designed as a basic monitoring project and as configured it seems unlikely to lead to new discoveries, or to provide fundamental advances in the subject area. The monitoring data will, however, address resource management alternatives with regard to the proposed changes in water withdrawal depth. It will also provide the needed data for linking reservoir and river productivity.

Response: Although research is not the main focus of the IWQP, discoveries have been found under the scope of the past program, even if not as directly under focussed research. The element suggested here implicates the need for the category of *necessary research* identified in chapter 2 that allows this type of research and discovery on a limited scale. Furthermore, elements of research are a necessary product of analyzing monitored data-sets.

Although several partnerships with other research groups were mentioned, the linkages between the groups were not clearly delineated. One linkage that appears to be entirely missing is between the GCMRC and the Utah Division of Wildlife Resources who monitor the fish populations in Lake Powell. Because of top-down controls on zooplankton by the fish in the reservoir, there are obvious potential interactions with the biotic community in the Colorado River. The hydroacoustic surveys mentioned in the proposal could be linked with the netting surveys of the Division of Wildlife Resources to gain a better understanding of the fish populations in the lake, and their importance in controlling the plankton community.

Response: It is agreed greater integration with reservoir fisheries would benefit both science in general as well as upstream and downstream linkages. These linkages are continuing to be forged and efforts will be increased to integrate Utah Div. Of Wildlife Resources. The IWQP, however, does not propose to do any first hand fisheries work.

C. TECHNICAL SOUNDNESS OF THE PROPOSED APPROACH. APPROPRIATENESS OF HYPOTHESES TO BE TESTED; METHODS ARE APPROPRIATE AND SCIENTIFICALLY VALID; PROPOSED SCHEDULE IS REALISTIC.

The monitoring program which has evolved over several decades is general quite sound. The sampling frequency and number of stations sampled is appropriate, and the methods are rigorous. Some minor modifications and/or additions that would improve the data sets include:

1. Because temperature stratification in the forebay is critically important for the river temperatures, it would be wise to install thermistor strings there. Fifteen HOBO temperature recorders, costing about \$70 each, could record data at 10-minute intervals throughout the water column for months. This would provide better data on seasonal cycles of temperature, and more importantly, would provide valuable information on internal waves (seiches). If the seiche data were combined with the wind data to be collected at the weather stations, one could model the variability expected in outflow temperatures at time scales varying from hourly to monthly. Thermistors strings could be profitably used at other sites along the reservoir, but they would seem to be critically important in the forebay.

Response: The effects of seiches on release water quality has been discussed for the monitoring suggested in item 1. This will be a priority item, particularly in the face of a possible BHBF, as these effects may significantly influence the interpretation of just such a short-duration experiment.

2. The zooplankton collection should include a metering device at the mouth of the net, as net efficiency can vary from 50-80% with an 80 um mesh, depending on the amount and size of phytoplankton in the water that can clog the net.

Response: The use of a flow meter for zooplankton tows has been considered previously and is being evaluated.

3. Depth-stratified sampling of zooplankton during the day at monthly intervals in the forebay may not be justified, as the plankton's depth distribution is dependent on time of day when sampled. It would be more informative to do depth-stratified sampling quarterly with both day and night samples taken. This would provide a clearer idea of the amount of zooplankton that would enter the outflow under different withdrawal scenarios.

Response: The concerns for diurnal zooplankton sampling are valid and may be accomplished under a separate monitoring program for the TCD, but are currently outside the scope of the IWQP. Collaborative work with BOR-Denver is being pursued to evaluate zooplankton distribution patterns and sampling methodology.

4. GF/F filters are not 0.45 μm (p. 72), but rather have a nominal pore size of 1.0 μm . It is likely that a portion of the picoplankton are being missed. These likely contribute 20-40% of chlorophyll in oligotrophic sections of the lake. GF/F filters, with a nominal pore size of 0.6 μm would retain nearly all of the phytoplankton, and would allow enough water to be filtered for the spectrophotometric method employed.

Response: The information on GF/F filters will be corrected and the recommendation for a smaller pore size adopted, with attention to initial duplication of effort to assess effects of methodology alteration. New filters will be GF/F 0.7 μm , the smallest pore size available.

5. A large portion of the productivity of Lake Powell may occur in the shallower, more productive side canyons. It would be wise to increase the monitoring of these smaller canyons with synoptic sampling twice a year. The *in vivo* monitoring of chlorophyll a with a fluorometer would greatly facilitate the broad-scale measurements of productive potential.

Response: It is agreed side-bays may have more significant effects on mainstem water quality than previously considered, as the drop in reservoir elevation from the BHBF demonstrated in 1996. The level of sampling suggested lies outside the current scope of the IWQP. It may be addressed as *necessary research* of the current program.

6. One basic limnological parameter that is not being collected is light penetration. Although the Secchi disk provides some information in this regard, it is difficult to use the Secchi data for modeling of light fields, and of the light available for primary production. It is likely that the Hydrolab could be equipped with an inexpensive LiCor PAR sensor. Alternatively, a stand-alone LiCor meter could be used to gather the light data. Presumably, the meteorological station(s) will have continuous monitoring of incident light and this data could be linked with extinction coefficients from the underwater LiCor profiles to help understand the potential for primary production in the reservoir.

Response: It is agreed that greater collections of light penetration data is desirable. It has been collected sporadically in the past using a LiCor meter and it is intended to be continued at whatever level time and staffing allow, preferably a series of profiles lake-wide in the peak productivity seasons.

Two more fundamental issues of the proposal that should be addressed are:

1. Few specific hypotheses were forwarded in the proposal. Although I realize that this work is primarily monitoring, addressing specific hypotheses would likely yield higher rewards/unit investment, than the current outlined program.

Response: Hypotheses will be developed as a part of specific research activities put forth in Chapter 2

2. Although the data management of the project seems to be progressing nicely, the proposal did not address how data reporting and/or publications would occur. Relatively few publications of the investigators are cited in the proposal, suggesting that large amounts of data are being collected and archived, but not published. If hypothesis testing were linked with a more aggressive publication objective, it is likely that there would be more benefits for others interested in the management of Lake Powell, the Grand Canyon, and reservoir-river linkages in general.

Response: A list of products is included in the final draft.

3. Curiously, no mention was made of limnological research related to the potential removal of Glen Canyon Dam. Perhaps other groups are addressing this issue, but it would be prudent to begin research in this area.

Response: Addressing information needs of this proposal lies outside the current scope of this program and the AMWG.

E. OVERALL RECOMMENDATION:

The basic monitoring plan is generally sound and should be funded. As no budget was provided, it is impossible to evaluate the cost/benefit of the work. If a more rigorous hypothesis-based approach were adopted it is likely that the project would yield more rewards. Some of the more innovative parts of the proposal were in the "Black" category, with applications above Glen Canyon Dam. However, much of the work described in the "Black" category would also have important implications for downstream river function. Funding should be sought for this additional work, not only for its intrinsic merit to understand Lake Powell's ecosystem, but because the processes in the lake will influence downstream water uses.

Response: As scientific knowledge of this system advances, the likelihood of finding further linkages to reservoir processes and downstream water quality increases. It may be important to revisit these categories as additional scientific understanding is developed.

REVIEWER 1 (Name, address, phone) (CONFIDENTIAL " TO BE BLANKED ON ANY COPY PROVIDED TO AUTHORS)

Reviewer 2:

GRAND CANYON MONITORING AND RESEARCH CENTER
2255 N. Gemini Dr., Room 341, Flagstaff, AZ 86001 (520) 556-7094

PROPOSAL EVALUATION FORM

PRINCIPAL INVESTIGATOR(S) (Name & Address: last name first
show first name and/or initials as shown in manuscript) W.S. Vernieu, S. J. Hueftle

PROPOSAL TITLE Grand Canyon Monitoring and Research Center Integrated Water Quality
Monitoring Plan

PROGRAM :

A. UTILITY OR RELEVANCE OF THE MONITORING/RESEARCH PROPOSAL - LIKELIHOOD THAT RESEARCH WILL CONTRIBUTE TO PROGRAMMATIC GOAL OR PROVIDE KNOWLEDGE THAT WILL SERVE AS THE BASIS FOR IMPROVED UNDERSTANDING AND MANAGEMENT OF COLORADO RIVER ECOSYSTEM.

Continuation of the Lake Powell water quality-monitoring program, begun in 1965, is to be strongly encouraged. Continued monitoring seems critical to providing the basic scientific information needed for the proper management of the river ecosystem. This monitoring program seems to have provided much of the information about trends in water quality in Lake Powell, and to discontinue it now or in the foreseeable future would seem ill-advised.

B. INTRINSIC MERIT OF THE MONITORING/RESEARCH PROPOSAL - LIKELIHOOD THAT RESEARCH WILL :

- LEAD TO NEW DISCOVERIES OR FUNDAMENTAL ADVANCES WITH REGARD TO PROGRAMMATIC GOALS; PROMOTE TECHNICAL ADVANCES IN THE SUBJECT AREA;
- PROVIDE RESOURCE MANAGEMENT ALTERNATIVES NOT PRESENTLY AVAILABLE; IMPROVE UNDERSTANDING OF THE LINKAGES BETWEEN RESOURCES; ANTICIPATED PARTNERSHIPS/LINKAGES WITH OTHER FACILITIES.

The monitoring program which is proposed here seems well-designed. There is a good mix of the necessary "routine" monitoring and more focused studies aimed at interesting and relevant topics such as the large releases of water that might occur in connection with beach replenishment programs.

C. TECHNICAL SOUNDNESS OF THE PROPOSED APPROACH. APPROPRIATENESS OF HYPOTHESES TO BE TESTED; METHODS ARE APPROPRIATE AND SCIENTIFICALLY VALID; PROPOSED SCHEDULE IS REALISTIC.

The methodologies proposed for water quality collections and analyses seem straightforward. Data management is important in long-term monitoring programs, and issues related to this topic seem to be under control.

E. OVERALL RECOMMENDATION:

Strong recommendation that long-term Lake Powell water quality monitoring programs described in proposal be continued.

Response: No comments or replies necessary.

REVIEWER (Name, address, phone) (CONFIDENTIAL ? TO BE BLANKED ON ANY COPY PROVIDED TO AUTHORS)

Reviewer 3:

GRAND CANYON MONITORING AND RESEARCH CENTER
2255 N. Gemini Dr., Room 341, Flagstaff, AZ 86001 (520) 556-7094

PROPOSAL EVALUATION FORM

PRINCIPAL INVESTIGATOR(S) (Name & Address: last name first; Vernieu, William S. & Susan J. Hueftle

show first name and/or initials as shown in manuscript)

INSTITUTION Grand Canyon Monitoring and Research Center

PROPOSAL TITLE Grand Canyon Monitoring and Research Center Integrated Water Quality Monitoring Plan

PROGRAM : Colorado River Adaptive Management Program

A. UTILITY OR RELEVANCE OF THE MONITORING/RESEARCH PROPOSAL - LIKELIHOOD THAT RESEARCH WILL CONTRIBUTE TO PROGRAMMATIC GOAL OR PROVIDE KNOWLEDGE THAT WILL SERVE AS THE BASIS FOR IMPROVED UNDERSTANDING AND MANAGEMENT OF COLORADO RIVER ECOSYSTEM.

This is a very comprehensive proposal for a monitoring program for Lake Powell. The proposed program shows a great likelihood for providing information that will serve as a baseline for further experimental and manipulative research which will further knowledge of reservoir ecosystems.

Response: No comments or replies necessary.

B. INTRINSIC MERIT OF THE MONITORING/RESEARCH PROPOSAL - LIKELIHOOD THAT RESEARCH WILL :

-LEAD TO NEW DISCOVERIES OR FUNDAMENTAL ADVANCES WITH REGARD TO PROGRAMMATIC GOALS; PROMOTE TECHNICAL ADVANCES IN THE SUBJECT AREA;

-PROVIDE RESOURCE MANAGEMENT ALTERNATIVES NOT PRESENTLY AVAILABLE; IMPROVE UNDERSTANDING OF THE LINKAGES BETWEEN RESOURCES; ANTICIPATED PARTNERSHIPS/LINKAGES WITH OTHER FACILITIES.

The proposal has very high merit and the research greatly improves understanding of another western reservoir. The research is interdisciplinary and well organized. Partnerships have a great likelihood of succeeding in the attainment of basic information on Lake Powell.

Response: No comments or replies necessary.

C. TECHNICAL SOUNDNESS OF THE PROPOSED APPROACH. APPROPRIATENESS OF HYPOTHESES TO BE TESTED; METHODS ARE APPROPRIATE AND SCIENTIFICALLY VALID; PROPOSED SCHEDULE IS REALISTIC.

The proposal is technically sound. The biological aspect of the proposed work is very comprehensive and well organized. Quality assurance and quality control section looks very good (QA/QC are 10% of samples generated). Will any inter-laboratory comparisons of replicates, blanks or spiked samples be carried out?

Response: Inter-laboratory analysis of samples has been done in the past, both for chemical and biological samples and will continue. QA is an integral part of the chemical sampling plan. Depending on the sampling objectives, detection limits are not yet satisfactory, so new labs are being sought to perform analyses.

E. OVERALL RECOMMENDATION:

Overall recommendation = excellent to very good. Funding recommended.

REVIEWER (Name, address, phone) (CONFIDENTIAL TO BE BLANKED ON ANY COPY PROVIDED TO
AUTHORS)

PROPOSAL EVALUATION FORM

Note: This review arrived Thursday June 24 1998 and the P.I.s were unable to address these comments. The review is provided as information. Addressing issues raised in this review will be done following the June 25th mailing.

Vernieu, William S., and Hueftle, Susan J.
Grand Canyon Monitoring and Research Center
P.O. Box 22459
Flagstaff, AZ 86002-2459

Grand Canyon Monitoring and Research Center Integrated Water Quality Monitoring Plan
Integrated Water Quality Monitoring Program

A. Utility or Relevance of the Monitoring/Research Proposal:

The focus of the proposed monitoring program is on the effects of dam operations on downstream resources. Although the program design may provide adequate information on this topic, it is unlikely that the program will provide sufficient knowledge and information that will serve as the basis for improved understanding and management of the entire Colorado River ecosystem. In particular, the monitoring program will not meet the informational needs of Glen Canyon National Recreation Area and other agencies engaged in monitoring reservoir water quality in Lake Powell (the so-called "Black" category). This is not to say that the monitoring program is flawed, but it is not designed to answer many of the complex resource questions upstream of Glen Canyon Dam. Therefore, the monitoring program should not claim that spin-off information from monitoring in Lake Powell will automatically benefit upstream users. To date, much information collected by the GCMRC has benefited upstream users because of the lack of agency coordination on monitoring and research in Lake Powell. However, the solution in Lake Powell is to target reservoir studies to upstream information needs, and to recognize that both upstream and downstream components are part of the same ecosystem.

Response: The portion of the monitoring program related to Lake Powell is designed to focus primarily on those aspects of water quality effected by dam operations that influence resources downstream of Glen Canyon Dam. Addressing information needs in the "Black" category has been determined to lie outside the current scope of the Adaptive Management Program and would require direction and additional funding by agencies in need of this information. It is hoped that the information collected by the IWQP and the methodologies employed would be of benefit to investigators outside the geographical scope of the AMP.

If upstream information needs were the primary factor in designing the proposed monitoring and research program, the reservoir components of this program would most likely be more costly and of greater detail. With proper coordination and identification of funding sources outside of the AMP a more comprehensive program could be developed to meet a broader range of information needs.

B. Intrinsic Merit of the Monitoring/Research Proposal:

Recent improvements in the GCMRC monitoring program is one example that the program proposal exhibits merit with regard to scientific advances in the field of monitoring and adjusting programmatic goals to provide answers to new questions and linkages between resources. However, when the program proposal discusses potential collaborations and partnerships, the focus is solely between GCMRC and the Bureau of Reclamation. In addition, all talk of integration and standardization in Appendix B is between GCMRC and BOR. It would be welcome to see a stated objective in the proposal to collaborate with other agencies with interests in the Colorado River ecosystem. Doesn't the Adaptive Management Program wish to involve and engage agencies such as the U.S. Geological Survey, State of Arizona, State of Utah, and the National Park Service in coordination of water quality monitoring? In addition, shouldn't the Lake Powell Interagency Group be consulted in decisions regarding monitoring in Lake Powell?

Response: Greater collaboration with other agencies is certainly appropriate. In fact, a certain degree of collaboration already exists. Sample collection is occasionally performed for other agencies such as the State of Utah Department of Environmental Quality. The USGS conducts water quality sampling and measurements at downstream gages. GCMRC worked closely and shared information with Arizona Game and Fish investigators in past years. The National Park Service has been involved with GCMRC activities for the past several years providing logistical and fields assistance. All of the above agencies participate in the Lake Powell Interagency Group and are kept informed of current activities and encouraged to comment and participate. Additional efforts at collaboration with these and other agencies will be made in the future pending approval by the AMWG.

C. Technical Soundness of the Proposed Approach:

The technical soundness of the proposal is intact for the most part. The methodologies and instrumentation employed are of high quality and appropriate scale. Quarterly sampling in Lake Powell represents a minimum frequency of monitoring; however, it is recognized that the GCMRC crew and financial resources are spread very thin. It would be informative to know more about the status of monitoring in the Colorado River and its tributaries.

Response: With improvements in data management techniques, it is expected that information from recent monitoring efforts can be more easily evaluated to achieve refinements in sampling frequency and location. This will be a focus of research activities during FY 2001. Detailed monitoring of inflows to Lake Powell has not been conducted because it has not been a primary objective of the program and resources have not been available to conduct this level of monitoring.

Since it appears that GCMRC does not perform extensive monitoring in the river below the tailwater (except water temperature), how does the GCMRC intend to incorporate data collected by others to assess downstream effects?

Response: There is currently a large amount of water quality data collected by other entities that is already incorporated into the existing GCMRC data management program. This information is readily linked to data sets containing stream gaging information and dam releases. Currently

this data is stored locally at GCMRC. In the future, the formation of dynamic links with other databases is anticipated. Future contracts for monitoring and research will stipulation data management and metadata requirements that must be met for acceptance of deliverables.

With respect to data management, what justification exists for GCMRC to develop a comprehensive data management system? Would it be feasible for GCMRC to simply acquire a free copy of the new EPA STORET database software and adapt it for their use? The new STORET program uses Oracle, like the database program proposed by GCMRC, and is not a main-frame archival system. Also, the new structure of STORET is not tied to individual parameter code IDs. In the proposal, GCMRC proposes to develop a Oracle data base, transfer these data into a MS Access database, and eventually transfer these data to the Web and STORET. This seems like a cumbersome process.

Response: GCMRC already has in place a workable and very useful data structure. This forms the basis for storage and retrieval of data for analysis and reporting. All existing data transfer protocols and analytical applications have been customized with this data structure. With further refinements in the existing data management system, such as centralization of files and the formation of relational linkages, all existing data can be viewed on a common platform. This is deemed to be the best way to perform error checking and necessary QA/QC validations. After this occurs these data will be uploaded onto the new STORET system. GCMRC has a copy of EPA's latest version of STORET. This system will be evaluated and the above approach reconsidered before full implementation.

Lastly, how will the hydrodynamic model for Lake Powell reduce monitoring in Lake Powell and measure effects of dam operation on downstream resources? Maybe the scope of the AMP should be expanded to encompass this and other topics of interest to other agencies.

Response: The development and calibration of a hydrodynamic model may reduce some aspects of monitoring in Lake Powell by simulating actual conditions, patterns, and trends in water quality. Sampling for easily predicted parameters could then be reduced to a level that verifies the predicted values. It is not expected to completely replace monitoring efforts. In some cases, the model effort may point to patterns that are poorly understood which may require additional monitoring efforts. It is anticipated that the model would guide further refinement of a long-term monitoring program as well as guide focussed research to answer specific needs.

D. Overall Recommendation:

The GCMRC monitoring proposal is well put together and develops rationale arguments for conducting the planned activities. However, one wonders why the agencies engaged in monitoring and research in the Colorado River ecosystem don't play a more active role in conducting similar monitoring activities. Part of the confusion lies in the roles of AMP, GCMRC, and other involved work groups and advisory boards. If the alternative to the proposal by GCMRC is that no long-term monitoring program will be continued, then the proposal not only should be recommended, but it should be supported at the highest level. Another alternative may be to combine the information and expertise of the ongoing monitoring program with other appropriate entities, information, and expertise to form a true collaborative approach to studying the Colorado River ecosystem.

Response: One of the purposes for which the Lake Powell interagency group was established was to communicate what monitoring and research activities were being conducted by various agencies for the purpose of coordination and reduction of redundancy. This group has supported the previous monitoring effort by GCES and GCMRC because of long-term consistency and experience. Another factor has been that the agencies involved have not had the authority or resources necessary to accomplish this work. There is a good deal of collaboration and integration that already exists with the Lake Powell group. Individual agencies conduct studies dealing with native and recreational fisheries, heavy metals contamination, bacteriology, and other resource areas. Efforts are ongoing to facilitate this collaboration by enhancing communication, information exchange, and integration.

In reading the document, Chapter 1 contained some confusing IN references, and the section on chemical analyses and QA/QC in Chapter 2 did not reference the appropriate information in Appendix D. Also, it may be useful to incorporate more material from the Appendices into the main proposal to make the proposal more complete and more easily understood.

Response: Corrections have been made in the final draft.