DRAFT FISCAL YEAR 1999

ANNUAL MONITORING AND RESEARCH PLAN

by

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INTRODUCTION

The Fiscal Year 1999 (FY 99) Annual Monitoring and Research Plan (Annual Plan) represents the second year of implementation of the Long-Term Monitoring and Research Strategic Plan (Strategic Plan)[1/] for the Colorado River ecosystem.[2/] The Colorado River ecosystem is defined as the Colorado River mainstem corridor and interacting resources in associated riparian and terrace zones, located primarily from the forebay of Glen Canyon Dam (GCD) to the western boundary of Grand Canyon National Park, a distance of approximately 293 river miles. The scope of the Grand Canyon Monitoring and Research Center's (GCMRC) activities also includes limited investigations into some tributaries (e.g., the Little Colorado and Paria Rivers). All projects proposed will relate to determined or potential resource impacts primarily in the Colorado River ecosystem related to dam operations. It also includes, in general, cultural resource impacts of dam operations for inundation levels associated primarily with flows

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[1/] The Final Draft Strategic Plan, which was reviewed by the Transition Work Group has been used by GCMRC as the basis for developing the FY 98 and FY 99 Annual Plans. It is anticipated that the Strategic Plan and the Stakeholder Objectives and Information Needs will be reviewed, and revised as appropriate for use in the development of the FY 2000 Annual Plan.

[2/] "Colorado River ecosystem" will be used throughout this document as the standard definition of the monitoring and study area for GCMRC.

up to 256,000 cubic feet per second (cfs) as addressed in the Programmatic Agreement[3/], and for physical, biological, recreational and other resources, impacts of dam operations for inundation levels associated primarily with flows up to 100,000 cfs. In between these levels, stakeholder concerns with respect to relict native vegetation, endangered species, and cultural resources may require activities by the GCMRC.

The FY 99 Annual Plan also describes GCMRC cooperative activities with other groups, whose geographic area of interest is contiguous with that of GCMRC. In all cases, these cooperative activities are judged by GCMRC to enhance its core program activities and are supported outside of GCMRC funds.

In most areas, the FY 99 Annual Plan represents only marginal program changes from the FY 1998 (FY 98) Annual Plan. For FY 99, GCMRC may extend FY 98 monitoring and research contracts or issue new RFPs to accomplish program goals identified by the Adaptive Management Work Group (AMWG). This follows the logic outlined in the Strategic Plan that targeted monitoring and research activities should be considered flexible long-term efforts that respond annually to Adaptive Management program needs. Significant change in monitoring and research activities are expected in the FY 2000 Annual Plan, following completion of conceptual modeling and synthesis activities in FY 99.

[3]The Programmatic Agreement, finalized in August 1994, is a legal agreement between federal and state agencies and tribal groups that specifies the responsibilities of the parties to comply with the National Historic Preservation Act (1996; 1992) and 36 CFR 800.

GENERAL OBJECTIVES

The Grand Canyon Protection Act of 1992 (GCPA) and Operation of Glen Canyon Dam - Final Environmental Impact Statement (GCDEIS) direct the Secretary of the Interior to establish and implement long-term monitoring programs and related research and scientific activities that will ensure that GCD is operated in a manner consistent with Section 1802 of the GCPA. The GCMRC was established to facilitate these activities. The mission and goals of the GCMRC are to develop monitoring and research programs and related scientific activities that evaluate short- and long-term impacts of "...the effects of the Secretary's actions..."[4/] on the biological, cultural, and physical resources of the Colorado River ecosystem. The GCMRC also provides information to meet needs concerning resources of the Colorado River ecosystem specified annually by the AMWG, and the Secretary of the Interior.

Long-term monitoring of all resources of concern occur to detect and quantify changes related to dam operations. Research efforts focus on interpreting and explaining trends, determining causal relationships, and defining inter-relationships among physical, biological and cultural processes. In addition to monitoring and research activities, the GCMRC develops information management programs to ensure information archiving and transfer to managers, stakeholders, and science organizations.

The Strategic Plan describes monitoring and research activities that will be implemented to determine the effect of dam operations on the natural, recreational, and cultural resources of

[4]As specified in the 1992 Grand Canyon Protection Act, the GCD Environmental Impact Statement (1995), and the Record of Decision (1996). The "Secretary's actions" include dam operations or alternative dam operating criteria as well as other authorized actions; and will be referred to in this document as "dam operations".

Grand Canyon National Park and Glen Canyon National Recreation Area as specified in the GCPA. General strategies outlined in the Strategic Plan must be made more definitive by drafting specific monitoring and research proposals to be implemented within a given year or across several years of the Strategic Plan.

The GCMRC's FY 99 Annual Plan describes individual monitoring and research projects that will be initiated in response to objectives and information needs identified annually by the stakeholders and outlined in general terms in the Strategic Plan. It is anticipated that the Strategic Plan will be revised following review by the AMWG and the National Research Council in FY 99 / FY 2000.

As a context for understanding the FY 99 Annual Plan, an overview of the Strategic Plan and a summary of each major element of the FY 99 Annual Plan is presented below.

AN OVERVIEW OF THE STRATEGIC PLAN: 1998-2002

The Strategic Plan is designed to implement the adaptive management and ecosystem science program called for in the GCPA and the GCDEIS. The areas of monitoring, research, and information technology outlined for physical, biological, cultural, and socioeconomic resources are to be implemented over a five-year period. Annual program plans are developed to assure appropriate progress on critical elements of the Strategic Plan. In response to the nature of the Adaptive Management program, the Strategic Plan may need to be modified in less than five years.

All elements of the Strategic Plan, and all monitoring programs, research projects, and information technologies drafted into annual program plans, have been developed in response to

management objectives and information needs specified by the AMWG.

Key elements of the Strategic Plan intended to ensure future monitoring and science programs will be effective at evaluating changes in critical resources associated with "the effects of the Secretary's actions" include:

1. Implementation of an adaptive management program to facilitate close interaction of science and management in evaluating potential new management criteria and the impacts of those criteria on specified management objectives and information needs.

2. Development of a conceptual model of the Colorado River ecosystem that describes critical attributes and linkages within and among resources

3. Synthesis of existing knowledge associated with baseline resource conditions in the Colorado River ecosystem, riverine resource changes associated with construction of Glen Canyon Dam, and changes associated with differing operating criteria for Glen Canyon Dam.

4. Specification by the AMWG of desired future environmental conditions[5/] that can serve as appropriate targets for the implementation and evaluation of the results of management actions.

5. Development of an annual report on the status of valued ecosystem components (VECs)[6/] within the Colorado River ecosystem that can be used to evaluate potential management actions to be undertaken in subsequent years.

MISSION AND SCOPE OF GCMRC AND THE STRATEGIC PLAN

Responding to continued concerns over potential impacts of Glen Canyon Dam operations on downstream resources, Congress in 1992, enacted the Grand Canyon Protection Act (P.L. 102-575, Title XVIII). The Act directs the Secretary of the Interior to "... *operate Glen Canyon Dam ... in such a manner as to protect, mitigate adverse impacts to, and improve the values for*

[5/] These were initially described in the Glen Canyon Dam Environmental Impact Statement, and will be reviewed by the AMWG/TWG in FY 98.

[6/] See Clark, 1986.

which Grand Canyon National Park and Glen Canyon National recreation Area were established, including, but not limited to, natural and cultural resources and visitor use." While not overturning or superceding existing law, this Act provides the basis for the adaptive management program prescribed in the GCDEIS by instructing that "*... the best and most recent scientific data.*" be used in making operating decisions and that appropriate consultation with stakeholders be undertaken. The Act also directs the Secretary to establish a long-term monitoring and a research program to, "*... determine the effects of the Secretary's actions under section 1804© on the natural, recreational, and cultural resources of Grand Canyon National Park and Glen Canyon National Recreation Area*." The closest the Act comes to using the words "adaptive management" is to state in the report language which accompanies the Act, under the discussion of Section 1805, that the Secretary shall "*... respond to information developed under the long-term monitoring program by <u>adapting</u> [emphasis added] the operation of Glen Canyon Dam,...as needed over time to protect the values for which Grand Canyon National Park and Glen Canyon National recreation Area were established*." (U.S. Senate, Report 102-267, March 31, 1992).

The Grand Canyon Protection Act does not explicitly state how the Secretary of the Interior is to implement the research and monitoring programs specified in the Act. However, in early 1993 EIS work groups began to develop ideas for an adaptive management program for Glen Canyon Dam. Following extensive debate, an Adaptive Management Program was incorporated into the GCDEIS, as the required process for developing scientific information

which directly addresses stakeholder concerns and provides the basis for evaluating management options for operating Glen Canyon Dam within existing legal frameworks.

The Adaptive Management program specified in the GCDEIS calls for continued interaction of managers and scientists, to both monitor "the effects of the Secretary's actions", primarily current dam operations, on the Colorado River ecosystem, and conduct research on new alternatives that increase protection of resources and improve natural processes.

Long-term monitoring of all resources of concern will occur to determine significant changes in VECs. Research will be used to interpret and explain trends observed from monitoring, to determine cause and effect relationships and resource associations, and to better define interrelationships among physical, biological and social processes. In addition to monitoring and research activities, the GCMRC will develop information technologies to assure information archiving and transfer to managers, stakeholders and science organizations.

One major change has already resulted that is not captured in the Strategic Plan. An assessment of dam operation impacts to water quality in Lake Powell completed in FY 1997 has resulted in a recommendation by the AMWG that GCMRC continue the current monitoring and research program for Lake Powell associated with impacts of the operation of Glen Canyon Dam for an additional year. The need for continued Lake Powell research and monitoring programs and their specifications will be evaluated by the TWG and GCMRC in FY 99 with recommendations forwarded to AMWG in FY 99.

STAKEHOLDER INFORMATION NEEDS AND CRITICAL RESOURCE ATTRIBUTES

The Strategic Plan was established to respond to the general objectives and information needs of managers and stakeholders regarding Glen and Grand Canyon and their resources. Objectives and information needs of stakeholders are specified in nine resource areas including: hydropower, water, sediment, fish and aquatic biology, vegetation, threatened and endangered species, terrestrial wildlife, cultural resources, and recreation (Figure 1).

Within each of the above resource areas, specific objectives were developed cooperatively by the Bureau of Reclamation (Reclamation) and representatives of the AMWG. Detailed information needs for various objectives and resource areas were defined by representatives of the AMWG working cooperatively with the GCMRC. These objectives and information needs may be found in the Strategic Plan and will be reviewed and revised in FY 1998 to.

PROPOSED MONITORING AND SCIENCE PROGRAMS

Monitoring and science programs proposed in the Strategic Plan include the following:

1. Conceptual modeling and synthesis of existing knowledge;
2. Physical resource program;
3. Cultural resource program;
4. Biological resource program;
5. Socioeconomic resource program;
6. Information technology program;
7. Science Advisory Board.

Each of these areas represent components of the long-term program from which information will be developed to address objectives and information needs specified by stakeholders.

Conceptual Modeling and Synthesis of Existing Knowledge

The development of conceptual models of the Colorado River and Lake Powell ecosystems will be completed in FY 98 and FY 99 of the Strategic Plan. The intent of the models will be to examine resource elements that respond to variable operating criteria of Glen Canyon Dam.

The synthesis of existing knowledge associated with Lake Powell and the riverine corridor's resources after Dam construction, as well as relevant data and information from other regulated and unregulated western riverine corridors, that are of similar character and structure to Lake Powell and the Colorado River ecosystem will be completed in the first two to three years of the Strategic Plan. These syntheses are addressed in the individual resource program areas.

Completion of these syntheses will provide an important tool for organizing our understanding of this riverine ecosystem and the impacts of flow regulation. Anticipated end products include a more integrated data assessment and interpretation of critical alternatives associated with resources of concern, and a major comprehensive transfer of information to stakeholders from GCMRC, regarding the potential impacts of alternative operating criteria on riverine ecosystems and associated resources.

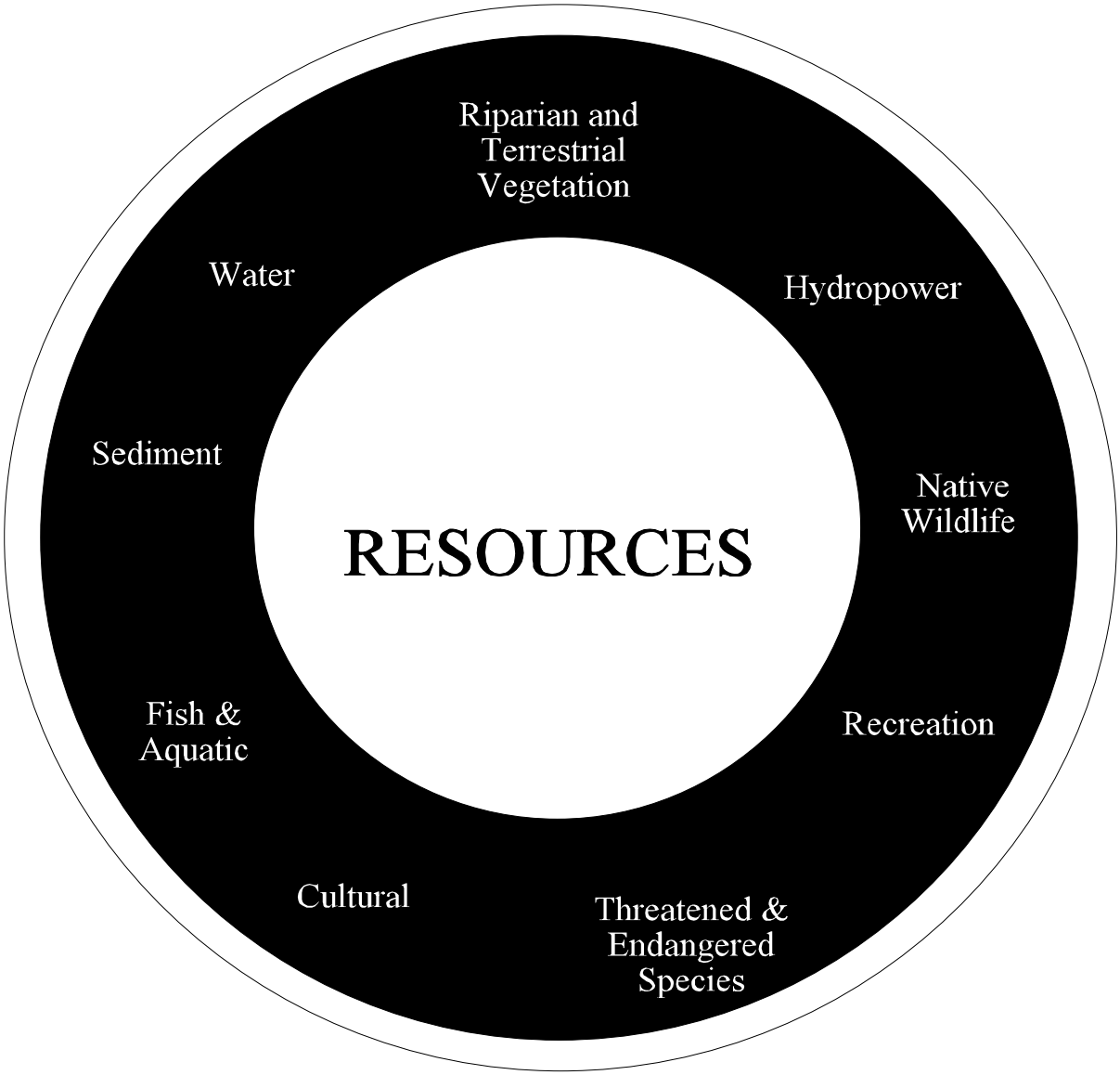
The Physical Resources Program

Hydrology and sediment are the two primary resources of concern in the physical resources area. Impacts from Glen Canyon Dam operations on these physical resources also extend to other resources, such as biological and cultural. For the most part, planned FY 99

monitoring and research efforts were started in the FY 98 program and will continue to focus on four areas of impact from dam operations as follows:

1. Influence on mainstem flows.

2. Sediment balance and geomorphic processes, including those related to active sandbars used as camping areas and terrestrial and aquatic habitats, and pre-dam river terrace deposits containing cultural resources.


Riparian and
Terrestrial
Vegetation
Water
Hydropower
Sediment
Native
Wildlife
RESOURCES
Fish &
Aquatic
Recreation
Cultural
Threatened &
Endangered
Species

3. Inter-relationship between mainstem and tributary sediment and flows, with particular emphasis on inputs from the Little Colorado and Paria Rivers, and physical impacts of tributary debris flows on mainstem geomorphology and related resources and processes.

4. Influences of dam releases and natural tributary inflows on mainstem hydrology and sediment transport .

The Biological Resources Program

Monitoring and research relating to biological resources is intended to refine and further develop information about the structure and function of the Colorado River ecosystem in relation to dam operations. Linkages between the biological resources program and the physical resources program should be made to facilitate the understanding of the influence of abiotic factors on biotic resources (e.g., discharge and sediment on fish habitat).

Monitoring and research efforts will address the following areas:

1. Aquatic food base.

   Programs will define the current and historic food base characteristics and structure as related to natural variation and to dam operations; evaluate if the aquatic food base is limiting in the Glen canyon reach; and examine how large fluctuations associated with dam operations affect the aquatic food base and associated native and non-native fish populations.

2. Native fish populations.

   Programs will evaluate native and non-native fish population dynamics, growth, survivorship, recruitment, habitat, health, and changes in population structure, to assess these communities' responses to alternative dam operations. Native fish species of concern are the humpback chub and flannelmouth sucker.

3. Lees Ferry Trout Fishery.

   Monitoring of the non-native trout fishery in the Lees Ferry reach will concentrate on growth, survivorship, recruitment, habitat, health, and changes in population structure, including the contribution from natural reproduction over time and angler

use. Monitoring of other non-native fish populations will be carried out in conjunction with ongoing native and non-native fish monitoring activities.

4. Wetland and Riparian Vegetation.

   Changes in species composition and vegetative area in the three primary riparian zones (the upper riparian zone, lower riparian zone, and hydro-riparian wetland communities) along the river will be monitored.

5. Riparian Avifauna and the Southwestern Willow Flycatcher.

   Avifauna monitoring will emphasize the Southwestern willow flycatcher and general riparian avifauna surveys and will collect data with respect to habitat conditions, and population censuses of riparian obligate species, resident non-obligate species, migrant species, and wintering and breeding waterfowl.

6. Threatened and endangered species: the Kanab Ambersnail.

   Monitoring of threatened and endangered species will remain a priority for GCMRC. For example, Kanab ambersnail monitoring and research activities will emphasize population age structure analysis, diet analysis, and habitat requirements.

The Cultural Resources Program

This program will address information needs of the AMWG relative to cultural resources taking into consideration the direction provided by the parties to the Programmatic Agreement (PA). Activities that are a part of the ongoing PA program may be included. Monitoring and research information needs and activities from the PA are expected to be a major component of the Strategic Plan.

The cultural resources program for the GCMRC will accommodates three primary components: (a) a core program, (b) a tribal projects element, and © a cooperative programming aspect. Objectives and information needs specified by the stakeholders have been utilized to incorporate the following monitoring and research proposals in the Strategic Plan:

1. Assess existing and develop additional data and monitoring systems to assess impacts.

2. Assess existing and develop additional data to assess risk of damage and loss of cultural resources from varying flow regimes from 45,000 cfs to 100,000 cfs.

3. Assess existing and develop additional tribal monitoring programs for evaluation of impacts to cultural resources.

4. Assess existing and test local and reach-scale predictive model of geomorphic processes that are related to archeological site erosion.

5. Assess existing and develop additional mitigating strategies related to documented dam impacts determined by monitoring assessments.

6. Characterize resource significance through scientific study.

The Lake Powell Program

The proposed Lake Powell program is not captured in the Strategic Plan as it was not approved by the AMWG until September 1997. The program for FY 98 and FY 99 are currently scheduled as a continuation of the FY 1996 Reclamation program. Program changes will be proposed by the TWG and recommended by the AMWG.

The Socio-economic Resources Program

There are many socioeconomic resources associated with the Colorado River ecosystem including recreation, camping beaches, electric power, and water delivery and water quality.

Areas of monitoring and research in the socioeconomic program will include the following:

1. Change in campsite beach area, number, location and quality.

   Camping beach changes will be determined by monitoring changes in sand bar areas and elevations using remotely sensed data and cooperative programs with boating guides and their associations.

2. Recreational safety.

3. Methods for and enhancement of the wilderness experience.

4. Changing user preferences.

Information Technology

Extensive data and information currently exist in the GCMRC collections relating to resource conditions, quality, and relationships to other resources. Potentially equal amounts of data and information exist within museums, universities, agencies, etc. However, much of this information has not been organized, managed or integrated into an analysis of the interrelationship among various resources and dam operations.

The following areas will be implemented in the information technology program:

1. Development of protocols for data collection, processing and use.

2. Development of extensive multi disciplinary databases and a database management system.

3. Development of a robust geographic information system (GIS) to accommodate multiple layers associated with all resources of interest to stakeholders.

4. Development of databases associated with remotely sensed data are not presently incorporated in the GCES database system.

5. Develop stakeholder interface mechanisms to access selected data and information in the database management system and GIS.

6. Development of outreach programs including identification and quantification of needs, to transport data and information, and to educate stakeholders in use of data and models incorporated in the information technologies program.

Science Advisory Board

The GCDEIS calls for the establishment of Independent Review Panel(s) to: (1) ensure that the long-term monitoring and research program initiated by the GCMRC is unbiased and objective, scientifically sound, and focused on the most important issues; (2) provide advice on the coordination and planning of the long-term monitoring and research program; and (3) annually review the results of the long-term monitoring and research program.

In response to this GCDEIS recommendation, the GCMRC proposes to establish as one of its independent review panels, a Science Advisory Board (SAB). The SAB would be an advisory and not a decision-making body. It is anticipated that the SAB would serve both the GCMRC and AMWG in providing assessments of performance of GCMRC. In any one year, the SAB may be comprised of up to 10 members.

The SAB would be an interdisciplinary board, composed of scientists who are qualified, based on their record of publication in the peer-reviewed literature, or other demonstrable scientific achievements. Members would be selected for their scientific expertise and not as representatives of a particular agency, organization, or other stakeholder group.

Members would be sought with expertise in the following areas:

1. Adaptive management
2. Anthropology
3. Archaeology
4. Fisheries biology
5. Ecosystem / Riparian ecology
6. Economics
7. Geomorphology
8. GIS
9. Hydrology and

10. Limnology

Members would be selected, through an RFP process, for a three-year term, renewable for one consecutive three-year term. Initial members of the SAB will be selected for staggered one-, two-, and three-year terms, to ensure continuity in membership on the SAB. One or more meetings of the committee will be called each year.

The SAB together and individually would be expected, among other things, to review and comment to the AMWG and GCMRC on: (1) GCMRC's long-term monitoring and research plans, (2) GCMRC's annual monitoring and research plans, (3) GCMRC's annual budget proposals, (4) the results of GCMRC's completed monitoring and research activities, (5) the results of any synthesis and assessment activities initiated by the GCMRC, and (6) any other activities (i.e., program specific scientific advice) it is asked to address by the GCMRC Chief or the AMWG.

The Strategic Plan proposes that the AMWG recommend implementation of some type of SAB within FY 98/99.

SCHEDULE AND BUDGET

The Strategic Plan is designed to address monitoring and research for a five-year period 1998-2002. Each year in October, an annual plan is drafted to guide implementation of specific elements of the Strategic Plan. It will have prior review by the AMWG and approval by the Secretary of the Interior. The Annual Plan outlined in this document addresses monitoring and research for FY 99, beginning October 1, 1998.

The Five-year annual budgets proposed in the Strategic Plan were approximately $7.0 million per year for years FY 1998, 1999, 2001, and 2002. The FY 2000 budget was proposed for $8.0 million to accommodate new monitoring technology.

The budget for the FY 99 Annual Plan contained in this document is programmed at $7,193,000. The budget is sufficient to implement the programs outlined in this FY 99 Annual Plan.

CHAPTER 2

STAKEHOLDER INFORMATION NEEDS WHICH GUIDE THE FY 99 ANNUAL PLAN

DEVELOPING STAKEHOLDER OBJECTIVES

In 1996 the Bureau of Reclamation worked with a subgroup of the Transition Work Group to develop stakeholder objectives to guide future monitoring and research programs of the GCMRC. This group was disbanded with release of their July, 1996[7/] recommendations.

All of the stakeholder objectives may be found in the Strategic Plan. The AMWG has decided to develop, review and/or revise stakeholder objectives in all programs in FY 98.

IDENTIFIED INFORMATION NEEDS

A synopsis of the information needs[8/] in each resource area is presented in the following text. These information needs were the primary basis for developing both FY 98 and FY 99 monitoring, research, and information transfer programs for the GCMRC. They are also the basis for continuation of FY 98 physical and biological science activities with minimal modifications through at least FY 99. In the cultural resource area, some information needs were predefined, based on ongoing activities within the Programmatic Agreement.[9/]

[7/] Adapted from *Glen Canyon Dam Management Objectives*, Bureau of Reclamation memorandum UC-205, ADM-1.10, July 1996, to Transition Work Group members.

[8/] For a detailed description see the GCMRC Strategic Plan.

[9/] The Programmatic Agreement is a legal cooperative agreement among the Advisory Council on Historic Preservation, National Park Service, Upper Colorado Region of Bureau of Reclamation, Arizona State Historic Preservation Office and six tribes as follows: Hopi, Hualapai, Kaibab Paiute, Navajo, Shivwits Paiute and Zuni.

Information needs specified by stakeholders are explicitly linked to stakeholder objectives. Generally, as new objectives are specified, they result in a new set of information needs. In FY 98 (Spring 1998), new management objectives may be defined by the TWG and approved by the AMWG, which will also require specification and approval of new information needs. Objectives and information needs will be specified for the Lake Powell program at that time. All new objectives and information needs will be used to define the FY 2000 program.

Current Information Needs include:

Water Resources

1. Monitor changes in water quality (physical and chemical characteristics such as temperature, salinity, nutrients, trace elements, etc.) over time and space.

2. Monitor concentrations of chemical constituents relative to historical levels, and with respect to identified Colorado River ecosystem requirements, and relative to established EPA/state and tribal standards.

3. Monitor water temperature changes throughout the Colorado River ecosystem over time and space with respect to influences of dam operations.

Sediment Resource

1. Monitor fine-grained sediment deposits, including pre-dam river terraces, active sandbars used by recreationists as camping areas, and aquatic habitats related to return-current backwater channels.

2. Monitor changes in backwater habitats relative to dam operations under the Record of Decision (ROD).

3. Define character and structure of pre-dam river terraces associated with cultural resources, and all other fine-grained sediment deposits, including camping beaches and backwater habitats found throughout the Colorado River ecosystem immediately following the 1996 test flow.

4. Define historical and current (character and structure) levels of channel-stored sediment throughout the Colorado River ecosystem and associated dam operations.

5. Determine baseline conditions of fine-sediment storage throughout the river ecosystem.

Cultural Resources

1. Develop data and monitoring systems to assess impacts to cultural resources.

2. Develop predictive model of geomorphic processes related to archaeological site erosion including:

   - Types of degradation
   - Rates of degradation

3. Define immediacy of threats to resources.

4. Protection methodologies.

5. Protection, monitoring and research costs.

6. Characterize through scientific study and data development all defined historical and current values of resources to tribal nations and to general public.

7. Characterize cultural associations of all sites associated with impacts of dam operating criteria.

8. Characterize all cultural resource sites as to the specific associated management/research needs, i.e.; preservation, stabilization, documentation, etc.; under alternative operating criteria.

9. Develop Tribal monitoring programs for evaluation of resource impacts.

10. Develop mitigation strategies relative to documented site impacts.

Fish And Aquatic Resources

1. Maintain and enhance the aquatic food base.

2. Improve monitoring protocol for adult Humpback Chubs and evaluate population trends.

3. Determine historic and current character and structure of species populations.

4. Conduct studies of temperature, habitat availability and use of mainstem and tributary habitats by native fish.

5. Determine importance of backwaters to native fish.

6. Develop criteria for self sustaining populations of humpback chub.

7. Monitor harvested and field sampled rainbow trout to determine the contribution of naturally reproduced fish to the population.

8. Determine impacts of dam operations on trout habitat and redds.

9. Define areas and conditions of current and future existing and potential interactions between native and non-native species.

10. Define current and historic food base character and structure.

11. Design and test an experimental program of steady flows to verify an effective flow regime and quantify, to the extent possible, effects on endangered and native fish.

Riparian And Terrestrial Vegetation Resources

1. Determine historic natural composition of riparian and upland communities.

2. Characterize normal range of variation and ecology of species.

3. Monitor impacts of dam operating criteria on the successional processes of natural vegetation communities.

4. Evaluate impacts of dam operations on establishment of and impacts from exotic plant species.

5. Evaluate impacts of alternate dam operating criteria on vegetation communities.

6. Determine historic and current distributions, range of variation and ecology of T&E and special status species.

7. Establish ecosystem requirements of special status species and determine probable impacts of proposed flow regimes.

8. Monitor population changes in special status species.

Native Terrestrial Wildlife Resources and Habitat

1. Define and specify ecology of native faunal components, especially threatened and endangered species.

2. Determine, where possible, species' natural ranges (pre- and post-dam).

3. Define food chain associations, interdependencies, requirements, etc., for native species population targets.

4. Characterize historic and current expected use by species.

5. Characterize historic and current populations of Kanab Ambersnail and their locations.

6. Determine range of natural variability/ecology and ecosystem requirements of wildlife occupying the Canyon.

Socio-Economic Resources

1. Determine criteria that are important to or detract from wilderness experience.

2. Determine adequate beach quality, character and structure for camping throughout the system.

3. Determine if operating criteria maintains safe and adequate power craft navigability in Glen and Grand Canyons and upper Lake Mead.

4. Determine flow regimes necessary to maintain fish populations of 100,000 adult trout (age class II plus).

5. Define pattern of waterfowl and other wildlife use and conflicts to other uses.

Information needs were not specified for Lake Powell for FY 98. In FY 97, an assessment was requested by the AMWG to define Lake Powell water quality impacts related to Glen Canyon Dam operations. The assessment revealed impacts from dam operations and resulted in the AMWG proposing continuation of current monitoring programs in FY 98, until new objectives and information needs could be specified for Lake Powell in FY 98. As noted,

these new objectives and information needs will be used to develop recommendations to the AMWG for future Lake Powell monitoring and research programs.

CHAPTER 3

FISCAL YEAR 1999 MONITORING AND RESEARCH PROGRAM ACTIVITIES

INTRODUCTION

This chapter presents the FY 99 program activities to be conducted for the following program areas:

- Conceptual modeling and synthesis
- Physical Resources
- Biological Resources
- Cultural Resources
- Socioeconomic Resources
- Lake Powell
- Information Technologies

For each of the above resource areas, we address three criteria to define projects for FY 99. First, we review the FY 98 monitoring and research programs to determine which elements of those programs need to be continued. Second, we review objectives and information needs to assure that those critical needs specified are appropriately incorporated in the FY 99 Annual Plan. Third, we evaluate the Strategic Plan to assure that FY 99 monitoring and research proposed is in fact fully supportive of programs planned and time schedules proposed in the Strategic Plan.

Contingency Planning

The AMWG/TWG and GCMRC works cooperatively in an adaptive environment of changing needs. As such, opportunities must exist for both the AMWG/TWG and GCMRC to recommend new or revised projects after an Annual Plan is complete and being implemented.

This will be accomodated by the TWG or GCMRC recommending a new or revised project and then cooperatively developing a budget for the new or revised project prior to implementation. These revised or new projects will generally be accomplished within the annual AMP budget allocation and therefore may not require the AMWG to recommend approval. Over budget programs will require AMWG to recommend approval.

Possible Symposium on the Results of an FY 98 Beach/Habitat-Building Flow

The AMWG/TWG have initiated discussions of a possible FY 98 Beach/Habitat-Builing Flow (BHBF) in response to projected FY 98 water year conditions. If the hydrologic conditions materialize and a BHBF is recommended with sufficient lead time for GCMRC to implement a monitoring and research program, then GCMRC would propose a modification of the FY 99 Annual Plan to accomodate a symposium to review the results of the 1998 BHBF.

CONCEPTUAL MODELING

Program Background

As part of the overall synthesis to guide monitoring and research programs in each resource area, a conceptual modeling effort will be initiated in FY 98 and will be completed in FY 99 to represent Colorado River ecosystems, resources and resource attribute linkages. Adaptive environmental assessment and management (AEAM) models will be used to guide more integrated ecosystem monitoring and research programming. All research and monitoring programs will contribute to the conceptual modeling activities.

Conceptual models will be developed to represent the Colorado River ecosystem from the forebay of GCD to the western most boundary of Grand Canyon National Park , as well as the Lake Powell ecosystem. These conceptual models will be used to: (1) guide monitoring and research planning, (2) more clearly define critical attributes and linkages within and between resource categories, (3) promote improved understanding of key factors that drive changes in the systems, (4) make qualitative assessments of resource change resulting from alternative dam operations, and (5) provide information to stakeholders and managers regarding the potential impacts of alternative dam operations on lake Powell and the Colorado River ecosystem and associated resources. Completion of thess conceptual models in FY 99 will provide important tools for organizing the GCMRC's understanding of the lake Powell and Colorado River ecosystems and the effects of dam operations.

Identified Stakeholder Information Needs

Development of a conceptual model of the Colorado River ecosystem is predicated on the information needs of stakeholders to have increased understanding of the river and reservoir as systems. Information needs for a Lake Powell conceptual model will be developed in FY 99. Needs for the Colorado River ecosystem are expressed as follows:

1. Develop a conceptual model to increase knowledge of resource interdependencies.
2. Identify key parameters relating impacts of dam operation changes.
3. Develop capability to predict or forecast resource impacts of differing operations.

The Conceptual Modeling Program

The conceptual modeling program, initiated in FY 98, is continued in the FY 99 Plan with additional requirements for Lake Powell which are described later in this document under the Lake Powell program. The FY 98 RFP for the conceptual model of the Colorado River ecosystem contained the following objectives:

1. State of the science synthesis of data needed for development of the Colorado River ecosystem conceptual model and identification of key information gaps, as well as priorities for monitoring and research.
2. Scoping meetings to define the scope of the problem, design the first modeling workshop, and develop list of participants.
3. Develop, using a workshop approach, a working conceptual model of the Colorado River ecosystem that can be run on an appropriate software platform and which identifies critical relationships that structure the ecosystem.

The FY 99 Program for the Colorado River ecosystem conceptual model will consist of the following objectives:

1. Revision of the conceptual model(s), through a second workshop, to the level of a prototype model which assigns numeric values to key parameters in the model and

which can be used to test alternative assumptions and hypotheses regarding changes to the ecosystem and associated resources from alternative dam operations.

2. Develop a prototype model with qualitative assessment capability.

Development of the Colorado River conceptual model is being carried out through a project led by J. Korman and C. Walters of Ecometric Research Inc. and the University of British Columbia entitled: **"A Proposal to Develop an Adaptive Environmental Assessment Model for the Colorado River Ecosystem."** This is a 15 month effort, with a total project budget, exclusive of logistic costs of $209,700. Logistics costs to support attendance at the scoping meeting and two modeling workshops has been estimated at $44,800.

In FY 98, for the Colorado River model, the GCMRC, together with the modeling team, will convene scoping meetings to define the problem scope, design subsequent modeling workshops, identify key people (scientists and stakeholders) to participate in the modeling workshops, and to assemble information that will be used in the first workshop.

Following the scoping meeting, an initial modeling workshop will be convened in FY 98 to develop explicit relationships among Colorado River attributes. These workshops will involve scientists and stakeholders knowledgeable about the Colorado River and Lake Powell ecosystems. The GCMRC will work with the modeling teams to develop information bases including maps, databases, published reports, etc., that will be necessary for these workshops. Scientists and stakeholders together will define resource variables/attributes that serve as linkages between/among resources. The goal for the first workshops is to produce a conceptual model of the Colorado River ecosystem based on critical relationships that structure the system, identify key information gaps, and suggest initial priorities for a long-term monitoring and research

program.

A second modeling workshop will be held in FY 98. This workshop will be to refine the conceptual model with first approximation parameter estimates, that can be used to evaluate resource responses to different management strategies. In both cases, appropriate time will elapse between the first and second modeling workshops to validate and refine submodels, develop additional needed data and information, and where needed, specify necessary subcomponents of submodels.

During the second workshop the process of assigning more definitive co-efficient values to what are believed to be key model parameters will begin, as well as model validation and sensitivity analysis to test key assumptions embedded in the models. Analysts will begin to explore the consequences of alternative dam operations based on the assumptions and hypothesis used to construct the model. These second workshop is intended to yield first approximation prototype model that, in association with new synthesis information being developed in FY 98 and FY 99, will provide sound basis for development of more robust long-term monitoring and research plans for the Colorado River ecosystem.

The "working" model will continue to be refined and developed over the course of the five-year strategic plan. More detailed submodels for specific elements of the systems (i.e., riparian vegetation, cultural resources, etc.) will be developed through prototypes to operational stages.

This program will take place over FY 98 and FY 99 with progress reports due following the scoping meeting and each workshop. The scoping meeting for the river ecosystem is scheduled for January 1998, with the first workshop tentatively scheduled for March 1998 and

the second workshop scheduled for September 1998. A draft final report on the river model is due in FY 99 on 15 December 1998, and a final report is due on March 31, 1999. The final report will contain an executive summary, suitable for dissemination to management entities.

Upon completion, the conceptual model will be delivered to the GCMRC in appropriate electronic format and with suitable documentation to allow GCMRC managers to operate and further develop the model.

THE PHYSICAL RESOURCES PROGRAM

Background and Introduction

Hydrology and sediment are the two primary resources of concern in the physical resources area, although impacts from Glen Canyon Dam operations on these physical resources also extend to other resources, such as biological and cultural. For the most part, FY 99 monitoring and research efforts will represent an extension of FY 98 projects, and will continue to focus on four areas of impact from dam operations as follows:

1. Influence of mainstem flows on sediment, and sediment related biophysical resource interactions.

2. Sediment budgeting and geomorphic processes, including those related to active sandbar processes that influence camping areas and terrestrial and aquatic habitats, and pre-dam river terrace deposits containing cultural resources.

3. Inter-relationship between mainstem and tributary sediment and flows, with emphasis on inputs from the Little Colorado and Paria Rivers, and physical impacts of unregulated tributary debris flows on mainstem geomorphology and related biophysical process interactions.

4. Influences of dam operations and natural tributary inflows on mainstem hydrology and sediment transport with respect to resource concerns of the Upper Lake Mead delta and related habitats, such as that of the southwest willow flycatcher.

Identified Stakeholder Information Needs

A synopsis of the information needs in each physical resource area is presented in the following text. These information needs were the primary basis for developing FY 98 monitoring and research programs for the GCMRC. They are also the basis for continuation of FY 98 physical science activities with minimal modifications through at least FY 99, and will provide information on the best approach for designing a revised long-term monitoring program beginning in FY 2000 and beyond:

For Water Resources:

1. Monitor concentrations of chemical constituents relative to historical levels, and with respect to identified Colorado River ecosystem requirements, and relative to established EPA/state and Tribal standards.

2. Monitor water temperature changes throughout the Colorado River ecosystem over time and space with respect to influences of dam operations, specifically with respect to biophysical processes.

For Sediment Resources:

1. Monitor fine-grained sediment deposits, including pre-dam river terraces where cultural resources are known to exist, active sand bars used by recreationists as camping areas, and aquatic habitats related to return-current backwater channels known to support native and non-native fishes.

2. Monitor physical changes in backwater habitats relative to dam operations under the Record of Decision (ROD).

3. Through annual monitoring, define annual changes relative to the character and structure of pre-dam river terraces associated with cultural resources, and all other fine-grained sediment deposits, including camping beaches and backwater habitats found throughout the Colorado River ecosystem relative to those observed immediately following the spring 1996 experimental flood.

4. Define historical (character and structure) pre-dam levels of channel-stored sediment throughout the Colorado River ecosystem relative to those associated with dam operations.

5. Determine baseline conditions of fine-sediment deposits throughout the river ecosystem relative to conditions observed since August 1991, (beginning of interim flows).

The FY 99 Physical Resources Program

Vital information needs targeted for the FY 99 physical resources program are presented in the following synopsis:

Mainstem and Tributary Streamflow Resources:

1. Monitor system-wide changes in the physical and chemical characteristics of mainstem streamflow through time relative to water quality in the forebay of Lake Powell.

2. Monitor mainstem concentrations of chemical/physical constituents to standards which influence river ecosystem health.

3. Maintain annually updated GCMRC database of unit streamflow values derived from: Paria River, Lees Ferry, Mainstem above the Little Colorado River (LCR) confluence, LCR near Cameron, and Grand Canyon near Phantom Ranch.

4. Monitor system-wide mainstem water temperature changes through time in ways that are useful to biotic investigations; especially where relevant to native fishes and mainstem productivity.

5. Monitor dam operations, mainstem and tributary flow/sediment contributions relative to mainstem sediment transport to Upper Lake Mead (as related to ongoing development of a system-wide sediment budget).

Sediment Resources

One of the most critical issues relating to the long-term health of the Colorado River ecosystem below Glen Canyon Dam is whether or not the ecosystem is in surplus or deficit with regard to sand and finer sediment inputs versus export. Future Beach/Habitat-Building Flows will only be effective in long-term preservation of sand bars if tributary supplies of sand and finer sediment are greater than the volume removed from the ecosystem to Upper Lake Mead by ROD dam operations. Based on previous studies, the most critical areas of the sediment budget question relate to sediment inputs from tributaries throughout Glen Canyon and the Paria River and the sediment budget of Marble Canyon. Cumulative inputs of fine sediment below the

confluence of the Little Colorado River may be sufficient to offset regulation effects, based on existing information.

The following are areas incorporated into the FY 99 program related to overall sediment availability and conditions of sediment resources:

1. Document planimetric changes in terrestrial sand bars, campsite areas and emergent backwaters in targeted GIS reaches and relate changes in these resources to changes in sediment availability and to dam operations between FY98 and FY99, as well as mainstem and tributary floods, if and when inflows from the Paria or Little Colorado Rivers, or releases from Glen Canyon Dam raise mainstem discharge above levels associated with normal operations at the dam.

2. Document annual changes in pre-dam, terrace-based drainage areas containing cultural exist in selected GIS reaches related to factors described above.

3. Define annual changes in volume and particle-size distribution of channel-bed stored sand between Glen Canyon Dam and Phantom Ranch (river mile 87, with emphasis on sediment budgets for reaches above and below the Paria and Little Colorado River confluences.

4. Determine annual changes in system-wide sediment budget based on all tributary inputs of streamflow, and on sediment transport to Lake Mead driven by combinations of ROD dam operations and tributary inflows.

Specific Physical Science Monitoring and Research Projects Supported by GCMRC, FY 98-FY 99:

The FY99 GCMRC physical-science program continues to focus on hydrology and sediment transport, the physical processes related to those resources, and how they act independently and together upon other resources under Record of Decision (ROD) dam operations. Programmed monitoring and research, including synthesis of existing data, will continue to focus on documenting changes in these resources through time. Science efforts initiated in FY 98 may be continued into FY 99 on existing, revised, or new agreements developed

by GCMRC. Additional information and details on these projects and funded proposals are on file at the GCMRC.

The following projects were implemented as part of the FY 98 physical science program for monitoring and research. All of these projects are currently proposed to continue into, and in some cases, throughout FY99 at the funding levels indicated below. However, the GCMRC may elect to revise existing agreements or issue new agreements based on FY 98 program accomplishments and AMWG concerns.

Project #1: "An Integrated Historical Analysis of Flow, Sediment Transport, and Channel-Side Sediment Storage Between Lees Ferry and Middle Granite Gorge in Grand Canyon," will be conducted by Principle Investigator Dr. John C. Schmidt, Geography Department, Utah State University, Logan, Utah. Cost of the project is projected at $200,000 over 2.0 years, or $100,000 in FY 98, and FY 99 if extended by GCMRC.

Research Objectives of the project are as follows:

1. To the greatest extent possible, electronically compile all pre-existing information on flow and sediment processes, and physical-resource conditions throughout the Colorado River ecosystem over the period in which historic records exist (including scanned data files of historic photographs whenever possible).

2. In the context of the above information, summarize and interpret identified patterns and conditions of sediment and sediment-related resources (including physical-habitat characteristics) throughout the Colorado River ecosystem; resolution of changes might vary from annual to decade scales.

3. As a hypothesis, propose one or more process-response model(s) to explain documented relations, if any, between historic patterns of change in sediment and sediment-related resources of the Colorado River ecosystem, and key flow regimes during the pre- versus post-dam eras.

Deliverables expected from the project include the following:

1. Quarterly progress reports;
2. Compiled historical data sets on flow and sediment transport in Glen and Marble Canyons;
3. Preliminary and final reports describing information on above research objectives;
4. Annual presentation to the AMWG/TWG.

Project #2: is "Monitoring Changes in Fine-Grained Sediment Deposits Throughout the Colorado River Ecosystem in Glen, Marble, and Grand Canyon During FY 98 and FY 99,"

will be conducted by Principle Investigator Dr. Roderick A. Parnell, Jr., Geology Department, Northern Arizona University, Flagstaff Arizona. The project may extend 2.0 years through FY 99 at approximately $110,000 per year.

Research objective of the project is as follows:

1. Identify and describe most-appropriate criteria (proposed monitoring parameters) for campsite areas. Parameters should reflect overall management, recreational boating, and back country user needs, based on post-1996 controlled flood conditions.

Monitoring objectives are as follows:

1. Annually, report significant changes in patterns of sandbars relative to dam operations, sediment availability and channel geomorphology; emphasis on reaches where sediment and sediment-related resources are most limited. Comparison of annual changes should also be made relative to agreed upon baseline conditions.

2. Report significant changes in distributions of sandbars, bar morphologies and other important bar characteristics that affect distributions and availability of aquatic and terrestrial habitats; emphasis on physical-habitat characteristics related to backwaters and shoreline-habitat distributions in critical reaches.

3. Report significant annual changes in the above-measured parameters of campsite areas on a site-by-site and system-wide basis relative to agreed upon baseline conditions for sandbars; emphasis on critical reaches where sediment supply and channel geomorphology are limiting factors.

4. Report significant changes in shoreline morphology, and total size of pre-dam river terraces in reaches known to contain cultural sites.

Deliverables from this project include the following:

1. Trip and quarterly progress reports;
2. Preliminary and final data sets;
3. Preliminary and final reports describing information on above monitoring and research objectives;
4. Annual presentations to the AMWG/TWG.

Project #3: "Estimates of Sediment Input From Ungaged Tributaries in Grand Canyon, Arizona: The Relative Importance of Streamflow and Debris Flow," will be conducted by Principle Investigator Dr. Robert H. Webb, Hydrologist, U.S. Geological Survey, WRD, National Research Program, Tucson, Arizona. Projected cost to complete the project during the first half of FY 99 will be $30,000, if extended by GCMRC.

Research objectives of the project are as follows:

1. Sediment yields should be reported from all ungaged drainage areas tributary to the Colorado River ecosystem in the following reaches: 1) Glen Canyon Dam to the Paria River, 2) Paria River to the Little Colorado River, 3) Little Colorado River to Kanab Creek, 4) Kanab Creek to Havasu Creek, 5) Havasu Creek to Diamond Creek, and 6) Diamond Creek to Upper Lake Mead (river mile 276). In addition, estimates for percentages of sand-sized and finer particles alone need to be reported.

2. Estimate sediment yield from ungaged perennial and ephemeral drainage basins, and verify sediment yield calculations using at least two separate methods as a means of testing the robustness of the calculations.

3. Because of the highly variable nature of runoff events in most arid and semi-arid land streams, estimation of reach-averaged sediment inputs must also attempt to evaluate and report on existing climatic records to estimate interannual variability of sediment yields as a secondary goal. Emphasis might be placed on relations, if any, between climate anomalies and antecedent conditions related to extreme events.

4. Lastly, debris-flow probabilities and estimates of sediment yield for ungaged drainage areas should be spatially correlated with sites and(or) reaches where: 1) significant increases in navigational hazards (rapids), 2) alteration of physical habitat characteristics of critical aquatic/terrestrial habitats, 3) and(or) campsite-area degradation, is likely to occur owing to debris-flow processes. Such tributary induced

changes may be of concern to managers and other researchers, and may influence use of flooding as a management tool.

Deliverables from this project include the following:

1. Trip and quarterly progress reports;
2. Preliminary and final data sets used to determine sediment-input estimates;
3. Preliminary and final reports describing information on above research objectives;
4. Annual presentations to the AMWG/TWG.

Project #4: "Monitoring and Research of Streamflow, Sediment Transport and Water Quality in the Colorado River, Glen Canyon Dam to Lake Mead," will be conducted by Principle Investigator Mr. Mark T. Anderson, Hydrologist, U.S. Geological Survey, WRD, Tucson, Arizona. If this project is extended by GCMRC, the cost to complete it in FY 99 is estimated at $450,000.

The monitoring objectives are as follows:

1. Report unit-values, daily means, and monthly volumes for streamflow along the Colorado River between Lakes Powell and Upper Lake Mead, as well as from the Paria and Little Colorado Rivers.

2. Report volumes and averaged grain-size distributions related to suspended-sediment (both sand and silt/clay) transport along the Colorado River between Lakes Powell and Mead, as well as from the Paria and Little Colorado Rivers; with emphasis on critical sediment-limited reaches.

3. Report volumes and averaged grain-size distributions for suspended-sediment outflow from the Colorado River ecosystem to Upper Lake Mead (delta), including estimates and (or) measurements of bed and near-bed components of sediment transport.

4. At appropriate intervals, report significant changes in the quantity and quality of fine-sediment stored in the main channel of the Colorado River between Lakes Powell and Mead; with emphasis on critical reaches, such as Glen and Marble Canyons, where sediment and sediment-related resources are most limited.

5. Report water-quality parameters (chemical and/or physical), such as temperature, turbidity and others collected at appropriate locations, time intervals, and standards so as to identify long-term trends that affect river-ecosystem health.

6. As a contingency, prepare and be ready to implement a plan to monitor changes in the above parameters resulting from Lake Powell releases that exceed the Record of Decision (ROD, see FY98 RFP).

Research objectives include:

1. Identify any process-response relations between dam operations, system-wide sediment flux (quantity and quality), and particle-size distributions, sedimentary structures and morphologies of sandbars. Emphasize sediment conditions, fluvial processes, reach-averaged channel characteristics, site-specific channel features related to aquatic and terrestrial habitats, and preferred physical attributes of campsite areas.

2. With respect to channel geomorphology and sediment availability, identify channel settings and(or) key reaches, if any, where fine-sediment storage occurs most readily, and responds most quickly to major departures in dam operations, such as flows exceeding the ROD.

3. For an estimated range of sediment availability, and based on existing data after August 1, 1991 ("Interim Flows"), identify any actual or potential flow regimes within those dam operations that have, or might have, optimized conditions for river-stored fine sediment within terrestrial and aquatic habitats. Emphasis should be on critical reaches that are sediment limited.

4. Under dam operations, and using appropriate available sediment quality/quantity data, evaluate the possible range of sediment budgets for Marble Canyon (Paria to Little Colorado Rivers), based on estimated minimum, mean, and maximum values of suspended-sediment inputs from the Paria River.

Deliverables from the project include:

1. Trip and progress reports;
2. Preliminary and final stream flow and sediment data sets and reports;
3. Water Quality data sets and report;
4. Annual presentations to the AMWG/TWG.

Project #5: "Developing Predictive Capabilities for Estimating Fine-Sediment Inputs From the Little Colorado River to the Colorado River Ecosystem" will be conducted by Principle Investigator Dr. David J. Topping, Hydrologist, U.S. Geological Survey, WRD, Denver,

Colorado. If extended by GCMRC, the cost to complete this project during the first half of FY 99 will be $20,000.

Research objectives of the project are as follows:

1. Analyze and interpret existing records of streamflow, suspended sediment, and other relevant hydrologic and geomorphic-process information for the Little Colorado River, with emphasis on high-flow events, to identify relations, if any, between non-stationary flood-frequency, climatic variability and sediment deliveries.

2. Based on existing streamflow and sediment-transport data, describe a conceptual model as the basis for developing increased predictive capabilities for estimating suspended-sediment yields to the Colorado River ecosystem.

3. Develop numerical code, along with user documentation, that provides managers and other decision-makers with a management tool for estimating fine-sediment contributions from the Little Colorado River, based on unit-value streamflow measurement associated with all significant sediment-transport events.

Deliverables from this project include the following:

1. Final report describing development of flow/sediment predictive model, and information on above research objectives;
2. All data sets for streamflow and sediment transport used to develop the simulation model;
3. Numerical simulation code for estimating sediment flux from streamflow hydrographs;
4. User guidelines for operation of simulation model.

Conceptual Modeling and Protocol Evaluations

In addition to the projects described above, FY 99 expenditures for development of the ecosystem conceptual model and completion of protocol evaluations will come, in part, from the physical-sciences program budget. The FY 99 contribution to the conceptual model will be $50,000, and the contribution to completing the evaluation of protocols for streamflow and sediment-related resources will be $80,000.

Unsolicited Proposals

Owing to budget constraints, the physical science program does not anticipate funding any unsolicited proposals in FY 99. Unsolicited proposals submitted to the GCMRC during the latter half of FY 98 and the beginning of FY 99 will be reviewed externally by the program managers. At present, the GCMRC physical-science program does not have any unsolicited proposals under review. After external review and a decision to propose for funding, the GCMRC Chief and program manager will review the project/program and justification for funding with the TWG. Unsolicited proposals deemed to be important may be programmed in FY 2000.

Contribution of the FY99 Program to the Strategic Plan

The FY99 physical resources monitoring program is intended to be a continuation of the program implemented by GCMRC in FY 98, and is designed to provide resource-status information to stakeholders/decision makers, and support implementation of the GCMRC five-year strategic plan. The strategic plan, and the FY 99 plan address information needs in three areas:

1. Dam releases and downstream discharge/stage relationships between Glen Canyon Dam and Upper Lake Mead;

2. The influence of (ROD)dam operations on mainstem geomorphic processes associated with streamflow and sediment;

3. Relations between (ROD) dam operations and the mainstem sediment budget, including tributary inputs of streamflow and fine sediment, local-scale physical changes in the river channel caused by tributary debris flows, changes in mainstem storage of sand and finer sediment, and outputs mainstem streamflow and sediment transport to Upper Lake Mead.

Contingency Expenditures in FY 99

No funds are expected to be available from the FY 99 physical science program budget for contingencies, except those that may be derived from logistical cost savings.

Physical Science Program Expenditures

Estimated FY 99 GCMRC costs to conduct planned physical-science projects are as follows:

Project	Cost
#1 (J. Schmidt, Utah State)	$100,000
#2 (R. Parnell, NAU)	$110,000
#3 (R. Webb, USGS)	$30,000
#4 (M. Anderson, USGS)	$450,000
#5 (D. Topping, USGS)	$20,000
Conceptual-Model	$50,000
Protocol Evaluations	$80,000
SCIENCE TOTAL	$840,000
LOGISTICS COST	$335,000
GRAND TOTAL	$1,175,000

CULTURAL RESOURCES PROGRAM

This section describes the FY 99 cultural resource activities conducted by the GCMRC. These activities are associated with two distinctly separate, complementary programs. The first program is the GCMRC cultural resource program that is a part of the Adaptive Management Program (AMP). The second program is the Bureau of Reclamation's (Reclamation) Programmatic Agreement (PA) program which is the legal responsibility of that agency. The PA program is a separate independent program that has been established in response to the National Historic Preservation Act (NHPA) of 1992, as amended. While there is information sharing and project coordination between PA and GCMRC programs, the PA program is the legal responsibility of Reclamation. In FY 99, the GCMRC has been requested by Reclamation to contract administer the PA program Each program and the related activities and budget are provided below.

GCMRC CULTURAL RESOURCES PROGRAM

Program Background

The FY 99 cultural resources program represents a plan to continue activities initiated in the FY 98 program and provides for only a limited number of new activities. All activities, ongoing and new, respond to the stakeholder objectives and information needs that have been identified during the formation of the Adaptive Management Program (AMP) and the establishment of the Adaptive Management Work Group (AMWG). In FY 98, the AMWG will revisit and reassess the objectives and information needs. Information provided by the GCMRC cultural program monitoring and research activities should assist in refining objectives and information needs. Agreements issued in FY 98 may be extended or revised in FY 99.

The stakeholder objectives identified in the area of cultural resources reflect a general concern for in-situ preservation of resources to the maximum extent feasible and they articulate well with goals identified within the PA program. Preservation of resources stems from a recognition by the stakeholders that these are irreplaceable resources that contain a special relationship to Native American stakeholders. If in-situ preservation is not possible, stakeholders are concerned that appropriate mitigative strategies be designed that integrate the full consideration of the values of all concerned tribes with scientific approaches. Protection and physical access to cultural resources for tribal cultural purposes have also been identified by the stakeholders and articulated in federal legislation. Finally, stakeholders are concerned that appropriate mitigation strategies are developed which maximize data collection from mitigation and monitoring efforts for understanding human use and occupation in the Canyon.

FY 1999 Cultural Resources Program

The FY 99 program plans to continue the activity areas developed in FY 98 and add one additional area. However, revisions may occur in all areas based on new information developed from the FY 98 program or AMWG needs. The FY 98 activity areas for the program were: 1) synthesize existing data; 2) develop a risk assessment for cultural resources relative to varying flow regimes and the related sediment deposition; 3) develop tribal programs to assess resource impacts; and 4) develop appropriate data systems and related technology. These program areas will continue in FY 99 with generally the same emphasis as in FY 98.

To respond to the activity areas, two Requests for Proposals (RFPs) funded in the FY 98 cultural resource program are currently planned to be continued in FY 99. These RFPs call for a synthesis of the existing cultural resource data, mainstem modeling and sediment dynamics relative

to cultural resources, and testing of a geomorphic model relative to erosion at selected cultural resource locations. Activity areas that are developed in FY 99, include, unsolicited proposals and an information technology development project to increase tribal access to GCMRC data. More explicit specification of these projects follow:

Project #1: "Mainstem Modeling and Sediment Dynamics at Selected Cultural Resource Locations," is expected to cost between $60,000-$80,000 in FY 99. Started in FY 98, the project is proposed to extend 2 years to the end of FY 99.

The project objectives of this effort include:

1. model stage-discharge relationships for varying flow regimes in selected reaches containing cultural resources up to the approximate elevation associated with the 100,000 cfs discharge;

2. model flow and sediment-transport dynamics at these resource locations up to the 100,000 cfs discharge elevation;

3. apply predictive flow and sediment modeling capabilities to specific river-terrace locations containing cultural resources to evaluate results of flow and sediment-transport model scenarios; and

4. provide recommendations on scenarios that optimize depositional rates along terraces or within arroyo confluences where cultural resources are located.

Deliverables expected from the project include the following:

This project will provide information on possible impacts to resources at specific stages-discharge elevations and the sediments that are predicted to be deposited in associated with those flows. Deposited sediments are believed to provide a buffer for pre-dam terraces that contain cultural materials. This information relates to stakeholder objectives that address in-situ preservation of cultural resources and mitigation strategies.

Project #2: "Test and Apply a Geomorphic Model Related to Erosion of Pre-dam Terraces Containing Cultural Materials," is expected to cost between $60,000 and $80,000 during FY 99. The project was awarded in FY 98 as a potential 2-year effort. Continuation is based on GCMRC review.

The project objectives of this effort include:

1. incorporation and evaluation of data from previous geomorphic work on river-and-terrace-based arroyos, existing archaeological monitoring data, and relevant research from sedimentation and climatological studies;

2. testing and evaluating the validity of the geomorphic hypothesis, refining and revising model as needed to improve predictive utility in determining how, when and where terrace-based erosion is likely to impact cultural resources;

3. identifying most threatened resources, prioritizing remedial action needs, and making management recommendations based on findings.

Deliverables expected from the project include the following:

The results of this study will provide guidance for targeting resources that are most threatened and most likely to be lost through dam related erosional processes. As such, this project will provide basic information that addresses stakeholder objectives relative to preservation and mitigation strategies.

Project #3: "Unsolicited Tribal Proposals Submitted to the GCMRC," are estimated to cost $100,000 in FY 99.

Tribal cultural programs are an important component of the GCMRC resource assessments. These programs supply different information on resource impacts that complement conventional assessments. They help to provide information on the full range of important qualities of the resource and they span and integrate GCMRC program areas. Tribal programs

also provide important technical information about a group's past and present resources. The GCMRC encourages proposals in areas related to technology, student education, and monitoring and research of affected resources that utilize Native American perspectives.

Tribal proposals for ethnobotanical resource assessments have been submitted to GCMRC by the Hopi Tribe, the Hualapai Nation and the Southern Paiute Consortium. The GCMRC is currently evaluating these proposals and budgets and scopes of work have not been finalized. Pending favorable external review and some project modifications and budget negotiations, the GCMRC anticipates funding these projects. The cost of funding these proposals is expected to total $100,000.

Activities proposed in this area relate to stakeholder objectives that incorporate Native American perspectives, concerns and participation in resource assessments and management.

Project # 4: "Continuation of the Development of Tribal Technology/procedures for Dissemination and Access to GCMRC Data," is estimated to cost $10,000 in FY 99. It will be scheduled as a 12-month Project.

The GCMRC continues to work with stakeholders to develop and implement appropriate technologies for data dissemination. On-going working groups of stakeholders continue to assist the GCMRC in defining protocols for scientific and/or sensitive data. Technological capabilities to receive and/or house appropriate data will be investigated in FY 99 as a continuation of efforts undertaken in FY 98. One specific concern in this area relates to the technological ability of tribal stakeholders to access data in a timely, cost efficient manner. Project costs are associated with working groups costs, assessment of technological capabilities, and co-funding opportunities.

Project #5: "Conceptual Modeling," is estimated to cost $ 30,000 in FY 99.

The conceptual modeling project has been previously described. Project costs represent the cultural resource program contribution to the overall conceptual modeling costs for the GCMRC conceptual model effort.

Project # 6: "Program Operations - Logistics" is estimated to cost $ 50,000 for GCMRC cultural resource projects.

Logistical costs are associated with river trips for the GCMRC cultural projects. Prior to FY 99, logistical costs were a separate GCMRC program line item. With the advent of FY 99, logistical costs are listed within related programs.

Project # 7: "Protocol Assessments" is estimated to cost $ 30,000 .

The project costs for protocol assessments represent the cultural resource program contribution to the overall costs for protocol assessment. This project was initiated in FY 98.

Project # 8: " Conceptual Modeling Research Projects" is estimated to cost $ 20,000 in FY 99.

Provision for research projects resulting from the conceptual modeling project and other unforseen activities are included within this category. Conceptual modeling will begin during FY 98 and continue into FY 99. Depending on the information generated during the modeling process, research projects may be proposed for the cultural resource program. Although it is not possible to define these activities at this time, implementation of projects will be contingent upon prioritization, funding, compatibility with stakeholder objectives and reviews by GCMRC and the TWG. It is anticipated that these activities, if proposed, would occur in the final portion of FY 99, based on the modeling effort schedule.

THE PROGRAMMATIC AGREEMENT PROGRAM

The Programmatic Agreement (PA) Program coordinates and describes the legal responsibilities of Reclamation and the National Park Service (NPS) to ensure the protection of historic properties within the Grand Canyon National Park and Glen Canyon National Recreation Area as specified in the National Historic Preservation Act (NHPA), the Archaeological Resources Protection Act (ARPA) and the NPS Organic Act. These responsibilities can not be delegated or abrogated by these agencies.

The legally binding responsibilities and general procedures of Reclamation and the NPS are identified within the PA to assist these agencies in maintaining compliance with the legislation for determining and mitigating adverse impacts on historic properties in the Colorado River corridor below Glen Canyon Dam resulting from "dam operations". The PA signatories include Reclamation, NPS, Native American Tribes, the Advisory Council on Historic Preservation and the Arizona State Historic Preservation Office. In addition, the funding for PA activities is the responsibility of Reclamation. The AMP has the ability to approve activities that are within the authority of the AMP. The PA activities that are not within the authority of the AMP may not be approved for funding under the AMP. However, because the PA program is a separate legal program and the AMP has no ability to affect the scope of this program, the unfunded activities will return to Reclamation for implementation and funding as there is a legal mandate that the activities be conducted and they remain the legal responsibility of Reclamation.

In FY 98 and FY 99, Reclamation has requested that the GCMRC administer the PA program contracts with the understanding that the GCMRC is an information gathering and

dissemination center and not a regulatory body. As such, Reclamation remains legally responsible for the implementation of the PA program although the GCMRC may administer activities identified within the PA program. The PA activities for FY 99 are described below.

Project #1: "Funding for NPS and Tribal Programmatic Agreement Proposals Submitted to the BOR, AMP and Transmitted to the GCMRC," is estimated to cost $735,000 in FY 99.

At the request of Reclamation, part or all of PA activities may be included in the GCMRC FY 99 program. At the present time, FY 99 activity categories include monitoring activities, remedial actions and associated analysis. Based on FY 97 scopes of work conducted by the NPS from Glen and Grand Canyons, logistic surveying and mapping efforts, and the work conducted by tribal groups, it is estimated that approximately two-thirds of the work effort and associated costs are allocated to monitoring activities and about one-third to remedial activities. The PA program activities proposed in FY 98 appear to reflect a similar allocation of work and it is anticipated that work proposed in FY 99 will also.

Information from past scopes of work for NPS units indicate a cost of approximately $ 295,000 and average costs for tribal proposals of $ 80,000 to $ 90,000 each. It is anticipated that FY 99 scopes of work and related budgets will be similar.

Project # 2: "PA Program Operations- Logistics" is estimated to cost $ 50,000.

Logistical costs are associated with tribal river trips for PA monitoring trips. These trips relate to monitoring activities identified within the PA program. These funds are contributed by the AMP/GCMRC cultural resource program to Reclamation's PA program. Prior to FY 99, logistical costs were a separate GCMRC program line item. With the advent of FY 99, logistical costs are listed within related programs.

Project # 3: " Program Administration/Reclamation" is estimated to cost $ 65,000.

These costs include Reclamation staff costs, overhead costs, and travel.

THE CONTRIBUTION OF THE FY 99 PROGRAM TO THE STRATEGIC PLAN

The GCMRC FY 99 cultural program is linked to the stakeholder objectives and information needs as formulated under the Adaptive Management Program. The information that is generated from these activities provide necessary data for the long-term management of cultural resources within the river corridor.

The PA program activities within the AMP provide complementary data to assist the GCMRC in formulating monitoring and research activities that address stakeholder objectives and contribute to the long-term management of cultural resources within the river corridor.

FY 99 BUDGET SUMMARY

GCMRC CULTURAL RESOURCES PROGRAM

GCMRC PROGRAM COSTS

RFP-Mainstem Model . . . . . $ 70,000

RFP-Geomorphology Model 80,000

Unsolicited Tribal Proposals. 100,000

Data Protocol Groups 10,000

Conceptual Modeling 30,000

Logistics Operations . . . . . 100,000[10/]

Conceptual Modeling Research Projects.....20,000

Protocol Assessments.....30,000

TOTAL **$390,000**

[10/]$ 50,000 of the logistics costs are contributed by the AMP/GCMRC budget to Reclamation's PA program and are not available for use in the GCMRC program.

FY 99 BUDGET SUMMARY

BUREAU OF RECLAMATION

PROGRAMMATIC AGREEMENT PROGRAM

PA PROGRAM COSTS

PA Administration/Reclamation Staff.....65,000

PA Activities[11/]

NPS - GRCA, GLCA 295,000

TRIBAL GROUPS: Estimated $90,000-

$100,000 ea. Hopi Tribe, Hualapai, Nation,

Navajo Nation, Southern Paiute Consortium,

Zuni Pueblo.....440,000

TOTAL $800,000

[11/] $50,000 in logistics costs are contributed from the AMP/ GCMRC budget and are not reflected in the $ 800,000 PA Program budget.

THE BIOLOGICAL RESOURCES PROGRAM

Program Background

The synthesis, monitoring and research activities proposed below for FY 98 and FY 99 are intended to develop and maintain critical data streams that relate to the structure (components) and function (processes) of the Colorado River ecosystem. The development of information on the structure and function of the Colorado River ecosystem is a prerequisite for effective adaptive management. It is key that relationships between the biotic and abiotic components of the ecosystem be addressed, for without an understanding of these relationships, no predictive capability exists to evaluate the effect of alternative dam operations on biological resources.

The FY 99 biological resources program is primarily a continuation of activities initiated in the FY 98 program. A limited number of new activities are proposed for initiation in FY 99.

Responding to Stakeholder Objectives and Information Needs

All FY 98 and FY 99 activities address the objectives and information needs that have been identified in consultation with stakeholders, as described in Chapter 2. In subsequent meetings with scientists these stakeholder information needs were stepped down into a knowledge base (i.e., scientists' knowledge and scientists' need to know), and the potential elements of a monitoring and research program (i.e., scientists' monitoring statements and scientists' research questions).

The FY 98 and FY 99 Biological Resources Program

The FY 98 Biological Resources Program awarded its FY 98 monitoring and research studies through a competitive process, as discussed in the Strategic Plan. The FY 98 program includes monitoring and research activities associated with the aquatic food base; humpback chub and other native fish; Lees Ferry trout fishery; wetland and riparian vegetation; riparian avifauna and the endangered Southwestern willow flycatcher, and the endangered Kanab ambersnail. The FY 99 program may award its monitoring and research studies through an extension of existing contracts and the competitive process used for the FY 98 awards. However, modifications to the FY 99 program, described below, may be made as a result of information developed from FY 98 activities. This could result in some or all of the existing FY 98 agreements not being extended.

Aquatic Food Base

The aquatic food base in the Colorado River ecosystem is composed primarily of macrophytes, macroinvertebrates, diatoms and detritus. Fluxes in the aquatic food base may be associated with water temperature, turbidity, and flow fluctuations, to name a few variables. Understanding the relationships between dam operations and productivity of the aquatic food base is an important link towards understanding the effects of dam operations on higher trophic levels. Fluctuations in the amount and types of aquatic food available can trigger changes in the population dynamics of many wildlife species, especially native and non-native fish.

The Project, "A Proposal to Monitor the Aquatic Food Base in the Colorado River, Arizona," is led by D.W. Blinn and J.P. Shannon of Northern Arizona University. This is a one-year research and monitoring effort initiated in FY 98 and potentially renewable for one additional year with a proposed budget for FY 99 of $178,086. This project involves monitoring community

structure, density, distribution and composition along the mainstem and tributaries, and making linkages and distinctions between dam operations, Lake Powell input, tributary influences, and inherent variation in the aquatic food base.

Specific objectives that are outlined in the FY 98 and FY 99 Program address questions concerning the structure and character of the food base as it relates to dam operations and natural variation, as follows:

1. Determine impacts alternative operating criteria have on the food base.

2. Monitor community structure, density, distribution, and composition of algae, macrophytes and macroinvertebrates along the mainstem and tributaries in a manner compatible with research and monitoring activities on fish.

3. Identification of key parameters (i.e., nutrient levels, water quality, community structure) associated with the maintenance and enhancement of aquatic food base for long-term monitoring.

4. Data collections that enable distinction between the effects of dam operations and natural variation on the aquatic food base and previous monitoring efforts.

5. Develop linkages between nutrient levels, water quality and community structure (benthos, drift, etc.) in relation to dam operations, Lake Powell input and tributary influences.

In addition, the FY 98 and FY 99 Project includes objectives that address linkages between trophic levels:

1. Determine if and at what densities the standing aquatic food base in Glen Canyon is a limiting factor in higher trophic level productivity in association with different operating criteria.

2. Determine the effects of large fluctuations associated with dam releases on the aquatic food base in Glen and Grand Canyons and associated fish resources.

Activities proposed by Blinn and Shannon include:

1. Monitor the effects of modified low fluctuation flows from Glen Canyon Dam on the benthic algal and microinvertebrate community in the Colorado River between GCD and Diamond Creek (RM226).

2. Monitor the effects of modified low fluctuating flows from GCD on the organic drift in the Colorado River between GCD and Diamond Creek.

3. Inventory the phytobenthos, macroinvertebrates and drift in 11 major tributaries in Grand Canyon National Park.

4. Construct an aquatic/riparian foodweb using stable isotope analyses.

Blinn and Shannon are collaborating with researchers funded to conduct native fish monitoring and research activities to address management questions concerning the linkages between the aquatic food base and fishery resources.

Collection methods used in Blinn and Shannon's objectives 1-3 and statistical analysis using abiotic predictor variables and biotic response variables are proposed to differentiate between operational effects on the food base and inherent natural variation. Linkages between trophic levels are addressed by the last activity, proposed by Blinn and Shannon, that strives to construct a foodweb.

New efforts also being considered for FY 99 address the synthesis of previous research and monitoring efforts, and the initiation of research that addresses poorly understood, or unknown information associated with nutrient cycling, lower trophic level interactions, and the effect of temperature on these interactions. Specific questions pertaining to aquatic food base productivity will include:

1. How do lower level interactions such as nutrient cycling (e.g. phosphorous availability) in the mainstem affect primary productivity?

2. What is the microbial contributions to organic processing in this system?

3. What are the recruitment mechanisms (i.e., zoospore vs. fragmentation) for Cladophora, a keystone species in the aquatic food base under different riverine environmental conditions?

4. How does temperature affect each of these subjects?

This last question should be considered critical as managers begin to evaluate alternative operating plans such as seasonally adjusted steady flows and selective withdrawal scenarios.

Native Fish

Native fish are an important part of the Colorado River ecosystem because of their intrinsic value and trophic role, and some are listed as threatened or endangered species. Native fish found in the Colorado River ecosystem represent a unique assemblage of species ecologically adapted to a fluvial riverine environment characterized by seasonally variable flows, temperature, and sediment loads. With the completion of Glen Canyon Dam, abrupt environmental changes (e.g., altered sediment transport, flow patterns and thermal characteristics) were imposed on this system. This resulted in abiotic and biotic changes to habitat, channel morphology, predation pressures, parasitism and diseases, food base and trophic linkages. These changes are reflected in the present relative abundance, reproductive success, survivorship, distribution, and movement of native fish.

The Colorado River ecosystem and its tributaries currently support four species of native fish, humpback chub (Gila cypha), flannelmouth sucker (Catostomus latipinnis), bluehead sucker (Catostomus discobolus), and speckled dace (Rhinichthys osculus). These native fish populations are variously dispersed throughout the Colorado River ecosystem, and reproductive success and recruitment is apparently impaired in all four species. Mainstem water temperatures (8-14ºC)

continue to be below optimum ranges (16-22°C) for reproduction and survival of eggs and larvae of these warmwater species. Razorback sucker (Xyrauchen texanus) have not recently been observed in the Colorado River ecosystem, except for individuals thought to be hybrids with flannelmouth suckers and it is therefore strongly suspected that they have been extirpated from this system.

An overall goal for GCMRC monitoring and research activities is to understand the processes that enable the maintenance and/or enhancement of native fish, especially the endangered humpback chub. Native fish populations depend on appropriate habitat for all life stages and an adequate food base for their continued survival. Both of these elements may change in response to dam operations. Changes in reproduction, recruitment, and growth in response to dam operations can also affect native fish population demographics. Recent dam operations, under interim flows (August 1991 - present) have reduced stage fluctuations, stabilized shoreline habitats and backwaters, and increased macroinvertebrate food production for fish. Effects on the humpback chub have not been documented.

For native fish populations to remain viable, successful recruitment must occur. Low temperature hypolimnetic releases from Glen Canyon Dam are thought to have negative effects on the reproduction and recruitment of native fishes. The four major factors thought to influence successful native fish recruitment are: hydrology and transport; food production and availability; water temperature; and predation. In general for fish, the timing of reproduction must coincide with local food production cycles, and larvae must be transported to a favorable nursery habitat for there to be successful recruitment. Food production and availability, habitat quality and availability, and competitive and predatory interactions can potentially increase risks at young life

stages, resulting in increased mortality and reduced recruitment. Also, the Asian tapeworm (Bothriocephalus acheilognathi) has been reported in humpback chub from the Colorado River ecosystem since 1990, but the effect on the species remains unknown.

In the Colorado River ecosystem, the endangered humpback chub is distributed throughout the mainstem and its associated tributaries. Nine aggregations of humpback chub have been identified in the mainstem, with minimal movement and exchange of individuals between aggregations. Population estimates for these mainstem aggregations range between 3,500 to 4,000 adults, with one aggregation accounting for almost 90% of this total. Another aggregation in the Little Colorado River (LCR) comprise approximately 4,500 adults. However, since the LCR is not closed or isolated from the mainstem, considerable questions exist regarding residency and rates of exchange between the LCR and mainstem aggregations. The LCR is the only known area of documented spawning (March-May) and successful recruitment for the Colorado River ecosystem. Adults in other mainstem aggregations peak in reproductive condition in May-June, but mainstem spawning remains undocumented. [12/] Recent synthesis suggests that the LCR aggregation, may be experiencing a decline in numbers of adults, although causes for this decline are unknown. An extensive database on PIT tagged humpback chub in the vicinity of the LCR has been developed through GCES sponsored projects. The consolidation of this PIT tag data base will be an FY 99 activity.

Different age-classes of humpback chub utilize dissimilar habitats. Adults typically use deep, large recirculating eddies, whereas young-of- year are thought to use shallow, nearshore

[12/] About 100 post-larval chub were observed and captured in a warm spring in 1993 at RM 30, where an aggregation of about 50 adults resides.

complex habitat and backwaters. The relative abundance of the aquatic food base (i.e., standing mass of benthic invertebrates and periphyton) has been suggested as a potential limiting factor for native fish populations. The diversity and abundance of the aquatic food base is thought to be largely controlled by dam operations.

The Biological Opinion on the November 1997 Fall Test Flow (31,000 cfs) from Glen Canyon Dam calls for the design and implementation of a program "...to evaluate effects of factors limiting overwintering survival of young-of-year humpback chubs in the Grand Canyon. The program shall evaluate the contributions of habitat restrictions, predation, reduced sediment loads, and cold water temperatures."

Flannelmouth sucker are dispersed throughout the Colorado River ecosystem, with the highest numbers recorded during spring spawning aggregations at tributary mouths, such as the Paria and Little Colorado Rivers, Bright Angel Creek, Shinumo Creek, Kanab Creek, Havasu Creek, Spencer Creek, and Surprise Creek. Although reproductive success is reported from numerous tributaries, juvenile suckers in the mainstem are uncommon, and length-frequency distributions indicate low recruitment to adult-sized fish. It has been hypothesized that larval flannelmouth suckers are succumbing to thermal shock as they drift from warm tributaries to the colder mainstem. Recently, about 500 adult flannelmouth suckers have been observed annually at RM 4 (above Lees Ferry) in spawning aggregations; despite cold water temperatures of about 10^{o}C.

The Project: "Monitoring and Studies of Native Fishes of the Colorado River Ecosystem in Grand Canyon," is led by Owen Gorman of the U.S. Fish and Wildlife Service (FWS). This is a one-year research and monitoring effort initiated in FY 98 and potentially renewable for one

additional year with a proposed budget for FY 99 of $524,990. This project involves assembling integrated data sets on the distribution of native fishes in relation to abiotic and biotic factors throughout the Colorado River ecosystem, and by developing life history models for each species from existing data and published works. Linkages among dam operations, flow regimes, abiotic and biotic factors, and the native fish community will be identified using multivariate analyses. Monitoring efforts to assess the current status of endangered and other native fishes, parrticularly in the context of changing dam operations and flow regimes will be conducted. In an attempt to detect trends in native fish populations, monitoring efforts will focus on the LCR and the associated Colorado River inflow reach because this si where the endnagered humpback chuib successfully reproduces, and on tributaries because almost all native fish in the Colorado River ecosystem appear to be dependent on these streams for reproductiona nd early life history stages. Growth experimenst are also proposed to address the thermal requirements for growth and survivorship of native fishes.

Specific activities that are outlined in the FY 98 and FY 99 addresses the following objectives:

1. Establish linkages among dam operations and the resulting flow regimes and related abiotic (e.g., temperature, turbidity) and biotic (e.g., food base) parameters on spawning, reproductive success, larval transport, recruitment, habitat use, food availability and diet.

2. Monitoring to annually evaluate the status and trends of native fish populations, especially humpback chub and flannelmouth sucker, in the Colorado River ecosystem. Monitoring activities should consider parameters such as: abundance, age structure, growth rates, condition, year class strength, distribution (i.e., spatial patterns of abundance) reproductive success and overall recruitment in response to dam operations. Monitoring activities should utilize PIT tags to augment existing databases, as appropriate.

3. Competitive and predator-prey interactions with non-native fish and the influence of dam operations, including potentially increased water temperatures, on these competitive and predatory interactions, if any.

4. Assess the condition of adult humpback chub and other native fish. Utilize results of aquatic food base studies, as appropriate. Evaluate the effects of existing and potential parasites, diseases, and other factors on the condition of mature humpback chub and other native fish.

5. Examine the importance of the LCR, backwaters, and nearshore habitats to differing parts of the life cycles of native fish.

6. Temperature studies: Determine optimal, upper and lower water temperature limits on reproductive success, and growth and survival of larval, juvenile, and adult fish. Evaluate effects of increased water temperatures on various factors which may affect population survival (e.g., parasite distribution and abundance, swimming performance).

New efforts being considered for FY 99 include: (1) review of the feasibility of, and the development of a plan for, the establishment of a second population of humpback chub, (2) a study focused on quantifying and understanding the causes and significance of overwintering mortality of humpback chub, and (3) an effort to integrate the scientific information needed to design and develop a plan for the implementation of endangered fish research flows. Descriptions of proposed activities are as follows:

Planning the Establishment of a Second Population of Humpback Chub in the Colorado River Ecosystem

The 1994 FWS Biological Opinion on the operation of Glen Canyon Dam has identified the need to establish a second population of endangered humpback chub in the Grand Canyon region by the year 2002. Formerly widely distributed throughout the unregulated Colorado River, the humpback chub is presently distributed in five populations in the upper Colorado River basin, and in nine aggregations in the Grand Canyon. Of the nine mainstem aggregations in the Grand

Canyon, only one large spawning population exists, in the Little Colorado River (LCR), 61 miles downstream from Lees Ferry, Arizona. Causes for the decline of this species are thought to include competition and predation from non-native fish, restricted distribution by numerous impoundments, and cold water temperatures. Because successful spawning is only documented for the LCR population, protection and recovery of this species involves mitigation of GCD impacts on habitat quality in the Colorado River mainstream and establishment of at least one additional self-sustaining population in the Grand Canyon region. Although considerable monitoring and natural history data have been synthesized for this species, little planning has been performed regarding the establishment of a second population.

A Request for Proposals (RFP) is recommended to be issued to facilitate this planning process. The overall objective of this RFP is to develop a report and schedule describing the steps required to accomplish establishment of a second humpback chub population in the Grand Canyon region. Specific objectives would include:

1. Outline the steps required to establish a second humpback chub population in the Grand Canyon region.

2. Relate the available information on habitat requirements to habitat availability in the Colorado River ecosystem.

3. Determine hatchery requirements, availability and costs for establishment of a second population.

4. Develop a stocking program, including a schedule, and a monitoring program to determine the effectiveness of this effort.

The information contained in the report resulting from this RFP will assist the AMWG cooperating agencies in recommending appropriate action to establish a second population of humpback chub in the Grand Canyon region.

Effects of Overwintering Mortality on Humpback Chub in the Colorado River Ecosystem

The FWS Biological Opinion on the November 1997 Fall Test Flow (31,000 cfs) from Glen Canyon Dam calls for the design and implementation of a program "... to evaluate effects of factors limiting overwintering survival of young-of-year humpback chubs in the Grand Canyon. The program shall evaluate the contributions of habitat restrictions, predation, reduced sediment loads, and cold water temperatures."

If these activities are initiated in FY98, no new activities will be started in FY99.

Design of, and Implementation Plan for Endangered Fish Research Flows

The GCDEIS states, "Although a considerable amount of research on endangered fish has been conducted, there has been no opportunity to study the effects of low, steady flows in the summer and fall combined with higher, steady spring flows -- which FWS believes are critical to native fish in the Colorado River. Therefore, studies to include endangered fish research flows would be coordinated with the long-term monitoring and research under the AMP."

Given the anticipated completion in FY 98 of the Data Integration Report (SWCA, Inc.) and the synthesis of GCES Phase II biological and physical science activities (Patten), as well as the conceptual modeling activities which will be underway, GCMRC recommends an RFP be issued to facilitate the design and development of a plan for implementing endangered fish research flows, consistent with the requirements of the Biological Opinion. The overall objective of this RFP is to develop a report and implementation plan that proposes one or more experimental flow scenarios, provides the data and scientific justification for each flow scenario, defines the hypotheses to be tested under each flow scenario, and outlines the steps required for implementation.

The report resulting from this RFP will assist the AMWG cooperating agencies in recommending appropriate action regarding the conduct of endangered fish experimental flows.

Lees Ferry Trout

With the completion of GCD in 1963, and the stocking of rainbow trout (Onchorynchus mykiss) below the dam in 1964, rainbow trout have become an important recreational resource in the GCD tailwaters. The Glen Canyon/Lees Ferry trout fishery has developed in response to the constantly cold and clear hypolimnetic releases. These releases have promoted the high primary productivity of algae and aquatic macrophytes, and its secondary production of aquatic invertebrates, essential elements for the fishery. The presence of coarse substrates for natural spawning and reproduction, and the regular stocking and management of this recreational trout fishery has resulted in a fishery of considerable socio-economic importance.

Currently, 70 percent of the rainbow trout in the tailwater are naturally produced, while 10 years ago, most fish were of hatchery origin. Although large trout in excess of 5 pounds were numerous before 1983, these large fish are now rare. Nevertheless, large numbers of reasonably well-conditioned fish are being sustained by a high biomass of amphipods (Gammarus lacustris) and midges (Chironomidae).

Understanding the processes that enable the maintenance and/or enhancement of the rainbow trout fishery requires managers to be able to accurately predict the aquatic resource's response to ecological changes that are a (direct or indirect) result of GCD operations. Since the Glen Canyon/Lees Ferry fishery has become an important social and economic resource to diverse publics, stakeholders have stated a management goal that natural reproduction comprise at least

50% of the total reproductive effort, that sufficient suitable spawning habitat be maintained to reach this objective, and that rainbow trout be maintained at a population level of approximately 100,000 fish.

The Project: "A Proposal to Monitor the Rainbow Trout Fishery of the Colorado River, Downstream from Glen Canyon Dam to Lees Ferry in Glen Canyon National Recreation Area," is led by W. Persons of the Arizona Game & Fish Department. This is a one-year research and monitoring effort initiated in FY 98 and potentially renewable for one additional year with a proposed budget for FY 99 of $125,000.

The objectives of this project are:

1. Synthesize existing information (published and unpublished data) on the Glen Canyon/Lees Ferry trout fishery and determine the fishery's likely response (growth, reproduction, recruitment population structure, size and distribution) to dam operations.

2. Monitoring activities for determining population size, structure, growth, distribution, reproductive success and overall recruitment in response to dam operations.

3. Develop methods for estimating the proportion of natural reproductive success in combination with stocking quantities and rates to determine desired levels of recruitment balanced against the carrying capacity for a range of dam operations.

4. Develop evaluation criteria for, and measure and assess the health and condition of the rainbow trout population.

5. Evaluate changing health and condition factors in relation to changes in the aquatic foodbase and nutrient levels as determined in the aquatic food base RFP.

The Rainbow Trout project involves:

1. Analyzing and summarizing existing data (lengths, weights, food habits, effort, catch location) from AGFD data collected from 1984 - 1997 and integrating these data with a review of literature associated with other regulated river trout fisheries.

2. Determining the existing status of the trout fishery as it relates to dam operations and developing an evaluation criteria that measures and assesses the health and condition of the rainbow trout.

3. Integrating these data with aquatic food base data to develop methods to estimate the extent of spawning success, and stocking needed to reach healthy, sustainable population levels of trout relative to dam operations.

Collection and analysis methods used to address these project objectives include electrofishing in times of the year that coincide with changes in the aquatic food base, creel surveys and PIT-tagged recapture information. Variables collected at such times include: lengths, weights, food habits, effort, catch location. Distinguishing between inherent variation and dam affects will be done using Canonical Correspondence Analysis, while the ANOVA and regression analysis will be used to examine the effects of time on stocking density and recruitment.

Lees Ferry Trout Symposium

During the planning for the Labor Day 8,000 cfs flows, concerns were raised regarding the effect of monitoring and test flows on the Lees Ferry trout fishery. It was proposed that GCMRC conduct a symposia that evaluates the scientific understanding of cold tailwater fisheries in the western United States with a focus on creating a base of scientific information that could be used in the development of future management plans for the Lees Ferry trout fishery. The symposium developed in FY 98 will result in a proceedings in FY 99 requiring publication costs from GCMRC.

The goal of the symposium is to provide a scientific forum to present and discuss the effects of flow regulation and management activities on the Lees Ferry trout fishery. The

objectives of the symposium are to present and discuss the present state of knowledge of the Lees Ferry trout fishery, as well as the state of knowledge developed at other cold, tailwater trout fisheries in the western United States.

It is proposed that a series of papers be published in FY 99 to address specific topics and that these be followed by panel discussions. Topics that may be addressed in the symposium include:

1. A perspective on the historical and present trout fishery (habitat use and availability, reproduction, growth, development and survival, stocking and genetic strains) in the context of flow releases and management activities.

2. A discussion of the effects of flow regulation on fish response in their habitat use, availability and behavioral energetics.

3. An evaluation of the spatial and trophic limitations on trout biomass and its distribution within the demographic structure of the population.

4. An evaluation of the appropriate use and inherent risks associated with different sampling methods.

The symposium will result in a proceedings document that represents the state of knowledge regarding cold, tailwater trout fisheries in the western United States. It is believed that such a compendium will be a valuable resource for managers and will help in discerning the effects of GCD operations on the Lees Ferry trout fishery.

Wetland and Riparian Vegetation

Riparian vegetation is recognized as an important resource serving many roles in the Colorado River ecosystem. The vegetation stabilizes the river's banks, provides habitat for fish and wildlife, and has aesthetic and recreational value. The riparian vegetation communities within the Colorado River ecosystem were changed drastically by the construction and subsequent

operations of GCD. Today the riparian vegetation is composed of three distinctive communities: (1) the upper riparian zone, (2) the lower riparian zone, and (3) the nearshore wetland community. The preservation or restoration of riparian communities affected by dam operations is an objective identified by the stakeholders.

The Project: "A Proposal to Monitor Wetland and Riparian Vegetation along the Colorado River Ecosystem between Glen Canyon Dam and Lake Mead," is led by T. Ayers and M. Kearsley of Northern Arizona University. This is a one-year research and monitoring effort, initiated in FY 98 and potentially renewable for one additional year with a proposed budget for FY 99 of $79,980.

The objectives of this project are:

1. Monitor the community response (i.e., community structure, diversity, density, distribution, and extent of riparian and marsh vegetation) to dam releases along the Colorado River ecosystem.

2. Compare 1998 riparian and marsh vegetation data with historical monitoring data to evaluate change over time (i.e., the spread and contraction of communities, change in species composition, etc.), in relation to dam operations.

3. Monitor non-native/invasive vegetation with respect to recruitment, spread and survivorship.

4. Examine habitat integrity and composition as it is related to threatened and endangered species (e.g., Southwestern willow flycatcher, Kanab ambersnail), and linkages between vegetation, aquatic food base, fish habitat, and sediment-related resources.

These research and monitoring objectives are directed towards understanding the effects of the Preferred Alternative on riparian vegetation.

This project involves collecting current data and synthesizing previous years data associated with riparian and marsh community productivity, composition, and distribution, and

integrating and developing linkages between terrestrial and aquatic biota. Specifically, the researchers propose to use vegetation maps derived from annual aerial photographs and on-the-ground censussing to describe the composition and extent of plant assemblages in eleven study sites. The proposed work will address the following questions:

1. Are riparian plant assemblages in the new high water zone changing through time in response to the hydrologic regime imposed by Glen Canyon Dam?

2. Are there important changes in the physical structure of vegetation in the study sites which affect the suitability of habitats for avifauna from one year to the next?

3. How do previous measurements of vegetation structure in the 11 study sites relate to more widely used measures of bird habitat structure?

4. Are the distributions of species of special concern changing in long-term study sites?

5. Can significant interactions between riparian vegetation and sediment and riparian vegetation and aquatic resources be measured?

New efforts also being considered for FY 99 will be directed toward evaluating the current monitoring sites and determining if the present sites are sufficient to characterize the status riparian vegetation (i.e., do more sites that coincide with fish, aquatic food base and terrestrial vertebrate study need to be added?). Additionally, the interactions between decomposition, nutrient availability, and nutrient cycling between terrestrial and aquatic interfaces need to begin to be examined. Efforts such as these will strengthen ties between aquatic and terrestrial primary productivity.

Riparian Avifauna and the Southwestern Willow Flycatcher

Avifauna are trophically significant secondary consumers. Their presence or absence can be an indicator of the status of habitat structure, food resource production, and predator

populations. Reduced flood frequency and sediment transport in this system has increased aquatic foodbase productivity, established trout populations, and promoted profuse stands of wetland and riparian vegetation. As a result, threatened or endangered Bald Eagle, Peregrine falcon, and Southwestern willow flycatcher (SWWF), other regionally significant Neotropical migrants, and other breeding bird species populations have increased in the post-dam river corridor.

Nearly 320 species of birds have been observed downstream from GCD in the Colorado River ecosystem since the 1920's. The avian assemblage within the Colorado River ecosystem includes more than 25 obligate and facultative riparian species, and at least 59 species of waterbirds. Little is known of the pre-dam (pre-1963) avian assemblage within the Colorado River ecosystem. However, numerous post-dam riparian Neotropical migrant species nest in and use the lush native and non-native vegetation along the river, and habitat patches vary considerably in size and condition.

The Colorado River ecosystem supports several avian species federally listed as threatened or endangered, including bald eagles, breeding peregrine falcons and Southwestern willow flycatchers. The Southwestern willow flycatcher (SWWF) has been the focus of intensive monitoring in upper Grand Canyon since 1983.

In contrast to other willow flycatcher subspecies, the breeding habitat of SWWF appears to be more closely related to riparian environments. In the Colorado River ecosystem, SWWF population status, breeding season distribution, nesting habitat, and nest characteristics are documented in published papers and monitoring reports from 1976 to 1995. Collectively, these data indicate that SWWF in the Colorado River ecosystem nest in relatively wide stands of riparian vegetation along the wide reaches of the Colorado River, particularly in dense groves of

tamarisk, occasionally with a scattered overstory of taller trees, and usually with nearby exposed sand bars or fluvial marshes. SWWF nests are typically 3.5 to 7 m above the ground and several meters below the canopy and nest sites have a high percentage of canopy from 0 to 4 m above the ground. SWWF usually nest over moist or wet soil, and all SWWF nests recorded during the high flow years of 1984-1986 occurred over water and nest trees were at the water's edge or stood in shallow water. However, all nests detected in the Colorado River ecosystem in the 1990's have been situated in tamarisk stands over dry ground on elevated terraces and at least several meters away from the river's edge.

Four areas have been consistently occupied by territorial SWWF in the upper Grand Canyon. These areas all lie in wide, low gradient reaches, with abundant riparian zone vegetation dominated by tamarisk (Tamarix sp.) and Coyote willow (Salix exigua) on upper bar surfaces, and with associated fluvial marshes in reattachment bar settings. Fluvial marsh vegetation at those sites consisted of common reed (Phragmites australis), horsetail (Equisetum spp.) and other wetland species.

SWWF failed to breed successfully in upper Grand Canyon in 1997 as a result of brown-headed cowbird (Molothrus ater) brood parasitism. One SWWF nest produced two fledglings on upper Lake Mead on the Hualapai Indian Reservation in 1997, and at least one nest was successful on upper Lake Mead in 1997.

The Project: "A Proposal to Monitor Southwestern Willow Flycatcher, Riparian Breeding Avifauna, and Overwintering Avifauna Along the Colorado River ecosystem from Glen Canyon Dam to Lake Mead," is led by J. Spence of Glen Canyon National Recreation Area. This is a one-year research and monitoring effort initiated in FY 98 and potentially renewable for

one additional year with a proposed budget for FY 99 of $80,900. This project involves monitoring SWWF and other riparian avifauna population trends in the river corridor, synthesizing existing information concerning SWWF biology and distribution in the corridor, and collecting data associated with life history and the effects of dam operations on life history traits and habitat requirements. Additionally, this project will census overwintering avifauna.

The objectives for this project are:

1. Collect and interpret data on the current and historic distribution and population densities of wintering and spring and summer avifauna, and their relation to habitat patches, within the Colorado River ecosystem (RM: -15 to 278).

2. Relate habitat structure/composition of survey areas to dam discharges and river flows during the study period, to breeding bird distribution and density.

3. Collect detailed monitoring data of SWWF habitat condition, habitat use and nesting success, and nesting fidelity, including the dynamic nature of its colonizing behavior through the study period and in comparison with previous data and other SWWF monitoring programs.

4. Relate current SWWF distribution to past data to provide a comprehensive analysis of population change through time.

5. Evaluate the effects of brown-headed cowbird (Molothrus ater) on the abundance and/or distribution of SWWF and what management alternatives should be considered to counteract this effect, in a fashion that does not interfere with SWWF territory occupation or nesting success.

These objectives will be addressed by using fixed-radius point counts and walking surveys to determine habitat use, home range size, and nest placement characteristics. He will use power analysis to determine which species are effectively monitored in this manner. Efforts will be made to correlate species composition and abundance with habitat to determine which variable are most closely linked to birds and are most useful for long-term monitoring. Lastly we will compare

current data with previous data to determine trends associated with changes in the riparian avifauna community.

Kanab ambersnail at Vaseys Paradise

The Kanab ambersnail (KAS) is a federally endangered snail that is presently known to exist in the United States from the Three Lakes location near Kanab, Utah, and from Vaseys Paradise in Marble Canyon, Arizona. The Utah population occurs on privately owned land at Three Lakes, a wetland habitat consisting of several, small spring-fed ponds at an elevation of 6,500 ft. Vaseys Paradise is a cool-water, dilute dolomitic spring located in Grand Canyon National Park, 31.5 mi downstream from Lees Ferry, Arizona. The spring issues at 3,200 ft elevation and flows about 300 ft to the Colorado River. Slope aspect protects the spring from hot, direct mid-afternoon sunlight during summer and may allow it to warm quickly after winter freezes. The site is dominated by diverse wetland vegetation, including a heavy overstory of poison ivy.

The Project: "A Proposal to Monitor Kanab Ambersnail at Vaseys Paradise, Grand Canyon National Park," is led by V. Meretsky of SWCA Inc. This is a one-year research and monitoring effort initiated in FY 98 and potentially renewable for one additional year with a proposed budget FY 99 of $43,511.

The objectives for this project are:

1. Relate food availability, habitat patch composition, area of cover, and condition at Vaseys Paradise to the historic and recent condition of those patches, and population requirements for sustainability.

2. Determine and statistically compare the historic (1995-98) and current population distribution, abundance, age-class/size distribution, population density, and condition (i.e., occurrence of KAS trematode parasite) of Oxyloma haydeni kanabensis at

Vaseys Paradise as it relates to natural variation and to the local stage-discharge relationship.

3. Evaluate the abundance of Peromyscus, a potential snail predator, at Vaseys Paradise.

Activities proposed by Meretsky involve conducting monitoring and research activities to determine how the KAS population at Vaseys Paradise may be affected by alternative dam operations and to distinguish natural population variation from the effects of dam operations.

Monitoring activities must be undertaken with limited impact to this fragile spring habitat, where researchers also will encounter dense stands of poison ivy and steep terrain. This project requires researchers to readily and reliably distinguish between Oxyloma haydeni kanabensis and two morphologically similar snail species.

GCMRC In-house Studies

In addition to the studies described above, GCMRC staff have proposed studies for FY 98 related to specific stakeholder objectives and information needs. These studies are currently undergoing independent, external peer review and are briefly described below:

a) The Project: Factors Influencing Benthic Standing Mass in the Colorado River.

Benthic production in Glen Canyon is thought to be significant for its trophic importance and linkage to other biological resources. Cladophora glomerata, the key filamentous benthic alga in this system serves as an important substrate for epiphytes, and as a food source for invertebrates and fish. Alternative dam operations may have critical effects on this trophically significant benthic production. Management of the regulated Colorado River is often compromised by a lack of understanding on how the interactions of flow regimes, dissolved constituents, suspended sediment loads, and light effect the food base in this aquatic ecosystem.

Therefore, resource managers will benefit from developing predictive aquatic food base models that are reliable and empirically based.

Light availability has been shown to be one of the key factors affecting benthic production in Glen and Grand Canyons. Understanding the availability of photosynthetically active radiation (PAR) and its role in primary production in this ecosystem is essential for developing a predictive model for benthic algal growth rates and standing mass. GCMRC has developed a preliminary model that incorporates existing hydrological data, predictive relationships and secondary models for sediment transport, channel morphometry, substrates, flow routing, solar insolation, optical properties, and primary production curves. Modeling availability of PAR provides both predictive and simulative capabilities for improving management of primary production in the Colorado River ecosystem.

The purpose of this GCMRC research proposal is to refine, validate and complete the model by addressing the monitoring and research objectives listed below: 1) monitor underwater light attenuation (K_O) for spatial and intra-seasonal variability, and continue to collect validation data for the primary production model, 2) determine growth rates (net photosynthetic and respiration rates) for Cladophora glomerata at varying irradiance, depths, temperatures and suspended sediment loads, and 3) determine standing mass susceptibility to drift and drift loss rates to Cladophora glomerata at varying velocities. The findings from this proposed research will provide the remaining empirical relationships for refining, validating and completing a primary production model.

b) The Project: Monitoring and Synthesis of Mainstem and Tributary Temperatures.

The purpose of this GCMRC proposed project is to analyze existed GCES / GCMRC temperature data collected during the 1991 research flows and over the last five years. This analysis will provide important information regarding longitudinal warming of the Colorado River from GCD to Diamond Creek during different times of the year and under different flow regimes, as well as the contribution to mainstem warming from tributary inflows.

c) The Project: Effects of GCD on Shoreline Habitat Suitability and Use by Native Fish.

An identified management need associated with native fish is to determine habitat use and availability. One of the proposed project's objectives is to determine the extent of shoreline fish habitat (talus, debris fan, eddy return channel etc.,) above and below the Little Colorado River, a primary spawning tributary of humpback chub and other native fish. Additional objectives include determining the effect of dam operations on suitable habitat, and estimating available habitat under different discharges (i.e., how much area of a particular habitat is available under a particular discharge).

The methods proposed to meet these objectives are to use existing GIS data (from 1965 - 1992) for some shoreline habitat (vegetation, eddy complexes) and augment these coverages with additional identified shoreline types. Coverages from 1965 will be used to define pre-dam conditions of shoreline habitat. Subsequent years' coverages will be used to estimate the effects of operations on shoreline habitat. Identified habitats and their availability under different discharges can be subsequently modeled using bathymetric data that currently exists for portions of the channel within the study area.

The project will use data developed during the GCES program, and will require little additional resources with regard to data collection. This project is intended to synthesize existing data in order to meet management information needs. Lastly, this project's primary resource expenditure is in the time of Dr. Ralston, and will require approximately a third of her time over 12 months. The results of this time investment will be to provide an inventory of shoreline habitat in a critical reach of the river (RM 60 - 72) and an idea of how this critical habitat changes with flow and discharge management. Lastly, this project emphasizes integration of research across disciplines another goal of the GCMRC.

d) The Project: Determine Genetic Relatedness of Ambersnail Populations and Review the Morphological Taxonomy of Ambersnail Species and Subspecies.

The succineid landsnail genus, Oxyloma, is represented in the American Southwest by two populations in each of two subspecies, the Niobrara ambersnail and the endangered Kanab ambersnail (O. h. haydeni and O.h. kanabensis, respectively). Recent genetics data reveal that all four southwestern ambersnail (Oxyloma h. haydeni and endangered O.h. kanabensis) populations may be distinct, but one Niobrara ambersnail population is more closely related to the type population of the endangered O.h. kanabensis than are the two O.h. kanabensis populations to each other. Because high flows from Glen Canyon Dam affect Kanab ambersnail at Vaseys Paradise, the taxonomic status of this endangered species is a primary concern for Colorado River ecosystem management. The objectives of this proposal are to determine the relatedness of other O. haydeni populations in the United States and Canada, and their relatedness to other Oxyloma species in United States. This information will provide sufficient insight into the taxonomy of this species complex and other members of the genus to resolve conflicts presented by the present

state of knowledge. The researchers will collect specimens from approximately 20 Oxyloma populations, conduct amplified fragment length polymorphism genetic analysis on those populations, and convene a panel of independent experts to review North American Oxyloma taxonomy. This is a one-year project, and the results should contribute substantially to addressing Kanab ambersnail information needs.

This GCMRC proposal was submitted by two eminently qualified researchers who are intimately familiar with the ecology, distribution and genetics of the genus Oxyloma. In addition, the project will include the participation of the recognized authority on Oxyloma morphology. GCMRC recognizes the need for this synthesis, and pending approval of the proposal by the independent peer-review process, GCMRC intends to support this project.

e) The Project: Synthesis of Backwater Information.

Recruitment failure of native fish in the Colorado River is one of the most significant ecological problems attributed to Glen Canyon Dam operations. The authors of this study propose to synthesize existing information regarding the changing availability of backwater habitats for young native fish in the Colorado River downstream from Glen Canyon Dam. Cold-stenothermic releases from the dam and the introduction of non-native fish species have limited the recruitment niche for young native fish to "safe nursery" sites in this system. Mainstream refugia for young fish exist in some Colorado River backwaters, which provide low-velocity, near-shore habitats that may warm substantially above the cold temperature of the mainstream. Short-term (hourly, daily, weekly and seasonal) fluctuating flow releases from Glen Canyon Dam reduce habitat availability by dewatering or flushing these backwater habitats, and longer-term (yearly and longer) impacts of flood control result in terrestrialization of these habitats. The spatial habitat

scale most relevant to a young fish is that of an individual backwater: if a backwater is flushed by high, cold mainstream flows the young fish may not tolerate the increased velocity and decreased temperature of the mainstream.

Synthesis of backwater habitat availability requires tracking the area and volumetric changes of individual backwaters over time and under different tributary and mainstream discharge patterns. The project objectives are to analyze aerial photography and videography collected from the river corridor from 1965 to 1997 to determine: (1) whether the area of individual Colorado River backwaters >100m^2 has changed over post-dam time (1965 to 1997), and whether reach-based and system-wide patterns of change exist in the context of individual habitat changes; (2) how the area of individual Colorado River backwaters >100m^2 in area changed across the stage-discharge relationship in the early 1990's and the late 1990's, and
whether these two time periods display comparable patterns in relation at individual, reach-based and system-wide spatial scales; and (3) whether backwater volume as a function of stage elevation of selected large, characteristic Colorado River backwaters has changed from 1990 to 1997 in relation to tributary and mainstream sediment transport

This GCMRC proposal was submitted by two researchers who are intimately familiar with the historic data base and analytical techniques, and both have the extensive, long-term familiarity with the Colorado River ecosystem required to accomplish this project. This is not a monitoring effort, but relies largely on existing data and imagery. GCMRC recognizes the need for such a synthesis, and pending approval of the proposal by the independent peer-review process, GCMRC elects to support this project.

Support for these in-house studies will account for less than 10% of the budget of the GCMRC biological resources program and is in keeping with the recommendation of the National Research Council (NRC, 1996) that the majority of research funding go to support external activities. In addition, utilization of GCMRC scientific expertise to undertake these studies will contribute to effective synthesis, largely of existing GCES/GCMRC data, that will contribute to the development and refining of conceptual and predictive models of Colorado River ecosystem processes and function.

Protocol Evaluation

GCMRC biological resources program staff propose to initiate protocol evaluation in FY 98 and continue this in FY 99 through the use of visiting committees of three scientists with relevant expertise in the field of study, as funding permits.

The strategy would be to identify a lead reviewer with relevant expertise in the field of study and work with that reviewer to identify two additional reviewers. These reviewers would be provided with the past two to three years of reports from a given project as well as the currently funded proposal to review. They would be invited to meet with the current PI(s) for a series of project briefings immediately before a scheduled river trip. They would accompany the PI(s) on a river trip to evaluate their field methodology and gain familiarity with the ecosystem.

The reviewers would be expected to provide a rigorous review of the protocols currently in use and recommendations for changes in protocols, as appropriate. This information would be used in designing the FY 2000 monitoring program.

Unsolicited Proposals

No biological program resource funds are currently budgeted in support of unsolicited proposals.

Program Operations/Logistics

These program funds represent the costs associated with the support of river trips associated with GCMRC biological resource projects and the support of the conceptual modeling workshops for FY 99. Previously, logistical costs were a separate GCMRC program line item.

The Contribution of the FY 99 Program to the Strategic Plan

The FY 99 program is linked to the stakeholder objectives and information needs. The information gained from the proposed synthesis, monitoring, and research activities when combined with the results of the conceptual modeling effort will make significant contributions to understanding the key components and processes that structure the Colorado River ecosystem. This information will be critical to the design of a sound long-term monitoring and research program that can be initiated in FY 2000.

FY 98 & FY 99 Biological Sciences Program Budgets

	Program Activities	**FY 98**	**FY 99**
1)	Proposal to Monitor the Aquatic Food Base Dean W. Blinn & Joe P. Shannon Northern Arizona University	$166,343	$178,086
2)	Proposal to Monitor the Native Fish Owen Gorman et. al.. U.S. Fish and Wildlife Service	$524,946 ($441,160)[13/]	$524,990 ($441,168)
	Additional Activities: -- Second Population of HBC -- Overwintering Mortality of HBC -- Endangered Fish Research Flows	$ -0- $ -0- $ -0-	$ TBD[14/] $ TBD $ TBD
3)	Proposal to Monitor the Rainbow Trout Fishery William R. Persons et al. Arizona Game and Fish Department	$125,000	$125,000
	Additional Activities: -- Lees Ferry Trout Symposium	$ TBD	$ -0-
4)	Proposal to Monitor Wetland and Riparian Vegetation Tina Ayers and Mike Kearsley Northern Arizona University	$ 78,060	$ 79,980
5)	Proposal to Monitor Avifauna and the Southwest Willow Flycatcher John Spence Glen Canyon National Recreation Area	$ 75,800	$ 80,900
6)	Proposal to Monitor the Kanab Ambersnail at Vaseys Paradise Vicky J. Meretsky & Dave Wegner SWCA, Inc.	$ 43,511	$ 43,511
	Program Activities	**FY 98**	**FY 99**

[13/] Reflects costs assuming waiver of overhead costs.

[14/] TBD = Cost to be determined as scope of activity is developed.

7)	Proposal to Develop an AEAM Model ($209,700) for the Colorado River Ecosystem Josh Korman, Ecometric Research Inc.	$ 70,000[15/]	$ 50,000
8)	Data Integration Report Ron Borkin, SWCA, Inc.	$ 20,000	$ -0-
9)	GCMRC In-house Studies[16/]		
	a) Factors Influencing Benthic Standing Mass in the Colorado River Mike Yard, GCMRC	$ 40,000	$ 40,000
	b) Mainstem and Tributary Monitoring Jeanne Korn, GCMRC	$ 3,000	$ -0-
	c) Effects of GCD on Shoreline Habitat Suitability and Use by Native Fish Barbara Ralston, GCMRC	$ 5,000	$ -0-
	d) Genetic Relatedness between Ambersnail Populations Larry Stevens, GCMRC	$ 34,000	$ -0-
	e) Synthesis of Backwater Information Larry Stevens, GCMRC	$ 46,000	$ -0-
	f) Protocol Evaluation	$ -0-	$ 40,000
	g) Synthesis and Data Integration	$ -0-	$ 20,000
10)	Contingency Funds / Unsolicited Proposals	$ -0-	$ --
11)	Program Operations/Logistics	$200,000	$200,000
	TOTAL[17/]	**$1,431,660**	**$1,382,467**
	($1,347,874)	($1,298,645)	

[15/] This program is also funded through contributions from the Physical and Cultural Resource programs.
[16/] Proposals all relate to Stakeholder Objectives and are currently undergoing independent, external peer review.
[17/] It is assumed that some level of overhead reduction will be negotiated with FWS which will prevent over spending of budget. In addition, two of the projects will provide their own logistics resulting in a savings from the funds budgeted for logistics ($200,000) of approximately $20,000.

THE SOCIO-ECONOMIC RESOURCES PROGRAM

Program Background

There are many socio-economic resources associated with the Grand Canyon riverine environment including recreation (i.e., boating, fishing, hiking, sightseeing), electric power, and water storage and delivery. Further, due to the biological and geologic distinctiveness of the Colorado River corridor, the Grand Canyon National Park has acquired national and international recognition, and all of the resources in the canyon are considered to be significant to the public.

The FY 96 and FY 97 socio-economic resources programs were reduced from the FY 94 and FY 95 programs, where studies were undertaken to evaluate non-market impacts of alternative dam operations. Although several projects in other resource areas have linkages to socioeconomic parameters and resources, (i.e., trout, sandbars, birds) only two projects in FY 97 were specifically oriented to socioeconomic assessments of alternative dam operations as follows:

1. Transition monitoring of riparian plant beach invasions and beach habitat building in Grand Canyon National Park.

2. Beach campsite area changes resulting from the beach habitat building flow.

These projects related to changes in recreation benefits resulting from a modified flow regimes. Both projects were completed in FY 97/FY 98, and are terminated as of FY 99. After a synthesis effort in FY 98, the socio-economic program, including campsite beach studies, are redesigned for FY 99.

Stakeholder Information Needs

Information needs specified for this resource area in the Strategic Plan cover issues of camping, beaches, water safety, sports fishing and wildlife (waterfowl) viewing and hunting. Following are a synopsis of specified information needs:

1. Determine criteria and aspects that are important to, or detract from the wilderness experience.

2. Determine adequate beach quality, character and structure for camping throughout the system.

3. Determine if operating criteria maintains safe and adequate power craft navigability in Glen Canyon and upper Lake Mead.

4. Determine flow regimes necessary to maintain fish populations of 100,000 adult Trout (age class II plus).

5. Define pattern of waterfowl and other wildlife use and conflicts to other uses.

The FY 99 Socio-economic Program

The FY 99 Program emphasizes several areas through monitoring and research projects as well as cooperative and volunteer programs as follows:

1. Use past monitoring, research and cooperative studies to develop synthesis of campsite beach changes through time associated with differing flow regimes, i.e., camping area, vegetation changes, etc.

2. Research user preferences and attitudes assessing wilderness experience relative to differing flow regimes.

3. Monitor trout anglers use and satisfaction through creel census and cooperative monitoring program with fishing guides and Trout Unlimited.

4. Evaluate effectiveness of new monitoring protocols for long-term assessments of camping beach changes from differing flow regimes.

5. Monitor beach changes and user preferences through cooperative programs with boating guides.

The FY 99 program will be conducted through various projects and programs as follows:

Evaluating Potential Future Campsite Beach Changes Over 30 Years Under ROD Dam Operations. This project will be developed through a 1-year RFP at a cost of $20,000. This project will have the following objectives:

1. Using aerial photography and FY 98 GCMRC study of beach changes define the changes that have occurred in beaches from the 1950s to present time above and below LCR by area.

2. Using past and current research studies, identify and associate these change factors that are related to dam operations.

3. Develop predicting methodologies to forecast on developed science and data 30-year potential future changes in beaches under ROD dam operations.

Evaluating User Preferences of Wilderness Experiences in the Grand Canyon. This 1-year potentially renewable RFP project initiated in FY 98 will be completed in FY 99. FY 99 costs are projected at $25,000.

Objectives of the project are as follows:

1. Develop updated preferences and attitudes of recreational users of the Grand Canyon riverine corridor.

2. Evaluate potential changes in preferences and attitudes associated with differing operation regimes for Glen Canyon Dam.

Evaluating Trout Angler User and Satisfaction in the Lees Ferry Reach. This program will be developed through a Proposed Cooperative Program involving fishing guides, Trout Unlimited, Arizona Game and Fish Department, and GCMRC staff. The goals is to establish a minimal cost

but more robust monitoring of user sport fishing satisfaction in the Lees Ferry Reach. It is projected that approximately $5,000 in total costs will be allocated to this project.

Objectives of this project are to:

1. Develop a pilot test low cost cooperative program that provides use and catch data for differing yearly time periods and dam operations.

2. Develop a pilot test trout fisherman satisfaction rating system to assess satisfaction under differing dam operations.

Evaluate Effectiveness of New Monitoring Protocols for Assessing Campsite Changes under Differing Dam Operations. This project, initiated as an RFP in FY 98, is potentiall renewable in FY 99. Although conducted under Physical Resources, it has a FY 99 cost in this program of $10,000. Objectives are specified in the Physical Resources Program, and focus on assessment of hydrography and videography as new, more cost effective protocols for monitoring beach changes through time under differing dam operations.

Cooperative Programs to Assess Boaters' Interpretation of User's Attitudes and Changes in Campsite Beaches. Boating guides are the primary contact for boater recreationists using the Colorado River of Grand Canyon. A pilot program is proposed to evaluate improved cooperative methods of monitoring user reactions to changes in flow regimes and boating use satisfaction at differing flow regimes. It is projected that a cost of $3,000 in GCMRC staff and resources will be obligated.

Objectives of the program are to:

1. Develop a pilot monitoring program of user satisfaction to be administered by boating guides.

2. Contrast findings with studies of boating satisfaction under differing flow regimes on other rivers.

GCMRC Budget Allocations

The expected FY 99 budget allocations to this program is as follows:

Socio-economic Program Elements and Costs

Project	Cost
Projecting 30-year Campsite Changes	$20,000
Wilderness Experience Preferences	25,000
Evaluating Trout Anglers' Satisfaction	5,000
New Campsite Monitoring Protocols	10,000
Evaluating Boater Satisfaction	3,000
Projected Total Costs	**$63,000**

THE LAKE POWELL PROGRAM

Program Background

The effects of the construction and operation of Glen Canyon Dam have been studied, documented, and manipulated in the downstream environment in Grand Canyon. Glen Canyon Environmental Studies led 13 years of study that focused on addressing and mitigating the adverse impacts of the Dam on the Colorado River ecosystem.

While data has been collected from Lake Powell throughout its filling history, there has been no concerted effort to evaluate the impacts of dam operations on the physical, biological, and chemical processes of the reservoir and downstream releases.

Using data from the 33-year history of water quality monitoring on Lake Powell, primarily from Reclamation efforts, GCMRC demonstrated the effect of dam operations and other factors on the water quality and hydrodynamics of Lake Powell in FY 97. Of special importance in this analysis were the historical record reflecting the flood years of 1980 to 1986, modified operations of Glen Canyon Dam which began in 1991, the results from the Spring 1996 Experimental Beach/Habitat-Building Flow, and most recently, the high sustained releases starting in February 1997.

No special data collection was designed to answer the question, but rather, the stock of existing data was analyzed to provide the answers and fuel the questions that formed the assessment. The results show that, combined with other influences, dam operations have an undeniable effect upon the stratification and mixing of the reservoir, and those effects are consequently passed downstream through the dam.

Not all aspects of dam operations could be answered or analyzed under the scope of the nine months allowed for this assessment. However, the experimental flood of 1996 demonstrated the effects of using alternate structures for the release of water, in this case, the hollow jet tubes that are positioned 100 feet below the penstock withdrawal ports. The historic record of the 1980s indicated that the combination of high and repeated spring floods and high and sustained discharge from penstocks as well as spillways and hollow jet tubes caused substantial mixing of the reservoir. The recent Spring's high-sustained releases that were not initially accompanied by high inflow demonstrate the isolated effects of above average powerplant withdrawal.

Stakeholder Information Needs

In September 1997, the AMWG evaluated GCMRC's assessment of Lake Powell water quality impacts from dam operations, and determined they were significant enough to warrant further assessments under the AMP. The GCMRC is directed to continue its FY 98 program into FY 99 or until such time that the AMWG/TWG can propose new information needs for this program.

The AMWG has directed the TWG, working with the GCMRC, to cooperatively develop longer term management objectives and information needs for the program. These activities are to be completed by April 1998 (FY 99).

FY 99 Program

The AMWG has directed the GCMRC to continue current programming in Lake Powell until information needs are specified by the TWG in April 1998 for a longer term program. In May/June 1998 the GCMRC, in cooperation with the TWG, is to develop a longer term

monitoring and research program based on these specified information needs. The program will be reviewed by the AMWG in July/August 1998.

Objectives of the FY 99 Lake Powell Program involve sampling as follows:

1. Quarterly lake-wide sampling.

   Based on characteristic seasonal patterns and conditions, lake-wide sampling is conducted on Lake Powell on a quarterly basis. Efforts are made to describe the physical and chemical conditions of the entire reservoir in the main Colorado River channel and the major tributary arms of the San Juan and Escalante Rivers.

   Sampling takes place over a week-long period and consists of measurements and chemical samples collected at 20-25 established stations along the main channel and major tributary arms. After initial surface observations are made, a profile of the physical parameters of temperature, specific conductance, dissolved oxygen, ph, redox potential, and turbidity throughout the water column is collected. This provides details of the density stratification patterns separating the significant layers of the reservoir, location of inflow currents, dissolved oxygen patterns and overall chemical conditions in the reservoir. Results are recorded on portable data logging equipment for immediate viewing in the field and automated transfer to data management systems.

   Based on the stratification patterns seen from the physical profile, depths for discrete chemical sampling are determined, with the objective of characterizing the major ion and nutrient content of the significant layers of the reservoir. Sample

processing is performed on shipboard for later analysis at a remote laboratory. Alkalinity titrations of these samples are also performed on shipboard.

Biological sampling consists of chlorophyll sampling of surface samples, collection of discrete samples for phytoplankton and vertical tows for zooplankton.

2. Monthly forebay sampling.

Monitoring of the forebay of Lake Powell is performed monthly at the Wahweap station, in the main channel at the confluence with Wahweap Bay, 2.4 channel kilometers upstream of Glen Canyon Dam. Sampling similar to that for lake-wide stations is also performed.

3. Tailwater monitoring.

Continuous water quality samples are maintained at three locations in the Glen Canyon Dam tailwater. The first and most long-term running station is a perforated pipe below the river outlet works hollow jet valves, immediately downstream of the Glen Canyon Dam powerplant on the left wall. This site has been in operation since August 1980 measuring temperature and specific conductance at intervals of 2 hours or less. Dissolved oxygen monitoring was initiated November 1990; pH measurements were started July 1995.

A second station is near the Lees Ferry stream gage, in operation since October 1991, recording temperature, specific conductance, and dissolved oxygen; pH measurements were added August 1996.

Lake Powell Conceptual Modeling

As part of the overall synthesis to guide monitoring and research programs in Lake Powell, a conceptual modeling effort will be initiated in FY 99. This adaptive environmental assessment and management (AEAM) model will be used to: (1) guide monitoring and research planning, (2) more clearly define critical attributes and linkages within and between resource categories, (3) promote improved understanding of key factors that drive changes in the system, (4) make qualitative assessments of resource change resulting from alternative dam operations, and (5) provide information to stakeholders and managers regarding the potential impacts of alternative dam operations on the Lake Powell ecosystem and associated resources. Completion of this conceptual model in FY 99 will provide an important tool for organizing the GCMRC's understanding of the Lake Powell ecosystem and the effects of dam operations.

GCMRC conceptual modeling activities were initiated in FY 98 with a focus on the Colorado River ecosystem, and is proposed for continuation in FY 99 with the following objectives related to Lake Powell:

1. State of Science assessment for development of a Lake Powell ecosystem model, identification of key information gaps and setting priorities for monitoring research.

2. Scoping meetings to define scope of Lake Powell model, design modeling workshop and identify participants.

3. In two workshops, develop a prototype model for Lake Powell with qualitative assessment capability.

Development of the Lake Powell conceptual model will require modification of the FY 98 RFP to develop a conceptual model of the Colorado River ecosystem or the issuance of a new RFP for FY 99.

In FY 99 for the Lake Powell model, the GCMRC, together with the selected modeling team, will convene scoping meetings to define the problem scope, design subsequent modeling workshops, identify key people (scientists and stakeholders) to participate in the modeling workshops, and to assemble information that will be used in the first workshop.

Following the scoping meeting, an initial modeling workshop will be convened in FY 99 to develop explicit relationships among Lake Powell attributes. This workshops will involve scientists and stakeholders knowledgeable about the Lake Powell ecosystem. Scientists and stakeholders together will define resource variables/attributes that serve as linkages between/among resources. The goal for the first workshop is to produce a conceptual model of the Lake Powell ecosystem based on critical relationships that structure the system, identify key information gaps, and suggest initial priorities for a long-term monitoring and research program.

A second modeling workshop will be held in FY 99 on the Lake Powell ecosystem. This workshop will be to refine the conceptual model with first approximation parameter estimates, that can be used to evaluate resource responses to different management strategies.

During the second workshop the process of assigning more definitive co-efficient values to what are believed to be key model parameters will begin, as well as model validation and sensitivity analysis to test key assumptions embedded in the model. Analysts will begin to explore the consequences of alternative dam operations based on the assumptions and hypothesis used to

construct the model. This second workshop is intended to yield a first approximation prototype model that, in association with new synthesis information being developed in FY 99, will provide sound basis for development of a more robust long-term monitoring and research plan for the Lake Powell ecosystem.

This program will take place in FY 99 with progress reports due following the scoping meeting and each workshop. The final report will contain an executive summary, suitable for dissemination to management entities. Upon completion, the conceptual model will be delivered to the GCMRC in appropriate electronic format and with suitable documentation to allow GCMRC managers to operate and further develop the model.

Lake Powell Budget

The Lake Powell program operations budget for FY 98 and FY 99 is $250,000. No additional programming or funds will be allocated until a new program is proposed by the AMWG.

INFORMATION TECHNOLOGIES

Program Background

The function of the information technology program is to satisfy the information needs of stakeholders, scientists, and the public relative to the GCMRC study area. Extensive data and information currently exists in the GCMRC database relating to resource conditions and their relationship to other resources. This information represents a valuable resource to researchers, manager, and interested stakeholders, but some of it has not been analyzed. Its potential utility for problem solving, formulating improved management guidelines, modeling relationships, or increasing understanding of the various resources and systems under study, justify an aggressive program of information acquisition, management, and evaluation.

The information technology program embraces the principles and objectives of the National Information Infrastructure (NII), the National Biological Information Infrastructure (NBII), and the National Spatial Data Infrastructure (NSDI). Guidelines and protocols promulgated by these infrastructures will be incorporated into the overall database design and delivery systems whenever possible. Implicit in the plan is support of the objective to increase access, sharing, and application of data among public and private cooperators and partners. The program recognizes that guidelines and protocols have not been established for all aspects of biological and spatial data warehousing. When lacking, the plan allows establishment of its own guidelines and protocols that will adhere as closely as possible to the intent and spirit of the infrastructures.

The information technology program is committed to making public data freely available to stakeholders, researchers, and the public while at the same time protecting sensitive and confidential data provided by private entities for the purpose of evaluating the Colorado River resources. To ensure critical access to developed data, scientists will be expected to provide their data to GCMRC after a reasonable period of exclusive use, currently being addressed by the TWG working group on data protocols. However, in some cases, such as archaeological-site data the Indian Tribes define as sensitive, or information on localized endangered species, a level of confidentiality will be necessary.

Objective of the Information Technology Program

The objective of the information technology program is to satisfy the information needs of stakeholders, scientists, and the public relative to the GCMRC study area.

Dependencies of a successful information technology program

The information technology program at the GCMRC is dependent upon several key components for it to successfully execute its objective:

1. An information system infrastructure capable of a state-of-the-art centralized data storage and delivery systems incorporating a high degree of information technology integration.

2. Strict data standards and protocols which assures the validity of data contained in the information system and facilitates the integration of data collected by different researchers at different times.

3. Cooperation among contributing Tribes, institutions, and agencies concerning timely transmittal of data relating to the GCMRC study area.

Building an Information Technology Program

Building an information technology program at the GCMRC requires the four following steps that result primarily from the dependencies of a successful information technology program:

1. Build the infrastructure;
2. Develop the data standards and protocols;
3. Populate the database;
4. Develop user interfaces.

Each of these steps are, however, monumental in themselves when considering that they need to built from the ground up incorporating legacy data collected over a 10-year period.

Build the infrastructure

The infrastructure of the information system consists primarily of the computer hardware and software needed to warehouse, access, report, and analyze the data. This requires careful selection of hardware and software to enable a tightly integrated system requiring minimal administration. The information infrastructure at the GCMRC depends upon the successful exploitation and integration of several key information technologies:

1. Database management system;
2. Geographic information system;
3. Computer hardware, software, and networking;
4. World Wide Web.

Aside from application of information technology to the warehousing of data, but no less important, is the ability of the information users to easily access, query, and obtain data from the information system. A process needs to be established by which the information user knows how to find and obtain the information he/she is looking for. Therefore, an additional key area of concern is adequate documentation and training in the use of the information system. Successful

application of information technology, a well defined process for obtaining data, and thorough documentation and training culminates in an information system that is accessible and easy to use.

Although the objective of the information technology program is to provide a centralized DBMS, it is our policy not to duplicate data warehousing already provided by other entities. In these circumstances it would be preferable to interrogate the remote database through an ODBC link when possible. However, the GCMRC will act as a clearinghouse of data owned by other entities in the case where remote database interrogation is not possible. In both of these cases, a common interface can be developed which will facilitate dissemination of data to interested parties.

Warehoused data will conform to the National Information Infrastructure (NII), the National Biological Information Infrastructure (NBII), and the National Spatial Data Infrastructure (NSDI). Guidelines and protocols promulgated by these infrastructures will be incorporated into the overall database design and delivery systems whenever possible.

The infrastructure will provide for database connectivity to compatible data analysis packages such as graphics, statistics, and GIS software, and World Wide Web interfaces.

Develop the Data Standards and Protocols

Development of data standards and protocols ensures that data contained in the information system is valid data and that the data can be integrated with data collected by different researchers at different times. Data standards define field descriptors within the database such as definitions, formats, units, significant figures, decimal places, etc. Protocols define standard

operating procedures for data collection, entry, and verification, which include quality control and quality assurance procedures, that guarantee the integrity of the warehoused data.

Populating the Database

Data and document holdings of interest to GCMRC will be identified by conducting an assessment of data and document holdings of interest to the GCMRC. Once holdings have been identified, they will be classified as to type and format. Database structures will be developed and the database populated. Since electronic data provides the greatest degree of dissemination with the least impact on GCMRC resources, holdings not currently in digital format but which can be converted to digital format, will be converted to digital format. This will be accomplished using digitizers, scanners, optical character recognition, and other automated data input and software processing technologies.

Developing User Interfaces

Indexing and retrieval of data, once in the database, will be accomplished by using existing DBMS, ftp, gopher, and WWW technology utilizing browser interfaces. The browser interface has the advantage of providing a consistent interface to the various technologies used by the infrastructure that will be intuitive to information users familiar with the Internet.

Outreach will be provided to stakeholders, partners, and the public in the form of training in the retrieval and utilization of electronic and paper data. Specifically, areas of training will include data and document retrieval interfaces to WWW enabled databases and GIS. Outreach will also be provide for public announcements, notifications, press releases, etc. and topics of

interest via WWW pages and newsletters. The GCMRC will also aid stakeholders in acquiring and using technology needed to fully exploit information systems developed by the GCMRC.

Ancillary Information Technology Program Services

System Administration of Computers and Networks

Computer hardware and operating systems at the GCMRC will largely be a combination of state-of-the-art Intel processors running Windows NT. Each workstation will have a core suite of software applications available that will include mainstream off-the-shelf integrated office products such as a word processor, spreadsheet, graphics, database, browser, etc. Additional software needed for specialized scientific data processing will also be available. To the extent possible, hardware and software will be standardized throughout the GCMRC. The information technology program anticipates standardization will facilitate inter-office exchange of information and reduce the administrative effort of hardware and software support to a level sustainable in-house.

A primary objective of the plan is to improve overall system performance, reliability and maintenance. T he information technology program believes that this can best be achieved by having competent individuals in-house trained in the administration, maintenance, and troubleshooting of the computer system. However, computer administration comes at a high cost in terms of manpower and expertise. A brief analysis of the current GCMRC computer environment has identified that most problems occur at the application - operating system - local area network layer and that few problems occur at the wide area network, or Internet, layer. Internet connectivity infrastructure can be very expensive. Therefore, it makes fiscal sense that Internet connectivity and associated services such as DNS, mail, and news will continue to be

administered by entities outside the GCMRC. Most notably the U.S. Geological Survey in the case of the Gemini office and U.S. Bureau of Reclamation in the case of the Bank of America office.

Geographic Information System (GIS) Services and GIS Library

Geographic Information System (GIS) services will be provided by the information technology program to stakeholders, researchers, and GCMRC staff. In addition to providing GIS services, the program will operate a clearinghouse of GIS coverages and metadata relevant to the GCMRC study area and populated by GCMRC studies and contributed data. A GIS specialist has been identified and is being trained for this assignment.

The GIS program is committed to the principles and objectives of the NII and NSDI. As such, guidelines and protocols promulgated by these infrastructures will be incorporated into the overall program design and development with specific consideration given to GIS metadata standards.

Library Services

A library containing written reference material, aerial photos, maps, videography, etc. will be maintained by the Information Technology group. The library will be a formal undertaking appropriately staffed to facilitate the archiving and dissemination of information in hard copy form to interested entities in a logical and safe manner. A bibliography of library holdings will be made available in searchable form on the WWW.

World Wide Web Publishing Services

The information technology program will operate a WWW server dedicated to the dissemination of information about its program. Pages will be developed specific to the needs of the Technical Work Group and the Adaptive Management Work Group to facilitate the dissemination of reports, minutes, and other documents in an efficient and timely manner.

PROGRAM TASKS AND TIMETABLE

Database

1.1 Identify and purchase additional hardware and software - FY 98

- 1.1.1 Database server hardware
- 1.1.2 Database Management software

1.2 Install software - FY 98

1.3 Conduct data assessment - FY 98

- 1.3.1 Assess historical data collected by GCES
  - 1.3.1.1 Identify field locations where samples have been collected
  - 1.3.1.2 Identify data collected at each location
- 1.3.2 Assess present and near-term future data collection activities
  - 1.3.2.1 Identify field locations where samples will be collected
  - 1.3.2.2 Identify data to be collected at each location

1.4 Compile list of data items to database - FY 98

1.5 Define field descriptors for each data item - FY 98

- 1.5.1 Definitions, format, units, significant figures, decimal places

1.6 Develop relational database structure - FY 99

1.7 Populate the database - FY 99

1.7.1 Electronic transfer

1.7.2 Data entry

1.8 Develop database interfaces - FY 99

1.8.1 Web interfaces

1.8.2 Forms and reports

1.9 Develop Lake Powell prototype - FY 99

SOP's and Verification Protocols

2.1 Identify data collected by GCMRC - FY 98

2.2 Develop SOP-s for data collection - FY 98

2.3 Develop verification protocols - FY 98

Protocols for Data Availability

3.1 Organize working group on data protocols - FY 98

3.1.1 Identify issues surrounding distribution of sensitive data

3.1.2 Develop protocols to protect sensitive data

Data Standards

4.1 Determine how data should be submitted to GCMRC - FY 98

4.1.1 Field descriptors - definitions, format, units, significant figures, decimal places

4.1.2 Metadata standards

Geographic Information System Services

5.1 Identify and purchase additional hardware and software - FY 98

5.1.1 GIS server hardware

5.1.2 GIS software

5.2 Install software - FY 98

5.3 Adopt metadata protocols - FY 98

5.4 Assessment of current data - location and format - FY 98

5.5 Begin creating and assimilating spatial data coverages into a library - FY 99

5.6 Catalog and organize GCES holdings - FY 99

Computer Hardware, Software, and Administration

6.1 Upgrade existing PC-s with Windows NT 4.0 - FY 98

6.1.1 Evaluate software compatibility issues with Windows NT

6.1.2 Resolve issues or don't upgrade

6.1.3 Identify administration functions we need to implement

6.1.4 Identify functions of Novell servers

6.1.5 Evaluate NT server in terms of these identified functions

6.2 Identify and obtain licensing for standard suite of software - FY 98

6.3 Identify and purchase equipment for upgrading network at Bank of America office location - FY 98

6.4 Begin in-house system administration - FY 98

Library - Maps, Photos, Documents

7.1 Assess the state of the library - FY 98

7.2 Identify scope and function of the library - FY 98

7.3 Organize library - FY 98

7.3.1 Catalog and organize holdings

7.3.2 Develop protocols for distribution and use of library holdings

Outreach

8.1 Develop instructions and training in the use of database interfaces - FY 99

8.2 Provide assistance in the application of information technology - FY 99

Website

9.1 Put Web server online - FY 98

9.2 Design and implement website - FY 98

9.2.1 GCMRC general home page

9.2.2 GCMRC technical home page

9.2.3 AMWG page

9.2.4 TWG page

INFORMATION TECHNOLOGIES BUDGET

The approved program budget for FY 99 is $408,000. FY 99 and FY 2000 will be accelerated budgets for this area to accommodate development and analysis of extensive older data sets.

CHAPTER 4

PROGRAM ADMINISTRATION

ORGANIZATION STRUCTURE

The GCMRC is restructuring to accommodate the challenges of both the Strategic Plan and the FY 99 Annual Plan. Three program managers (physical, biological, and cultural, Lake Powell) will manage the individual resource areas and together with the chief, continue to create greater focus on evaluation of ecosystem resource interactions and integration under differing dam operations. An information technologies director will oversee an extensive program of data analysis and management, GIS technology and information transfer.

Positions that will be critical to stakeholders are defined in the following text as to their primary roles.

Logistics Coordinator. The GCMRC has decided to conduct all logistics for its programs internally in FY 98 and FY 99, with direct coordination with appropriate NPS offices. This effort is projected to reduce logistics costs by up to 25% from FY 97 to FY 99. All river trip logistics and permitting, air photography, rescue, etc, will be programmed by the logistics coordinator in cooperation with the NPS. An annual logistics plan will be drafted, incorporating joint GCMRC/NPS workshops for principal investigators, and published guidelines for permitting and reporting.

Review Coordinator. All completed proposals, PI reports, GCMRC reports, cooperative programs, etc. will be subjected to specific independent review protocols of the GCMRC. Monitoring and research projects to be subjected to competitive reviews and awards will be

specified each year in the Annual Program Plan. This program, under the Associate Center Chief, who also currently serves as the Biological Resources Program Manager, will be managed by a Review Coordinator, currently a member of the Biological Resources Program staff. The Review Coordinator can be contacted by PIs and/or their organizations, managers and other stakeholders to access critical documents detailing GCMRC programs.

All research proposed by GCMRC program managers and scientists with annual salary/operating expenses greater than $20,000 will undergo an independent external review and will be included in the Annual Plan. Such projects, if one year in nature, will also conform to the above reporting schedule.

A Programmatic Agreement Task Group Is proposed to facilitate articulation between the Cultural Resource Program and the Programmatic Agreement program. The Task Group will consist of the GCMRC Cultural Program Manager, Bureau and NPS managers, and tribal representatives.

A Biological Opinion Task Group will be linked to the Biological Resources Program Managers office. It will assure GCMRC responds, as appropriate, to the monitoring and research needs of the Bureau and USFWS. The Task Group will consist of the GCMRC Biological Resources Program Manager and appropriate representatives of BOR and FWS. All proposed activities will be reviewed by the AMWG.

Coordinators are specified for Data Base Management, GIS and Technology Transfer programs. These positions will assure critical timely support to managers and other stakeholders in their interactions with the GCMRC, especially in their requests for information.

Independent Review Panel(s) will be utilized to evaluate GCMRC's Strategic and Annual Plan, review proposals submitted to GCMRC for potential funding, review reports resulting from GCMRC sponsored activities, and provide advice to GCMRC and the AMWG. These panels include the National Research Council which will be asked to review GCMRC's Strategic and Annual Plans, independent external peer-reviewers and review panels, which are used as needed to review proposals and reports, and a proposed Science Advisory Board which can provide advice to both the AMWG and GCMRC on the effectiveness of the overall science program.

In regard to the above, GCMRC proposes to establish in cooperation with the AMWG, a Science Advisory Board (SAB). The SAB would satisfy the GCDEIS requirements for an Independent Review Panel. This group of approximately ten scientists, selected on the basis of their record of scientific accomplishment, would provide information to the AMWG on the effectiveness of GCMRC programs. It would provide guidance to GCMRC on long-term and annual plans, program structure and information technology. The SAB would meet annually with the AMWG and GCMRC staff to provide council on overall program direction.

PROGRAM SCHEDULE

The FY 99 Annual Plan Schedule:

The tentative schedule for implementation of the FY 99 plan is as follows:

January 15-16, 1998	AMWG review of FY 99 Annual Plan and recommendations for implementation
January 30, 1998	Announcement of intent to issue RFPs
March 1, 1998	Review of FY 96/97 program accomplishments and new monitoring and science protocols
March 1, 1998	Release of RFPs
March 16, 1998	Develop Overview package for potential researchers and reviewers
April 1, 1998	First Progress Report due on FY 98 program activities
June 1 , 1998	Receipt of Proposals for FY 99 program
July 1, 1998	Second Progress Report due on FY 98 program activities
August 3, 1998	Panel Review of FY 99 Proposals
August 21, 1998	Notification of Intent to Award FY 99 Contracts
September 1, 1998	Draft Final Report due on FY 98 program activities
October 1, 1998	Award Contracts
October 1, 1998	Logistics Plan for FY 99 program
October 15, 1998	Draft FY 2000 Annual Plan and FY 99 "State of Colorado River Ecosystem Resources" for review by TWG/AMWG
November 15, 1998	Approval of NPS permits on FY 99 program activities
December 1, 1998	Final Reports on FY 98 programs with all contract deliverables
December 15, 1998	Final "State of Colorado River Ecosystem Resources" report to AMWG
January 1999	AMWG approval of FY 2000 Annual Plan and recommendations for implementation

ADAPTIVE MANAGEMENT PROGRAM BUDGET

The FY 99 budget for the Adaptive Management Program is proposed at $7,193,000. The GCMRC anticipates the budget level will accommodate the FY 99 Annual Plan, if the plan is approved without significant changes. Following are the tentative budget allocations toward the FY 99 Adaptive Management Program.

• Bureau Administration of AMWG	147,000
• Bureau Administration of TWG	64,000
• Bureau Administrative Support to GCMRC	283,000
• Bureau Programmatic Agreement Costs	800,000
• Bureau / Native American Support	50,000[18/]
• GCMRC Logistics Support to PA Program	(50,000)[19/]
GCMRC Program and Operating Costs	
• Operations, Personnel, Contract Services	1,930,000
• Physical Resources Science, including Logistics	1,175,000
• Biological Resources Science, including Logistics	1,390,000
• Cultural Resources Science, including Logistics	390,000[20/]
• Socioeconomic Resources Science Program Operations	63,000
• Information Technologies Program	408,000
• Lake Powell Program	250,000
• Independent Review Groups	243,000
TOTAL:	$7,193,000

[18/] These funds have been obtained by Reclamation from Native Affairs Office appropriated funds and have been shown in the program narrative as part of the Cultural Resources program.

[19/] This amount is contributed by the AMP/GCMRC program to support logistics for Reclamation's PA program and while shown below as part of the GCMRC Cultural Resources program budget, these funds are not available to the GCMRC Cultural Resources program.

[20/] $50,000 of this amount is contributed by the AMP/GCMRC program to support logistics for Reclamation's PA program and are not available to the GCMRC Cultural Resources program.