THE U.S. GEOLOGICAL SURVEY
GRAND CANYON MONITORING AND RESEARCH CENTER

FISCAL YEARS 2005-2006

DRAFT INTERIM MONITORING AND RESEARCH WORK PLAN

by

THE U.S. GEOLOGICAL SURVEY
GRAND CANYON MONITORING AND RESEARCH CENTER

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November 10, 2003

TABLE OF CONTENTS

CHAPER 1. THE USGS, GCMRC FY 2005-2006 INTERIM DRAFT ANNUAL WORK PLAN 1
INTRODUCTION 1
GEOGRAPHIC SCOPE 1
USGS, GRAND CANYON MONITORING AND RESEARCH CENTER 3
Mission of GCMRC 3
Role and Responsibilities 4
ENSURING OBJECTIVE, QUALITY SCIENCE 4
GCMRC SCIENTIFIC ACTIVITIES 5
PROGRAM DESCRIPTIONS AND STATUS UPDATE 6
INTEGRATED SCIENCE PROGRAM 7
Integrat5ed Quality-of-Water Program Upstream Component 7
Downstream Component 9
IQWP Downstream 9
Evolving Geomorphic Framework 10
Fine-Sediment Habitats 12
Terrestrial Resources 12
Aquatic Resources 15
Foodbase Resources 16
Fisheries Resources 18
Experimental Flows Update 18
Humpback Chub – New Initiatives 18
SOCIO-CULTURAL RESOURCES 24
RESEARCH COORDINATION AND SUPPORT PROGRAM 31
INFORMATION PROGRAM FUNCTIONS 36
Library Operations 38
Decision Support System 40
Systems Administration 41
MANAGEMENT OBJECTIVES AND INFORMATION NEEDS 42
Introduction 42
Historical Development of the Management Objectives and Information Needs 42
Revision Process 42
PROTOCOL EVALUATION PROGRAM 43
CONTINGENCY PLANNING 43
SCIENCE SYMPOSIUU 44
CHALLENGES 44
SCHEDULE AND BUDGET 45
Budget Review 45

CHAPTER 2. SCIENCE ACTIVITIES 47
PROJECT A. INTEGRATED ECOSYSTEM SCIENCE PROGRAM 47
Project A.1.a. Core Monitoring – IQWP – Upstream Core Monitoring of Lake Powell Water Quality – Funding from Bureau of Reclamation O&M 47
Project A.1.b. Core Monitoring – IQWP – Downstream Core Monitoring of Quality-of Water for Physical, Biological and Chemical Sampling 49
Project A.1.c. Core Monitoring – IQWP – Downstream Core Monitoring of Streamflow & Suspended-Sediment Mass Balance 52
Project A.2. Coarse-Sediment Inputs, Storage & Impacts 55
Project A.3. Core Monitoring – Fine-Sediment Storage 58
Project A.4a. Core Monitoring – Terrestrial Biological Resources 62
Project A.4.b. Core Monitoring – Terrestrial Ecosystem: Tribal Involvement Component 65
Project A.5. Core Monitoring – Kanab Ambersnail at Vasey's Paradise 68
Project A.6. Core Monitoring – Habitat Map and Inventory 70
Project A.7. Research - Kanab Ambersnail Taxonomy Project 72
Project A.8. Research and development - Aquatic Foodbase, Organic Mass Balance, and Foodweb Linkage Program 74
Project A.9. Core Monitoring - Status and Trends of Downstream Fish Community 76
Project A.10. Core Monitoring - Status and Trends Lees Ferry Trout 77
Project A.11. New Research - State of Primary Productivity, Carbon Flux And Alteration of Food Base 79
Project A.12. Experimental Treatments – Nearshore Warming and Habitat Utilization by Native and Non-Native Fishes 80
Project A.13. Experimental treatments - Kanab Ambersnail Experimental High Flow Compliance Monitoring 82
Project A.14. Experimental Treatments - Foodbase Impacts of Experimental High Flows 83
Project A.15. Experimental Treatments - Mapping Redds Distribution & Identifying Mechanisms for Mortality of Salmonids under Fluctuating Flows 84
Project A.16. Experimental Treatments - Foodbase Impacts of Non-ROD Fluctuating Flows 88
Project A.17. Experimental Treatments - Mechanical Removal of Non-Native Fishes in the Colorado River 89
Project A.18. Non Experimental Treatments - -Native Diet and Predation Analysis 91
Project A.19. Humpback Chub Actions - Remove Humpback Chub from Mainstem Colorado River at 30-mile to Maintain Genetic Stock in Refugia 93

Project A.20. Humpback Chub Actions – Translocation of Native Fishes to Tributaries of the Colorado River, Grand Canyon National Park and Tribal Lands 95
Project A.21. Humpback Chub Actions - Use Dam Operations to Benefit Humpback Chub 96
Project A.22. Humpback Chub Actions - Scientific/Recreation Impact Assessment on Humpback Chub Survival and Reproduction 97
Project A.23. Humpback Chub Actions - Humpback Chub AD HOD Project 17 Monitoring Fish Downstream of Diamond Creek 99
Project A.24. Humpback Chub Actions - Monitoring Fish Disease and Parasites in the Colorado River Ecosystem 100
Project A.25. Humpback Chub Actions - LCR Watershed Management Plan 101
Project A.26. Humpback Chub Actions - Combined Mainstem Colorado River And Little Colorado River Humpback Chub Abundance Assessment 103
Project A.27. Humpback Chub Actions - Development of an Adaptive Management Work Group Outreach Program 104
Project A.28. Humpback Chub Actions - Development of a Humpback Chub Genetics Management Plan 105
Project A.29. Humpback Chub Actions - Complete Feasibility Study of Selective Withdrawal Device at Glen Canyon Dam and, if Feasible, Finish Compliance, Construct, and Test the Device 106
Project A.30a. Data Acquisition (DASA) - Canyon-Wide Digital Imagery & Automated Photogrammetry Over-Flights 107
Project A.30b. Data Acquisition (DASA) - Very High Resolution, Sub-Aerial LiDAR Over-Flights 109
Project A.30c. Data Acquisition (DASA) - Sub-Aqueous LiDAR Over-Flights and Multi-Beam Sonar Missions 111
Project A.31. Data Acquisition (DASA) - Grand Canyon Integrated (Oracle) Database Management System 114
Project A.32a. Analysis (DASA) - Automated Core Monitoring Technologies and Applications 116
Project A.32b. ISP Support (DASA) - GIS General Support to Science Programs 118
B. CULTURAL RESOURCES 121
Project B.1. Core Monitoring of Cultural Resources 121
Project B.2. Development of Geomorphology Process Model for Predicting Erosion of Cultural Resources 124
Project B.3. Implement Priority Recommendations of the Recreation Protocol Evaluation Panel Review 126
Project B.4. Implement Priority Recommendations of the Socioeconomic Protocol Evaluation Panel Review 128
Project B.5. Economic Impacts of Experimental Flows to Whitewater Boaters and Angler Concessionaires 130
Project B.6. Comprehensive Inventory of River-based Camp Sites in the CRE 131

C. LOGISTICS OR SUPPORT SERVICES PROGRAM **134**
Project C.1. Coordination and Support Program-Logistics Operations 134
Project C.2. Survey Operations 137
Project C.3. Geodetic Control Network 146
D. INFORMATION MANAGEMENT PROGRAM **144**
Project D.1. Information Office 144
Project D.2. Systems Administration 147
Project D.3 Library 150
CHAPTER 3. ADMINISTRATION AND TECHNICAL SUPPORT SERVCICES **153**
INTRODUCTION 153
GCMRC ADMINISTRATION 153
E. ADMINISTRATIVE AND MANAGEMENT 154
E.1. Administrative Operations 154
E.2. Program Planning and Management 155
E.3. AMWG/TWG Participation 155
E.4. Independent Review Panels 156
TASK GROUPS 158
GCMRC BUDGET 159
REFERENCES CITED 160

CHAPTER 1

THE USGS, GCMRC FY 2005-2006 DRAFT ANNUAL WORK PLAN

INTRODUCTION

The Fiscal Years 2005-2006 (FY's 2005-06) U.S. Geological Survey, Grand Canyon Monitoring and Research Center (GCMRC) Work Plan describes scientific activities intended to provide the information needed to address the management objectives developed by the Adaptive Management Work Group (AMWG). These management objectives have been recommended by the AMWG to the Secretary of the Interior to meet the intent of the 1992 Grand Canyon Protection Act (GCPA), and the Record of Decision (ROD, 1996) for the final Environmental Impact Statement on the operations of Glen Canyon Dam (GCDEIS, 1995).

GEOGRAPHIC SCOPE

The geographic scope of the Adaptive Management Program is the Colorado River mainstem corridor and interacting resources in associated riparian and terrace zones, located primarily from the forebay of Glen Canyon Dam to the western boundary of Grand Canyon National Park (Figure 1.1). It includes the area where dam operations impact physical, biological, recreational, cultural, and other resources. The scope of Adaptive Management Program activities may include limited investigations into some tributaries (e.g., the Little Colorado and Paria Rivers). The lateral scope is an issue of ongoing research and investigation to determine where the effects of dam operations are located along the floodplain and where opportunities exist for mitigation of dam operations (e.g., sediment in the Paria River, or humpback chub breeding habitat in the Little Colorado River). The Adaptive Management Program may do research outside the geographic scope defined above to obtain needed information. Such linkages with other areas "should be made on a case-by-case basis, considering ecosystem processes, management alternatives, funding sources, and stakeholder interests" (National Research Council 1999:43; Loveless 2000).

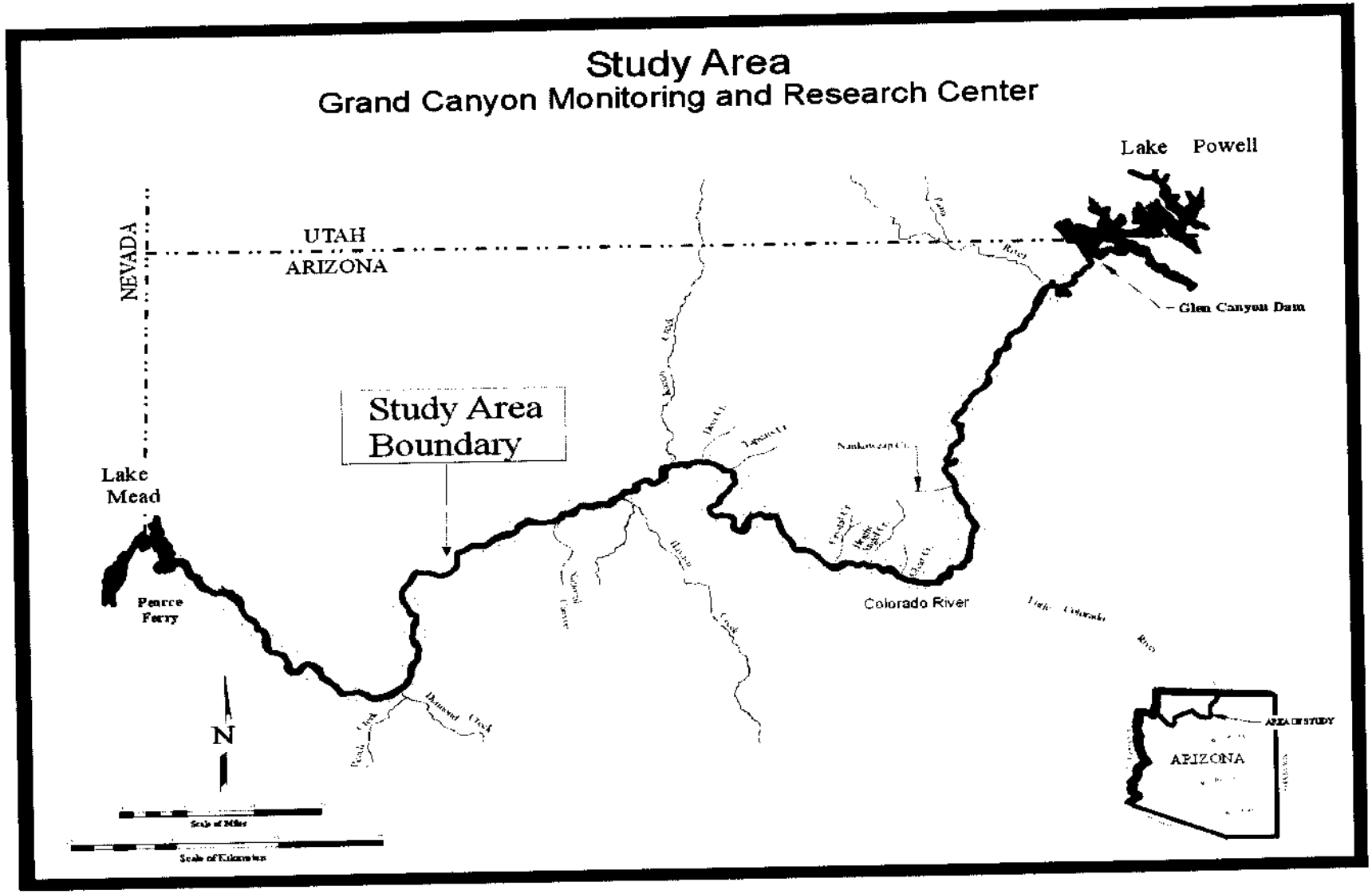

Figure 1.1. Map of the Colorado River Ecosystem (GCMRC Study Area).

GCMRC scientific activities are intended to determine the effects of Record of Decision (ROD) dam operations and other management actions primarily on downstream natural, recreational, and cultural resources of the Colorado River Ecosystem (CRE). GCMRC activities include limited investigations into tributaries (e.g., the Little Colorado and Paria Rivers) and reservoirs (e.g., Lake Powell). The AMWG, in drawing these boundaries on the geographic scope of GCMR scientific activities, acknowledge that these constraints may inhibit the ability to distinguish the effects of dam operations on CRE resources from other effects. Therefore, scientific information from programs outside the GCDAMP may be needed as a means of strengthening the understanding of the entire CRE. For additional information on programmatic and institutional scope of the Adaptive Management Program, please refer to the AMWG Strategic Plan on the web (http://www.uc.usbr.gov/amp/amwg/02jan17/Attach_06.pdf).

USGS, GRAND CANYON MONITORING AND RESEARCH CENTER

The USGS is the primary science provider for the U.S. Department of the Interior. The scientific nature of the USGS, its national perspective, and its non-regulatory role enable the USGS to provide information and understanding that are policy relevant and policy neutral. The USGS serves the Nation as an independent fact-finding agency that collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems.

The mission of the USGS is to serve the Nation by providing reliable scientific information to:

1. describe and understand the Earth;
2. minimize loss of life and property from natural disasters;
3. manage water, biological, energy, and mineral resources; and enhance and protect our quality of life

Mission of GCMRC

The GCDEIS direct the Secretary of the Interior, "To establish and implement long-term monitoring programs and activities that will ensure that Glen Canyon Dam is operated in a manner consistent with that of Section 1802..." of the GCPA. The mission of the USGS, GCMRC is:

> To provide credible, objective scientific information to the Glen Canyon Dam Adaptive Management Program on the effects of operating Glen Canyon Dam under the Record of Decision and other management actions on the downstream resources of the Colorado River ecosystem, utilizing an ecosystem science approach.

Roles and Responsibilities

1. Provide quality, objective science and the use of that science in the adaptive management decision process.
2. Provide scientific information for all resources of concern identified in the "Operation of Glen Canyon Dam Final Environmental Impact Statement."
3. Support the Secretary's designee and the Adaptive Management Work Group in a technical advisory role.
4. Develop research designs and proposals for implementing, by GCMRC and/or its contractors, monitoring and research activities in support of information needs identified by the Adaptive Management Work Group.
5. Coordinate review of the monitoring and research program with independent review panel(s).
6. Coordinate, prepare, and distribute technical reports and documentation for review and as final products.
7. Prepare and forward technical management recommendations and annual reports, as specified in Section 1804 of the Grand Canyon Protection Act to the Technical Work Group.
8. Manage all data collected as part of the Adaptive Management Program. Serve as a repository (source of information) for others (stakeholders, students, public, etc.) in various formats (paper, electronic, etc.) about the effects of operating Glen Canyon Dam on the downstream resources of the Colorado River ecosystem and the Adaptive Management Program.
9. Administer research proposals through a competitive contract process, as appropriate.
10. Manage GCMRC finances and personnel efficiently and effectively.

ENSURING OBJECTIVE, QUALITY SCIENCE

The GCMRC was established to provide objective, high quality scientific information to the Secretary of the Interior and to the AMWG. To accomplish these goals, specific operating protocols for GCMRC were established.[1] The quality and objectivity of GCMRC research findings is ensured through competition and independent external scientific peer review.[2] All proposals, data, reports, etc., are reviewed by independent, external scientists as well as by the GCMRC science team.

1 Operating Protocols for GCMRC, June, 1996.
2 GCMRC Peer Review Guidelines, October 26, 2001.

GCMRC SCIENTIFIC ACTIVITIES

The FY's 2005-2006 Work Plan describes monitoring and research activities that address the management objectives (MOs) and information needs (INs)[3] of the GCDAMP. Long-term monitoring is designed to determine changes in resource attributes. Research is used to improve monitoring, interpret and explain trends observed from monitoring to determine cause-and-effect relationships and research associations, and to better define interrelationships among physical, biological and social processes.

Monitoring and research efforts have been defined in the 12/14/01 draft Information Needs document as:

A) **Core Monitoring Information Need (CMIN):** Core monitoring is consistent, long-term, repeated measurements using set protocols and is designed to establish status and trends in meeting specific management objectives. Core monitoring is implemented on a fixed schedule regardless of variable factors or circumstances (e.g., water year, experimental flows, temperature control, stocking strategy, non-native control, etc.) affecting target resources.

B) **Effects Monitoring Information Need (EIN):** Effects monitoring is the collection of data associated with an experiment performed under the Record of Decision, unanticipated event, or other management action. Changes in resource conditions measured by effects monitoring generally will be short-term responses. The purpose of effects monitoring is to supplement the fixed schedule and variables collected under core monitoring. This will both increase the understanding of the resource status and trends and provide a research opportunity to discover the effects of the experiment or management action.

C) **Research Information Need (RIN):** Research can be descriptive or experimental. When descriptive it describes relationships in the Colorado River ecosystem (e.g., describe trophic interactions in the aquatic ecosystem). When experimental it tests specific hypotheses for determining and understanding cause-and-effect relationships between dam operations, or other driving variables, and resource responses (e.g., how is the abundance and composition of benthic invertebrates affected by grazers, predators and dam operations?). Research requires a purposeful design with established statistical criteria, including allowable errors for accepting and rejecting null hypotheses. Research may also result in the collection of data that can be used to help determine or refine Core Monitoring Information Needs.

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3 The MOs and the IN's are currently undergoing revision. This Work Plan references the draft revised MOs. The INs are being revised and they are not included in this document. See the following section for a description of the revision process and see Appendix One for the AMWG vision and mission, principles, and the current MOs.

D) **Supporting Information Need (SIN):** A Supporting Information Need contributes to understanding the basis for a resource response and its link to other management goals.

E) **Other Definitions Are:**

- Status and Trends: Status refers to the condition of a resource at a given time or place. Trends refer to a statistically-based temporal or spatial series for a given resource, during the periods and at the locations where data was collected.

- Cause and Effect: Cause and effect assigns a resource response to a particular event(s) or driving variable(s).

In addition, GCMRC has responsibility for management and dissemination of technical information in the AMP program. Included is development and maintenance of a database management system for archiving data collected as a result of monitoring and research activities, maintenance of a geographic information system for analysis and archiving of spatial data, and a central library for additional archiving and data dissemination activities. A major emphasis is placed on serving digital publications, data, and analytical tools to our stakeholders and the public through the portal of the GCMRC website (www.gcmrc.gov). GCMRC also operates a surveying department to provide consistent, quality, cost-effective support to monitoring and research projects. Finally, GCMRC operates a logistics program to provide cost-effective support to scientific field activities.

PROGRAM DESCRIPTIONS AND STATUS UPDATE

Historically, GCMRC operated under an organizational structure that included the following four program areas, each with a program manager: Biology, Physical Science, Cultural Resources, and Information Technology. At times, that organizational structure hindered efforts to better integrate monitoring and research activities as stipulated in the GCMRC mission statement (see above).

Furthermore, the existence of an Information Technology program formed a barrier to integrating the included logistical support-activities (e.g., GIS, survey, database management) into a larger, Center-based framework. In recognition of these challenges, the GCMRC Chief instituted a reorganization of the Center on October 9. Fundamental changes included combining the Biology and Physical Science programs into a new Integrated Ecosystem Science program, and strategically merging elements of the old Information Technology into the newly constituted

science programs. The reorganization is expected to increase the effectiveness of GCMRC, particularly as it relates to the conduct of integrated, or ecosystem science. Details of the reorganization will be provided to TWG and AMWG members at the November 2003 and January 2004 meetings. The new program numbering system, on the Project Summary Sheets that follow, reflect the reorganization.

INTEGRATED SCIENCE PROGRAM

The Integrated Science Program (ISP) represents the GCMRC's new initiative in FY 2005-06, and beyond, for achieving science integration between physical, biological and socio-cultural elements of the monitoring and research program. Under the new organizational approach, integrated analysis of data on the Colorado River ecosystem is driven by team-based initiatives aimed at acquiring resource data, with integrated objectives for analysis clearly identified prior to data acquisition. Following data acquisition and storage, integrated analyses are possible in relatively short timelines owing to the functionality of the GCMRC's state-of-the-art Oracle relational data engine. Through a combination of technological advances in database and positioning methods, as well as a new organizational structure, barriers that have hindered past integration efforts are eliminated in the ISP. Following, are descriptions and updates on current knowledge related to the individual elements of the ISP.

Integrated Quality-of-Water Program Upstream Component

Lake Powell Owing to prolonged drought conditions in the Colorado River Basin, Lake Powell has been drawn down to its lowest surface elevation since 1973. At an elevation of 3603.73 feet above mean sea level the reservoir was at about 50% of its total capacity. Also associated with the reservoir drawdown was an increased release temperatures through the summer of 2003 as the warmer surface layers of the reservoir were brought closer to the penstock withdrawal elevation. Release temperatures reached 12 deg C in September 2003, the warmest temperatures observed for that time of year since 1973. Dissolved oxygen levels were at very low levels throughout the reservoir in September 2003 owing to resuspension of deltaic sediments. These conditions were reported at the October 2003 Colorado Ecosystem Science Symposium in Tucson, AZ.

The GCMRC long-term monitoring program for Lake Powell continues, with monthly forebay and quarterly reservoir surveys. These surveys consist of the collection of a profile of

physical and chemical parameters through the water column, sampling at discrete depths for major ion and nutrient concentrations, and biological sampling for chlorophyll, phytoplankton, and zooplankton at selected stations in the reservoir forebay, main channel, and major tributary arms of the reservoir. Continuous water quality monitors are in place for thermal monitoring in the reservoir forebay and for a broader suite of parameters in the reservoir tailwater. Sampling is conducted from the GCMRC 32; Uniflite limnology vessel, with assistance from the National Park Service and Bureau of Reclamation Upper Colorado Regional Office.

The database (WQDB) for Lake Powell and Grand Canyon water quality is nearing completion and being integrated with GCMRC's Oracle database management system system. These data comprise all Bureau of Reclamation, GCES, and GCMRC water quality monitoring information collected since 1965, representing the entire water quality history of Lake Powell. The consolidation and management of these data has made it possible to evaluate the information collected from this long-term effort and make changes to achieve a more efficient program. Revisions in major ion and nutrient sampling, plankton sampling, and inflow monitoring are expected during FY 2004.

These data are available for input to the CEQUAL-W2 reservoir model in cooperation with the USBR. Initial model development and calibration is being provided my Amy Cutler of the Bureau of Reclamation (BuRec). Eventually there is the prospect that simulation modeling may replace some of the extensive field sampling effort on the reservoir. Beginning in November 2003, GCMRC will provide monthly web-based updates for water quality conditions on Lake Powell. An annual report of 2003 monitoring results is in development.

GCMRC receives funding for the Lake Powell Water Quality Monitoring Program from Bureau of Reclamation Operation and Maintenance funds, based on an agreement with the Technical Work Group. Adaptive Management Program funds are not used directly for Lake Powell monitoring. The Bureau provides additional support for model development and technical field assistance. In 2003, Reclamation agreed to provide laboratory analytical services through a service agreement, eliminating the need for GCMRC to contract directly for these services and reducing its direct funding to GCMRC. GCMRC has further reduced salary requirements for Lake Powell as the downstream water quality program has developed.

Downstream Component

IQWP *Core-Ensemble Parameters (Temperature, Conductivity, pH, DO, etc.)* - Downstream integrated quality-of-water project (DIQWP) sampling has been aimed primarily at establishing a robust record of mainstem temperature data under different flow conditions. Much of the downstream water quality program has been undergoing redesign and reconsideration in light of the recent PEP report and the development of a new five-year plan for the Integrated Quality-of-Water Program presented to the TWG in 2002.

In the mainstem, during the Low Steady Summer Flows of 2000, the highest temperatures in at least the last decade were observed in Grand Canyon, reaching nearly 20 deg. C at Diamond Creek. This reflected a warming of 10 deg. C above Glen Canyon Dam release temperatures, compared to a warming of 5 deg. C during the high steady flows of 1997, showing a strong inverse correlation of in-stream warming with discharge level. Warming of over 7 deg. C above main channel river temperature occurred in some main channel near-shore environments; in backwater habitats, warming of over 12 deg C above river temperatures was observed. This near-shore warming was dependent on incident solar radiation, and little or no water velocity.

IQWP Downstream

Fine-Sediment Mass Balance - Results of sand-transport mass-balance calculations for the period of fall 1999 through September 2000, show that sand loads passing the Grand Canyon gage, located 102 miles downstream of Glen Canyon Dam, exceeded total estimated tributary inputs; except during the period of June through August 2000 (Low Summer Steady Flow test), when dam operations were held constant at 8,000 cfs. Sand mass-balance data for October 2000 through November 2001, do show evidence of some accumulation of sand upstream of Phantom Ranch (river mile 87), in response to an approximate 1,000,000 metric ton input of sand from the Paria River in October 2000, in combination with relatively low-flow releases from Glen Canyon Dam throughout Water Year 2001. Additional sand inputs from the tributaries that occurred during September of Water Year 2002, also accumulated in the channel bed under the low-flow operations of September through December 2002. However, preliminary observations during January through March 2003, suggest that experimental fluctuating flows exported 2002 sand inputs from critical reaches above Phantom Ranch.

Overview of Suspended-Sediment Transport Monitoring - Existing management actions taken through WY 2003, under the Record-of-Decision (ROD) have failed to meet even the expectations contained in the Glen Canyon Dam EIS that, compared to the no action alternative, the preferred alternative would result in sand resources in the CRE increasing over time. The basic finding of the mass-balance project team is that downstream transport of new sand inputs occurs much more rapidly than was previously predicted by the Glen Canyon Dam EIS writing team (Rubin et al., 2002). The rapid export of new sand inputs measured during 1999 through 2003, from sediment-starved upstream reaches such as Marble Canyon, indicates that the ecosystem's sand supply does not become progressively enriched over multi-year periods, except during periods when monthly release volumes are at about 700,000 acre feet or lower. If most ROD dam operations prevent new sand inputs from accumulating within the river channel, then re-deposition of new sand inputs cannot occur during occasional controlled floods, termed "Beach/Habitat-Building Flows." Such periodic releases are intended to restore and maintain sand bars that have experienced erosion since dam closure. Suggested alternatives for better conserving new sand inputs include timing the release of bar-building floods to more closely follow significant periods of sand input from tributaries. Another alternative is to schedule BHBF releases during periods when ROD operations at Glen Canyon Dam reflect below-average basin-hydrology conditions.

Nutrient Mass Balance – Under Construction

Evolving Geomorphic Framework

Coarse-Grained Inputs and Impacts: Webb and others, of the USGS, have estimated lesser tributary contributions for both fine and coarse sediments between Glen Canyon Dam and Upper Lake Mead. They find that fine sediment inputs from the Glen and Marble Canyon reaches of the ecosystem are, on average, likely to be a factor of two greater than the estimate used by the EIS writing team in preparing the fine-sediment mass balance reported in the GCD-EIS. Although the fine sediment inputs into this critical upstream reach may be significantly higher than previously assumed, the grain-size data published in the report indicate that those sediment inputs are as fine or finer than inputs from the Paria River. This finding suggests that while sand inputs from ungaged sources are significant and worth monitoring for management

purposes, these inputs likely have a short residence time in critical reaches, similar to those sand inputs derived from the Paria River (see section on Mass Balance, above). This is important information that further supports development of a fine-sediment budget for the ecosystem, as well as technical discussions about how best to conserve fine sediment inputs through dam operations. Perhaps more importantly to the ecosystem, lesser tributaries below Lees Ferry continue to input fine-to-coarse size gravel into the main channel. The implications for these ongoing, accumulated gravel inputs is still being studied, but several possibilities exist for how these deposits may influence the aquatic and terrestrial elements of the Colorado River ecosystem: 1) aggradation of the channel's rapids leading to increased navigational challenges, but also expanded eddies where sand can accumulate, 2) aggradation of low-velocity pools and higher velocity runs, with potential changes to aquatic food base dynamics, 3) increased spatial abundance of fine gravels that effectively expand spawning and rearing habitats throughout the main channel in Glen, Marble and Grand Canyons, 4) burial and/or erosion of existing sand bars during debris flows and stream-flow floods.

A long-term monitoring program for coarse-sediment inputs and impacts throughout the ecosystem was initiated in FY 2001, although coarse-sediment inputs from lesser tributaries have been studied since 1984. The current annual monitoring effort for coarse sediment inputs is also intended to document the occurrence of periodic debris flows within 800 lesser tributaries, where and when they occur. The project is also focused on documenting how such coarse-sediment inputs alter the geomorphic framework of the river by directly impacting both sediment and non-sediment resources of the ecosystem at hundreds of locations through time under dam operations. This project represents one of the lead participants in the Advanced Conceptual Modeling project that was conducted from FY 2001 through 2003 (see below).

Summer storms of August and September 2002 and 2003, resulted in numerous localized changes in the river ecosystem's geomorphology owing to several new debris flows and widespread tributary stream flow flooding. Extensive deposits of new gravel were deposited in the river throughout Marble and eastern Grand Canyon. The debris flows that occurred in September 2002, buried or eroded some existing campsite areas, and in one case created a significant new rapid near river mile 74.

Fine-Sediment Habitats

Fine-Sediment Storage Monitoring: Individual sand bar data collected from 1990 through fall 2001, show that sand bars in the actively fluctuating zone (8,000 to 25,000 cfs), and above the 25,000 cfs stage within Marble Canyon (river miles 0-61) have continued to decline since 1990, despite bar restoration gains achieved by the Beach/Habitat-Building Flow test of 1996, and peak power-plant test flows released in November 1997 and May and September 2000. Although high-elevation sand bars (above 25,000 cfs) below river mile 61 (Grand Canyon) appear to be in somewhat better condition in 2000 versus 1990, than bars in Marble Canyon, deposits within the actively fluctuating zone continue to show decline throughout the ecosystem. The sand-bar time series (1990 through 2002) suggests that the long-term fate of beaches in the upper, critical reaches of the ecosystem will likely be in continued decline under current ROD operations. Beach data collected in fall 2003 show decline in bar conditions at many sites within the first 100 miles below the dam. The most probable reason for the continuing decline of sand bars appears to be related to depletion of the ecosystem's sediment supply. This trend might be reversed if new fine-sediment inputs from tributaries can be managed more strategically using combinations of power-plant operations and BHBF's following tributary floods. Declining beach trends correlate with the findings of the sediment mass-balance project that indicate that new sand inputs from tributaries are transported downstream relatively quickly rather than being retained throughout the river channel and periodically re-deposited on diminishing bars.

Terrestrial Resources

Specific terrestrial resources of interest to the adaptive management program include riparian vegetation, riparian breeding birds and waterfowl, invertebrates including Kanab ambersnail, small mammals, and reptiles associated with the river corridor. Monitoring approaches for terrestrial biologic resources underwent review in late 1999 (KAS expert panel) and 2000 (Urqhart, 2000). Recommendations from these reviews were incorporated into 2001 monitoring and research plans and continue to be evaluated and implemented through 2005.

A review of previous riparian studies and their applicability to monitoring, as well as the information that these studies provide for assessing change, was completed in 2001 (Kearsley and Ayers, 2001). Power analysis of historic data indicates that change detection of vegetation

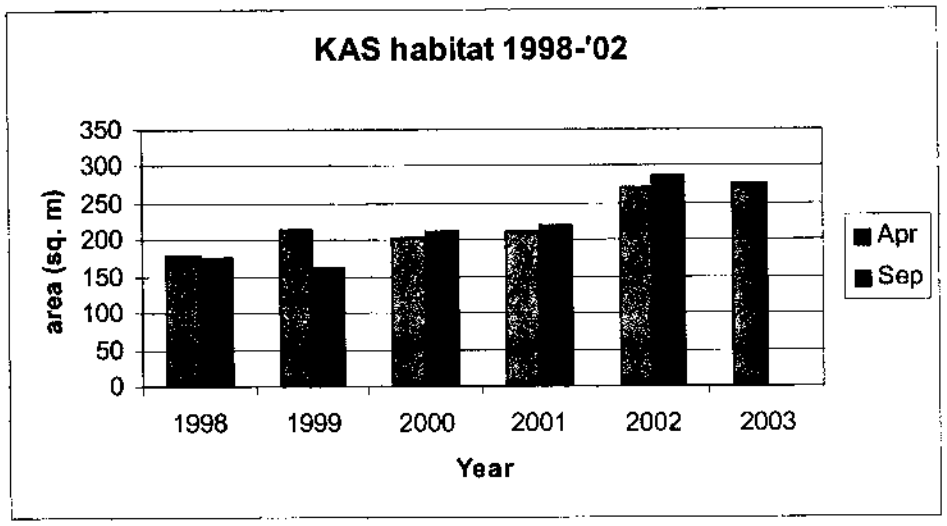
attributes varied by vegetation type and parameter measured (e.g., species richness, density). For example, changes in cover can be detected within a year's time for mixed scrub, but changes in diversity for the same community type may take over 20 years. Kearsley and Ayers (2001) analysis also indicated that the minimum number of sites needed to detect change in species richness and cover is between 30 and 70, depending on the type of vegetation (Kearsley and Ayers, 2001), and that previous approaches and sites over-represented some types of vegetation (e.g., tamarisk) and under-represented others (e.g., seep willow). Areas of high density, single species composition were more likely to show little change compared to mixed communities and would require longer time periods for change detection. In most cases, change was detectable within five years of measurement. The temporal and spatial scale as well as number of sites needed to detect change was taken into account in the development of core monitoring approaches for terrestrial resources.

Currently core monitoring includes yearly field-based assessment of vegetation cover, species richness and diversity at 60 sites that are linked to stage/discharge changes up to 60,000 cfs, and five-year change detection at the landscape scale using GIS and image processing. The basemap of vegetated areas initiated in FY2003 and to be completed in FY2004 serves as a template for past and future large-scale change detection, as well as for randomized selection of monitoring sites for vertebrates including bird patches. Results from the monitoring project for vegetation indicate measures of plant abundance, species richness, diversity, and distribution all showed a decline in 2002 compared to 2001 (Kearsley 2002), data from 2003 is still to be provided. Herbaceous desert annuals and perennial grasses and herbs like cheat grass, sand dropseed and spiny aster showed the greatest decline and are affected by yearly precipitation. Compositional shifts did not occur for zones below 35k cfs, but at sites of 45k and 60 k cfs, species composition did change significantly compared to 2001, again the change is associated more with a loss of annual and rarely encounter plant species. The mean wetland score, which most closely tracks operational effects on vegetation and available groundwater, showed no change within zones between years, but an increase in value for all zones compared to 2001 (Kearsely 2002). As long-term data accumulate we will be better able to see how yearly operations and weather patterns affect vegetation.

Monitoring for riparian breeding birds, including southwest willow flycatcher, and over-wintering waterfowl continues. Power analysis by Spence et al. 2003 indicates that

approximately 64 sites visited three time in the spring provides sufficient power to detect change in bird abundances between years for the 18 most common bird species. In FY05, due to funding limitations, bird surveys will be suspended with the anticipation that they will be re-initiated in FY06. In FY2001, this program was combined with vegetation monitoring and insect, reptile and mammal inventories to provide an integrated picture of the terrestrial resources and long-term patterns associated with these resources and Glen Canyon Dam operations. Surveys to assess riparian bird abundance and distribution were done in April, May and June of 2002. 64 vegetation patches were surveyed in 2002 and 17 of these sites were repeated from the previous year. A total of 2627 passerine birds of 66 species were detected in the three surveys. Bird detections were highest in May when birds are both migrating through and establishing nests. Bird abundance and density, which included migrants and permanent winter and summer residents, was greater in the New High Water Zone ($t=3.4$, $p=0.001$) (Yard and Blake 2002). Species richness was also higher in the New High Water Zone. This was in contrast to 2001 where species abundance was greater in the Old High Water Zone. Comparison of 15 common species between years showed a significant difference in abundance for only 2 species: Black-chinned Hummingbirds had increased in abundance in 2002 and Mourning Doves had decreased in abundance in 2002. The shift in bird abundance between Old and New High Water Zones may be associated with lower abundance and diversity of arthropods or seeds from annual grasses and herbs in the Old High Water Zone related to the drought conditions. Synthesis of invertebrate data will take place in 2003-04 and it is anticipated that trophic level interactions will be more developed by 2004.

Lastly, Kanab ambersnail monitoring at Vasey's Paradise has continued to follow the protocols begun 1997. Data collection efforts continue at two trips per year: one in spring and one in fall. Population estimates for the snail indicate that the snail numbers vary widely throughout the year (10,000 in the spring to 100,000+ in the fall), influenced by climatic and concomitant habitat variability (SWCA, 1999). Measured snail habitat at Vasey's Paradise increased 6 % in area between spring and fall of 2002. Total surveyed habitat changed from 270.01 m^2 in April to 288.36 m^2 by August 24, 2002. Yearly average total habitat has increased steadily and significantly since 1998 ($p = 0.014$; $F=5.19_{4,5}$) from 176 m^2 in 1998 to 279 m^2 in 2002.



Estimated snail numbers have not changed significantly since 1998, but numbers have shown a decline to a value of 7,444 snails in August 2002. Curiously, while habitat has increased, snail numbers have not had a correlated increase. The lack of increase in snail numbers may be associated with soil moisture rather than the amount of habitat available. The discharge from the spring at Vasey's Paradise was lower in 2003, and the habitat was also visited by bighorn sheep. Tramping by sheep may have been a contributor to lower snail numbers recorded for 2002.

Aquatic Resources

Aquatic resources continue to undergo review of methodologies and historic data and incorporation of new methods into monitoring the sport fishery, native fish communities, food base, and water quality monitoring. Protocol review panels were held for the water quality program (Ruane et al., 2001), the Lees Ferry trout fishery (Culver et al., 2000) and for the aquatic program (Bradford et al., 2001), which includes the mainstem fishery downstream of Lees Ferry, and the aquatic food base program a system-wide perspective. Recommendations made for the native and non-native fishery programs have included increasing random sampling efforts, strengthening efforts associated with integration across disciplines and developing modeling efforts.

The water quality program is in the process of incorporating recommendations into a revised program, and the downstream fishery and food base program is also incorporating panel

suggestions into the development of monitoring programs for these resources. As a result of recommendations, an effective mark-recapture program in the LCR and different stock assessment models for assessing the status and trends of the humpback chub have been developed. However, review findings on the aquatic food base program were insufficient because current understanding about linkages between lower trophic levels and food availability of fish were deemed inadequate to interpret foodbase in relation to management goals. They identified that further research was needed before a long-term monitoring program existed, because assumed linkages between foodbase and fishes had not been empirically established.

Foodbase Resources

The aquatic protocol evaluation panel had concerns with the lack of empirically established linkages between food base and fishes (Bradford et al., 2001), and identified that a possible consequence of the recent increase in primary and secondary production may differentially benefit non-native species (competitors or predators) over native species. Because of this, additional research and the restructuring of the existing foodbase monitoring program is warranted in light of its importance toward meeting stakeholder objectives. For this reason, a refocusing of the monitoring and research efforts is to be undertaken toward assessing whether primary production is actually limiting the abundance and structure of the downstream fish community directly or indirectly through abiotic and biotic interactions.

A series of integrated studies will address a number of issues identified by the aquatic protocol evaluation panel (Bradford 2001). Primary focus is on the research and development of an organic budget and foodweb linkage program as an organizational framework to determine whether or not the aquatic foodbase is limiting, and to determine what organic sources, and where limitations occur within the Colorado River system. This requires multiple approaches: 1) continuation of the conventional phyto-benthic and invertebrate monitoring, focused initially in the Lees Ferry section; conduct in-stream metabolism and community respiration experiments; 3) quantify organic and inorganic carbon supply and fluxes (decomposition, transformations and residency); 4) based on findings of the organic mass balance research design and effective sampling program having the appropriate sampling locations, methods and frequency for assessing and quantifying organic flux (sources, pools, transformations and movement), and 5)

develop a better understanding of foodweb linkages within the spatial distribution of the entire fish community.

In Lees Ferry the food base derived from primary production is considered an important biotic resource because of its direct linkage to higher trophic levels, potential limitations (density dependence), use and availability required to support the waterfowl and rainbow trout fishery. Algae/macrophytes and invertebrates consisting mostly of midge larvae (chironomids), and amphipods (Gammarus) form the major components of the aquatic food base in Lees Ferry. The conventional phyto-benthic and invertebrate monitoring will be continued in this upstream section. The frequency of these sampling efforts will be intensified to monitor effects due to experimental fluctuating flows and beach habitat building flows. Additionally, a new method for measuring community metabolism and respiration will be assessed to determine its feasibility for estimating primary production in Lees Ferry. Contingent on study outcome, community metabolism may be more effective and serve as a surrogate to conventional indexes used for evaluating primary production.

Several research projects assessing food-fish linkages have been recently implemented. These include: bioenergetics modeling (Peterson 2003) and diet and predation associated with non-native trout removal project at the LCR (Coggins and Yard 2003). Following the aquatic protocol evaluation panel recommendations, it is proposed that an organic mass balance project be used as an indicator of system-wide production and export. A request for proposals will be developed during 2004 for this initiative.

Fisheries Resources

The Lees Ferry trout fishery has developed a stock assessment model using historic angling data and catch effort data from past monitoring efforts. The model provides a three-to five-year view of the state of this fishery resource and provides an opportunity to evaluate management strategies associated with this fishery (Speas et al., 2001). The monitoring program that is in place through a cooperative effort between GCMRC and Arizona Game and Fish includes the historic fixed sampling sites and new random, stratified sites based on shoreline type. The program's design is intended to increase sampling areas to better characterize the trout fishery as a whole. Recent data indicate that the fishery is strongly influenced by diel changes in flows and that growth is likely density dependent: The stable flows associated with ROD

operations has increased recruitment and the increased numbers of fish has resulted in smaller fish (Speas et al., 2001).

The downstream fishery program has approached the development of a long-term monitoring program in a step-wise fashion to allow for analysis of historic data and to ensure that new monitoring protocols address adaptive management program needs. Steps that have been taken in the downstream fishery program include development of population estimates for rainbow trout and brown trout in the mainstem and for humpback chub in the LCR and its confluence with the mainstem. Stock assessment models of current and historic data suggest that the LCR population of humpback chub has been in decline for over a decade. This downward trend in population abundance is based on an estimated chronic recruitment decline. Multiple hypotheses exist for the apparent recruitment decline including dam operations, tributary flooding, parasitism, predation/competition and mainstem temperature effects. Due to some controversy over appropriate methods to estimate the abundance humpback chub in Grand Canyon, an independent panel of experts has been convened to review current stock assessment methods. A report from this panel will be available at the January 2004 AMWG meeting.

Associated with the 2003-2004 adaptive management experiment approved by the Secretary of Interior, a program of mechanical removal of non-native fishes near the confluence of the Little Colorado was implemented in 2003. This work will continue in 2004 as recommended. Early results suggest the efficacy of mechanical removal of non-native salmonids is quite high (>50%), but that immigration of fish back into the removal reaches is substantial. Therefore, frequent removal of non-native fishes is necessary to maintain low abundance.

Experimental Flows Update – (Under construction)

Humpback Chub – New Initiatives – (Under construction)

Data Acquisition, Storage and Analysis (DASA): Based on results of the Remote Sensing Initiative (Davis, et al, 2003) and the success of several automated analysis projects undertaken in FY2003, the GCMRC proposes to refocus many of its core monitoring data acquisition and analysis efforts around a common theme entitled, **automated core monitoring technologies and applications.** This approach envisions: (1) adoption of a suite of remote sensing technologies that have either been proven or are very likely to produce terrestrial and hydrographic data of sufficient accuracy to satisfy many of the scientific needs of the physical, biological and cultural resource programs, as well as information requirements of resource

managers, and (2) development or adoption of digital analysis routines for automating the extraction and classification of information formatted to the core monitoring needs of scientists or cooperators attached to the physical, biological and cultural resource programs and to those of resource managers. This approach is designed to supplement and enhance more traditional scientific data collection and analysis technologies, and, in some cases, supplant them. Airborne and ground-based sensors have joined the ranks of more traditional gauging stations as technologies for monitoring the environment. This approach is adaptive. It recognizes that, while all scientific data collection cannot be automated, many analysis and field-support activities can be. Where applicable, the GIS program exists to provide this support. In this vision, 'storage' is that component of the triad that provides the framework for housing and accessing an expanding digital database composed of traditional and remotely sensed data together with their derived information products.

Core Data Acquisition (Remote Sensing) - The **automated core monitoring technologies and applications** approach envisions implementation of many findings and remote sensing technologies recommended to the Technical Work Group in the final report from the remote sensing initiative. The suggested suite of remote sensing technologies and selected applications includes: (1) multi-spectral and panchromatic digital imagery (25 cm and 12.5 cm spatial resolutions) together with digital elevation data (1 meter spatial resolution), whose analysis was automated in 2003 to produce terrestrial vegetation and fine-grained sediment inventories, (2) very high resolution LiDAR (7 to 14 points per square meter), whose analysis may be automated to produce survey-accurate, terrestrial sand bar morphologies and vegetation canopies, and (3) hydrographic LiDAR (3 meter spatial resolution) and multi-beam sonar (up to 2 cm spatial resolution), whose analysis may be automated to produce both macro and micro-scale bathymetry and channel-bottom sediment-type classifications. The GCMRC proposes to fly these instrument suites on a biennial basis, collecting: (1) canyon-wide multi-spectral and perhaps hydrographic LiDAR data in support of macro-scale channel, vegetation and fine-grained sediment core monitoring activities, and (2) very high resolution LiDAR and multi-beam sonar data in Marble Canyon in support of micro-scale sediment and vegetation morphology studies and monitoring.

Remote sensing accomplishments in FY2002-03 included acquisition of a canyon-wide set of multi-spectral digital imagery and a 1-meter digital elevation model (DEM), a successful

test of very high resolution LiDAR within Marble Canyon, and the publication of results from the remote sensing initiative. Several automated products were developed from the multi-spectral imagery. These include: a canyon-wide fine-grained sediment inventory, a camping beach characteristic inventory, and the development of digital topographic cross-sections (based on the May, 2002 1-meter digital elevation model) to support hydrographic modeling. FY2004 accomplishments will include: a detailed, canyon-wide vegetation map developed from the May, 2002 multi-spectral digital imagery; acquisition of canyon-wide multi-spectral and panchromatic digital imagery (assuming available funds); and very high resolution LiDAR, hydrographic LiDAR and selected multi-beam sonar to support a final assessment of these technologies as primary core monitoring technologies. These data will form the basis of detailed inventories, change analyses and technology assessments that will be produced in FY2004 and FY2005.

Terrestrial digital elevation base maps - Prior to 2001, GCMRC had sub-meter accuracy terrestrial topographic maps of approximately 80 miles of the ecosystem in 17 areas of concentrated scientific effort that have been referred to as GIS sites. GCMRC also has similar topographic maps from GCD to Badger Rapid near river mile (RM) 8 derived from our LiDAR evaluation in 1998. In FY2000, the GCMRC collected high-resolution orthophotography and topography of the entire CRE. This dataset provides one-foot resolution geo-referenced and rectified imagery and one meter interval contour maps as well as a four-meter digital elevation model. This data set was delivered, inspected, and incorporated into the GCMRC FTP site (accessible from the GCMRC web page or directly at ftp.gcmrc.gov) in the /data/orthophotos and /data/lidar subdirectories. In addition to sub-meter terrestrial base maps described above, we have high-resolution field surveys of 35 sand bar sites that have been repeated at varying intervals since 1991. We also have numerous field surveys of vegetation, cultural, and endangered species habitat such as KAS surveys. Additional sub-meter accuracy terrestrial topographic coverage needs to be obtained for the remainder of the ecosystem.

Hydrographic base maps - The hydrographic mapping program was established for the purpose of producing a sub-aqueous channel map of the Colorado River within the ecosystem. Hydrographic mapping supports several GCMRC scientific initiatives including: streamflow and fine-grained sediment transport, fine-grained sediment storage, streamflows and suspended sediment modeling, advanced conceptual modeling of coarse grained sediment, fish habitat mapping, and measuring changes in morphology and topography of the sub-aqueous canyon

ecosystem. We currently have low resolution (20 meter transects) single beam base data from GDC to Badger Rapid, and GIS Site 7. We currently have single beam data (10 meter square) repeated since 1993 at 35 NAU sand bar sites (Hazel et al., 1999; Kaplinski, 2000), repeated surveys from Paria (RM 1) to Cathedral Wash (RM 3), 4 large pool sites in Site 5 (Wiele, 1998), 5 repeated surveys in RM 42-43 and RM 62-65 to monitor the 1996 flood, and a pre- and post-flood survey on the Lake Mead Delta. We also have high resolution (multi-beam) surveys in the pools from RM 1-3, RM 9-11, 29-42, and 45-68. Additional channel mapping of all the remaining river channel needs to be obtained as control is established. In FY2001-03, hydrographic channel data was collected for approximately 60 additional miles of the CRE. This data was processed in FY2002-03. New technology for channel mapping (Navy's CHARTS sensor) will be tested and evaluated in FY04-06.

Mapping Riparian Vegetation - We examined various airborne remote-sensing data that were collected during different seasons within a one-year time frame, with different spatial resolutions (11 cm to 100 cm), and with various technologies (CIR film, CIR CCDs, and multi-spectral data) to determine the relative merits of each data set for mapping riparian vegetation within the Grand Canyon. This study determined that digital, 3-4 band image data using appropriate wavelength bands can provide maps of riparian vegetation communities at a 60-70% accuracy level without field surveys. Field verification and limited surveys can increase this accuracy to about 80% or greater.

Mapping Warm-Water Fish Habitats and Cultural Features - We evaluated airborne thermal-infrared (TIR) data that were acquired at 100-cm resolution during maximum solar heating (at 1:30 p.m.) to determine the capability of such data for mapping warm backwaters and near-shore habitats for fish, in addition to mapping archaeological structural sites and natural springs within the Grand Canyon. Airborne TIR data can provide an instantaneous map of surface water temperature for very large regions, which cannot be obtained by in-situ measurement methods. Detection of archaeological structures requires the use of an airborne TIR sensor that can detect temperature differences as small as 0.1 degrees C, and provide at a spatial resolution of no more than 25 cm. Detection would be optimized by data collection after sunset or just after sunrise. Safety issues after dark and shadows during early morning make such data collections very difficult. Detection of natural springs is better approached using TIR data

collected after sunset. TIR data collected during daylight hours detect only the largest springs, whose existence is already known. Detection of natural springs after sunset can and has been accomplished using rather low-resolution imagery (1-3 meters) because the spring waters spread from their source and present a large area and the spring water is much colder than the surrounding warm, dry ground.

Monitoring Sand-Bar Deposits - The GCMRC evaluated light detection and ranging (LiDAR) and photogrammetric methods for remotely mapping sand bar deposits along the Colorado River to determine if these two remote-sensing technologies for mapping topography could approach the accuracies currently obtained using field survey methods and at a comparable cost, while providing more aerial coverage. Thus far, our studies have determined that LiDAR appears to be a suitable method for rapidly obtaining the topography of bare sediment surfaces over very large regions whereas photogrammetry produces more accurate ground topography in vegetated terrain than LiDAR.

Members of the DASA are further investigating LiDAR and photogrammetry in terms of their ability to map volumes of terrestrial sediments, which does not require knowledge of absolute elevations. In FY2002-03, we investigated remote-sensing technologies to determine vegetation habitat structures (area, volumes, heights), to map and monitor older river terraces, to map and monitor channel bottom deposits, and to monitor the river water's suspended load and turbidity.

The remote sensing initiative was completed at the end of FY2003. A report was completed in Fall FY2003 that recommended technologies for implementation within all GCMRC program areas to the Technical Work Group (see Davis et al., 2003). Remote sensing activities in FY's 2005-06 will largely consist of data collection in support of the biological, cultural, and physical science programs at GCMRC, with airborne data proposed for collection in Spring of FY2006 in support of Core Monitoring.

Core Data Storage (Database management) - The DASA is the first of three fundamental technologies for consolidating, storing, and distributing data gathered as part of monitoring and research projects at GCMRC. Its purpose is to store all tabular data available in electronic form and to reference additional data that is either not available in electronic form or is not tabular (e.g., digital imagery). The Oracle data base engine was selected for GCMRC data base development. Oracle is a state-of-the-art data storage and delivery system that can function either

as a centralized or distributed data base and incorporates a high degree of information technology integration. The DBMS program is currently working on bringing together years of disparate historical data collected by multiple entities located in databases across the southwest, in an organized fashion and then deliver it transparently to stakeholders and researchers for decision-making and modeling purposes. A key aspect of this work has been integrating Oracle's database management software with the Center's ARC/INFO GIS, so that all tabular data sets can be viewed and queried in a spatial context.

After several failed attempts at contracting for an Oracle database developer to advise us on overall infrastructure and design issues, we are now negotiating with the Center for Data Insight (CDI) located at Northern Arizona University to assist in these activities through a cooperative agreement. The CDI has experience working with large disparate datasets in a research environment on an Oracle platform. A requirements analysis describing the data management framework of the database has been developed. It is anticipated that a pilot project that demonstrates the look, feel, and functionality of the completed DBMS using a subset of GCMRC data will be completed by the end of February 2003. After completion of this pilot project, remaining data collection efforts at the Center will be prioritized and integrated with the database design, and corresponding data sets imported.

Core Data Analysis (Geographic Information Systems) – The Geographic Information Systems (GIS) Program provides technical support, spatial databases and spatial analysis capabilities to scientists in the physical, biological and cultural resource programs and their cooperators. Monitoring activities within the CRE are inherently spatial in nature, any cross many scientific disciplines. In this context, spatial database integration is an extremely important component of a successful integrated science program. It provides the framework for canyon-wide ecosystem studies. In combination with canyon-wide remote sensing data, GIS provides an important tool for integrating and analyzing large amounts of site-specific, regional and canyon-wide data in formats that are supportive of scientists as well as resource managers. Over the past several years, the GIS program has provided many important products and services to scientists and cooperators operating within the GCMRC framework. These have included: spatial database collection, development and integration; field operation and mapping support activities; the development of common spatial referencing systems; and custom GIS programming and analysis for specific scientific projects. Some important GIS products have

included: a canyon-wide shoreline habitat map; an automated fine-grained sediment inventory and camping beach analysis developed from digital imagery; an automated tool for generating composite terrestrial / hydrographic cross-sections and virtual shorelines in support of hydrologic modeling; and large-scale river map guides.

The GIS program will lead the effort in implementing the **automated core monitoring technologies and applications** approach. This effort is designed to quickly and accurately classify large sets of raster and vector data into core monitoring information that are useful to scientists and resource managers. Future GIS efforts will focus on automated analyses of remotely-sensed data in support of specific physical, biological and cultural resource projects and core monitoring missions, as well as continued integration of spatial information for scientific analysis and reporting. In FY2003, the GIS program demonstrated that automated processing of multi-spectral digital imagery could be utilized to accurately map vegetation and the two-dimensional distribution of fine-grained sediment deposits above 8,000 cfs on a canyon-wide basis. In FY2004-05, these analyses will be repeated with an emphasis on change detection. Techniques will also be developed for automated processing and classification of data acquired from the terrestrial and hydrographic LiDAR missions and existing multi-beam sonar data.

SOCIO-CULTURAL RESOURCES

The Sociocultural Program has traditionally been a stand alone program within the GCMRC's organizational structure. In GCMRC's new organization structure, the program's independent status has been maintained, but the research and monitoring initiatives of the program will be realigned with GCMRC's over-arching integrated science framework. Under GCMRC's new organizational structure and approach, research and monitoring projects conducted in support of sociocultural program needs will be coordinated and integrated with ongoing research and monitoring activities in the Integrated Science Program. Data collected through the sociocultural program's research and monitoring projects will be stored and analyzed using the Oracle database engine and GIS spatial positioning technologies, allowing impacts of dam operations on cultural components of the Colorado River Ecosystem to be evaluated and analyzed in conjunction with physical and biological elements.

In the past, GCMRC's sociocultural program has been defined in terms of three program elements: cultural resources, recreational resources, and socioeconomics. In reality, these

program elements are closely interrelated. For example, recreational campsites are essentially modern equivalent of prehistoric archaeological sites, in that they are places preferentially selected for human activity according to the dictates of the culture currently making active use of the Grand Canyon river corridor. Values attached to traditional cultural places by Native American communities have counterparts in the values attached to beaches, rapids, fishing holes, and trails by modern recreational (angler and whitewater boating) communities. While the specific values associated with particular places in the CRE may be very different, the fundamental concern with protecting specific valued attributes and the river corridor as a whole from adverse effects of dam operations is similar in that the concern is focused on retaining the intrinsic values of places that foster and perpetuate a community's sense of identity and tradition.

There are specific legal obligations and regulations that pertain to historic cultural resources, especially those that are deemed eligible for listing on the National Register of Historic Places; these legal mandates require that certain classes of cultural resources be treated and managed in accordance with regulatory guidelines and standards promulgated by the Secretary of Interior. The Bureau of Reclamation has primary responsibility for managing and treating National Register-eligible cultural resources within the CRE for the purposes of meeting the legal requirements of Section 106 of the National Historic Preservation Act. BOR fulfills its Section 106 responsibilities through conforming to the stipulations of a Programmatic Agreement with the the Advisory Council on Historic Preservation ; the Arizona State Historic Preservation Office, National Park Service, and six Native American Tribes are also signatories to this agreement. From time to time, GCMRC assists the BOR and PA signatories with fulfilling their Section 106 obligations through contracting required studies and conducting protocol assessments. The GCMRC sociocultural program also addresses the cultural resource needs for research and monitoring that fall outside the purview of the PA and relate directly to the mandates of the Grand Canyon Protection Act. Furthermore, due to the need for continuing consultation with the Native American tribes who have a continuing affiliation with the landscape and resources of the Grand Canyon, and because of the unique trust responsibilities of the federal government in relation to Native Americans, GCMRC's sociocultural program involves more than implementing and directing science projects. Therefore, the sociocultural program has retained its independent status within the new GCMRC organization, while at the

same time moving towards increased levels of integration with other components of the Integrated Science Program (ISP).

Cultural Resources - Cultural resources of interest to the AMP along the Colorado River corridor include National Register eligible archaeological sites and traditional cultural places, as well as non-eligible resources of traditional cultural importance such as springs, landforms, and traditionally used plants and animals. In keeping with the stated purpose of the Grand Canyon Protection Act (Section 1802) to "operate Glen Canyon Dam in … such a manner as to protect, mitigate adverse impacts to, and improve the values for with Grand Canyon National Park and Glen Canyon National Recreation Area were established," the goal of GCMRC's cultural resource research and monitoring efforts is seek to ensure the *in-situ* preservation of cultural resources with minimal impact to the integrity of those resources. When *in situ* preservation is not possible, data recovery through excavation or other mitigation measures as appropriate may be implemented. GCMRC works with the signatories to the Programmatic Agreement for Cultural Resources to help devise research projects that will assist in the preservation and treatment of National Register eligible properties. In addition, GCMRC is concerned with devising and implementing projects that address the non-eligible resources of traditional importance to Native American tribes who have cultural affiliation with the Grand Canyon.

Since 1992, cultural resources have been monitored by National Park Service and by tribal representatives. The cultural resource monitoring work conducted to date has primarily been carried out in fulfillment of the Programmatic Agreement requirement to provide information for use in developing a long-term Historic Preservation Plan. The PA-driven monitoring activities typically have included site visits, using repeat photography and qualitative observation to track changes in resource condition, plus tribal assessments of traditional cultural resources and overall "health" of the ecosystem according to traditional perspectives. Cultural resources are monitored routinely and during high flow events. Beginning in FY05, monitoring of cultural resources in the CRE will be redirected to focus on the specific requirements of the Grand Canyon Protection Act: to generate data that will improve understanding of the effects of dam operations on these highly valued and largely non-renewable resources and to provide information to the AMP that will be useful in formulating recommendations to the Secretary of the Interior about managing dam operations so as to "protect, mitigate adverse impacts to, and improve" the cultural resource values in the CRE.

Many of the archaeological resources along the river corridor are contained in the sediment deposits that form alluvial terraces. Since the completion of Glen Canyon Dam, the sediment resource has declined. The alluvial terraces where many archaeological sites are located continue to erode. A system-wide method for regenerating the river terraces and redistributing sediment has been identified as an essential component to maintaining future integrity for cultural resources (Balsom, 1996).

Previous Cultural Resource Investigations: The 1996 BHBF presented an opportunity to study the effects of high flow discharge from Glen Canyon Dam on alluvial terraces and margin deposits along the river corridor. The flow was expected to provide system-wide mitigation to most cultural sites in the Colorado River corridor through the accumulation of additional sediment. The overall findings of the cultural resources studies strongly suggested that the 45,000 cfs BHBF flow had either no effect, no adverse effect, or a beneficial effect on cultural resources. These findings support the original contention that beach habitat-building flows above power plant capacity can offer a system-wide mitigation for cultural resources. Some locations, especially in the Glen Canyon reach, did experience loss of sediments or re-deposition of sediments in a way that, in the long run, could be detrimental to cultural resources (Balsom, 1996). More recent research in the physical resources area (see pages 9 through 10) indicates that the timing of artificial "floods" relative to tributary inputs is the most beneficial.

In the past five years, the following projects have been completed: a synthesis of data collected by the NPS and Tribal groups (Neal et al. 2000), mainstem flow and deposition modeling (Wiele 2003), and development of a geomorphic model for predicting the susceptibility of archaeological sites to erosion (Thompson and Potochnik 2000). The data synthesis report (Neal et al., 2000) identified crucial data gaps in previously collected data. Wiele's (2003) stage flow and deposition modeling project provided information on estimated sediment deposition at selected archaeological resource locations, given particular water releases and modeled sediment loads. The geomorphic model by Thompson and Potochnik (2000) attempted to distinguish erosional processes that are related to dam operations versus naturally-occurring processes. Also in FY2000, a cultural resource protocol evaluation panel (PEP) was organized. The panel's report (Doelle et al., 2000) provided GCMRC and USBR with a series of recommendations for program coordination and future activities. The work activities undertaken since 2001 have been driven by the PEP recommendations (see below).

Recent and Ongoing Cultural Resource Investigations: Current resource monitoring of archaeological and traditional resources indicate that archaeological resources continue to be impacted by physical impacts such as surface erosion and gullying in both the Grand and Glen Canyon areas. In the CRE, some surface erosion is clearly due to natural processes that are unrelated to dam operations; however, other sediment loss from archaeological sites is believed to be related to dam operations. The contributing effects of dam operations to the ongoing erosion of the river corridor's alluvial terraces (where many archaeological sites) are located remains uncertain and a issue of continuing controversy. Furthermore, the contributing effects of visitor use to the erosion of archaeological resources have never been systematically evaluated, although a relationship between human recreational activities and soil compaction and erosion is known to exist.

Qualitative monitoring of cultural resources continued in FY03, as it has since the program began in 1992. Aside from the cultural resource monitoring program (which is conducted under the auspices of the PA program and falls outside the purview of the GCMRC-sponsored scientific peer-review process), several new initiatives have been implemented by GCRMC in the last few years, following recommendations of the 2000 cultural PEP. A project to evaluate the effectiveness of check dams as a mitigation strategy to slow erosion at archaeological sites was initiated in FY01 and is due to be completed by December, 2003. The initial results of this project (Pederson et al. 2003) suggest that check dams are effective if they are situated appropriately, use appropriate materials (brush appears to be more effective and less damaging than rock checks), and are continually maintained. Another related goal of this research initiative was to test the accuracy of photogrammetry as a tool for detecting geomorphic changes at archaeological sites. Pederson et al. (2003) concluded that errors associated with low-level, high resolution photogrammetry are too great to detect meaningful changes in arroyo depths and nick point migration at the level most desirable for tracking erosion at archaeological sites (less than 20 cm vertical change); however, they noted that newly developed remote sensing technologies such as LiDAR may be able to provide remote data with the necessary accuracy. One cultural project proposed for FY05 (B.2) will build upon the initial results of this research project by continuing to evaluate the effectiveness of the check dams and by testing the accuracy of LiDAR. This new project will also develop a mathematical model to predict areas of sites

most likely to erode under specified hill slope gradients, soil conditions, and dam-controlled flow parameters.

Another cultural PEP recommendation that was initiated in FY2002 involved the preparation of a comprehensive research design to guide future research and monitoring initiatives in the river corridor. The research design was identified by the PEP as a key component of the Historic Preservation Plan mandated as a stipulation of the current PA. Although originally intended to serve the needs of the PA, the scope and purpose of the research design was expanded to include a framework for researching and monitoring the full spectrum of cultural resources found within the CRE, to meet not only the requirements of the National Historic Preservation Act but also the broader mandates of the Grand Canyon Protection Act. A draft version of the research design was submitted to GCMRC and reviewed by both independent scientists and PA signatories in spring, 2003; the final research design is scheduled to be completed by December, 2003.

A new cultural resource research project initiated in FY2003 is designed to track the effects of aeolian transport of fine sediment on the preservation of archaeological resources in the CRE. This research project is one of the integrated research initiatives being conducted as a component of Project A.3. Sand-Storage Monitoring. (See project A.3 for more details).

Recreational Resources - Recreational resources encompass several diverse, tangible elements: the blue-ribbon trout fishery at Lees Ferry, the challenging whitewater rapids in the Colorado River, and camping "beaches" in Grand Canyon. Recreational resources also encompass experiential attributes, such as opportunities to experience solitude, natural quiet, and physical challenges in a wilderness-like environment. Recreational issues of specific concern to the GCMRC sociocultural program include changes in the size and availability of camping beaches due to dam operations, changes in the quality of recreational experiences within the CRE (including trout sport fishing, recreational river trips, and wilderness-dependent recreational opportunities) due to effects of dam operations, plus the economic impacts to the recreation industry from varying flow regimes. GCMRC has supported studies in all of these areas.

Previous Recreation Investigations: Sand bars serve as campsites for rafting groups and are highly valued based on size, boat mooring quality, wind protection, access to side canyon hikes, scenery, and shade. Historically, these "beaches" were replenished annually by sand and silt transported by the river during spring runoff. Since this sediment now settles out in Lake

Powell, the beaches downstream are eroding due to the river's clear, sediment-free flows (Kearsley et al., 1994). Camping beaches are also being eroded through gullying induced by monsoon rainstorm runoff, and due to the lack of periodic floods, these increasingly degraded beaches are not being replenished. Most pre-dam beaches are now considerably smaller, and some have disappeared completely. The size and availability of camping beaches is directly tied to visitor experience parameters in that the decreasing size, abundance, and distribution of campsites constrains the visitor carrying capacity of the CRE and may lead to crowding or reduction in visitor access, thereby creating adverse impacts to visitor use values in the CRE.

In 1994, change in campable area was analyzed using aerial photographs (Kearsley et al., 1994). This analysis revealed that loss of campsites was an ongoing process. They noted that not all sand bars responded in the same manner to flows and vegetation encroachment, and that campsite availability in critical reaches (Marble Canyon, the Inner Gorge, and the Muav Gorge) had decreased the most. Effects of the 1996 controlled flood at selected campsites were also evaluated, and it was found that the increase in the number and size of campsites was of short duration (Kearsley et al. 1999). The post-BHBF data indicated that while floods temporarily increased campsite number and size, the beneficial effects to campsites were temporary, and that campsite size rapidly degenerated to pre-BHBF levels and then continued to erode more slowly. Although the effects of the 1996 artificial flood were temporary, periodic "floods" above power plant capacity appear to be the only feasible means of depositing sediment and rejuvenating camping "beaches" above normal fluctuations (Kearsley et al., 1999).

One previous study assessed recreational preferences relative to dam-controlled flows and quality of camping opportunities (Stewart et al. 2000). The study concluded that users of the Colorado River were relatively unconcerned about impacts of fluctuating flows, had strong concerns (generally positive) about impacts of spike flows, and strongly preferred sandy beaches with shade (especially from trees) for camping.

Recent and Ongoing Recreation Investigations: Recent GCMRC studies have assessed camping beaches, trout fishing activities, and recreational river running in terms of visitor experience issues and safety concerns associated with varying flow levels. Low Steady Summer Flows in summer 2000, provided data on impacts to recreational experiences (Jonas and Stewart 2002), travel rates and safety (Jalbert 2001) and economic impacts to concessionaires (Hjerpe and Kim 2001). Final reports have been received for all projects except the safety study.

Annual monitoring of 31 campsite areas is on-going as part of the FIST. Interim results from this monitoring indicate that camping areas continue to erode slowly but steadily. However, research results also suggest that erosion can be offset by flows greater than power plant capacity combined with adequate sediment supply (Hazel et al., 2001). A more complete discussion of sediment monitoring is found in the previous sediment resources section for fine-sediment storage and sand bar monitoring. In addition to the quantitative evaluation of beach size, camping beaches are also being monitored less rigorously by Grand Canyon River Guides through the Adopt-A-Beach (AAB) program. Initiated in 1996, the low cost Adopt-A-Beach effort relies largely on volunteer contributions of commercial guides to provide qualitative and anecdotal information on changing beach conditions. It program lies on repeat photography taken from established photo points, supplemented by the guide's observations. The results of the AAB monitoring effort supplements the quantitatively derived information derived from the campsite surveys. The FY03 AAB report generally supports the findings of the recent beach surveys that campsite areas are generally declining due to both loss of sediment from the beaches and encroachment of vegetation.

An on-going effort is an analysis of past campsite assessment and monitoring protocols used to qualitatively and quantitatively assess changes in beaches (sand bars) and detect area and volume changes. A draft report on this work is available (Kaplinksi et al. 2003), and will be finalized by December 2003. One recommendation of this assessment effort is that GCMRC should convene a panel of recreational experts to assess the effectiveness of current approaches for monitoring visitor use values over the long-term. This recommendation is being implemented through organizing a recreational PEP review in FY04. In addition, the researcher pointed out that despite 30 years of monitoring human and dam-related impacts at campsites, we lack a comprehensive inventory of campsites in the river corridor. This deficiency will be addressed through a new project initiative (B.6) proposed for FY06.

RESEARCH COORDINATION AND SUPPORT PROGRAM

Implementation of the GCMRC mission to provide credible, objective scientific information to the AMP begins with effective coordination of all technical and logistical support of research activities. The Research Coordination and Support Program staff functions as a team to facilitate collaboration with the Integrated Science and Cultural Programs through effective

communication with Program Managers, PI's and the Technical Support Services. The program encompasses the integration of 5 elements:

- Permitting
- Library Operations Coordination
- Technical Support Coordination
- Survey Support Coordination
- Logistics Operations

Program Staff address each of these elements in assessment of support requests from researchers to determine which tools and processes will best facilitate the most effective collection and delivery of information from research projects. Through the combined effort of the program elements the process of research support is executed as a complete and fully integrated support service. The process is initiated in the proposal review and permitting stage, continued through the support coordination stage and completed with information delivery. The process acts as an accountability checkpoint, failure to meet agreed data collection and delivery standards is addressed immediately and corrective solutions are sought to avoid any delay in project completion.

Permitting-Research projects supported by the GCMRC must hold all required permits in compliance with Federal, State, Tribal and Local Agencies in which project activities are conducted and accessed. Research activities conducted within Grand Canyon National Park and Glen Canyon National Recreation Area require National Park Service **Research and Collecting Permits** and **Access Permits** for all river launches, back country use, over flights, and media (filming) production. All permits acquired for GCMRC supported projects are processed and submitted through the Research Coordination and Support Program. Copies of all approved permits are kept on file in the Research Coordinator's Office.

All Investigators, Permitees, and project cooperators are responsible for compliance with the regulations and restrictions of their Research and Collection Permit. All trip participants are expected to comply with all GCNP Commercial Operating Requirements while participating on research trips. All PI's and their designated Permitee are required to sign a Research Use Affidavit/Notice of Adverse Actions and Penalties Form which specifies potential penalties for violations of permit conditions. **Failure on the part of investigators or their representatives to adhere to Park and Permit Regulations may result in withdrawal of their permit and other penalties.**

- **Research and Collecting Permits**-Reseachers submit project proposals and all other required information (guidelines available on NPS web site) to the GCMRC Research Coordinator. Proposals are distributed externally for review in accordance with the GCMRC Peer Review Guidelines and Protocols. Internal review is completed by Program Managers, support coordinators, and are submitted to the GCMRC Chief for final approval. Finalized permit information is then submitted to the NPS for final review and approval. **NPS Research and Collecting Permit applications require 90 days for processing.**

- **Access Permits**-Researchers holding approved R & C Permits submit a Trip Request Form to the Research Coordinator 60 days in advance of their planned research activity. This form includes request for logistical and support services and all information required for an NPS access permit application. **NPS Access Permit applications require 45 days for processing.**

Library Operations Coordination - Interaction with Library Operations is a vital component in the success of the support of GCMRC's monitoring and research projects. Coordination with Library Operations facilitates the support of research activities in two key aspects:

1. The Library provides a centralized repository for hard copy information such as books, reports, maps, photography, and videos. A fundamental function of the library is to provide funded researchers access and use of these library's materials unique to the GCMRC collection.
2. The Library has also implemented a consistent peer review process to help ensure the quality of scientific projects conducted by the GCMRC. The Peer Review Protocols developed and administered by the library are utilized in the NPS permitting process for external review of project proposals prior to submittal to the NPS Research Office for review and approval.

Survey Operations - The long term monitoring objectives of GCMRC require positions and elevations for past, present, and future spatial datasets. The GCMRC Survey Department's mission is to provide survey support for 1) collection of these spatial measurements and, 2) referencing the spatial data collected in the Colorado River ecosystem to the primary control network. The survey department is also responsible for establishing and maintaining the geodetic control network in Grand Canyon. The geodetic control network serves as the foundation for all spatial measurements necessary for long term monitoring. This control network also serves as the spatial framework for the Geographic Information System (GIS). The referencing of spatial data must be consistent in order to perform accurate change detection. All measurements collected for

studies approved by the Adaptive Management Program are archived for quality assurance, quality control, network adjustment, and database integration.

The survey department provides network control point coordinates and error estimates, QA/QC for remote sensing, topographic and hydrographic maps, and the additional manpower necessary to collect these data. The survey department staff also incorporates historical datasets that had been previously referenced to superceded or local control coordinates into the CRE database. This integration requires translation and rotation of the instrument and reference azimuth stations to match the most current coordinates, which reference the primary geodetic control network.

The survey department is familiar with data collection and processing of topographic, hydrographic, and geodetic data. Specific equipment available to researchers includes static, kinematic, and Real Time Kinematic (RTK) Global Positioning Systems, single-beam and multi-beam hydrography, acoustic Doppler sensors, laser scanners and conventional survey equipment. The Survey coordinator assesses the level of survey support required to efficiently implement individual studies and evaluates and schedules equipment and personnel requests.

Technical Support Coordination - Integration of support capabilities in the areas of GIS and Remote Sensing is critical to the success of scientific data collection and integration for all of GCMRC's research and monitoring projects. Technical Support Coordination requires effective communication with Researchers, Program Managers and GIS and DASA personnel to facilitate collection and delivery of information that complies with GCMRC Data Standards. Coordination entails evaluation of requests and scheduling of the appropriate equipment, materials, services and personnel required to implement research activities. Examples of Technical Support requests include:

- Copies of existing map products and aerial photo sets.
- Processing requests to GIS for new map products.
- Scheduling Field Equipment (i.e. Computers, handheld GPS units, digital cameras, etc.).
- Scheduling personnel required to assist with field work.
- Consultation with GIS personnel for recommendations on data collection methods to achieve effective integration with the GIS.
- Consultation with Data Base personnel for advice on data collection formatting to achieve effective integration with the GCMRC Data Base.

Additionally, future dissemination of essential information to researchers related to permitting procedures, trip planning and survey and technical support requests will necessitate utilization of the GCMRC web page. Development of a Research Coordination and Support Program web page will include information pages and access to on-line forms to submit requests for scheduling river trips, and survey and technical support. The web pages will be developed in cooperation with the Information Management Program staff.

Logistics Operations - The GCMRC provides complete logistical support for 35-50 research, monitoring and administrative river trips through the Grand Canyon annually. These trips range in length from 7 to 21 days and from 4 to 36 people in size. Trips are comprised of a variety of motor and oar powered boats operated by contracted boat operators. Projects operating in the Glen Canyon reach of the Colorado River (Glen Canyon Dam to Lee's Ferry) are supported by a variety of motor powered boats operated by GCMRC researchers and contracted boat operators. Additionally, research activities on the Little Colorado River and at other locations outside of the Grand Canyon National Park boundaries are supported by helicopter services contracted with the Bureau of Reclamation. Ground based support for other research activities outside of the river corridor are also coordinated with the use of GCMRC leased vehicles.

The GCMRC uses a method of supporting trips in which government owned boats and river logistical equipment are used in conjunction with a contracted vendor who supplies Technical and Logistical Boat Operators. A concerted effort is made to match PI's with the best possible Boat Operators for their particular study. Food packs, trip supplies, and equipment are organized, packed and maintained at the GCMRC warehouse. Put-in and take-out transportation is provided with the use of GSA leased vehicles and contracted shuttle drivers.

This logistical approach has evolved since the GCES phase to allow a detailed overview of trip particulars that most influence cost and efficiency, ultimately giving the GCMRC control over trip costs and productivity. Effective communication with PI's and sensitivity to and awareness of the challenges they face in implementing their studies enable the GCMRC to offer more customized (and therefore more cost-effective and productive) logistical support than other support strategies utilized previously. Retaining control over the process of supporting trips also facilitates compliance with NPS regulations and allows greater control over issues sensitive to the general public and the "recreational river community".

The trip planning and scheduling process begins in the fall when the Logistics Coordinator, in cooperation with contracted PI's, Program Managers and the Research Coordination and Support Staff work together to generate a draft schedule of trips for the fiscal year. The schedule includes; launch and take-out dates, numbers of personnel and specific boat and boat operator requests for each trip. Researchers must submit a Trip Request Form a minimum of 60 days prior to the scheduled launch date. This form provides information for two purposes: 1) determine and schedule logistical and support services and 2) complete a GCNP River Trip Application in order to meet the GCNP 45 day deadline for submitting access permit applications.

The Logistics Budget is distributed to GCMRC projects based on a formula proportional to use of services. The formula takes into account contractor costs, trip size and length, and a percentage of operating expenses, salaries and permitting costs.

INFORMATION AND OUTREACH

The newly constituted Information Program at GCMRC coordinates the systems administration program and the library functions of the Center. The following describes the technologies as they existed prior to the FY03 GCMRC reorganization. Under the new organization, the IT program coordinates the activities of systems administration and the library. Other functions are now housed under the structure of the IESP and the Logistics Program. The functions have not changed, but their organizational affiliation has. With the preceding caveats noted, and for the sake of continuity, the following discussion follows the old organization. The next annual work plan will be reorganized to recognize the changes.

The goal of the Information Program (IP) is to satisfy the information needs of the GCDAMP relative to the Colorado River ecosystem in terms of content and delivery.Key to achieving this goal is the development and maintenance of three core information technologies:) a data base management system (DBMS) for tabular information and other electronic non-spatial information, 2) a geographic information system (GIS) for electronic spatial information, and 3) a library for hardcopy information. Content of these systems consists of all information gathered as the result of GCMRC investigations, GCES investigations, and additional information relating to the Colorado River ecosystem.

Data in itself is of little use without sufficient information as to its context, quality, and comparability. Therefore, data standards have been be developed which preserve the context under which the data was collected and ensures its quality and comparability from year to year, place to place, researcher to researcher, and discipline to discipline. Data collection efforts supported by the GCMRC incorporate strict data standards and protocols that provide consistency in data collection, storage, and delivery from disparate sources.

The GCMRC has extensive historical data and information collected over many years relating to the condition of resources in the Colorado River ecosystem. This information represents an extremely valuable asset to the Glen Canyon Dam Adaptive Management Program (GCDAMP). Its potential for problem solving, improving management guidelines, modeling relationships, or increasing understanding of the key resources and systems under study requires placing this legacy data into an ecologically integrated database and geographic information system (GIS).

Delivery of electronic content will be automated where possible using user-friendly World Wide Web browser interfaces. Library content, while not deliverable across the Internet, has been cataloged and is searchable electronically utilizing similar interfaces.

Warehoused data conforms 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 is being incorporated into GCMRC database design and delivery systems whenever possible.

DBMS, GIS, and library operations together form the core information system infrastructure for storing and retrieving information at the GCMRC. Data standards and protocols ensure the quality and compatibility of the information contained within those systems. World Wide Web browsers provide intuitive, consistent interfaces to the information. However, information technology at the GCMRC goes beyond the content and delivery of information. In addition, the IP also provides:

- Computer support to GCMRC staff
- Survey support to researchers
- Development of remote sensing applications

These additional services augment the core information infrastructures by providing the support, training, technology transfer, and development necessary to provide a comprehensive IP.

INFORMATION PROGRAM FUNCTIONS

To satisfy the information needs of the GCDAMP in FY2004, the IP and the IESP will focus on 7 functions: 1) GIS operations, 2) database management, 3) library operations, 4) survey operations, 5) decision support, 6) systems administration, and 7) aerial photography. Each information/support function of the IP and IESP program is described in detail below. Descriptions include general information concerning the role of the function within the GCMRC, proposed objectives to be accomplished in FY2004, and proposed budgets. DASA functions are either performed by GCMRC staff or procured through a contracting process. Non-contracted program budgets include operating costs and salaries that combine to represent the total cost of the function (less the cost of space and administrative overhead). Operating costs include equipment, supplies, technical training, and travel relating to program functions. Contracted DASA functions represents the total cost of the contracted service or product to GCMRC less the cost of administrating the contract by the appropriate contracting officers technical representative.

Non-contracted DASA program functions have associated with them ongoing objectives that are necessary to organize and manage the various types of scientific data acquired by GCMRC or its contractors. These ongoing objectives include administration of the function, servicing work requests, servicing data requests, incorporating new data into developed data systems, and performing annual inventories.

Library Operations

Library operations facilitate monitoring and research by providing a centralized repository for hard copy information such as books, reports, maps, photography, and videos. The scope and purpose of the library is to collect, archive and deliver materials that assist GCMRC in its efforts to administer long-term monitoring and research.

Inherent in the administration of long term monitoring and research plans is the delivery of hard copy documents, photographs, slides, videotapes, and ARC/Info coverages. A policy for loaning these materials has been developed in a manner that is fair to all researchers, with

underlying GCMRC staffing resources determining the ability to deliver and track loaned materials. Delivery of materials also emphasizes technologies that permit remote multi-user access.

A secondary function is to provide funded researchers access and use of the library's materials and to provide non-funded researchers and the general public with access to documents unique to GCMRC's holdings (duplicate documents available at other institutions provide non-funded researchers access to these materials). The singularity of a document requires a special policy concerning the borrowing of these materials. Because these unique documents are considered part of the public domain, their availability to the public is required

Materials collection, for the purpose of research and monitoring efforts, are coordinated with program managers and information technology managers. Criteria for the accession of materials include:

1. Applicability of materials to specific research efforts and to overall research and management goals; adequacy of the facility and equipment needs of the GCMRC to house materials; ability of the staff to archive and deliver materials;
2. Availability of funding for materials (e.g., general reference books, government publications, CD ROM's, etc.).

Material collection also includes accessioning documents that are the product of research funded by GCMRC.

Library holdings included the following:

1. Hard copies and electronic copy of final funded research reports.
2. Reprints of articles resulting from funded research.
3. Books resulting from research efforts associated with GCMRC.
4. Books and articles related to Grand and Glen Canyons.
5. Books and articles related to natural and controlled riverine environments.
6. Photographs and slides developed by GCMRC staff (aerial and field documentation).
7. CD-ROM and DVD-ROM versions of aerial photographs and slides.
8. Videotapes (overflights, programs related to Glen and Grand Canyon).
9. Maps (topographic, flightline maps, Arc/Info Coverages, Orthophotos).

Archival materials are one of a kind, or hard to replace items (e.g., original aerial photographs, slides, videotapes). Utilizing imaging technology (e.g., CD-ROM's) and electronic

media to develop copies of archived materials should always be investigated and promoted so that copies of these materials can be made available to the general collection, and thus reducing the incidence of loss of unique and irreplaceable materials.

Ongoing library activities are:

- Administer library operations
- Service library requests
- Integrate current year data into library
- Continue making content available on-line
- Annual inventory

FY2004 library activities are:

- Aerial photography scanning project

Aerial photography scanning project

The GCMRC's library collection includes almost 26,000 aerial photographs of the Colorado River spanning a period of 65 years. Of all of the types of media available in the library, including reports, photos, videotapes, slides, and maps, the aerial photos are the most used by researchers. Repeated use has degraded the quality of the photographs; some have been damaged and others have been lost. While some of the negatives are available through the various contractors who have collected the data, others are not. Presently, the photo collection is at risk because it is not stored under fireproof and waterproof conditions. Transferring these images into a digital format will provide greater accessibility to researchers and better preservation of the original media. Photographs, including both black and white and color infrared images would be selected, scanned, compressed, and archived onto GCMRC electronic data systems and DVD. The aerial photography scanning project is a four year project that is scheduled to begin in FY2004 and continue through FY2006. In FY2004, activities of this project include acquiring an appropriate scanner and conducting a pilot study.

Decision Support System

GCMRC provides objective, scientific information to the AMWG for use in making recommendations to the Secretary of the Interior regarding the effects of dam operations on the Colorado River ecosystem (CRE). In support of this effort, GCMRC has developed: (1) a conceptual (i.e., computer) model of the CRE, (2) a detailed map of the CRE and GIS overlays

for the CRE. In addition, in FY 2003, significant progress was made in the development of an integrated Oracle database of scientific information pertaining to the CRE. Missing from this equation is the decision-support system (DSS) overlay that can act to integrate these various efforts and support the AMWG in examining various management actions / policy changes that they may wish to recommend to the Secretary. The decision support system development and implementation is a three to five year project that will begin in FY2003 and continue until FY2005-2007 depending on contracting needs. In FY2004 activities of this project will focus on:

- Conducting needs assessment
- Evaluating existing tools and approaches

Systems Administration

The GCMRC computing environment is a complex system of servers, workstations, laptops, printers, plotters, modems, routers, hubs, switches, copy machines, FAX's, and telecommunications equipment networked together using 100baseT networking media. Most of the computers are PCs running the Windows NT/2000 operating system. In addition, over 50 applications are utilized by GCMRC scientists and support personnel in carrying out the collective mission of the GCMRC. Applications are primarily off-the-shelf products but in many cases are highly specialized. It is anticipated that World Wide Web development and maintenance will be moved to within this program in FY2004.

Ongoing activities are:

- Administering GCMRC network, computers, and software
- Administering the GCMRC website
- Troubleshooting day-to-day computer problems
- Upgrading existing computing infrastructure and provide new functionality
- Creating improved web content

MANAGEMENT OBJECTIVES AND INFORMATION NEEDS

Introduction

Management objectives (MOs) and information needs (INs) help to define measurable standards of desired future resource conditions to be achieved by the AMP. The MOs and INs also drive the strategic planning process and they provide the basis for the annual monitoring and research program described in this plan.

Historical Development of the Management Objectives and Information Needs

Using the nine resource areas in the EIS, meetings and workshops were held in 1996 to formulate management objectives and to define information needs associated with the various management objectives. These were intended to guide the development of GCMRC monitoring and research activities. In 1997 and 1998, additional discussions were held to revise Management Objectives and prioritize Information Needs. In FY 2001, the AMWG adopted a new set of MOs that resulted from its effort to develop an AMP strategic plan. The full AMP strategic plan was completed in FY 2002-03.

Revision Process

As part of the AMP strategic planning process, the INs are being revised through a collaborative process led by the Grand Canyon Monitoring and Research Center. This process was initiated during Spring 2001, with a series of workshops and meetings with TWG representatives to discuss and refine the INs. A final meeting was held in October 2001 and the final draft of the Information Needs will be discussed at the November 2003 TWG meeting and forwarded to AMWG for their approval in January 2004. This plan references the current MOs, as the INs are currently under revision and have not been finalized. The MOs are listed in Appendix One.

The monitoring and research activities proposed in the FY 2005 Work Plan are intended to address the current management objectives and provide information to address INs that will be finalized in the future for monitoring and research activities for the Colorado River ecosystem. The specific MOs addressed by the monitoring and research activities proposed in this plan are listed in Appendix Two and referenced in the project descriptions.

PROTOCOL EVALUATION PROGRAM

The Protocol Evaluation Program (PEP) was initiated in 1997 to provide independent external review of all GCMRC monitoring and research programs and provide recommendations to GCMRC regarding the specific monitoring protocols that will be used. Phase I of the PEP process for evaluating current and new alternative protocols in all program resource areas, except socio-economic and recreation, was completed by the end of FY 2003. A PEP was conducted during winter 2002 for assessment of survey support services to GCMRC. The recommendations resulting from these workshops have been distributed to the TWG and AMWG and are being used to develop a core-monitoring plan for the Colorado River ecosystem and modify the FY's 2005-06 work plans as appropriate. All PEP workshops and evaluations are conducted in cooperation with external experts identified through a competitive, nationwide selection process, as well as in collaboration with GCMRC science cooperators, contractors, and Technical Work Group members. All PEP final and draft reports are available through the GCMRC's web site. Phase II PEP reviews are proposed in FY 2005 for remote-sensing and physical-resource categories of core-monitoring toward implementation of the GCMRC's core monitoring plan.

CONTINGENCY PLANNING

The GCDAMP has adopted hydrologic criteria and resource criteria for triggering releases above peak power plant discharge from Glen Canyon Dam. When triggered, these criteria provide little lead time for monitoring and research planning. In addition, hydrologic conditions can lead to unplanned release events which may also require GCMRC to implement monitoring and research activities with little to no lead time. The possibility for unanticipated hydrologic events to force experimental treatments results in the need for contingency planning. Annually, GCMRC develops contingency plans for implementation of:

1. Effects monitoring before and (or) after unplanned events, as appropriate;
2. research assessments of above peak power plant discharges from GCD (as per the GCDEIS) or other short-duration high flow unplanned events; and
3. an effects monitoring and research program for planned events between January-July of a given year.

An experimental flows fund to support additional monitoring and research activities resulting from implementing test flows in response to these triggering criteria has been

established. In FY 2003-04, the amount of funds in this account was sufficient to support a test. It is unclear what the state of the fund will be in FY's 2005-06.

SCIENCE SYMPOSIUM

The GCMRC has initiated a program of regular scientific symposia to discuss the current state of scientific knowledge regarding the Colorado River ecosystem, as well as to learn about similar research in other systems. The GCMRC convenes a biennial Colorado River ecosystem science symposium, and between these years GCMRC program managers and participating scientists make presentations at the biennial Colorado Plateau symposium hosted by the Colorado Plateau Field Station of the Biological Resources Division of the USGS. The initial science symposium was convened in Flagstaff in Spring 1997, and focused on results of the 1996 controlled flood experiment. A second symposium, convened at Grand Canyon National Park in 1999, focused on monitoring and research related to the 1996 Record-of-Decision operations at Glen Canyon Dam. GCMRC hosted a third symposium in Spring 2001 that focused on the preliminary results of the Low-Steady Summer Flows implemented during Summer 2000. A fourth science symposium was held in Tucson in Fall 2003. The GCMRC proposes to host its fifth science symposium in either Fall 2004 or Fall 2005, to present preliminary results from the FY 2003-04 experimental treatments, as well as report on the current status of knowledge about the initial phase of its long-term monitoring program. The decision to hold the meeting in 2004 or 2005 will be made based on internal (USGS) discussions regarding the value of combining the GCMRC science symposium with future Colorado Plateau symposia, also hosted by the USGS, Southwest Biological Science Center.

CHALLENGES

GCMRC and the adaptive management program, in general, face a number of challenges with respect to designing monitoring and research activities to gather information on specific experimental management actions. These include potentially both the construction and operation of a temperature control device (TCD) on Glen Canyon Dam and the implementation of experimental endangered fish flows to satisfy the 1995 biological opinion on the operation of Glen Canyon Dam.

FY's 2005-06 Work Plan is based on the assumption that the TCD, if built, will not be operational until FY 2007 and that any activities required to supplement the planned monitoring

and research activities will be supported out of the Bureau of Reclamation's Section 8 funds. We also assume that a decision for implementation of endangered fish flows in FY 2004 will not be made until January 2004, and given the short lead time, any supplemental activities will be implemented as modifications to contracts already in place. As with the issue of contingency planning discussed earlier, a mechanism for funding this additional work needs to be developed.

SCHEDULE AND BUDGET

The FY 2005-06 Draft Annual Work Plan and budgets described in this document are intended to be reviewed by the TWG in Fall 2003, with revision of the draft plan intended to occur prior to the AMWG's January 2004 meeting. The total FY2005 and FY2006 budget for the GCMRC are $10,083,610, and $13,779,610 respectively. These totals include $8,672,600 and $8,932,800 from AMP – Power Revenues, $282,000 from the Bureau of Reclamation Water Qualify fund in both years; and $1,482,000 requested from Federal appropriations in both years. In FY2006 an additional $3,400,000 is required to restore funding levels to those of FY2004 for Core Monitoring and ongoing Experimental Treatments, plus implementation of all new Humpback Chub Actions (see FY04-06 Spreadsheet Handout).

Additionally, GCMRC has been tasked by the TWG to prepare a draft Core Monitoring Plan for presentation at the January 2004 AMWG meeting. A decision to implement the revised Core Monitoring Plan is expected from the TWG by April 2004. Since the FY 2005-06 interim draft Annual Work Plan and Core Monitoring Plans are being developed in parallel, additional revisions to this work plan are expected as they interrelate between the two final documents.

For information about other AMP activities and budget, and the Programmatic Agreement, please contact Mr. Dennis Kubly at the Bureau of Reclamation, Salt Lake City, Utah.

Budget Review

Should the appropriated funds requested to support the GCMRC FY's 2005-2006 Work Plan not be fully funded, GCMRC will work with the AMWG to try and secure the required funds using all available budget mechanisms. Second, GCMRC will review the FY's 2005-2006 budget and identify specific work activities that could be deferred. The list of activities that could be potentially deferred will be discussed with the TWG and the AMWG. A

recommendation supporting GCMRC's proposed prioritization and deferral of specific work activities in FY's 2005-2006 will be sought from the AMWG.

CHAPTER 2

SCIENCE ACTIVITIES

A. INTEGRATED ECOSYSTEM SCIENCE PROGRAM

Project A.1.a. ***Core Monitoring*** **- IQWP – Upstream Monitoring of Lake Powell Water Quality - Funding From Bureau of Reclamation O&M**

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	75,000	94,000	25,000	25,000	29,000	29,000
Logistics	0	0	0	0	0	0
Operations	40,000	25,000	25,000	25,000	35,000	35,000
Salary	134,000	146,000	151,000	128,000	115,000	115,000
USGS Assessment (15%)	0	0	36,000	32,000	31,000	31,000
Funding to GCMRC	249,000	265,000	237,000	210,000	210,000	210,000
Reclamation Assistance	35,000	35,000	114,000	75,000	75,000	75,000
Project Total	284,000	300,000	351,000	285,000	282,000	282,000
% total outsourced	30%	35%	10%	~12%	~14%	~14%

Principal Investigators: Vernieu, U.S. Geological Survey (GCMRC)

Statement of Problem: Water quality refers to the physical, chemical and biological characteristics of water. The components effect higher-level community composition, quality and interactions and represent a cornerstone resource upon which all other downstream aquatic and terrestrial resources depend. The water quality parameters are linked to upper basin inflows, reservoir dynamics, and operations of Glen Canyon Dam, and downstream tributary inputs. The relationship between operations of Glen Canyon Dam and water quality variables affecting downstream resources is a management concern. Monitoring data on these ecosystem elements provide information on the effectiveness of the primary experimental flow treatment (Secretary's 1996 Record-of-Decision) relative to stated resource management objectives. Of special concern is the current draw-down condition in Lake Powell, resulting from several years of drought.

Total capacity has been reduced 50%, resulting in warm releases, deltaic sediment resuspension, dissolved oxygen reductions and salinity increases.

Summary Project Description: Funded by an interagency agreement with the Bureau of Reclamation Upper Colorado Regional Office, GCMRC conducts monitoring and research on Lake Powell to meet the following information needs:

- Determine status and trends of physical, chemical, and biological components of water quality in the Lake Powell reservoir as a function of regional hydrologic conditions and their relation to downstream releases. These components include temperature, specific conductance, dissolved oxygen, pH, turbidity, major ions, nutrients, trace elements, chlorophyll, plankton, and organic matter.
- Determine stratification, convective mixing patterns, and behavior of advective currents in Lake Powell and their relation to Glen Canyon Dam operations to predict seasonal patterns and trends in downstream releases.
- Determine status and trends of physical, chemical, and biological components of water quality in Glen Canyon Dam releases.
- Develop simulation models for Lake Powell to predict water quality conditions under various operating scenarios, reduce monitoring efforts, and elucidate understanding of the effects of dam operations, climate, and basin hydrology on Colorado River water quality.
- Evaluate quality and collection methods of existing data and determine where monitoring activities should be implemented, augmented, revised, decreased, or discontinued.

MO's and IN's ADDRESSED: Goal 7, MO's 7.1 – 7.3

Consequences of FY05 - 06 Funding Recommendations: Decreased funding reflects a combination of reduced field sampling frequency and parameters based on analysis of long-term data and as increasing use of CE-QUAL-W2 model ensues. Salary reductions reflect redirection of effort to development of downstream water quality program. USBR supplies support personnel for model development and technical field assistance. As of FY 2003 USBR is providing laboratory analyses with a service agreement with its Denver Technical Center, further reducing the amount of direct funding to GCMRC.

Status/Schedule: FY01-06: Monthly and quarterly monitoring program for Lake Powell. Sampling for major ions and nutrients, temperature, conductivity and dissolved oxygen, transition to CE-QUAL-W2-based predictive capability ongoing. Project forms basis for most predictive capability for downstream water quality parameters, including temperature.

Expected Products/Deliverables: Understanding and predicting water quality parameters: (1) allows managers to assess the effects of dam operations on downstream water quality; (2) provides data that allows identification and interpretation of linkages between physical, chemical and biotic variables; Monthly, Quarterly, Annual and Web Site Reports.

Integration: (In development)

Experimental Component: (TCD & High-flow elements need to be added)

Project A.1.b. ***Core Monitoring*** **- IQWP – Downstream Monitoring of Quality-of Water for Physical, Biological and Chemical Sampling**

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	80,750?	79,200?	46,000?	31,000	20,000	35,000
Logistics	0*	0*	0*	32,000?**	40,000**	40,000**
Operations	35,500	36,000	42,500?	42,500	30,000	60,000
Salary	66,000	64,303	65,000	95,000	108,000	108,000
Project Total	182,250	179,503?	153,500?	200,500?	198,000	243,000
% total outsourced	48.4%	44.1%	30.0%	23.4%	20.2%	22.6%

* logistics costs supported by trips for other projects
** logistics costs are shared with Project A.1.c and include boat and helicopter support

Principal Investigators: Hueftle, Wright, Topping, U.S. Geological Survey - GCMRC

Statement of Problem: Water quality is the foundation of the food web in an aquatic ecosystem. Many valued resources in the canyon may depend in part on attributes of water quality, such as temperature, nutrient supply, oxygen, and salinity. The fundamental nature of the data is best answered by an integrated team approach to ensure maximum efficiency, communication, and integration.

Summary Project Description:

Monitoring Component:

1. **Thermal monitoring** in the CRE from 33 mile to Lake Mead boundary buoy. 11 mainstem sites, 9 tributary sites. Continuous (10-20 minute intervals) using Onset thermistors. Mainstem Sites: (Miles below Lees Ferry): 33, 62, 66, 76, 88, 132, 166, 194, 225, 246, 276.
   Tributary Sites: Paria, Nankoweap, Little Colorado (duplicate sites), Bright Angel, Shinumo, Tapeats, Kanab, Havasu

2. **Continuous multi-parameter sonde (MPS) monitoring** at 8 sites from Glen Canyon Dam to Diamond gage. 15-30 minute intervals on temperature, conductivity, dissolved oxygen, pH and turbidity (4 tailwater locations). Sites: (Miles): -16, 0, 30, 60, 88, 149, 225.

3. **Monthly chemical and biological sampling in the tailwaters**. Nutrient, major ion, zooplankton, phytoplankton, chlorophyll samples. Sites: inside & below GCD, Lees Ferry.

4. **Air temperature monitoring**: Air thermistors collecting 15' interval data at various MPS sites

Research Component:

1. In-stream Metabolism experiments:
2. Protocol evaluation of methods
3. Nutrient- Carbon budgeting

MO's and IN's ADDRESSED:

Directly supports:

Goal 7: Establish water temperature, quality and flow dynamics to achieve ecosystem goals. Includes MO 7.1 ("attain water temperatures") and 7.2 ("maintain water quality in mainstem of the CRE")

Indirectly supports:

Goal 7: Establish water temperature, quality and flow dynamics to achieve ecosystem goals. Includes MO 7.1 ("attain water temperatures") and 7.2 ("maintain water quality in mainstem of the CRE")

Indirectly supports:

Goal 1: "Protect the aquatic foodbase" including core and research monitoring 1.1-1.3, MOs 1.3 & 1.4 "attain primary producers and benthic communities in mainstem and tributaries.

Goal 2: Maintain viable populations of existing native fish, establish their habitat requirements, including water quality

Goal 4. Maintain a wild reproducing population of rainbow trout, establish their habitat requirements, including water quality

Goal 6. Protect or improve the biotic riparian and spring communities

Consequences of FY05-06 Funding Recommendations: About a ten percent increase in the overall need in FY 2006 to cover additional operational and outsourced costs associated with chemical analyses of water samples.

Status/Schedule: FY01-06: It is anticipated that with the initiation of TCD construction, water quality monitoring will require enhancements that may be expected to be covered under Experimental funding. This may include telemetered data at 2-4 sites from the dam to Lake Mead, or other innovations or enhancements.

Nutrient-carbon research is expected to provide a foundation of knowledge upon which a more rigorous downstream monitoring program may be indicated. This would necessitate enhancements in the budget. This work has been detailed by the PEP as a critical shortcoming of the existing knowledge of the CRE.

I expect to install telemetry on at least one site this year (below the dam) at a cost of $5000-7000 plus operating expenses ($360/year). I would also like to install at least 2 or 3 meteorological stations through the canyon at a cost of $3000-4000 each, though I was hoping to get some cost-sharing with the Park and maybe the Aeolian folks.
These items have not been integrated into the budget

Expected Products/Deliverables:

- Website on tailwater conditions updated monthly
- Website will be added to update on downstream conditions on a quarterly basis.
- Telemetered data is intended to be secured soon with website access
- Annual report on status and trends of Grand Canyon water quality program
- Peer review publications where appropriate
- Presentations at AMWG/TWG meetings as well as other professional meetings
- Data requests processed on demand

Integration: (Food base, TCD, suspended-sediment mass balance, nutrient flux, etc.)

Experimental Component: (TCD & High-flow elements need to be added)

Project A.1.c. *Core Monitoring* - IQWP – Downstream Monitoring of Streamflow & Suspended-Sediment Mass Balance

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	234,000	250,000	430,000	605,000	160,000	600,000
Logistics	40,000	40,000	40,000	120,000	*40,000	120,000
Operations	200,000	239,000	188,000	100,000	20,000	80,000
Salary	15,000	35,000	97,000	100,000	80,000	100,000
Full Sediment Experiment	N/A	N/A	No	Assume Yes	Assume Yes	Assume Yes
Project Total	489,000	564,000	755,000	925,000	300,000	900,000
% total outsourced	54%	50%	61%	~77%	~64%	~79%

*Field work is coordinated with project A.1.b. River trips and helicopter trips are shared between these 2 projects. Add these numbers to the logistics costs in A.1.b to arrive at the total logistics costs required for this project.

Principal Investigators: Topping, Rubin, Melis, and Wright, U.S. Geological Survey (WRD, GD & BRD)

Statement of Problem: Recent work has shown that sand transport in the post-dam river is supply limited, and is equally regulated by the discharge of water and short-term changes in the grain size of sand available for transport. During and following tributary floods, fine sand supplied to the Colorado River travels downstream as an elongating sediment wave. As the front of a sediment wave passes a given location, sand on the bed first fines and suspended-sand concentrations increase independently of the discharge of water. Subsequently, the bed is winnowed and suspended-sand concentrations decrease independently of the discharge of water. By virtue of this process, sand supplied by tributaries is typically exported within months under normal dam releases. Thus, newly input sand may be available to rebuild sandbars during controlled floods conducted only following large tributary floods.

Summary Project Description: To monitor sediment (sand, silt, and clay) transport in the Colorado River, we have designed and have evaluated a laser-acoustic system for measuring the concentration and grain size of suspended-sediment every 15 minutes. Data collected at this frequency are sufficient to capture changes in sediment transport driven by tributary activity, changes in dam operations, and changes in ramping rates. The project is combining

measurements from this new system with conventional sediment-transport measurements to compute continuous records of sand, silt, and clay export at 4 locations on the Colorado River: at river-mile 30, the lower end of Marble Canyon, the Grand Canyon gage at river-mile 87, and above Diamond Creek at river-mile 225. Data from this project are required to place the results of project A.2 Core Monitoring of Fine-Sediment Storage in context, and are required to determine whether sediment-related thresholds for the BHBF and HMF experiments currently in progress.

MO's and IN's ADDRESSED: MOs under Goal 8 including 8.1, 8.2. 8.3., 8.4., and 8.5.

Consequences of FY05-06 Funding Recommendations:

1) Regardless of the magnitude of Paria River flooding, cancel the sediment component of the current experiment during FY 2005, and jeopardize conducting this component in FY 2006
2) Greatly curtail sediment-transport measurements on the Paria and Little Colorado Rivers (reduces our ability to evaluate model predictions of sediment input from these tributaries).
3) Elimination of GCMRC funding for the Grand Canyon gaging station.
4) Decommissioning streamflow-gaging station on the Colorado River above Diamond Creek. This action will eliminate all flow, sediment-transport, and water-quality information on the Colorado River downstream from river-mile 87.
5) De-emphasize sediment-transport station at river-mile 30 (greatly hinders our ability to document retention of Paria-derived in upper Marble Canyon, required for the experiment).

Status/Schedule: FY01-06

Reports Published to Date:

- Rubin, D.M., and Topping, D.J., 2001, Quantifying the relative importance of flow regulation and grain-size regulation of suspended-sediment transport (□), and tracking changes in bed-sediment grain size (□): Water Resources Research, v. 37, p. 133-146.
- Rubin, D.M., Tate., G.M., Topping, D.J., and Anima, R.A., 2001, Use of rotating side-scan sonar to measure bedload: Proceedings of the 7th Inter-Agency Sedimentation Conference, v. 1, p. III-139 through III-143.
- Rubin, D.M., and Topping, D.J., 2001, What regulates suspended-sediment transport in a given setting? Grain size of bed sediment or flow: Proceedings of the 7th Inter-Agency Sedimentation Conference, v. 1, p. I-199 through I-205.

- Rubin, D.M., Topping, D.J., Schmidt, J.C., Hazel, J., Kaplinski, K., and Melis, T.S., 2002, Recent sediment studies refute Glen Canyon Dam hypothesis: EOS, Transactions, American Geophysical Union, v. 83, n. 25, p. 273, 277-278.
- Annual data reports from t he USGS-WRD Arizona District.

Expected Products/Deliverables:

Reports & Data:

- Melis, T.S., Topping, D.J., and Rubin D.M., in press, Testing laser-based sensors for continuous, in-situ monitoring of suspended sediment in the Colorado River, Arizona: Proceedings of the ICCE/IAHS Oslo Workshop on Erosion and Sediment Transport Measurement: Technological and Methodological Advances
- Topping, D.J., Melis, T.S., and Rubin, D.M., Evaluation of a laser-acoustic system for continuously monitoring suspended-sediment concentration and grain size in the Colorado River in Grand Canyon, to be submitted to Journal of Geophysical Research - Earth Surface during January 2004.
- 2 more peer-reviewed journal articles or USGS reports during FY 2005-2006.
- Annual data reports from t he USGS-WRD Arizona District.
- All data from this project delivered to the GCMRC database coordinator every 2 months.
- Installment of satellite telemetry to transmit data from the laser-acoustic sediment-transport data in real-time.
- Development of a semi-automated on-line system for continuously tracking sediment budgets in key reaches in the Colorado River ecosystem.

Experimental Components: Under full experimental implementation of a controlled flood, the following additional studies are planned: high-resolution suspended-sediment monitoring before, during and after release of a sediment-conservation controlled flood, as well as aeolian transport fate of new beaches near archeological sites, beach cohesion and erosion research, beach drainage erosion, sand deposition within arroyos and campsite changes and suitability.

Integration: Fine-sediment deposits along the main channel form many physical habitats for both terrestrial and aquatic organisms of the ecosystem; including ethno-botanical resources. Fine-grained deposits are also sources and sinks for nutrients, recreational campsites and settings for in-situ preservation of cultural resources. Information on the distribution and characteristics of these deposits must be measured in ways that can be related to dam operations. Further, the measurements must be made over spatial and temporal scales that allow fine-sediment related resources to be linked to changing conditions of the sediment budget. To promote limited

integration of fine-sediment data, oversight for this project is provided jointly by the GCMRC's Integrated Science and Cultural program managers.

Integration: (Food base, TCD, nutrient flux, physical substrate for aquatic and terrestrial habitats, etc.)

Experimental Component: (TCD & High-flow elements related to sand-storage changes and habitat restoration need to be added)

Project A.2. *Core Monitoring* - Coarse-Sediment Inputs, Storage & Impacts

FUNDING HISTORY & PROPOSALS FOR FY05-06	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Component	72,000	75,000	77,000	79,000	0	83,000
Logistics	15,000	16,000	18,000	12,000	0	12,000
Operations	3,000	5,000	5,000	5,000	0	5,000
Salary	10,000	17,000	16,000	16,000	0	10,000
Project Total	100,000	113,000	116,000	112,000	0	110,000
% total outsourced	80%	79%	82%	~80%	N/A	~85%

Principal Investigators: Webb and Melis, U.S. Geological Survey (WRD & BRD)

Statement of Problem: Coarse-grained sediment deposits (composed of particles larger than sand-sized) are influenced by dam operations, and are also linked to biological, physical and recreational resources. Specifically, coarse-sediment deposits containing boulders form debris-fans that are stable features of the main channel. Debris fans impinge on the flow of the channel at hundreds of locations, and thus control stream flow and fine-sediment deposition and structure in the Colorado River ecosystem. Dam operations influence continued inputs of coarse-grained sediment from tributaries in unique ways that modify upper pool and downstream eddy environments where fine sediments are stored.

With respect to biological resources, coarse sediments form the substrates needed by benthic organisms associated with the food base, as well as spawning habitats for fish. Coarse-sediment deposits contribute to the formation and maintenance of hundreds of rapids that attract

whitewater recreation enthusiasts; supporting a tourism industry that contributes substantially to the regional economy. Recent research has also documented that recreational camping areas are periodically degraded through erosion and (or) burial when tributary debris flows deposit coarse sediments along the main channel of the ecosystem (Melis et al., 1994). Results from the 1996 Beach/Habitat-Building Test, indicate that dam operations can be used to manage new coarse-sediment deposits through river reworking during controlled floods (Webb et al., 1999).

Summary Project Description: Monitoring Glen Canyon Dam operations and their interactions with coarse-grained sediment deposits that structure the geomorphic framework of the Colorado River ecosystem. Specifically, interactions between coarse-sediment deposits introduced to the main channel by tributary debris flows and Glen Canyon Dam operations, relative to system-wide distributions of aquatic and terrestrial habitats. This sediment monitoring activity consists mainly of change detection with respect to coarse-sediment inputs and channel features that support physical habitats, such as debris fans, cobble bars, and channel-bed topography and distribution of channel-bed coarse-sediment substrates.

Monitoring tributary debris-flow impacts and resulting coarse-sediment deposits, with respect to operations of Glen Canyon Dam, provides data on: (1) changing physical-habitat conditions related to coarse sediment that influence biological resources (such as the food base and spawning habitats for fish) and are of interest to scientists conducting related monitoring projects; (2) changing navigational conditions of whitewater rapids; (3) degradation of camping areas owing to erosion and (or) burial by coarse debris; (4) system-wide influences of flow regulation on the geomorphology of the main channel with respect to potential distribution and storage of fine sediment deposits.

MO's and IN's ADDRESSED: MOs under Goal 8 including 8.6. and 8.7.

Consequences of FY05 - 06 Funding Recommendations: The currently proposed budget for FY 2005 completely eliminates this project in its fifth and final year. One option is to defer its completion to FY 2006, contingent upon restoration of funding at that time. During FY's 2006-2010, this core monitoring project is recommended to continue if funding is available.

Status/Schedule: FY01-06: Initiated in its current design as a research & monitoring effort in FY 2001, this project was originally intended for Phase 1 completion and external peer review in

FY 2005, as a step toward identifying a core-monitoring protocol for tracking the influence of tributary inputs of gravel by stream floods and debris flows. FY's 2004-05, were identified to be years in which remote-sensing options for long-term monitoring were to be specifically evaluated. Reports from the pre-GCMRC, as well as those completed in FY's 2001-04, are available through GCMRC library.

Expected Products/Deliverables:

- USGS Water Resources Investigation Reports,
- Digital files for early historical images of the Colorado River (Stanton, circa 1889-90),
- Journal articles on Grand Canyon debris flow occurrences (frequency and magnitude) and influences of dam releases on reworking of aggraded debris fans and rapids,
- Longitudinal survey data of rapids steepened by tributary debris flows and accompanying reports,
- Revision and upgrade of STARS stage prediction modeling package on basis of 2002 shoreline topography-based cross sections, and
- Annually published USGS Fact Sheets.

Original Time Line for Coarse-Sediment Monitoring of Inputs, Impacts & Storage FY01-05:

	2001	2002	2003	2004	2005
Competitive Solicitation Released, October 2000	Management Agreement, Spring 2001	Modification of MA, Fall 2001	Modification of MA, Fall 2002	Modification of MA, Fall 2003	Modification of MA, Fall 2004
Schedule for Data Collection and Analysis	Annual, Fall/Winter '01-'02	Annual, Fall/Winter '02-'03	Annual, Fall/Winter '03-'04	Annual, Fall/Winter '04-'05	Annual, Fall/Winter '05-'06
Report/Data Delivery	Annually, 12/31/01	Annually, 12/31/02	Annually, 12/31/003	Annually, 12/31/04	Draft Final Reports by 12/31/05
Project Technical Coordination, Review/Evaluation	Annually, GCMRC & SA's	Annually, GCMRC & SA's	Annually, GCMRC & SA's	Annually, GCMRC & SA's	Externally Reviewed by PEP-SA
Project Completion Schedule	Progress Report 12/31/01	Progress Report 12/31/02	Progress Report 12/31/03	Progress Report 12/31/04	Final Report, 06/30/06

Experimental Component: None planned for FY 2005, but studies of debris-fan reworking at sites of recent debris flows might occur during FY 2006 in conjunction with implementation of a controlled flood, contingent upon funding availability.

Integration: (Suspended-sediment mass balance, aquatic substrate type and distribution related to benthic organisms and salmonid spawning gravels, evolving geomorphic framework under regulation, etc.)

Coarse sediments of the main channel provide both substrates and a geomorphic framework that makes the Colorado River in Grand Canyon unique. Coarse lag deposits of the channel such as cobble bars and debris fans are physical habitats that support the benthic organisms of the food base, and support spawning and rearing habitats. Consistent measurements of changes in coarse-grain sediment storage are essential to linking dam operations to food base trends and patterns of fish behavior related to physical habitat use. In addition, this integrated project team shall provide sediment input data from hundreds of contributing tributary drainage areas. Basic information on total drainage area between the dam and Lake Mead is one basis for estimating contributions of organic Carbon, such as woody matter, as well as dissolved Carbon and other nutrients carried into the ecosystem along with fine sediments. Basic information derived from this project about the timing and frequency of tributary spates is intended to support efforts to expand the program's downstream water quality protocols, as well as further support conceptual modeling efforts.

Project A.3. *Core Monitoring* - Fine-Sediment Storage

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	340,000	300,000	300,000	720,000	760,000	740,000
Logistics	30,000	58,000	18,000	120,000	120,000	120,000
Operations	60,000	100,000	93,000	63,000	60,000	60,000
Salary	20,000	53,000	31,000	56,000	60,000	60,000
Full Sediment Experiment	N/A	N/A	No	Assume Yes	Assume Yes	Assume Yes
Project Total	450,000	511,000	442,000	959,000	1,000,000	980,000
% total outsourced	82%	68%	71%	~70%	~87%	~87%

Principal Investigators: Rubin, Topping, Schmidt, Parnell and Melis, U.S. Geological Survey (WRD, GD & BRD, plus Utah State and Northern Arizona Universities)

Statement of Problem: Sandbars and other sandy deposits in and along the Colorado River in Grand Canyon National Park (GCNP) were an integral part of the pre-dam riverscape, and are important for habitat, protecting archeological sites, and recreation. These deposits have eroded substantially following the 1963 closure of Glen Canyon Dam that reduced the supply of sand at the upstream boundary of GCNP by about 94%; sandbars in Marble Canyon have decreased in size by about 25% during only the last 15 years. Results from the geomorphic synthesis project have shown that the deeper portions of eddies and the channel pools also contain about 25% less sand, silt, and clay than they contained in the early 1990s.

Relationships between Glen Canyon Dam operations, fine-sediments input from gaged and ungaged tributaries below the dam, and interrelated downstream biological, socio-cultural resources are of primary management concern. This is true owing to the fact that sand bars are the primary substrate along many shoreline areas of the ecosystem. Monitoring data on fine-grained (sand and finer) deposits, linkages with physical habitats and relationships to non-physical resources and processes offer insight on the effectiveness of the Secretary's 1996 Record-of-Decision (ROD), relative to management objectives.

Annual-to-biennial monitoring of fine-grained sediment storage provides information: (1) on the status of near-shore aquatic and terrestrial habitats where vegetation and associated fauna, socio-cultural resources are of management concern; (2) on the availability of fine-grained sediment that can be periodically manipulated through controlled floods to preserve and sustain downstream resources dependent on fine sediment; (3) on identification and interpretation of linkages between dam operations and changes in physical habitats and related ecosystem resources. All three areas of information support science-based evaluations of large-scale flow experiments (e.g., the Secretary's actions), and associated decision responses required for adaptive management to succeed.

Summary Project Description: Fine-grained deposits (sand and finer) of the main channel constitute a major storage component of the Colorado River ecosystem's sediment budget. Glen Canyon Dam operations influence fine deposits in ways that affect aquatic and terrestrial habitats over both short and long periods. The emphasis of this long-term monitoring project shall be to

document system-wide changes in fine-grained deposits relative to dam operations and natural inputs, with emphasis on key storage settings within critical reaches. This project was initiated through release of a competitive solicitation in October 2000, and shall be continued into year four during FY 2004. The first phase of this project is scheduled for completion at the end of FY 2005, and will be externally reviewed through the PEP process. This project shall be ongoing from FY 2006 through FY 2010, following external review and approval of funding. In addition, the project is also focused on researching the fate of campsite areas on an annual basis, as well as the fate of sand bars reworked by wind in the vicinity of archeological preservation sites. This latter component is completed in FY 2004, but might be extended through FTY 2005 if high-flow sediment experimentation occurs.

MO's and IN's ADDRESSED: MOs under Goal 8 including 8.1, 8.2. 8.3, 8.4., and 8.5.

Consequences of FY05-06 Funding Recommendations: The reporting schedule for this biennial component of this research and monitoring project is hindered by the fact that full field terrestrial & sub aqueous collection will not occur in FY04, as originally proposed. Monitoring results and analysis shall be limited to hydrographic mapping coverage collected in FY2000 and 2002, while terrestrial mapping data shall be evaluated from the FY 2004 acquisition (LiDAR and ground surveys). The sand-storage change detection of this project becomes centered around sediment enrichment periods and high-flow experiments, rather than collection of mapping data on a biennial schedule under "non-event" conditions.

Status/Schedule: FY01-06

- 2000 LSSF reach data
- Processing of terrestrial surveying completed
- Processing of multibeam bathymetric data completed in 3 of the 4 LSSF reaches
- 2002 reach data
- Processing of terrestrial surveying completed
- Processing of multibeam bathymetric data completed in 9 of the 11 reaches

Annual sandbar and campsite surveys have been completed by NAU during FY2001-2003.

Reports published to date:

- Rubin, D.M., in press, A simple autocorrelation algorithm for determining grain size from digital images of sediment: *Sedimentology*.

Expected Products/Deliverables:

Reports & Data:

- Hazel, J.E., Jr., Topping, D.J., Schmidt, J.C., Kaplinski, M., and Melis, T.S., Downstream effects of a dam on sediment storage in a bedrock canyon: the relative roles of eddy and channel storage for the Colorado River in Marble Canyon, AZ, in review.
- 2-3 more peer-reviewed journal articles or USGS reports during FY 2004-2006.
- All reach data from this project delivered to the GCMRC database coordinator during FY2005 as scheduled under the original project timeline defined in FY2001.

Integration: (terrestrial and aquatic habitats relative to sand storage, interface with IQWP for nutrients and suspended-sediment mass balance)

Experimental Component: Under full sediment enrichment and high-flow experimentation, the following additional studies are planned: aeolian transport fate of new beaches near archeological sites, beach cohesion and erosion research, beach drainage erosion, sand deposition within arroyos and campsite changes and suitability.

Time Line for Core Monitoring of Fine-Sediment Storage 2001-2006:

	2001	2002	2003	2004	2005	2006
Project Solicitation Released, October 2000	Three New Agreements, in 2001	Renewed as Modification, Winter 2002	Renewed as Modification, Winter 2003	Renewed as Modification, Winter 2004	Renewed as Modification, Fall 2005	Ongoing, following revisions from review
Integrated, Reach-Based Field Data Collection/Analysis (12 reaches), plus Selected Camping Areas & Sand bars	Planning for Reaches, plus Collect Annual Camp Areas & Sandbars	Collect Biennial Reach Data, plus Annual Camp Areas & Sandbars	Processing Reach Data, plus Annual Camp Areas & Sandbars	Collect Biennial Reach Data, plus Annual Camp Areas & Sandbars	Processing Reach Data, plus Collect Annual Camp Areas & Sandbars	Processing Reach Data, plus Collect Annual Camp Areas & Sandbars
Report and Data Delivery	Semiannual and Annual	Semiannual and Annual	Semiannual and Annual	Semiannual and Annual	Draft Final Reports	Ongoing
Project Technical Coordination, plus Review/ Evaluation	Monthly to Annually, GCMRC	Monthly to Annually GCMRC	Monthly to Annually GCMRC	Monthly to Annually GCMRC	Externally Reviewed PEP & SA	Ongoing through a new RFP
Scheduled Project Progress and Completion Dates	Progress Report, by 12/31/01	Progress Report, by 12/31/02	Progress Report, by 12/31/03	Progress Report, by 12/31/04	Final Reports by June 30 2006	Annual progress report & data

Project A.4a. ***Core Monitoring*** **- Terrestrial Biological Resources**

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	262,000	325,000	300,000	167,000	290,000
Logistics	N/A	88,000	208,000	147,000	18,000	90,000
Operations	N/A	0	5,000	6,000	0	8,500
Salary	N/A	38,000	32,000	52,000	65,000	36,500
Project Total	N/A	388,000	570,000	505,000	250,000	425,000
% total outsourced	N/A	89%	93%	~87%	~70%	~88%

Principal Investigators: Kearsley (Northern Arizona University), TBD in FY'06

Statement of Problem: The terrestrial ecosystem within the Colorado River Ecosystem (CRE) is comprised of habitat that varies from open beaches and marshes to debris fans, alluvial deposits like high terraces, and talus slopes. Overlaid on these areas are plant communities that fall out along a moisture gradient (e.g., cattails by the river and cacti and mesquite farther away from the river). Along the river corridor, these plant communities can be delineated into pre-

dam or old high water zone vegetation and post-dam or new high water zone vegetation, including a marsh community. The presence or absence, distribution and abundance of plant species effect the distribution and abundance of animals, including humans, and collectively these species (plants and animals) reflect the quality of terrestrial habitats along the Colorado River ecosystem.

The terrestrial ecosystem constitute resources that provide recreational and intrinsic benefit, are of cultural value to tribes (e.g., marsh plants, yellow birds, or eagles) or other entities, or are indicators of change and health of the system (invasive exotic plant or high abundances of particular animal species like harvester ants or mice). The abundance and distribution of these resources are influenced by available habitat associated with sediment dynamics and inter-specific interactions. Elements addressed in this monitoring program are habitat structure and composition and distribution of plants within the zone affected by dam operations. Other aspects addressed include linkages to distribution, abundance and composition of birds, insects and other animals.

Summary Project Description: The goal of this project is the collection of data necessary to monitor the effects of Glen Canyon Dam operations on terrestrial biological resources of concern. Analysis includes: (1) the composition, distribution and structure of vegetative communities and plant species; and (2) the abundance and distribution of faunal constituents linked to these vegetative communities, (3) the relative abundance and distribution of waterfowl, raptors and riparian breeding birds (including southwestern willow flycatcher). The project is multidisciplinary and will seek to include Native American perspectives in ecosystem monitoring and interpretation. Data are collected annually to measure, evaluate and report structural and compositional changes in terrestrial vegetation zones (old and new high water zones) that support avifaunal and traditional cultural resources. These vegetation data will be related to changes in sediment monitoring relative to annual operations of Glen Canyon Dam.

Monitoring the composition and structure of vegetation, and the abundance and distribution of plants, insects, and animals within the terrestrial zones (NHWZ and OHWZ): (1) allows managers to assess the status of terrestrial vegetation and faunal diversity in association with biological, cultural and recreational resources; (2) provides data that allows identification and interpretation of linkages between physical and biological variables within the Colorado River ecosystem; and (3) provides data on the effect of periodic management of sediment

through high flows under the Record of Decision on higher trophic levels associated with terrestrial habitats.

MO's and IN's ADDRESSED: MOs under Goal 6, including 6.1, 6.2, 6.3, 6.4, 6.5, 6.7.

Consequences of FY05 – 06 Funding Recommendations: FY05 represents the final year of a five-year project to establish methodologies for long-term monitoring of terrestrial resources. The currently proposed budget for FY 2005 reduces funding for core monitoring by more than 50%, essentially eliminating the intent of the program. With respect to trend detection and power analysis, given the limited funds available, it is recommended that data collection be focused on fall vegetation transect data, and that other components (e.g., bird surveys) be eliminated. Funds for FY06 could be restored to a level that would permit more inclusive monitoring efforts of other terrestrial resources.

Status/Schedule: FY01-05 – Initiated in its current design as a research & monitoring effort in FY 2001, this project was originally intended for Phase 1 completion and external peer review in FY 2005, as a step toward identifying a core-monitoring protocol for tracking changes in terrestrial resources. FY2004-05, were identified to be years for analysis and synthesis for refinement of monitoring.

Expected Products/Deliverables:

- Annual and final report,
- Annually published Fact Sheets.
- Annual data delivery and data reporting with tribes and National Park Service

Original Time Line for Terrestrial Ecosystem Monitoring FY01-05:

	2001	2002	2003	2004	2005
Competitive Solicitation Released, October 2000	Management Agreement, Spring 2001	Modification of MA, Fall 2001	Modification of MA, Fall 2002	Modification of MA, Fall 2003	Modification of MA, Fall 2004
Schedule for Data Collection and Analysis	Annual, Fall/Winter '01-'02	Annual, Fall/Winter '02-'03	Annual, Fall/Winter '03-'04	Annual, Fall/Winter '04-'05	Annual, Fall/Winter '05-'06
Report/Data Delivery	Annually, 12/31/01	Annually, 12/31/02	Annually, 12/31/003	Annually, 12/31/04	Draft Final Reports by 12/31/05
Project Technical Coordination, Review/Evaluation	Annually, GCMRC & SA's	Annually, GCMRC & SA's	Annually, GCMRC & SA's	Annually, GCMRC & SA's	Externally Reviewed by PEP-SA
Project Completion Schedule	Progress Report 12/31/01	Progress Report 12/31/02	Progress Report 12/31/03	Progress Report 12/31/04	Final Report, 3/30/06

Project A.4.b. *Core Monitoring* - Terrestrial Ecosystem: Tribal Involvement Component

Note: The budget and project described below are subsumed within Project A.4 "Core Monitoring of Terrestrial Biological Projects". This is a subset of A.4, not a separate project.

FUNDING HISTORY	**Fiscal year**					
	2001	**2002**	**2003**	**2004**	**2005**	**2006**
Outsourced Science/Labor	**N/A**	**N/A**	**N/A**	**N/A**	**75,000**	**50,000**
Logistics (All)	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Operations	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
GCMRC Salaries	**N/A**	**N/A**	**N/A**	**N/A**	**5,000**	**5,000**
Project Total	**N/A**	**N/A**	**N/A**	**N/A**	**80,000**	**55,000**
% total outsourced*	**N/A**	**N/A**	**N/A**	**N/A**	**~94%**	**~91%**

Principal Investigators: To Be Decided

Statement of Problem: Terrestrial ecosystem within the Colorado River ecosystem is comprised of habitat that varies from open beaches, debris fans, alluvial deposits like high terraces and talus slopes. Overlaid on these areas are plant communities that fall out along a moisture gradient (e.g., cattails by the river and cacti and mesquite farther away from the river). Along the river corridor, these plant communities can be delineated into pre-dam, or old high

water zone vegetation and post-dam or new high water zone vegetation, including a marsh community (USBOR, 1995). These plant communities and the space absent of vegetation influence or define the animal community. Vegetation provides either shelter or structure for nesting or foraging (either by direct consumption or indirectly by being the host for insects that are the food source). Likewise, space absent of vegetation also represents habitats. The presence or absence, distribution or abundance of plant species effects the distribution and abundance of animals, including humans, and collectively these species (plants and animals) reflect the quality of terrestrial habitats along the Colorado River ecosystem.

While western scientists may describe the terrestrial system in a particular manner under certain parameters, tribal members traditionally use a different framework to evaluate terrestrial resources. This project attempts to obtain and merge information from both sources to assess the resources more comprehensively. The primary goal of the tribal component of this project is to incorporate Native American perspectives in the interpretation of significant changes in the abundance and distribution of terrestrial animals including waterfowl, nesting avifauna, raptors, and other culturally important birds. (See the biological project description for the integration of this project across physical, cultural and recreational resource areas.)

After FY05, tribal perspectives for monitoring terrestrial resources that are significant to the tribes will be integrated within the overall terrestrial monitoring effort. A pilot program initiated in FY01 sought to incorporate tribal perspectives through transferring monitoring data to the tribe for interpretation and subsequent evaluation of ecosystem conditions, through augmenting monitoring methods with tribal monitoring methods and/or tribal monitors, and through other means. Tribes have been actively participating in the program since FY02. The budget for FY 2004 is specified at $129,000 to incorporate all five AMP participating tribal groups in finalizing terrestrial ecosystem monitoring protocols.

General Project Description: The purpose of this project is to provide a mechanism for Tribal stakeholders to 1) interpret the data collected by the terrestrial monitoring program using traditional tribal perspectives and 2) present their own annual assessments of the monitoring information to the Adaptive Management Program, using the information collected through the terrestrial ecosystem monitoring program. The specific objectives of this project are to: 1) create tools and interpretive materials that will allow the tribes to translate scientific information on terrestrial ecosystem components into culturally-relevant terms and images, thereby facilitating

2) the interpretation of biological resource data from a tribal perspective; 3) the Identification of significant impacts to resources from tribal perspectives; and 4) the presentation of tribal recommendations to the Adaptive Management Program to improve management of biological resources in the future.

Data necessary to monitor the effects of Glen Canyon Dam operations on terrestrial biological resources of traditional tribal concern currently include: (1) the relative abundance and distribution of waterfowl, raptors and riparian breeding birds (including southwestern willow flycatcher); (2) the composition, distribution and structure of vegetative communities and plant species; and (3) the abundance and distribution of faunal constituents linked to these vegetative communities. Three tribes are currently participating in the Terrestrial Ecosystem Pilot Monitoring Study and will be providing their input for incorporation into the long term monitoring program in FY04. The project FY05-06 project will fund the development of booklets, CDs and other media that will allow the tribes to interpret the monitoring data in terms that are more consistent with tribal perspectives, and it will part-time provide support for one individual to review the annual monitoring results and prepare a written assessment of those results for consideration by the Adaptive Management Program on an annual basis.

MO's and IN's ADDRESSED: MO 11.2

Consequences of FY05 - 06 Funding Recommendations: The budget provides $10,000 annually for each tribe to hire a consultant or internal staff person to review the results of the annual terrestrial monitoring effort and prepare an annual report assessing those results from a tribal perspective. This report will provide recommendations to the AMP for consideration in future management of the resources. In addition, the FY05 budget includes $25,000 dollars to develop booklets, CDs and other tools that will translate scientific terminology and data into culturally relevant categories and terms. These media will allow the tribes to readily interpret the results of the terrestrial ecosystem monitoring results and will also be useful for public outreach and educational purposes.

Status/Schedule: FY05 -- develop interpretive materials tailored to the individual participating tribes and provide an assessment of ecosystem condition from a tribal perspective based on analysis of TEM annual monitoring results; FY06-FY10 provide annual assessments to the AMP

on ecosystem conditions, using tribal perspectives to analyze TEM annual monitoring results and make recommendations

Expected Products/Deliverables:

- Booklets, CDs and other outreach products interpreting TEM scientific data using culturally relevant terms and concepts (FY05).
- Annual reports by each tribe, assessing ecosystem condition and providing recommendations to the AMP (FY05-06 and beyond).

Project A.5. ***Core Monitoring*** **- Kanab Ambersnail at Vasey's Paradise**

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	10,000	30,000	21,000	22,000	33,000
Logistics	N/A	40,000	33,000	37,000	35,000	37,000
Operations	N/A	16,000	6,000	7,000	7,000	8,000
Salary	N/A	16,000	12,000	14,000	15,000	35,000
Project Total	N/A	82,000	81,000	79,000	79,000	113,000
% total outsourced	N/A	48%	69%	64%	63%	54%

Principal Investigators: Sorenson, Arizona Game and Fish Department

Statement of Problem: Kanab ambersnail is a federally listed endangered species occurring in one location in Grand Canyon: Vasey's Paradise. While the taxonomic ranking and the systematics of the ambersnail is currently unresolved, it represents a taxon that is endemic to Vasey's Paradise. The snail and its habitat is a unique ecosystem determined to be of concern by stakeholders. The site is also a traditional cultural resource to all Native American stakeholders. The abundance and distribution of the snail and the quality of its habitat is influenced by operations of Glen Canyon Dam, as well as by springs located at Vasey's Paradise. Monitoring of habitat area and ambersnail numbers occurs on a more detailed scale due to the limited nature of the habitat. These surveys occur twice per year. The relationships between operations from

Glen Canyon Dam, habitat and Kanab ambersnail population numbers at Vasey's Paradise are a management concern.

Monitoring of Kanab ambersnail densities, size classes and utilized habitat: (1) allows managers to assess the status of this endangered species; (2) provides data that allows identification and interpretation of linkages between physical and biological variables within the Colorado River ecosystem; (3) provides data on the effect of periodic management of sediment through high flows under the Record of Decision on the population dynamics and habitat interactions of this species.

Summary Project Description: To determine the abundance of Kanab ambersnails that inhabit the Vasey's Paradise Springs vegetation and to determine how snail densities change over time with respect to available habitat, as habitat is influenced by operations and discharge from the spring. Monitoring of Kanab ambersnail densities, size classes and utilized habitat: (1) allows managers to assess the status of this endangered species; (2) provides data that allows identification and interpretation of linkages between physical and biological variables within the Colorado River ecosystem; (3) provides data on the effect of periodic management of sediment through high flows under the Record of Decision on the population dynamics and habitat interactions of this species. Specific objectives of the project include:

- Provide yearly estimates of adult snails at Vasey's Paradise.
- Provide habitat estimates and change detection of habitat for varying stage levels.
- Provide data to use in population model development for snails at Vasey's Paradise.

MO's and IN's ADDRESSED: MOs under Goal 5, including 5.1, 5.2.

Consequences of FY05 - 06 Funding Recommendations: Funding in FY05 did not change from FY04. The result of the funding reduction in FY04 was the increased dependence on volunteers to identify and count snails, and no estimates of habitat or snails above 100,000 cfs. It also does not account adequately for GCMRC science and survey staff time. FY06 moneys represent an estimate of costs that include GCMRC staff costs. Additionally, exploration of alternative methods to monitor snails will be delayed. Increasing funding in FY06 is recommended to comparable FY03 funding levels to initiate alternative monitoring methodologies for comparison with current monitoring methods. Logistic costs can be shared with other terrestrial trips.

Status/Schedule: FY01-05 – Initiated in its current design as a monitoring effort in FY 2001 through a cooperative agreement with AGFD. FY2005 should initiate review of methodologies and incorporation of methods that utilize less intrusive methods to estimate KAS numbers.

Expected Products/Deliverables:

- Annual data delivery Trip reports providing area estimates of vegetation and general description of status of snails at Vaseys Paradise.

Experimental Component: (Monitoring of KAS habitat before and after high-flow treatments)

Integration: (mapping of Vaseys Paradise habitat using new remote sensing technologies will be explored in conjunction with DASA and ISP activities)

Project A.6. *Core Monitoring* - Habitat Map and Inventory

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	195,000	40,000	0	20,000
Logistics	N/A	N/A	8,000	0	0	15,000
Operations	N/A	N/A	20,000	0	0	0
Salary	N/A	N/A	51,000	8,000	0	25,000
Project Total	N/A	N/A	274,000	48,000	0	60,000
% total outsourced	N/A	N/A	74%	83%	N/A	54%

Principal Investigators: To be determined

Statement of Problem: This project addresses recommendations made in the terrestrial, cultural resource, and sediment protocol review reports. Terrestrial mapping of the Colorado River corridor is required for spatial monitoring of physical, biological, and cultural resources. In core monitoring, this project addresses landscape scale changes that core terrestrial ecosystem monitoring misses. The time-scale for mapping landscape scale changes is every five years. Periodic mapping of the same areas can be used for change detection of resources. This would

be the case for this project. Attributes associated with a coverage type can also be used as a predictive tool for monitoring and research.

Summary Project Description: The basemap for this project was produced using 2002 and completed in 2004. This project will use the previous basemap and reference library of vegetation signatures developed from the first project to determine the area and extent of changes in vegetation alliances and formations along the river corridor. Imagery for this project will be acquired in 2006. In FY06, ground-truthing of areas during the overflight will be done in and the bulk of the project will be initiated and completed in the following fiscal year.

MO's and IN's ADDRESSED: MOs under Goal 6, including 6.1, 6.2, 6.3, 6.4, 6.5

Consequences of FY05 - 06 Funding Recommendations: Funds for this project are requested in FY06 to improve mapping accuracy vegetation change along the river corridor by documenting vegetation composition at specific sites for using in future analysis to be completed in FY07. Funding in FY07 is anticipated to be similar to values of 2003.

Status/Schedule: Inactive in FY05, RFP released in FY06.

Expected Products/Deliverables:

- Ground-truthed sites for reference sites to be included in second mapping integration.

Experimental Component: (None proposed)

Integration: (In coordination with the DASA, mapping of habitats and analyzing their distributions relative to distribution and abundances of sand and associated flora and fauna)

Project A.7. *Research* - Kanab Ambersnail Taxonomy Project

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor			122,000	86,000	86,000	0
Logistics			0	0	0	0
Operations			0	0	0	0
Salary			36,000	2,000	2,000	0
Project Total			158,000	88,000	88,000	0
% total outsourced			77%	98%	98%	N/A

Principal Investigators: To be determined

Statement of Problem: Kanab ambersnail is a federally listed endangered species occurring in one location in Grand Canyon: Vasey's Paradise. The taxonomic ranking and the systematics of the ambersnail is currently unresolved, it represents a taxon that is endemic to Vasey's Paradise. The snail and its habitat is a unique ecosystem determined to be of concern by stakeholders. Management of this snail has implications for adaptive management experiments associated with releases from Glen Canyon Dam. Resolving the taxonomy of this snail and learning more about its relationship with other taxa within the Succinidea will assist the AMP and Grand Canyon National Park in management strategies associated with this taxon with regard to dam operations as well as accessibility to its habitat by humans.

Summary Project Description: The Kanab ambersnail taxonomy project will use existing collections as well as expand on the collection of snails within the Oxlyoma complex in order to better understand and delineate relationships of the Vasey's Paradise taxon to other species and populations within the Colorado Plateau. Resolution of these relationships may clarify management strategies associated with this taxon relative to adaptive management experiments. The project will use a phylogenetic approach to resolve the systematic relationships and should include all characters (e.g., morphological, molecular, biogeographical) that delineate the relationships among taxa in the Complex.

MO's and IN's ADDRESSED: MOs under Goal 5, including 5.1.

Consequences of FY05 - 06 Funding Recommendations: Funding for this project is based solely on USGS appropriated funds. It is recommended that the FY04 be carried forward to FY05 to increase the single source amount and ensure sufficient money is guaranteed to complete this project.

Status/Schedule: FY03-05 – RFP may be released in FY04 pending available funds. In which case this would be the second year of the project. Alternatively, RFP would be released in FY05 with combined funds.

Expected Products/Deliverables:

- Yearly progress reports and a final report.

Experimental Component: (None proposed)

Integration: To be determined

Project A.8. ***Research and Development*– Aquatic Foodbase, Organic Mass Balance, and Foodweb Linkage Program**

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	160,000	220,000	220,000
Logistics	N/A	N/A	N/A	40,000	40,000	40,000
Operations	N/A	N/A	N/A	18,000	25,000	25,000
Salary	N/A	N/A	N/A	30,000	30,000	30,000
Project Total	N/A	N/A	N/A	248,000	315,000	315,000
% total outsourced	N/A	N/A	N/A	~79%	~81%	~81%

Principal Investigators: Ralston, B.; Yard, M.; and Hueftle, S., U.S. Geological Survey (GCMRC) and TBD

Statement of Problem: River systems are fueled by different sources of organic material that originate from a combination of allochthonous (organic debris from terrestrial environments) and

autochthonus production (algae, and macrophytes). These organics serve as the fundamental food source and linkage between aquatic invertebrates and higher level consumers such as fish and waterfowl. The proportion of these organic sources and their overall quantity and quality varies between and within different river systems. Since the closure of Glen Canyon Dam some of the coarser larger organics (woody debris) supplied to the Colorado River are sequestered in Lake Powell. Owing to increased water clarity conditions algal production has become very extensive in the upper river section; however downstream periodic suspended sediment and organic debris supplied from tributaries causes a decline in algal production. The aquatic foodbase is assumed to be both derived from primary production and limited to consumers such as native and endangered fish. Algal production appears to support the major component of the foodbase in the upper river section, yet it remains uncertain whether or not algal production is as important, or as limiting to the downstream foodweb. The aquatic protocol evaluation panel had concerns with the lack of empirically established linkages between food base and fishes, and identified that a possible consequence of the recent increase in primary and secondary production may differentially benefit non-native species (competitors or predators) over native species. Research and the restructuring of the existing foodbase monitoring program is warranted in light of its importance toward meeting stakeholder objectives.

Summary Project Description: This study will address a number of issues identified by the aquatic protocol evaluation panel. This project focuses on the research and development of an organic budget and foodweb linkage program as an organizational framework to determine whether or not the aquatic foodbase is limiting, and to determine what organic sources, and where limitations occur within the Colorado River system. This requires multiple approaches: 1) continuation of the conventional phyto-benthic and invertebrate monitoring; focused solely in the Lees Ferry section; 2) conduct in-stream metabolism and community respiration experiments; 3) quantifying organic and inorganic carbon flux and decompositional rates; and 4) based on findings of the organic mass balance research develop an effective sampling design having the appropriate sampling methods and frequency for assessing and quantifying organic flux (sources, pools, transformations and movement). Continuation of historic monitoring methods within the Lees Ferry Reach of the Colorado River will be supplemented with research and development of alternate collecting devices (Hester-Dendie, drift sample collections) and alternate sample processing techniques during 2004 – 2006. Request for proposals will be developed during 2004

addressing items 2-4 above for initiation during 2005. Development of long term monitoring protocols will proceed during 2005-2006 based on the results of research and development during 2005-2006. It is anticipated that a request for proposals to implement a long term monitoring program will be developed in 2007.

MO's and RIN's ADDRESSED: MOs under Goal 6.

Consequences of FY05-06 Funding Recommendations: Program eliminates benthic sampling at six downstream sampling sites implemented in FY02. Program emphasizes monitoring in the Lees Ferry section, an area known to be strongly linked to the phytobenthic and invertebrate community. Sampling program is designed to assess effects relative to experimental flows associated with winter fluctuating flow and experimental high flows. Activities are to be conducted by GCMRC and the successful respondent to a request for proposals.

Status/Schedule: Project scheduled for implementation in FY04 and to continue through FY06.

Expected Products/Deliverables:

- Base-line monitoring of phytobenthic and invertebrate community of Lees Ferry
- Annual report on productivity and relative measures of benthic abundance and composition, linked with water quality data collection
- Fact sheet summary
- Publications on in-stream metabolism
- Publications on organic and inorganic flux and decompositional processes
- Development of an organic mass balance sampling program
- Research, design and feasibility analysis for developing long-term monitoring program.

Experimental Component: (Additional effort focused on high-flow releases and comparisons of ROD operations with non-ROD fluctuations)

Integration: (Linkages downstream IQWP and with fisheries and terrestrial ecosystem dynamics)

Project A.9. *Core Monitoring* - Status and Trends of Downstream Fish Community

FUNDING HISTORY	Fiscal Year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor		469,000	570,000	596,000	546,000	596,000
Logistics		176,000	153,000	150,000	150,000	150,000
Operations		0	15,000	30,000	30,000	30,000
Salary		28,000	71,000	94,000	94,000	94,000
Project Total		673,000	809,000	870,000	820,000	870,000
% total outsourced		92%	88%	84%	83%	84%

Principal Investigators: Coggins and Yard, U.S. Geological Survey, (GCMRC), U.S. Fish and Wildlife Service, Arizona Game and Fish Department, and SWCA, Inc.

Statement of Problem: The downstream fish community is an assemblage of native and non-native fish that occur in the Colorado River ecosystem. This assemblage is exclusive of the trout fishery that is managed in Glen Canyon by the Arizona Game and Fish Department. The constituents include four native fish and introduced competitors/predators like rainbow trout, brown trout, channel catfish, carp, and other non-native forms. The status and trends of the fishery are regulated by biotic and abiotic mechanisms that may in turn be affected by the operations of Glen Canyon Dam. Monitoring basic population statistics including recruitment, abundance, and distribution of native and non-native fishes provide the fundamental information necessary to assess the status of these resources and the attainment of program goals and objectives.

Summary Project Description: Since 2000, GCMRC and cooperators have been developing a long-term monitoring program for fishes in the CRE. To date, significant progress has been made toward this end such that it is now appropriate for GCMRC to formalize a long-term monitoring program for key non-native fishes (i.e. rainbow trout, brown trout, and common carp). This will be accomplished by releasing a request for proposals (RFP) during 2004 for implementation during 2005-06. Research and development of the long-term native fish

monitoring program will continue through 2005 with a target goal of final implementation in 2006.

MO's and RIN's ADDRESSED: Goal 2, MOs 2.1, 2.2, 2.3, 2.8, and Goal 4

Consequences of FY05-06 Funding Recommendations: The FY 05-06 funding recommendation is sufficient to continue development and implementation of the long-term monitoring program.

Expected Products/Deliverables:

- Annual stock assessment reports for native and non-native fish.
- Annual Fact Sheet
- Trip reports following each trip summarizing general catch effort and preliminary results.
- Evaluation of alternative sampling designs that may be tested.
- Data delivery following every sampling trip.

Experimental Component: (Additional effort focused on comparisons of ROD operations with non-ROD fluctuations, mechanical removal, food base and diet studies, turbidity history and role in early life history of native species,)

Integration: (Linkages downstream IQWP and with fishery life histories and ecosystem dynamics, distribution and abundance of fishes relative physical habitat elements)

Project A.10. ***Core Monitoring*** **- Status & Trends of Lees Ferry Trout**

FUNDING HISTORY				
	2003	2004	2005	2006
Outsourced Science/Labor	90,000	116,000	80,000	120,000
Logistics	20,000	20,000	10,000	10,000
Operations	10,000	16,000	10,000	18,000
Salary	18,000	9,000	11,000	17,000
Project Total	138,000	161,000	111,000	165,000
% total outsourced	78%	83%	85%	81%

Principal Investigators: Persons, Arizona Game and Fish Department

Statement of Problem: The Lees Ferry trout fishery refers to the tailwaters portion of the Colorado River ecosystem managed by Arizona Game and Fish Department. This fishery represents an important recreational and economic resource. This assemblage includes flannelmouth suckers and competitors such as carp. The status and trends of the fishery is linked to the phytobenthic community and to operations of Glen Canyon Dam. Community traits such as spawning and recruitment are influenced by the quality of substrate, water, and food. Competitive interactions between trout and other fish species and among trout may also account for population status. The relationships between operations from Glen Canyon Dam, and the coarse-sediment that forms the spawning substrate and the near shoreline habitat used by young developing trout in the Glen Canyon portion of the Colorado River ecosystem resources are a management concern.

Summary Project Description: Primary method uses electrofishing as the sampling method over multiple nights, which occurs tri-annually. Electrofishing equipment and trained operators are contracted personnel through the GCMRC logistical contract. As of FY01 this monitoring project has used a random stratified sampling approach based on shoreline habitat characteristics for site selection. Nine sites are consistently sampled and linked to past monitoring efforts conducted since 1990. The other remaining 27 sites are randomly selected. Direct and derived metrics for assessing status and trends are to be reported including CPE, stock assessment, PSD and condition factor of fish.

MO's and RIN's ADDRESSED: Goal 4 and M.O. 4.1

Consequences of FY05-06 Funding Recommendations: Recommended changes in funding will eliminate methodological comparisons between snorkel surveys and current electrofishing efforts.

Status/Schedule: Renewal for monitoring status and trends of Lees Ferry Trout are expected to continue for FY04 and FY05. Scheduled development of an RFP for monitoring the status and trends of Lees Ferry Trout and technical proposal review are scheduled for FY05. Five-year assessment is to be used to determine whether or not future modifications are needed.

Expected Products/Deliverables:

- Annual report of status and trends of fishery
- Fact sheet of fishery
- Data delivery following each sampling period.
- Trip report following each sampling period

Experimental Component: (Additional effort focused on comparisons of ROD operations with non-ROD fluctuations, mechanical removal, food base and diet studies, turbidity history and role in early life history of native and non-native species,)

Integration: (Linkages downstream IQWP and with fishery life histories and ecosystem dynamics, distribution and abundance of fishes relative physical habitat elements)

Project A.11. ***New Research*** **- State of Primary Productivity, Carbon Flux and Alteration of Food Base**

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	10,000	0	20,000
Logistics	N/A	N/A	N/A	10,000	0	10,000
Operations	N/A	N/A	N/A	10,000	0	10,000
Salary	N/A	N/A	N/A	29,000	0	25,000
Project Total	N/A	N/A	N/A	59,000	0	65,000
% total outsourced	N/A	N/A	N/A	~28%	N/A	~42%

Principal Investigators: Ralston, B.; Yard, M.; and Hueftle, S., U.S. Geological Survey (GCMRC) and TBD

Statement of Problem: Changes in Glen Canyon Dam operations can have dramatic affects on the benthic community and foodbase available to fishes. This project as described in the WY 04-05 science plan was intended to examine changes in foodbase as a result of low fall flows in response to a sediment input from the Paria River.

Summary Project Description: As a result of changes in the foodbase monitoring program towards research and development of a more robust long-term monitoring program as described

in project A.8, we recommend using these funds to support new research and development activities as described in A.8.

MO's and RIN's ADDRESSED: Goals 1, 2 and 3 and associated MO's

Consequences of FY05-06 Funding Recommendations: Work on this element of the program will cease in FY05 and therefore the outcomes of the project will be delayed (implementation of core-monitoring protocol) until FY07.

Status/Schedule: FY04-06, with off year in FY05.

Expected Products/Deliverables:

- Annual and final reports

Experimental Component: To be determined

Integration: (Linkages downstream IQWP, food base questions and with fishery life history and diet)

Project A.12. ***Experimental Treatments*** **- Nearshore Warming and Habitat Utilization by Native and Non-Native Fishes**

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	105,000	85,000	85,000
Logistics	N/A	N/A	N/A	20,000	20,000	20,000
Operations	N/A	N/A	N/A	25,000	15,000	15,000
Salary	N/A	N/A	N/A	50,000	30,000	30,000
Project Total	N/A	N/A	N/A	200,000	150,000	150,000
% total outsourced	N/A	N/A	N/A	~60%	~68%	~68%

Principal Investigators: To be determined

Statement of Problem: A supposed benefit to elevated release temperatures from Glen Canyon Dam associated with a temperature control device is an increase in nearshore water temperature. These nearshore environments are rearing habitat utilized by native fishes. In addition to monitoring water temperature, it may also be important to monitor use of these potential rearing habitats by native and non-native fishes.

Summary Project Description: BOR has allocated 200k/year in FY 04 and FY05 to complete final compliance for the TCD as well as support baseline monitoring of nearshore habitats prior to implementation of the TCD. We recommend that whatever portion of these funds that are available following compliance be used to fund a project to monitor key nearshore habitats near the Little Colorado River for both warming and fish utilization. Proposals will be solicited for this work by releasing an RFP for award in FY05. We recommend carrying FY 04 funds forward to fund this project beginning in FY05. Award of project funding will be contingent on rigorous scientific review of project proposal.

MO's and RIN's ADDRESSED: Goal 2

Consequences of FY05-06 Funding Recommendations: (In progress)

Expected Products/Deliverables:

- Annual and Final Reports

Experimental Component: (TCD related activities to document and research the influence of that treatment on physical habitats (thermal regime) of the main channel.)

Integration: (Linkages downstream IQWP, food base dynamics, and non-native proliferations related to habitat availability for warmer-water fishes, and native fishery life history and diet)

Project A.13. *Experimental Treatments* - Kanab Ambersnail Experimental High Flow Compliance Monitoring

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	10,000	10,000	10,000
Logistics	N/A	N/A	N/A	0	0	0
Operations	N/A	N/A	N/A	0	0	0
Salary	N/A	N/A	N/A	0	0	0
Project Total	N/A	N/A	N/A	10,000	10,000	10,000
% total outsourced	N/A	N/A	N/A	~100%	~100%	~100%

Principal Investigators: AGFD

Statement of Problem: Kanab ambersnail is a federally listed endangered species occurring in one location in Grand Canyon: Vasey's Paradise. In the event of a high flow event, KAS habitat will be affected by immediate habitat loss. It is important to determine potential and actual loss of habitat to evaluate the effects of the high flow event on the population status of KAS as Vasey's Paradise.

Summary Project Description: Trips will be made before and after a high flow event to determine area changes in habitat and estimates of snail numbers.

MO's and IN's ADDRESSED: MO's under Goal 5 including 5.1.

Consequences of FY05-06 Funding Recommendations: Funds do not presently address logistical costs for trips, nor do they cover any costs for administration of dollars or science/survey staff time. Funds would be carry forwarded to FY05 from FY04.

Status/Schedule: Program implemented in FY05.

Expected Products/Deliverables:

- Data delivery for incorporation into yearly status and trends report.

Experimental Component: (Habitat mapping of "take" around high-flow test releases)

Integration: (Linkages downstream IQWP (streamflow) and scouring of terrestrial vegetation at Vaseys Paradise)

Project A.14. ***Experimental Treatments*** **- Foodbase Impacts of Experimental High Flows**

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	10,000	N/A	10,000
Logistics	N/A	N/A	N/A	10,000	N/A	10,000
Operations	N/A	N/A	N/A	10,000	N/A	10,000
Salary	N/A	N/A	N/A	20,000	N/A	20,000
Project Total	N/A	N/A	N/A	50,000	N/A	50,000
% total outsourced	N/A	N/A	N/A	~33%	N/A	~33%

Principal Investigators: Ralston, B.; Yard, M.; and Hueftle, S., U.S. Geological Survey and TBD

Statement of Problem: Changes in Glen Canyon Dam operations can have dramatic affects on the benthic community and foodbase available to fishes. This project as described in the WY 04-05 science plan was intended to examine changes in foodbase as a result of experimental high flows in response to a sediment input from the Paria River.

Summary Project Description: As a result of changes in the foodbase monitoring program towards research and development of a more robust long-term monitoring program as described in project A.8, we recommend using these funds to support new research and development activities as described in A.8.

MO's and IN's ADDRESSED: MO's under Goal 1 including 1.3, 1.4 and 1.5.

Consequences of FY05-06 Funding Recommendations: Funds are not available for this experimental element in FY05 if a high-flow experiment is implemented. FY06 restores funding for this work to the FY04 level.

Status/Schedule: Done only in FY06 in the event of a high flow, contingent upon funding availability.

Expected Products/Deliverables: Annual report and associated data.

Experimental Component: (Influence of high-flow test releases on food base components)

Integration: (Linkages downstream IQWP (streamflow), nutrient flux, food base perturbation, etc.)

Project A.15. *Experimental Treatments* - Mapping Redds Distribution & Identifying Mechanisms for Mortality of Salmonids under Fluctuating Flows

FUNDING HISTORY & PROPOSALS FOR FY05-06	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Component	0	0	131,000	125,000	0	100,000
Logistics	0	0	5,000	25,000	0	25,000
Operations	0	0	0	10,000	0	10,000
Salary	0	0	3,000	15,000	0	5,000
Project Total	0	0	139,000	175,000	0	140,000
% total outsourced	N/A	N/A	94%	71%	N/A	71%

Principal Investigators: Korman et al. (Ecometric Research, Inc.)

Statement of Problem: Increasing abundance of trout below the Lees Ferry reach is deemed an adverse threat to the early life history of Humpback chub who disperse from the Little Colorado River. If Rainbow trout abundance in the Marble Canyon reach is significantly related to main channel spawning success under ROD operations, then operational alternatives for limiting spawning success in the mainstem need to be identified. Winter season fluctuations in stage (non-ROD) have been identified as a possible source of early life history mortality for salmonids

below the Lees Ferry reach. This project is aimed at identifying mainstem spawning by salmonids below Lees Ferry if it is occurring, and then to identify the mechanism for mortality if non-ROD fluctuations limit spawning success by trout.

Summary Project Description: This section describes work that was conducted in FY 04 to assess the feasibility of using experimental flows as a means of controlling populations of rainbow trout in the Lees Ferry reach and in Grand Canyon. In FY03, a series of redd and fry surveys in the Lees Ferry reach were used to determine: a) the timing of redd deposition; b) the hypsometry of redds; c) an estimate of potential redd mortality based on flows, redd hypsometry, and intra-gravel temperatures; d) the relationships between physical conditions (depth velocity, and substrate) and spawning site selection; e) timing of fry emergence; and f) the feasibility of measuring the survival rate of fry using a combination of catch-per-effort sampling supplemented with direct ageing and length-frequency analysis.

Results from the FY03 effort will provide useful information to managers. Knowing the timing of redd deposition (a) and fry emergence (e) are required to refine the timing of experimental fluctuating flows aimed at reducing rainbow trout abundance. An assessment of the number of redds lost due to fluctuating flows (c) can be made based on redd hypsometry (b) and the timing of redd deposition (a). Understanding the relationship between physical conditions and spawning site selection (d) may be useful for predicting how flows will determine redd hypsometry, which in turn determines the potential redd loss from increased flow fluctuations. Determination of annual or within-year fry survival rates has the potential to provide a high resolution monitoring technique for assessing the impacts of any flow change from Glen Canyon Dam on rainbow trout populations.

The FY04 work plan continued work in the Lees Ferry reach but also included a new component in Grand Canyon. Owing to the logistical difficulties and increased costs associated with working in Grand Canyon it was not possible to perform as many surveys as were completed in the Lees Ferry reach in 03. Consequently, our objectives for the Grand Canyon component of the '04 study are more modest. The objectives in Grand Canyon are to:

a) provide a quantitative estimate of the number of redds in the Colorado mainstem near the assumed peak of spawning (Feb., L. Coggins, pers. comm..) and to compare this estimate with the number of redds in tributaries;
b) document the spatial gradient in fry densities and the proportions of fry-at-age; and to

c) assess the feasibility of estimating the fry emergence timing and survival rate through sequential (bi-monthly) sampling.

Information on the extent of mainstem spawning will address the long-standing management uncertainty about the source of rainbow trout in Grand Canyon (are they produced locally or do they immigrate from the Lees Ferry reach?). It may not be feasible to estimate the timing of redd deposition in Grand Canyon as was done in the Lees Ferry reach in 03 because of reduced water clarity and increased depths in Grand Canyon. We have scheduled 2 redd survey trips (Feb, Apr) to increase our chances of having adequate water clarity and flows on at least one survey.

Fry surveys in Grand Canyon will also be useful to address the issue of the source of rainbow trout in Grand Canyon. For example, the presence of very small fry in Grand Canyon at a time when similar sized fish are not present in the Lees Ferry reach will provide fairly convincing evidence of mainstem spawning below Lees Ferry. Alternatively, a spatial gradient of decreasing densities of fry at an increasing distance downstream from Lees Ferry would provide evidence that the origin of rainbow trout in Grand Canyon is from the Lees Ferry reach. The feasibility of using repeat fry surveys to provide an estimate of fry survival rates in Grand Canyon will be evaluated from the 04 sampling and will depends on the variation in immigration rate, timing of local egg deposition, the extent of spatial variability in catches, and sensitivity of catchability to river conditions (turbidity and flow).

MO's and IN's ADDRESSED: MOs under Goals 2 and 3.

Consequences of FY05-06 Funding Recommendations: The currently proposed budget for FY 2005 completely eliminates this project in FY 2005. One option is to resume the project in FY 2006 with respect to the mechanisms of mortality component downstream of the Lees Ferry reach. This approach would allow for the identified mechanism for mortality to compared with the normal ROD operations during the Jan. through Mar. period. This approach is recommended, if additional experimental funding is available.

Status/Schedule: FY01-06, the work is set to be mostly completed in FY 2005, but there may be a need for ongoing monitoring and research below the Lees Ferry reach if flow experiments are ongoing.

Expected Products/Deliverables: The work plan is logically divided into surveys conducted in the Lees Ferry reach and Grand Canyon between Lees Ferry and Phantom Ranch.

Lees Ferry Reach

- Monthly rapid assessment redd surveys from Jan to May 04. The number of redds and their approximate elevations will be determined throughout the reach using the same rapid assessment methodology developed in 03.
- Monthly intensive redd surveys at index sites (four mile, ferry swale, powerline) from Jan-May 04. This component includes redd mapping by surveying redd locations but does not include collection of any habitat data (depth, velocity, substrate).
- Apr – Aug 04 fry surveys conducted on a monthly basis.

Grand Canyon (Lees Ferry to Phantom Ranch)

- Two rapid assessment redd surveys will be conducted during the winter (Feb and Apr) to determine the number of redds and their approximate stages in the mainstem. Surveys of redds in tributaries above the LCR will also be conducted.
- Three fry surveys will be conducted between Spring and Fall (Apr, Jun, Aug) using a combination of backpack and boat electrofishing at a series of randomly selected index sites. As in the LF 03 fry survey, a subsample of fish will be retained for direct ageing from otoliths to establish a length-age relationship. This relationship will be used in conjunction with length-frequency data to determine the timing of emergence and fry survival rate by December '04.

Experimental Component: (Influence of non-ROD fluctuating-flow test releases on spawning activity and success of non-native salmonids)

Integration: (Linkages downstream of Lees Ferry with native and non-native interactions of fishes)

Project A.16. *Experimental Treatments* - Foodbase Impacts of Non-ROD Fluctuating Flows

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	40,000	10,000	0	0
Logistics	N/A	N/A	20,000	10,000	0	0
Operations	N/A	N/A	0	10,000	0	0
Salary	N/A	N/A	0	30,000	0	0
Project Total	N/A	N/A	60,000	60,000	0	0
% total outsourced	N/A	N/A	~83%	~27%	N/A	N/A

Principal Investigators: Yard, M., U.S. Geological Survey (GCMRC)

Statement of Problem: Algae/macrophytes and invertebrates form the major components of the aquatic food base in the Colorado River ecosystem. The different macroinvertebrates consisting mostly of midge larvae (chironomids), black flies (simulids) and amphipods (Gamarus) trophically supports the trout fishery found in the Glen Canyon reach. The foodbase is considered an important biotic resource because of the potential limitations, use, and availability required to support this fishery. Research has shown that widely fluctuating flow releases reduce phytobenthic biomass and invertebrate densities primarily due to mechanisms of atmospheric desiccation. The duration of exposure time determines the area and vertical extent of the aquatic community. Although this affect reduces the standing crop of the phytobenthic and invertebrate community it also influences the availability of food for higher trophic levels. Fluctuating flows provide hydraulic mechanism to supply aquatic invertebrates for fish consumption.

Summary Project Description: Phytobenthic and macro-invertebrate sampling is to be conducted at six sample sites in the Glen Canyon reach to assess effects for pre-, during, and post flow fluctuations. Site locations are relevant to canyon orientation (north-south and east-west). Phytobenthic scrapes and artificial substrate (Hester-Dendies) are to be used for standing ash-free dry mass determination and determining compositional densities of invertebrates.

MO's and RIN's ADDRESSED: Goal 1, MO's 1.3, 1.4 and 1.5.

Consequences of FY05-06 Funding Recommendations: No known consequences relative to funding recommendations. If ROD operations are implemented as part of the overall recommended experimental design (GCMRC plan), then comparisons will be made between experimental fluctuations (FY03-04) and non-experimental fluctuating flows (FY05-06) on the basis of ongoing, annual food base data collected in the Lees Ferry reach.

Status/Schedule: GCMRC will take on data collection activities and analysis previously provided in FY03 by a cooperative agreement with NAU cooperators.

Expected Products/Deliverables:

- Annual report on changes to phytobenthic standing biomass and composition
- Fact sheet in association with water quality data

Experimental Component: (Lees Ferry monitoring is basis for comparing experimental versus non-experimental fluctuations from FY03 through FY06)

Integration: (Linkages between Lees Ferry fishery and food base)

Project A.17. *Experimental Treatments* - Mechanical Removal of Non-Native Fishes in the Colorado River

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	130,000	130,000	160,000	324,000
Logistics	N/A	N/A	375,000	375,000	375,000	375,000
Operations	N/A	N/A	15,000	15,000	15,000	15,000
Salary	N/A	N/A	66000	66000	36000	36000
Project Total	N/A	N/A	586,000	586,000	586,000	750,000
% total outsourced	N/A	N/A	~77%	~77%	~83%	~92%

Principal Investigators: L. Coggins and M. Yard, U.S. Geological Survey (GCMRC), and new contract in FY05-06.

Statement of Problem: Trends in the abundance and recruitment of the Little Colorado River population of humpback chub suggest this population has been in decline for over a decade.

Factors contributing to this decline are unknown but likely include: interaction (predation and/or competition) with non-native fishes, infection by alien parasites, sub optimal mainstem water temperatures, hydrological conditions in the mainstem Colorado and Little Colorado Rivers, and decline of near-shore rearing habitat in the mainstem Colorado River. Though it is unknown which factor(s) are most responsible for humpback chub mortality, it is likely that interactions with non-native forms are a contributing element.

Summary Project Description: Following a recommendation from the adaptive management work group, the first two years of a long-term experimental design was implemented during 2003. This project addresses one element of that experiment and is designed to provide a better understanding of the interactions between humpback chub and non-native fishes. Additionally, this project addresses the feasibility of non-native fish control in a large segment of the mainstem Colorado River utilizing electrofishing as a method for mechanical removal. This project was proposed for 4 years and received approval for FY 03 and FY04. Contingent on AWG approval for FY 05-06, a request for proposals will be issued for this work to be completed during the third and fourth years.

MO's and RIN's ADDRESSED: Goal 2: M.O. 2.6

Consequences of FY05-06 Funding Recommendations: As written, adequate funding is available assuming outside contractors do not require substantially more funds than has been required to conduct this project within GCMRC.

Status/Schedule: First year field efforts completed. First biennial draft report completed and in the process of finalization. Planning for subsequent years underway.

Expected Products/Deliverables:

- Biennial reports on project status to the AMWG.
- Final reports and publications in 2007.

Experimental Component: (Mechanical removal of trout in the main channel during FY03 through FY06)

Integration: (Linkages between recruitment of Humpback chub and abundance and distribution of salmonids in the Marble and eastern Grand Canyon reaches)

Project A.18. ***Experimental Treatments*** **- Non-Native Diet and Predation Analysis**

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	30,000	0	30,000
Logistics	N/A	N/A	N/A	0	0	0
Operations	N/A	N/A	N/A	5,000	0	5,000
Salary	N/A	N/A	N/A	15,000	0	15,000
Project Total	N/A	N/A	N/A	50,000	0	50,000
% total outsourced	N/A	N/A	N/A	~60%	N/A	~60%

Principal Investigators: Yard, M.D. and Coggins, L. – U.S. Geological Survey (GCMRC)

Statement of Problem: Recent analyses of historical humpback chub data suggest that the abundance of the Little Colorado River population is in decline. Change in abundance is due to a reduction in recruitment of young-year fish. These early life-stages are vulnerable to a number of sources of mortality. Evidence would suggest that non-native predation is a likely source of this mortality and is experimentally testable using multiple-year depletion treatments. However, foraging preferences and nutritional requirements for these different fish species are not well known for this particular system. Certain observational studies have shown that the overall assemblage of fish use different aquatic and terrestrial invertebrates, as well as fish that are either young or small-sized. It is ecologically recognized that most young developing fish do not survive to recruit into the reproductive population. Most of the mortality occurring to these vulnerable fish is due to predation. Therefore, small sized fish represent a proportion of the overall foodbase in this ecosystem. The physical and biotic factors that regulate their availability as a food item, as well as their survival, influence the population dynamics of these different fish species. Although predation has been documented for the different trout species (rainbow and brown trout), their apparent food habits as indicated by stomach content analysis are not

conclusive. Especially, when it comes to understanding the possible trophic interactions that exist between different size-age classes and the environmental pressures associated with different population densities and variable food availability. Additionally, independent technical review by the NRC and aquatic PEP panel have identified a number of issues of concern that linkages between food base and fishes are empirically lacking, and further identified that a possible consequence of the recent increase in primary and secondary production may differentially benefit non-native species (competitors or predators) over native species. Furthermore, the panel identified the need for establishing a better understanding of the trophic linkages between the foodbase and non-native fish.

Summary Project Description: This diet-predation project is an integrated component of the non-native fish removal study. The primary objectives are designed to determine if abiotic and biotic interactions occur in relation to changes in environmental factors (flow, turbidity, & temperature), foodbase availability, and changes due to prey and predator densities from mechanical removal and increased survivorship. The unit of measure for assessing change is diet item composition and proportion, biomass intake, and incidence of predation. This analysis provides empirical information to validate and improve on the development of a bioenergetics model developed for assessing native fish vulnerability to predation in relation to temperature and establishing foodweb linkages with the aquatic foodbase. The trout dietary analysis is to be integrated with other existing GCMRC long-term monitoring and research programs that are the presently collecting or proposing to collect data specific to: 1) aquatic benthic foodbase, and 2) carbon productivity monitoring program. These alternate studies are assessing stable isotopes, drift and benthic invertebrate abundance as part of the trout removal study.

MO's and RIN's ADDRESSED: Goals 2 and 4, RIN's 2.4.2, 4.2.6

Consequences of FY05-06 Funding Recommendations: Project was originally funded in FY03; however, owing to funding changes for FY04 and discontinuation as of FY05, this study will be unable to address most of the study objectives requiring multiple year comparisons in diet. Consequences are having only minimal capabilities of detecting significant changes in food items consumed. This includes incidence of predation in response to differences in environmental factors (flow, turbidity, & temperature), seasons, food availability and changes in

prey and predator densities due to mechanical removal. At present funding levels for this project allow for the total completion of the winter and summer FY03 sampling period, and only partial completion of the anticipated FY04 winter sample collections.

Status/Schedule: Diet and incidence of predation is completed for the FY03 winter sampling period (January, February, and March).

Expected Products/Deliverables:

- Revised in response to funding reduction – "Seasonal diet comparison of rainbow and brown trout for 2003."

Experimental Component: (Conducted in conjunction with ongoing mechanical removal of trout in the main channel during FY03 and FY04, but not in FY05 owing to lack of funds, but then the effort is undertaken again in FY06)

Integration: (Linkages between recruitment of Humpback chub and abundance/distribution of salmonids in the Marble and eastern Grand Canyon reaches, with respect to predation and competition for food)

Project A.19. *Humpback Chub Actions* - Remove Humpback Chub from Mainstem Colorado River at 30-mile to Maintain Genetic Stock in Refugia

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	20,000	60,000	60,000
Logistics	N/A	N/A	N/A	10,000	20,000	20,000
Operations	N/A	N/A	N/A	5,000	10,000	10,000
Salary	N/A	N/A	N/A	5,000	10,000	10,000
Project Total	N/A	N/A	N/A	40,000	100,000	100,000
% total outsourced	N/A	N/A	N/A	~71%	~77%	~77%

Principal Investigators: To be determined

Statement of Problem: As identified by the AMWG ad hoc committee on humpback chub, this project would remove humpback chub from the Colorado River and maintain them in captivity (see HBC Ad Hoc Group Report). The motivation for this project is to promote a program of conservation aquaculture for HBC or as a safeguard to allow supplemental stocking in the event of catastrophic population decline.

Summary Project Description: New project to be initiated based on recommendation of the AMWG HBC Ad Hoc Group. Initiation of this project should be contingent on final results of the captive breeding feasibility project completed in FY-03. If this project is to proceed, we recommend preparing an RFP for initiation in 2005 and carrying forward 2004 funds. Award of project funding will be contingent on rigorous scientific review of project proposal.

MO's and RIN's ADDRESSED: Goal 2, M.O. 2.1

Consequences of FY05-06 Funding Recommendations: Increased level of activity associated with this experimental Humpback chub activity

Status/Schedule: Yet to be Determined

Expected Products/Deliverables:

- To be determined

Experimental Component: (Yet to be determined)

Integration: (Yet to be fully determined)

Project A.20. *Humpback Chub Actions* - Translocation of Native Fishes to Tributaries of the Colorado River, Grand Canyon National Park and Tribal Lands

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	10,000	10,000	30,000	10,000
Logistics	N/A	N/A	15,000	15,000	20,000	15,000
Operations	N/A	N/A	0	0	0	0
Salary	N/A	N/A	0	0	0	0
Project Total	N/A	N/A	25,000	25,000	50,000	25,000
% total outsourced	N/A	N/A	~70%	~70%	~80%	~70%

Principal Investigators: U.S. Fish & Wildlife Service

Statement of Problem: As identified by the AMWG ad hoc committee on humpback chub and the December 2002 USFWS Biological Opinion, the first phase of this project is aimed at increasing the survival and expanding the geographic range of humpback chub in the LCR. Additionally, a second phase addresses identifying other tributaries where translocation of humpback chub and other native fishes would be appropriate.

Summary Project Description: Phase 1 initiated in 2003 by USFWS with translocation of juvenile humpback chub to the upper reaches of the perennial flowing LCR with follow-up monitoring. If this phase 2 of this project is to proceed, we recommend preparing an RFP for initiation in 2005. Award of project funding will be contingent on rigorous scientific review of project proposal.

MO's and RIN's ADDRESSED: MO 2.1 and 2.6

Consequences of FY05-06Funding Recommendations: To be determined.

Status/Schedule: Initiated in FY03, but future schedule is yet to be determined.

Expected Products/Deliverables:

- Annual and final reports.

Experimental Component: (non-flow treatment)

Integration: (Yet to be fully determined)

Project A.21. Humpback Chub Actions - Use Dam Operations to Benefit Humpback Chub

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	20,000	20,000	20,000
Logistics	N/A	N/A	N/A	0	0	0
Operations	N/A	N/A	N/A	0	0	0
Salary	N/A	N/A	N/A	30,000	30,000	30,000
Project Total	N/A	N/A	N/A	50,000	50,000	50,000
% total outsourced	N/A	N/A	N/A	~40%	~40%	~40%

Principal Investigators: U.S. Geological Survey (GCMRC), stakeholders, science cooperators

Statement of Problem: The Glen Canyon Dam Adaptive Management Program is charged with implementing experiments to better understand the linkages between operation of Glen Canyon Dam and other experimental manipulations and resources for which management goals and objectives have been established. Experimental planning is a crucial element in this process. With the approval of the 2003-2004 recommended experimental treatments, the GCDAMP has begun long-term experimental planning. However, adequate time and resources must be made available to continue this process.

Summary Project Description: We propose to use the funds identified in this project to continue the planning process for experimentation during 2005 and beyond. This will be accomplished in part by convening a workshop for GCDAMP participants during December of 2003. This workshop will utilize the multi-attribute trade off analysis begun earlier this year. Expected results of the workshop will include recommendations for future year experiments. This project will also fund additional GCMRC staff to develop RFP's associated with GCMRC

sponsored activities related to core monitoring, experimental treatments, new research initiatives, and AMWG ad hoc humpback chub committee recommendations.

MO's and RIN's ADDRESSED: Goal 2 and MO 2.1 - 2.5

Consequences of FY05-06Funding Recommendations: To be determined.

Status/Schedule: Yet to be determined.

Expected Products/Deliverables:

- Annual and final reports.

Experimental Component: (supports long-term experimental planning and Multi-Attribute Trade-off and Risk Assessments (MATA workshops and other related experimental planning activities)

Integration: (Planning for integrated ecosystem outcomes)

Project A.22. *Humpback Chub Actions* - Scientific/Recreation Impact Assessment on Humpback Chub Survival and Reproduction

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	11,000	20,000	0
Logistics	N/A	N/A	N/A	0	10,000	0
Operations	N/A	N/A	N/A	0	0	0
Salary	N/A	N/A	N/A	0	0	0
Project Total	N/A	N/A	N/A	11,000	30,000	0
% total outsourced	N/A	N/A	N/A	~100%	~83%	N/A

Principal Investigators: Craig Paukert, U.S. Geological Survey (GCMRC), Pamela Sponholtz, U.S. Fish & Wildlife Service, and David Ward, Arizona Game & Fish Department

Statement of Problem: As identified by the AMWG ad hoc committee on humpback chub and the USFWS recovery goals for humpback chub, one factor that must be considered in an evaluation of recovery status is an evaluation of overutilization by scientific or recreational uses. This project will address this issue in two phases. Phase 1 will assess scientific overutilization and phase 2 will address recreational overutilization. In the case of humpback chub, recreational overutilization will focus on impacts of recreation utilization of the lower Little Colorado River, an area of critical humpback chub habitat, by Grand Canyon visitors.

Summary Project Description: Phase 1 research commenced in late 2003 with the initiation of a peer-reviewed project proposal assessing handling effects on humpback chub. This study is designed to mirror the protocols of routine monitoring of humpback chub within the Little Colorado River. Bonytail chub are used as a surrogate species to assess mortality and growth of fishes subjected to routine handling and PIT tagging. Phase 2 of this project will be initiated following development of an RFP to assess potential effects of recreation activity in the lower Little Colorado River on humpback chub reproduction and survival. As recommended by the AMWG Ad Hoc HBC group, this research could consist of various modeling approaches and fact-finding workshops. Award of project funding will be contingent on rigorous scientific review of project proposal.

MO's and RIN's ADDRESSED: Goal 2: M.O. 2.1, and 2.2. Goal 9: M.O. 9.1 and R.I.N 9.1. Goal 12: M.O. 12.2.

Consequences of FY05-06 Funding Recommendations: Increased funding in FY05 is assumed to result in this project being completed in FY05. No additional funding is currently requested for an FY06 project element.

Expected Products/Deliverables:

- Phase 1 Final Report in July 2004

Experimental Component: (Related to both the flow and non-flow components of experimental treatments, science activities and influences on the recreational user community)

Integration: (Recreational and fisheries management)

Project A.23. *Humpback Chub Actions* - Humpback Chub AD HOC Project 17 Monitoring Fish Downstream of Diamond Creek

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	33,000	8,000	8,000
Logistics	N/A	N/A	N/A	10,000	10,000	10,000
Operations	N/A	N/A	N/A	2,000	2,000	2,000
Salary	N/A	N/A	N/A	5,000	5,000	5,000
Project Total	N/A	N/A	N/A	50,000	25,000	25,000
% total outsourced	N/A	N/A	N/A	~84%	~65%	~65%

Principal Investigators: To be determined

Statement of Problem: The portion of the river corridor below Diamond Creek is influenced by dam operations of Glen Canyon and Hoover Dam by affecting discharges from Lake Powell and inflow elevations of Lake Mead. Lake Mead is a sport fishery and is considered habitat for razorback suckers. With the advent of instream warming from the temperature control device, upstream movement of warm-water exotics from Lake Mead may affect CRE fish community structure upstream of Diamond Creek. Incorporating the status of fish numbers and species encounters is important to evaluate the full effects of dam operations involving temperature as well as discharges.

Summary Project Description: Development and implementation of monitoring fish downstream of Diamond Creek will be done in such a manner that data are compatible with core monitoring of fish in the CRE. Eventually, this project may be incorporated into the core monitoring program for fisheries.

MO's and IN's ADDRESSED: MO's under Goal 2 and 7 including 2.1-2.6; 7.1, 7.2.

Consequences of FY05-06 Funding Recommendations: Funds for FY04 should be carry forward into FY05 and RFP released in FY05. A portion of the funds ($10,000) provided for by Lower Colorado Multi-species Recovery Program.

Status/Schedule: RFP released in FY05.

Expected Products/Deliverables:

- Data delivery for incorporation into yearly status and trends report.

Experimental Component: (Not directly related to flow experiments, but influenced relative to basin hydrology and storage conditions in Lake Mead)

Integration: (Native and non-native fishes abundance and distribution relative to changing habitat conditions associated with Upper Lake Mead conditions)

Project A.24. *Humpback Chub Actions* - Monitoring Fish Disease and Parasites in the Colorado River Ecosystem

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	30,000	35,000	35,000
Logistics	N/A	N/A	N/A	15,000	15,000	15,000
Operations	N/A	N/A	N/A	0	0	0
Salary	N/A	N/A	N/A	5,000	5,000	5,000
Project Total	N/A	N/A	N/A	50,000	55,000	55,000
% total outsourced	N/A	N/A	N/A	~88%	~89%	~89%

Principal Investigators: To be determined.

Statement of Problem: With the advent of increased river warming as reservoir water levels fall and particularly with the operation of a temperature control devise, increased fish disease and parasitism may occur. As potential disease could represent a significant mortality threat to fishes within the CRE, important not only to monitor the future incidence of parasitism and disease but to document a baseline condition before initiation of TCD.

Summary Project Description: Proposals for a disease and parasite monitoring program will be solicited via an RFP released in 2004 to be awarded in 2005. Suggest carrying 2004 funds forward for expenditure in 2005.

MO's and RIN's ADDRESSED: Goal 2: M.O. 2.5

Consequences of FY05-06 Funding Recommendations: Funding remains level throughout this planning period.

Expected Products/Deliverables:

- Annual and Final Reports

Experimental Component: (Related to implementation and testing the TCD proposed for Glen Canyon Dam)

Integration: (Downstream elements of the IQWP, such as temperature and relationship to pathogens and parasites in the main channel – influence on fisheries and food base)

Project A.25. ***Humpback Chub Actions*** **- LCR Watershed Management Plan**

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	N/A	100,000	0
Logistics	N/A	N/A	N/A	N/A	0	0
Operations	N/A	N/A	N/A	N/A	0	0
Salary	N/A	N/A	N/A	N/A	0	0
Project Total	N/A	N/A	N/A	N/A	100,000	0
% total outsourced	N/A	N/A	N/A	N/A	~100%	N/A

Principal Investigators: To be determined

Statement of Problem: Recovery goals for Humpback chub includes an emergency response plan in the event of a spill in the LCR as well as addressing non-native fish introductions into the

LCR. The Little Colorado River (LCR) watershed is a large area with many political jurisdictions and authorities. The Little Colorado River Multi-Objective Management group was formed to facilitate discussions among these interest groups. The development of a watershed plan that aims toward protection and improvement of the watershed is linked to the maintenance of habitat for humpback chub in the LCR. The plan should address surface and groundwater quantity and quality, pesticide use, and non-native fish stocking.

Summary Project Description: This project will review the status of the LCR Multi-Objective Management group and the watershed development management plan and follow through in implementation of the plan. NOTE: Projects from the ad hoc group addressing pollution, emergency response, and invasive species are combined into this project funding. It is unclear if the lead agency for this project is GCMRC or the USFWS recovery implementation program or some other agency.

MO's and IN's ADDRESSED: Recovery Goals 5.2.2.4, Factor D

Consequences of FY05-06 Funding Recommendations: Funding for this project includes addressing pollution, emergency response, and invasive species for the watershed.

Status/Schedule: RFP released in FY05.

Expected Products/Deliverables:

- Convene workshops and Management Plan document

Experimental Component: (No direct relationship to experimental flow treatments)

Integration: (Basin hydrology, and changing environmental conditions throughout the LCR drainage)

Project A.26. *Humpback Chub Actions* - A Combined Mainstem Colorado River and Little Colorado River Humpback Chub Abundance Assessment

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	180,000	140,000	140,000
Logistics	N/A	N/A	N/A	50,000	40,000	40,000
Operations	N/A	N/A	N/A	10,000	10,000	10,000
Salary	N/A	N/A	N/A	10,000	10,000	10,000
Project Total	N/A	N/A	N/A	250,000	200,000	200,000
% total outsourced	N/A	N/A	N/A	~91%	~88%	~88%

Principal Investigators: Not yet determined

Statement of Problem: Disagreements among scientists, managers, and policy makers exist concerning methods used to infer the status of humpback chub populations in Grand Canyon. These concerns exist on a variety of levels including: accuracy, precision, and scientific impact. The AMWG ad hoc humpback chub committee suggested that an independent review panel be convened to assess the appropriateness of various approaches being used or suggested to conduct stock assessment of humpback chub in Grand Canyon. Additionally, the committee recommended that a novel approach, concurrent mainstem Colorado River and Little Colorado River assessment, be conducted depending on the recommendations of the panel and the AMWG.

Summary Project Description: Funding in FY04 to convene a review panel and conduct a concurrent mainstem Colorado River and Little Colorado River assessment. We recommend that if the review panel and the AMWG call for a concurrent estimate, proposals to conduct the assessment be solicited from an RFP to be awarded in 2005. Award of project funding will be contingent on rigorous scientific review of project proposal.

MO's and RIN's ADDRESSED: Goal 2: M.O. 2.1

Consequences of FY05-06 Funding Recommendations: Funding is level throughout the planning period. However, it is still not clear how this action will actually be implemented as part of long-term monitoring of humpback chub.

Expected Products/Deliverables:

- To be determined

Experimental Component: (Related to flow and non-flow related experimental treatments, as well as long-term monitoring considerations for most effective methods for assessing population dynamics of native fishes)

Integration: (Mainstem versus tributary food sources, habitats and native versus non-native interactions that influence Humpback chub recruitment success)

Project A.27. *Humpback Chub Actions* - Development of an Adaptive Management Work Group Outreach Program

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	TBD	TBD	TBD
Logistics	N/A	N/A	N/A	TBD	TBD	TBD
Operations	N/A	N/A	N/A	TBD	TBD	TBD
Salary	N/A	N/A	N/A	TBD	TBD	TBD
Project Total	N/A	N/A	N/A	0	0	0
% total outsourced	N/A	N/A	N/A	TBD	TBD	TBD

Principal Investigators: Not yet determined.

Statement of Problem: As identified in the AMWG ad hoc humpback chub committee, there is a need for an outreach program that delivers consistent, accurate, and objective information to the public.

Summary Project Description: Description of formation and implementation of the outreach program is contained in the ad hoc humpback chub report.

MO's and RIN's ADDRESSED: Goal 12: M.O. 12.9

Consequences of FY05-06 Funding Recommendations: To be determined

Expected Products/Deliverables:

- Establishment of an AMWG outreach program

Project A.28. *Humpback Chub Actions* - Development of a Humpback Chub Genetics Management Plan

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	TBD	TBD	TBD
Logistics	N/A	N/A	N/A	TBD	TBD	TBD
Operations	N/A	N/A	N/A	TBD	TBD	TBD
Salary	N/A	N/A	N/A	TBD	TBD	TBD
Project Total	N/A	N/A	N/A	0	0	0
% total outsourced	N/A	N/A	N/A	TBD	TBD	TBD

Principal Investigators: Yet to be determined.

Statement of Problem: As identified in the AMWG ad hoc humpback chub committee, there is a need for a comprehensive genetic management plan for humpback chub.

Summary Project Description: A genetic management plan for humpback chub should be formulated. It is unclear whether the lead agency for this undertaking should be GCMRC, USFWS recovery implementation program, or some other entity.

MO's and RIN's ADDRESSED: Goal 2

Consequences of FY05-06 Funding Recommendations: To be determined

Expected Products/Deliverables:

- Develop a humpback chub genetic management program.

Project A.29. *Humpback Chub Actions* - Complete Feasibility Study of Selective Withdrawal Device at Glen Canyon Dam and, if Feasible, Finish Compliance, Construct, and Test the Device

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	100,000	10,000	100,000
Logistics	N/A	N/A	N/A	40,000	TBD	40,000
Operations	N/A	N/A	N/A	15,000	TBD	15,000
Salary	N/A	N/A	N/A	35,000	40,000	35,000
Project Total	N/A	N/A	N/A	200,000	50,000	200,000
% total outsourced	N/A	N/A	N/A	~67%	~20%	~67%

Principal Investigators: To be determined.

Statement of Problem: Cold water releases from Glen Canyon Dam are implicated as a factor in the decline and/or extirpation of native fishes in the CRE. A selective withdrawal device could be used to warm the temperature of release water and possibly benefit native fishes. A risk assessment of a TCD was conducted by the GCDAMP Science Advisors resulting in a recommendation to construct and test such a device.

Summary Project Description: As lead agency for the TCD, BOR will complete compliance activities. Additional research on nearshore warming and habitat utilization will be funded by this project as detailed under project A.12.

MO's and RIN's ADDRESSED: Goal 2

Consequences of FY05-06 Funding Recommendations: Severely decreased activities in FY05 toward completion of baseline monitoring prior to implementation of TCD. FY06 funding levels are restored.

Expected Products/Deliverables:

- Complete compliance
- Produce annual and final reports

Experimental Component: (Planning and TCD implementation at Glen Canyon Dam)

Integration: (Mainstem temperature changes and related changes on downstream food base and fisheries dynamics)

Project A.30.a. Data Acquisition (DASA) - Canyon-Wide Digital Imagery & Automated Photogrammetry Over-Flights

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	0	0	150,000[1]	273,000[2]	180,000[3]	200,000
Logistics	0	0	0	20,000	0	20,000
Operations	0	0	0	0	0	20,000
GCMRC Salary	0	0	20,000	20,000	20,000	50,000
Project Total	0	0	[1]170,000	[1]313,000	200,000	290,000
% total outsourced	N/A	N/A	88%	~93%	~90%	~75%

[1]Carryover of ~$150,000 to fund 2004 over-flight.
[2]Budget cut from original request of $450,000.
[3]Carryover to fund 2006 over-flight.

Principal Investigators: Melis, Davis, Breedlove and Gonzales, U.S. Geological Survey (GCMRC).

Statement of Problem: Sediment and vegetation data are important at various scales to numerous scientists and resource managers. Past monitoring efforts have focused on expensive, large-scale, manual data collection aimed at small areas of the CRE. These were supplemented by collecting hard-copy aerial photography to help in manual interpretation. In FY2003, GCMRC showed that automated processing of multi-spectral digital imagery could be utilized to accurately map the two-dimensional distribution of fine-grained sediment deposits (sand) above 8,000 cfs on a canyon-wide basis. These products had a spatial resolution of 44 cm and a horizontal accuracy (RMSE) of 30 cm. Digital elevation data accompanying the imagery

provided 1-meter resolution with a vertical accuracy (RMSE) of approximately 40 cm as measured against survey data. While these vertical accuracies are just outside the error range deemed acceptable to physical scientists for change detection, they are more than acceptable to resource managers that are concerned with canyon-wide changes in sediment, vegetation and camping beaches.

Summary Project Description: Starting in FY2004, the GCMRC proposes to collect multi-spectral and panchromatic digital imagery together with digital elevation data on a biennual basis for the entire CRE in late May of each over-flight year. These products will have a minimum spatial resolution of 25, 12.5 and 100 cm respectively. Imagery will be checked for accuracy and selected automated-classification products produced (See section A.32.A).

MO's and RIN's ADDRESSED: Goal 12 and others related to specific resource monitoring and research objectives.

Consequences of FY05-06 Funding Recommendations: The FY05-06 funding levels allow for the multi-spectral sensor to be flown simultaneously in two aircraft system-wide so that the mission can be completed in half the time required by flying a single airborne sensor.

Project Goals and Objectives: Canyon-wide digital imagery is collected as detailed source data from which automated analyses extract information such as vegetation and sub-aerial sand deposits in support of scientific core monitoring activities and as information for resource managers.

Expected Products:

- Canyon-wide, four band, multi-spectral digital imagery at 25 cm spatial resolution.
- Canyon-wide, panchromatic digital imagery at 12.5 cm spatial resolution.
- Canyon-wide, digital elevation model at 1 meter spatial resolution.

Recommended Approach/Methods: Digital sensors with airborne solutions for positioning that have been previously flown and evaluated in the Colorado River ecosystem.

Status/Schedule: Products to be delivered in June, 2004 and June, 2006.

Integration: These imagery, together with selected automated-classification products (See section A.32.A) will be provided to the physical, biological and cultural resource programs as baseline core monitoring data and information from which program assessments can be made, resource theses tested, and more detailed data collection efforts planned.

Experimental Component: No additional system-wide multi-spectral imagery is scheduled in support of experimental releases.

Project A.30.b. ***Data Acquisition*** **(DASA) - Very High Resolution, Sub-Aerial LiDAR Over-Flights**

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	0	0	46,000	[1](180,000)	0	150,000
Logistics	0	0	0	[2]10,000	0	20,000
Operations	0	0	0	[2]10,000	0	10,000
GCMRC Salary	0	0	0	[2]10,000	[2]10,000	[2]20,000
Project Total	0	0	46,000	210,000	[2]10,000	200,000
% total outsourced	N/A	N/A	100%	~90%	0%	~84%

[1]Potential for USGS funds to cover the cost of additional LiDAR testing in FY 2004.
2Additional costs associated with LiDAR data acquisition to be derived from project A.3 (sand storage monitoring)

Principal Investigators: Melis, Davis, Breedlove and Gonzales, U.S. Geological Survey (GCMRC)

Statement of Problem: For the past 12 years, GCMRC cooperators have collected detailed elevation data across 11 long-term monitoring reaches to monitor fine-grained sediment changes within the CRE due to Glen Canyon Dam operations. These data were collected using manual survey techniques. In FY2003, GCMRC contracted for very high resolution LiDAR data covering two long-term monitoring reaches. Analysis suggests that these data are at least as accurate (horizontally and vertically) as manually collected survey data and are 20 to 40 times as dense. The conclusion is that detailed, fine-grained sediment monitoring can be accomplished

over a larger area, in greater detail and with the same precision as manual surveys with a lower per unit cost.

Integration: These digital elevation data, together with selected automated-classification products (See section A.32.A) will be provided to the physical, biological and cultural resource programs as baseline core monitoring data and information from which program assessments can be made, resource theses tested, and more detailed data collection efforts planned.

Summary Project Description: Starting in FY2004, the GCMRC proposes to collect very high resolution LiDAR data on a biennual basis for as much of Marble Canyon as possible in late May of each over-light year. These products will have a minimum horizontal accuracy of 20 cm and a vertical accuracy of 5-6 cm on un-vegetated terrain. The LiDAR products will be checked for accuracy and selected automated-classification products produced (See section A.32.A).

Project Goals and Objectives: Very high resolution LiDAR data will be collected as detailed source data from which vegetation canopy, fine-grained sediment and sand bar morphology changes can be monitored and evaluated. These data and derived information support scientific core monitoring activities and provide information for resource managers.

MO's and RIN's ADDRESSED: Goal 12 and others related to specific resource monitoring and research objectives.

Consequences of FY05-06 Funding Recommendations: The FY06 funding levels allow for use of very high resolution LiDAR for core monitoring of terrestrial vegetation, erosion of archeological sites and sand bars on a biennial timescale.

Expected Products:

- LiDAR elevation and reflectance data at a resolution of 7 to 14 points per square meter for large areas of Marble Canyon.

Recommended Approach/Methods: Existing technology and methods for acquisition as demonstrated by the FY 2003 test overflight by John Chance and Associates, Inc., as well as results reported by Davis (2003). The GCMRC shall also attempt to develop automated methods

for editing of vegetated areas of these data toward achieving efficiency in production of bare-Earth topographic models of shoreline areas for improving sand-storage change detection.

Status/Schedule: Products to be delivered in June, 2004 and June, 2006.

Experimental Component: In the event of high-flow testing, two to four additional very high-resolution over flights of the Marble and eastern Grand Canyon reaches (Lees Ferry to Phantom Ranch) will be conducted to document changes in sand storage between the 8,000 and 45,000 cfs stages. These added over flights will be funded under Project A.3.

Project A.30.c. *Data Acquisition* (DASA) - Sub-Aqueous LiDAR Over-Flights and Multi-Beam Sonar Missions

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	0	0	0	0	0	[1]180,000
Logistics	0	0	0	0	0	[1]80,000
Operations	0	0	0	0	0	[1]17,000
GCMRC Salary	0	0	0	10,000	10,000	[1]42,000
Project Total	0	0	0	10,000	10,000	[1]319,000
% total outsourced	N/A	N/A	N/A	0%	0%	~85%

[1]Additional funds are requested in FY06 to complete the system-wide channel mapping project through use of the Navy's CHART system (contingent upon successful testing in FY 2004), or through use of the GCMRC's multi-beam hydrographic system (if CHART test fails to achieve required specifications).

Principal Investigators: Melis, Davis, Breedlove and Gonzales U.S. Geological Survey (GCMRC) and Rubin et al. (FIST team)

Statement of Problem: Preliminary conclusions from research activities conducted by the Fine-Grained Investigative Sediment Team (FIST) suggest that much of the remaining fine-grained sediment located in the sub-aqueous environments of Marble Canyon resides in the long-term eddy systems. These deposits are thought to provide the primary source of sediment for nourishing beaches within the system and probably have some, as yet un-quantified, relationship with associated sub-aerial eddy deposits, which form core camping areas along the CRE. These

environments have traditionally been difficult to measure. Boat-mounted multi-beam sonar has provided important, detailed texture and elevation data for selected reaches, but is rather slow and labor intensive in comparison to aerial surveys and cannot easily be collected in a time-synchronous fashion for large stretches of the river. Airborne hydrographic LiDAR provides a possibly important, relatively low-cost alternative for collecting such core monitoring data.

Integration: These digital elevation data, together with selected automated-classification products (See section A.32.A) will be provided to the physical, biological and cultural resource programs as baseline core monitoring data and information from which program assessments can be made, resource theses tested, and more detailed data collection efforts planned.

Summary Project Description: Starting in FY2004, the GCMRC proposes to test airborne hydrographic LiDAR as a comprehensive, low-cost technology for acquiring digital, sub-aqueous bathymetry and bottom reflectance data whose analysis could be automated to provide time-synchronous hydrographic modeling cross-sections and quantitative estimates of eddy-resident fine-grained materials in conjunction with sub-aerial data-collection missions. If successful, such missions would be incorporated as an integrated component of the biannual, core monitoring data collection missions with multi-beam sonar providing the more detailed data for selected research sites. Lacking hydrographic LiDAR, multi-beam sonar would be utilized as necessary to collect the required data sets.

Project Goals and Objectives: Hydrographic LiDAR and/or multi-beam sonar data will be collected as detailed source data from which channel bathymetry and sub-aqueous, fine-grained sediment deposits can be monitored and evaluated. These data and derived information support scientific core monitoring activities and provide information for resource managers.

MO's and RIN's ADDRESSED: Goal 12 and others related to specific resource monitoring and research objectives.

Consequences of FY05-06 Funding Recommendations: The FY05-06 funding levels allow for the CHART LiDAR sensor to be flown (contingent upon results of the FY04 test overflight) to achieve the channel mapping objectives in a more efficient way that results in data being obtained sooner with less impact to Canyon resources.

Expected Products: LiDAR elevation and reflectance data at a resolution of 7 to 14 points per square meter for large areas of Marble Canyon.

Recommended Approach/Methods: The effort will use either new and improved LiDAR technologies and methods for underwater mapping (a one-year effort to map the entire channel in FY 2006, if the FY 2004 CHART test is conducted and deemed successful), or will continue as ongoing, multi-year project, using the GCMRC's multi-beam hydrographic mapping system over the period of FY 2006 through FY 2010.

Status/Schedule: Products to be delivered in June, 2004 and June, 2006.

Experimental Components: In the event of high-flow experimental releases, the GCMRC's mutli-beam hydrographic system will be used an additional two to four times in FY05-06 to document sand-storage changes in the lower portions of the river channel (below 8,000 cfs stage). The costs for this additional work will be covered under Project A.3. No additional use of underwater LiDAR (CHART system) is currently proposed for sand-storage change detection. Test results from the CHART in FY04 might prove suitable for substituting this method in place of the multi-beam system for purposes of mapping channel-bed topography.

Project A.31. *Data Storage* (DASA) – Grand Canyon Integrated (Oracle) Database Management System

FUNDING HISTORY	Fiscal year				
	2002	2003	2004	2005	2006
Salary	56,000	67,000	80,000	89,000	100,000
Outsourced Science/Labor	100,000	251,000	18,000	8,000	100,000
Travel	3,000	1,000	2,000	1,000	5,000
Outsourced Science/Labor (Oracle)	10,000	10,000	10,000	10,000	10,000
Services	3,000	5,000	3,000	5,000	5,000
Supplies and Materials	10,000	10,000	5,000	5,000	10,000
Equipment	19,000	20,000	10,000	10,000	20,000
Project Total	201,000	363,000	128,000	128,000	250,000
% total outsourced	55%	72%	~22%	~14%	~46%

Principal Investigators: DASA Coordinator (TBD), U.S. Geological Survey (GCMRC)

Statement of Problem: The need for a comprehensive database for maintaining this information was recognized by the National Academy of Sciences in their initial review of the GCES Program in 1987, and reinforced during a second review in 1990. Extensive data and information currently exists 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.

Summary Project Description: The purpose of the GCMRC DBMS is to store and deliver all tabular and spatial data, via our Spatial Data Engine (SDE), gathered as the result of GCMRC investigations and legacy data. Developing the DBMS requires inventorying, organizing, archiving, and developing delivery systems for many years worth of environmental data collection activities representing a vast array of disparate data including physical, biological, cultural, socio-economic, and climatic information. Many datasets have been integrated into our

DBMS with additional datasets in working progress. The additional data yet to be included in our DBMS are organized in Microsoft Excel files, Microsoft Access databases, SAS, or another proprietary format. The DBMS program is currently working on bringing together years of disparate historical data, collected by multiple entities located in databases across the southwest, in an organized fashion and then deliver it transparently to stakeholders and researchers for decision making and modeling purposes. Delivering data in an automated fashion is key to the success of the DBMS. Accommodating such a task will be done utilizing database driven web pages and ArcIMS, a web accessible tool to allow access to our spatial data. These technologies can be integrated to deliver tabular on top of spatial data or allow tabular data to reference spatial data. In addition, the DBMS program is developing a process that includes adequate documentation and training for users to easily access, query, and obtain data from the information system.

MO's and IN's ADDRESSED: Besides supporting Goal 12, the DBMS indirectly assists GCMRC personnel and cooperators in completing the majority of other resource MO's and IN's.

Consequences of FY05-06 Funding Recommendations: The currently proposed budget for FY 2005 will allow the database development to continue, but at a very minimal level and pace. The proposed increase for FY 2006 is needed to accommodate equipment purchases, software licensing, and hire consultants to accelerate database and application development so as to more quickly support achievement of integrated science analyses by the Integrated Science Program within the GCMRC. Most of the additional and ongoing database development is proposed to be achieved through external sources of Oracle expertise. Without additional funding the database development will be stifled, existing datasets won't be updated, and applications won't be implemented until funding is increased to meet the requirements.

Status/Schedule: FY01-03 – DBMS development produced the following datasets: Fish Monitoring Data (1977 to present); Discharge unit values (1921 to present); Lake Powell water quality (1986 to present); Sediment transport data (1921 to present); Water temperature (downstream); Survey Control database. FY04-Indefinate – Develop applications to interact with database, set up database outside firewall for external read-only access, conduct training

sessions, manage (backup, recover, and tune), service data requests, and continue developing schemas.

Expected Products/Deliverables:

- Integrated DBMS (Internal read-write database and external read-only database)
- Applications for accessing both databases
- Documentation for backups, recoveries, DBMS daily tasks, and disaster recovery

Project A.32.a. *Analysis* (DASA) - Automated Core Monitoring Technologies and Applications

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	0	0	8,000	0	0	0
Logistics	0	0	0	0	0	0
Operations	0	0	0	10,000	10,000	30,000
GCMRC Salary	0	0	20,000	50,000	50,000	100,000
Project Total	0	0	28,000	60,000	60,000	130,000
% total outsourced	N/A	N/A	30%	0%	0%	0%

Principal Investigators: GIS Coordinator (Breedlove–acting), DASA Coordinator (TBD) and ISP science staff.

Statement of Problem: Data collection in the CRE is inherently difficult and expensive owing to the remote nature of the canyon environment. Past efforts have focused on expensive, large-scale, manual data collection efforts aimed at small areas of the CRE. Research and analysis conducted during the Remote Sensing Initiative (FY2000-3) concluded that various remote sensing data products could be utilized for numerous core monitoring activities, with a coincident increase in the area being monitored and a reduction in the per unit cost. Within GCMRC, the Geographic Information Systems (GIS) program is focusing on selecting a suite of remote sensing technologies / products and developing analysis routines for automating the extraction and classification of information formatted to the core monitoring needs of scientists within the physical, biological and cultural resource programs and to resource managers.

Integration: Classification products will be provided to the physical, biological and cultural resource programs as baseline core monitoring data and information from which program assessments can be made, resource issues tested, and more detailed data collection efforts planned.

Summary Project Description: In FY2003, GCMRC showed that automated processing of multi-spectral digital imagery could be utilized to accurately map vegetation and the two-dimensional distribution of fine-grained sediment deposits (sand) above 8,000 cfs on a canyon wide basis. In FY2004-05, these analyses will be repeated with an emphasis on change detection for the two-year period (May, 2002-04). Techniques will also be developed for automated processing and classification of data acquired from the terrestrial and hydrographic LiDAR missions and existing multi-beam sonar data.

Project Goals and Objectives: Automated processing of remotely sensed data products is designed to quickly and accurately classify large sets of raster and vector data into core monitoring information that are useful to scientists and resource managers.

MO's and RIN's ADDRESSED: Goal 12 and others related to specific resource monitoring and research objectives.

Consequences of FY05-06 Funding Recommendations: The funding levels are increased sufficiently to support and achieve any new stakeholder identified integrated science initiatives under the direction of the DASA Coordinator, GIS Leader and cooperating scientists.

Expected Products: Products derived from multi-spectral digital imagery.

- Fine-grained sediment inventory and change detection: May, 2002-4 and May, 2004-6.
- Undifferentiated vegetation inventory and change detection: May, 2002-4 and May, 2004-6.
- Camping Beach inventory and change detection: May, 2002-4 and May, 2004-6.
- Products derived from very high resolution LiDAR.
- Technical report outlining methodology for automated or semi-automated classification of very high resolution LiDAR into vegetation and non-vegetation components.
- Bare earth elevation models for selected monitoring areas in Marble Canyon: May, 2004 and May, 2006.

117

Integration: Classification products will be provided to the physical, biological and cultural resource programs as baseline core monitoring data and information from which program assessments can be made, resource issues tested, and more detailed data collection efforts planned.

Summary Project Description: In FY2003, GCMRC showed that automated processing of multi-spectral digital imagery could be utilized to accurately map vegetation and the two-dimensional distribution of fine-grained sediment deposits (sand) above 8,000 cfs on a canyon wide basis. In FY2004-05, these analyses will be repeated with an emphasis on change detection for the two-year period (May, 2002-04). Techniques will also be developed for automated processing and classification of data acquired from the terrestrial and hydrographic LiDAR missions and existing multi-beam sonar data.

Project Goals and Objectives: Automated processing of remotely sensed data products is designed to quickly and accurately classify large sets of raster and vector data into core monitoring information that are useful to scientists and resource managers.

MO's and RIN's ADDRESSED: Goal 12 and others related to specific resource monitoring and research objectives.

Consequences of FY05-06 Funding Recommendations: The funding levels are increased sufficiently to support and achieve any new stakeholder identified integrated science initiatives under the direction of the DASA Coordinator, GIS Leader and cooperating scientists.

Expected Products: Products derived from multi-spectral digital imagery.

- Fine-grained sediment inventory and change detection: May, 2002-4 and May, 2004-6.
- Undifferentiated vegetation inventory and change detection: May, 2002-4 and May, 2004-6.
- Camping Beach inventory and change detection: May, 2002-4 and May, 2004-6.
- Products derived from very high resolution LiDAR.
- Technical report outlining methodology for automated or semi-automated classification of very high resolution LiDAR into vegetation and non-vegetation components.
- Bare earth elevation models for selected monitoring areas in Marble Canyon: May, 2004 and May, 2006.

GCMRC FY2005-2006 Draft Annual Work Plan (November 10, 2003)
Section: FY2005-2006 Draft Annual Work Plan (NOVEMBER 10, 2003)

117

Integration: Classification products will be provided to the physical, biological and cultural resource programs as baseline core monitoring data and information from which program assessments can be made, resource issues tested, and more detailed data collection efforts planned.

Summary Project Description: In FY2003, GCMRC showed that automated processing of multi-spectral digital imagery could be utilized to accurately map vegetation and the two-dimensional distribution of fine-grained sediment deposits (sand) above 8,000 cfs on a canyon wide basis. In FY2004-05, these analyses will be repeated with an emphasis on change detection for the two-year period (May, 2002-04). Techniques will also be developed for automated processing and classification of data acquired from the terrestrial and hydrographic LiDAR missions and existing multi-beam sonar data.

Project Goals and Objectives: Automated processing of remotely sensed data products is designed to quickly and accurately classify large sets of raster and vector data into core monitoring information that are useful to scientists and resource managers.

MO's and RIN's ADDRESSED: Goal 12 and others related to specific resource monitoring and research objectives.

Consequences of FY05-06 Funding Recommendations: The funding levels are increased sufficiently to support and achieve any new stakeholder identified integrated science initiatives under the direction of the DASA Coordinator, GIS Leader and cooperating scientists.

Expected Products: Products derived from multi-spectral digital imagery.

- Fine-grained sediment inventory and change detection: May, 2002-4 and May, 2004-6.
- Undifferentiated vegetation inventory and change detection: May, 2002-4 and May, 2004-6.
- Camping Beach inventory and change detection: May, 2002-4 and May, 2004-6.
- Products derived from very high resolution LiDAR.
- Technical report outlining methodology for automated or semi-automated classification of very high resolution LiDAR into vegetation and non-vegetation components.
- Bare earth elevation models for selected monitoring areas in Marble Canyon: May, 2004 and May, 2006.

GCMRC FY2005-2006 Draft Annual Work Plan (November 10, 2003)
Section: FY2005-2006 Draft Annual Work Plan (NOVEMBER 10, 2003)

- Changes in sub-aerial sand bar morphology based on very high resolution LiDAR: May, 2004-06.
- Vegetation canopy volumes derived from very high resolution LiDAR: May, 2004 and May, 2006.
- Products derived from hydrographic LiDAR and multi-beam sonar.
- Report summarizing the applicability of hydrographic LiDAR for monitoring sub-aqueous bathymetry and fine-grained sediment deposits in the CRE.
- Technical report outlining methodology for automated classification and estimation of eddy deposit volumes using multi-beam sonar.
- Changes in sub-aqueous eddy deposit volumes based on hydrographic LiDAR and / or multi-beam sonar.

Recommended Approach/Methods: A variety of existing methods will be customized to achieve automation in analysis of remotely sensed imagery. In addition, new applications will be developed on an "as-need" basis to meet the requirements of conducting change detection for resources of concern in the Colorado River ecosystem.

Status/Schedule: Products to be delivered in FYs 2004-06.

Experimental Component: GIS applications will be applied, as needed, to a variety of remotely sensed data sets collected in support of high-flow experiments designed to test various sediment-conservation hypotheses. Examples include: sand volume and area change detection and channel-bed substrate classification.

Project A.32.b. *ISP Support* (DASA) - GIS General Support to Science Programs

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	0	8,000	8,000	0	0	13,000
Logistics	0	0	0	0	0	0
Operations	12,000	50,000	46,000	10,000	10,000	44,000
GCMRC Salary	91,000	91,000	76,000	60,000	60,000	123,000
Project Total	103,000	149,000	130,000	70,000	70,000	180,000
% total outsourced	~0%	5%	6%	~0%	~0%	~7%

Principal Investigators: GIS Coordinator (Breedlove–acting) and DASA Coordinator.

Statement of Problem: The traditional role of the GIS Program is inherently service-oriented, providing spatial database development, programming and analysis support to the science programs and their cooperators on both a planned and ad-hoc basis. To continue functioning in this capacity it is imperative to factor in designated blocks of time to continue and in some cases improve the level of GIS support. There is also a need for a higher level of support for more specific GIS application development and analysis of available spatial data.

Integration: Analyses performed using GIS tools will allow for, and in many cases, require the integration of datasets from across several scientific disciplines. An example of this would be using the existing shoreline habitat dataset, which is geomorphic in nature, in junction with terrestrial vegetation or food base generation data.

Summary Project Description: Work performed by GIS personnel for physical, biological and cultural resource projects include but are not limited to the following: Data entry and GIS database development, analysis of new and existing spatial data, map and graphic generation for field collection, presentation and publication purposes.

Project Goals and Objectives: To provide spatial products and analysis capabilities to the physical, biological and cultural resource programs and their cooperators.

MO's and RIN's ADDRESSED: Those associated with Goal 12 and others related to specific resource monitoring and research objectives for the Colorado River ecosystem.

Consequences of FY05-06 Funding Recommendations: The increased level of support within this part of the DASA will meet the additional needs of the science program as new fisheries and TCD initiatives are implemented.

Expected Products: Products from general GIS support include maps for publications, generation and printing of maps and graphics for posters, creation of improved base maps for Lake Powell and Grand Canyon, instructional sessions for staff, cooperators and contractors on GIS layer development, integration and analysis, and advanced spatial analysis for core monitoring projects.

Recommended Approach / Methods: Standard GIS applications, plus customized programming developed by the DASA coordinator intended to facilitate and expedite rapid analysis of data collected by GCMRC science staff, cooperators and various contractors.

Status/ Schedule: Products to be delivered in FYs 2004-06.

Experimental Component: Standard GIS and Oracle data applications will be applied, as needed, to a variety of remotely sensed data sets collected in support of high-flow experiments designed to test various sediment-conservation hypotheses. The GIS department will also assist in directing data collection protocols of scientists prior to and during key experimental treatment and will also assist in post-processing and analysis of experimental data sets.

B. CULTURAL RESOURCES

Project B.1. Core Monitoring of Cultural Resources

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/labor					32,500	350,000
Logistics						100,000
Operations						4,000
GCMRC Salary					7,500	26,000
Project Total					40,000	480,000
% total outsourced*					81%	93%

*Includes 50% of logistical costs

Principal Investigators: Fairley, U.S. Geological Survey (GCMRC) and others TBD.

Statement of Problem: Cultural resources (composed of National Register eligible archaeological sites, cultural landscapes, and places of traditional significance, plus biotic and mineral resources of cultural importance to Native American tribes) are influenced by dam operations and are also affected by physical processes unrelated to dam operations and by human activities. Specifically, dam operations directly affect cultural resources through inundation and other stream flow processes. The dam also affects these resources indirectly and cumulatively through the continuing loss of sediment in a sediment-depleted ecosystem and from changes in the riparian ecosystem. The dam controls inputs and deposition of fine-grained sediment which forms the matrix of archaeological sites in the river corridor; the flows determine the availability of low elevation sand for transportation to higher elevation terraces where most of the cultural resources occur.

Monitoring of archaeological sites has been ongoing in the river corridor since the late 1970s, but intensive monitoring of cultural resources to determine effects of dam operations began in 1992. Monitoring since 1992 has been conducted under the Programmatic Agreement for Cultural Resources. Although these past 12 years of monitoring have documented ongoing erosion of archaeological sites, the data have not been collected in a manner that allows rates and

amounts of erosion to be quantified or for the effects of dam-related vs. non-dam-related erosion to be distinguished in any meaningful manner. Monitoring of diverse kinds of cultural resources (archaeological sites, plants, mineral resources) has also been conducted by individual Native American tribes using a variety of field methods, none of which appear to be leading to a meaningful understanding of the status or trends of the resources of concern.

In 2000, a Protocol Evaluation Panel reviewed the entire cultural program and recommended that the PA monitoring program be redesigned and "reoriented to contribute information to: 1) prioritize historic properties for treatment decisions, and 2) evaluate the effectiveness of treatment options" (Doelle 2000:8). The panel also recommended that in the future "monitoring should be used in a much more focused manner to document progressive erosion at sites where preservation actions have not been implemented, to assess the effectiveness of particular protection measures, and to ensure that effects of visitor activities remain a below a threshold that causes long-term damage" (Doelle 2000:8). Specific protocols were not recommended. Although the National Park Service instituted some minor changes to their previous monitoring approach as a result of these recommendations, the fundamental issues that prompted the PEP to make these recommendations were not addressed.

Summary Project Description: This project will develop and implement monitoring protocols that will allow for the quantification of erosion and other types of dam-related impacts at all types of cultural resource sites and will address the issue of interactions between dam operations, non-fluvial physical processes, and human activities in causing impacts to cultural resources. The first year of the project (FY05) will focus on developing new protocols. National experts in geomorphology, statistical sampling, and cultural resource integrity evaluation will be brought in to review the current program and help refine or redesign current monitoring approaches. In FY06, a pilot program will be implemented and the results assessed to ensure that the selected approaches will be able to provide the requisite quality and quantity of data necessary to detect meaningful changes within a reasonable time frame.

The monitoring program will be explicitly structured to establish the nature and extent of linkages between dam operations and cultural resource conditions and to quantifiably assess the effectiveness of preservation measures. Monitoring of cultural resources will provide measured data on: (1) changing physical conditions of cultural resources related to direct and indirect effects of dam operations; (2) linkages between dam operations and non-dam physical processes

in the ongoing erosion of archaeological sites and other cultural resources; (3) rates and types of degradation to cultural resources due to human activities, as influenced specifically by dam operations; (4) effectiveness of erosion control devices and other preservation actions; (5) system-wide influences of flow regulation on cultural resources with respect to potential redistribution and long-term stability of high elevation fluvially-derived sediment deposits.

MO's and IN's ADDRESSED: MO 11.1, 11.2, and MO 12.2; CMINs 11.1.1, 11.1.2, 11.1.3a,11.1.4 and 11.2.1 (and also RINs 11.2.2 and 11.2.4)

Consequences of FY05-06 Funding Recommendations: FY05 will be the first year of development for what will be a long term core monitoring program for cultural resources focused specifically on addressing the mandates of the Grand Canyon Protection Act. During FY's 2006-2010, this core monitoring effort will continue, subject to funding availability.

Status/Schedule: FY05 – Convene review committee to develop and refine specific protocols for quantitatively monitoring changes in the condition of cultural resources and linking observed changes to dam operations. FY06 – 07 pilot the protocols and reassess their effectiveness for detecting change. FY 08-10 – implement the long-term monitoring program.

Expected Products/Deliverables:

- Annual monitoring reports, documenting changes in the condition of monitored resources and tracking effectiveness of preservation measures
- Digital files of photographs and data resulting from the monitoring effort
- Peer-reviewed journal articles documenting influences of dam releases on the status and long-term condition trends of cultural resources in the Colorado river ecosystem,
- Longitudinal survey profiles of gullies impacting cultural sites and accompanying reports.

Project B.2. Development of Geomorphology Process Model for Predicting Erosion of Cultural Resources

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/labor					80,000	90,000
Logistics					40,000	40,000
Operations					2,000	4,000
GCMRC Salary					13,000	16,000
Project Total					135,000	150,000
% total outsourced*					74%	73%

*Includes 50% of logistical costs.

Principal Investigators: To be determined.

Statement of Problem: Archaeological sites in the river corridor are affected by dam operations and are also affected by physical processes unrelated to dam operations, as well as by human activities. Dam operations affect these resources directly through inundation, bank destabilization, and other stream flow processes. Dam operations also affect the archaeological resources indirectly and cumulatively due to the continuing export of sediment from a sediment-depleted ecosystem. Fine sediment forms the matrix of archaeological sites in the river corridor. Dam operations control the inputs and placement of fine-grained sediment and determine the availability of low elevation sand for transportation to higher elevation terraces where most cultural resource sites occur.

Monitoring of archaeological since 1992 has documented continuing erosion of archaeological resources in the river corridor, but the data have not been collected in a manner that allows rates and amounts of erosion to be quantified or for the effects of dam-related vs. non-dam-related erosion to be distinguished in a meaningful manner. Hereford and others (1993) proposed a hypothesis to account for apparent changes in observed rates of erosion during post-Glen Canyon dam decades. They hypothesized that a change in precipitation patterns, combined with a lowering of the effective base level of the river, had caused tributary channels to become rejuvenated, exacerbating the rate of terrace erosion and causing accelerated erosion of archaeological features. This hypothesis formed the basis for subsequent development of a

mathematical model predicting vulnerability of archaeological sites to future erosion (Thompson and Potochnik 2000). This model was subsequently criticized for its over-reliance on a formula for calculating soil loss that was not appropriate to the steep terrain characteristic of the Grand Canyon and for other inherent conceptual flaws (Doelle 2000:30-31).

One recommendation resulting from the 2000 Cultural PEP review was to develop a new, explicitly process-based geomorphic model that incorporates hill slope gradient and other geomorphic parameters for predicting vulnerability of archaeological sites to future erosive impacts. This model could also help to distinguish the specific role of base level parameters relative to other factors that affect the amount and rates of erosion at archaeological sites. Results of recent research (Pederson et al. 2003) outline the steps needed to develop a numerical model for more confidently predicting erosion and understanding the influence of different controlling factors including base level.

Summary Project Description: This three-year project will develop and test a mathematical model to help predict which areas of archaeological sites are most vulnerable to future erosive impacts. The model will quantify the relative contribution of hill slope processes and other geomorphic parameters relative to river base levels in affecting rates of erosion at archaeological sites. The specific components of the research will include the following steps: 1) test initial findings of Pederson and others (2003) regarding the success of erosion-control efforts through collecting additional monitoring data at selected archaeological sites (FY05-06); 2) gather empirical data to develop the numerical model (FY05-06); 3) develop a 3-dimensional, GIS-based hydrologic model predicting gully erosion and prepare report (FY07).

MO's and IN's ADDRESSED: CMIN 11.1.2 and RINs 11.1.1a-c

Consequences of FY05-06 Funding Recommendations: FY05 will be the first year of development for what will be a three-year project. The FY05 budget does not fully

Status/Schedule: The field research will begin at the start of FY05. The project is dependent upon a biannual schedule of field work and data collection bracketing the summer monsoon season. FY05 – collect empirical data and evaluate status of erosion at selected sites. FY06 –

continue field data acquisition and begin building numerical model using FY05 and FY06 field data. FY07 – test and field check model predictions and prepare final reports.

Expected Products/Deliverables:

- Annual reports, documenting project progress and a final comprehensive report
- Numerical model predicting where future erosion is most likely to occur at selected sites
- Digital files of maps, photographs and data resulting from the field effort
- Peer-reviewed journal articles documenting influences of dam releases on the erosion of cultural resources in the Colorado River ecosystem.

Project B.3. Implement Priority Recommendations of the Recreation Protocol Evaluation Panel Review

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor					33,000	100,000
Logistics						43,000
Operations						1,500
Salary					7,000	10,500
Project Total					40,000	155,000
% total outsourced*					83%	79%

* includes 50% of logistical costs.

Principal Investigators: To be determined.

Statement of Problem: Although the Grand Canyon Protection Act specifically identified "visitor use" as an important value that needs to be considered in developing dam operation criteria, the recreational and sociological effects of dam operations have tended to receive less emphasis in the Adaptive Management Program than the physical and biological components of the ecosystem. The reasons for this disparity are unclear but perhaps reflect an inherent bias in the AMP towards studying and monitoring those processes most amenable to analysis using traditional hard science approaches.

Many of the recreation-related studies that have been funded through GCD-AMP in the past have been geared towards documenting changes in the size and quality of camping

"beaches" (sand bars) in the river corridor (Kearsley and Warren 1993; Kearsley 1994, 1995; Kearsley et al. 1999; Kaplinski et al. 1995, 1998, 2001; Hazel et al. 2002). While this is an important parameter to monitor because of the high value of sand bars to recreational boaters, these previous studies have tended to emphasize the physical parameters of camping opportunities, rather than the experiential qualities of those opportunities (Kaplinski et al. 2003). Other recreational studies have examined issues relating to boater safety (Jalbert 2003) and visitor enjoyment (Stewart et al. 2000; Jonas and Steward 2002) at different flow levels, and one study modeled the effect of flow levels on crowding (Roberts et al. 2001). None of the studies conducted to date have explicitly focused on developing useful parameters for measuring (monitoring) the success or failure of the Adaptive Management Program relative to visitor experience.

In FY03, the Technical Working Group of the GCD-AMP recommended funding for a Protocol Evaluation Panel to review the recreational components of GCMRC's sociocultural program in FY04. This review is likely to produce a series of recommendations for bringing recreational research and monitoring in line with other GCMRC program areas for future core monitoring purposes. This proposed project will provide "seed money" to begin implementing the highest priority recommendation(s) of the FY04 PEP review.

Summary Project Description: To be determined

MO's and IN's ADDRESSED: CMINs 9.1.1, 9.1.2, 9.1.3, 9.2.1, and 9.4.1

Consequences of FY05-06 Funding Recommendations: The budget proposed in FY05 will not be adequate to implement all or perhaps even one of the highest priority recommendations that are likely to emerge from the FY04 PEP review. However, with increased funding proposed in FY06, substantial progress in developing and implementing a core monitoring program for recreation/visitor experience values will be possible.

Status/Schedule: FY05 will be the first year of what is anticipated to be a multiyear effort to develop, test, and implement core monitoring of visitor experience values.

Expected Products/Deliverables:

- Definition of core monitoring parameters for evaluating changes in visitor experience
- Reports tracking trends in visitor experience parameters affected by dam operations

Project B.4. Implement Priority Recommendations of the Socioeconomic Protocol Evaluation Panel Review

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor					33,000	120,000
Logistics						
Operations						3,000
Salary					7,000	7,000
Project Total					40,000	130,000
% total outsourced					83%	92%

Principal Investigators: To be determined.

Statement of Problem: The socioeconomic effects of dam operations have tended to receive less emphasis in the Adaptive Management Program than physical and biological components of the ecosystem, despite the fact that the Grand Canyon Protection Act specifically identified "visitor use" and other "values" as central considerations in the development and implementation of dam operation criteria. The reasons for this disparity are unclear but perhaps reflect an inherent bias in the AMP towards studying and monitoring those processes most amenable to analysis using traditional hard science approaches.

Since the inception of GCMRC, socioeconomic studies on the effects of dam operations have been confined to relatively small scale analyses tied to experimental flows. For example, during the LSSF, the economic effects of this flow regime on concessionaires and hydropower revenue generation capacity were analyzed. In the National Research Council's 1999 review of the Adaptive Management Program, the AMP as a whole and GCMRC specifically were strongly criticized for not placing more emphasis on researching and analyzing the economic

implications and effects of current and potential future dam operations and incorporating the results of economic analyses in their decision-making process.

In FY03, the Technical Working Group of the GCD-AMP recommended funding for a Protocol Evaluation Panel review of the socioeconomic component of GCMRC's sociocultural program in FY04. This review is likely to produce a series of recommendations for bringing socioeconomic research and related monitoring efforts in line with other GCMRC program areas. This proposed project will provide "seed money" to begin implementing the recommendations of the FY04 PEP review.

Summary Project Description: To be determined

MO's and IN's ADDRESSED: MO 12.1, IN 12.1, CMIN 10.1, RIN 12.9.2

Consequences of FY05-06 Funding Recommendations: The budget proposed in FY05 will not be adequate to implement all or perhaps even one of the highest priority recommendations that are likely to emerge from the FY04 PEP review. However, with increased funding proposed in FY06, substantial progress in developing and implementing a research and core monitoring program related to socioeconomic variables will be possible.

Status/Schedule: FY05 will be the first year of what is anticipated to be a multiyear effort to develop, test, and implement a long-term socioeconomic program.

Expected Products/Deliverables:

- Definition of core monitoring parameters for evaluating impacts to and changes in resources values from an economic standpoint
- Reports tracking socioeconomic trends relative to dam operations

Project B.5. Economic Impacts of Experimental Flows to Whitewater Boaters and Angler Concessionaires

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor						20,000
Logistics						
Operations						
Salary						
Project Total						20,000
% total outsourced						100%

Principal Investigators: To be determined.

Statement of Problem: The proposed hydrograph may have economic impacts to river-based recreation industries and associated service industries. The high flow periods may affect fishing opportunities in the Lees Ferry reach and affect revenues associated with whitewater boating. Possible sources of impact include changes in frequency of guided trips by both fishing and whitewater concessionaires, changes in numbers of fishermen, and possible motor and equipment damage due to flows. This study will investigate the economic impacts to river runners, fishing guides, and local service providers relative to proposed experimental high flows and subsequent fluctuating flows.

Summary Project Description: Using existing records supplemented with direct interviews, a contracted researcher will compare and contrast numbers of guided fishing trips, numbers of fishing licenses sold locally, and numbers of whitewater water boating trips launching from Lees Ferry and launching or taking out from Diamond Creek in relation to previous years. These figures will be used to estimate overall economic impacts, taking into account national economic trends in the final analysis.

MO's and IN's ADDRESSED: MOs 9.1 and 12.1; EIN 9.1.1

Consequences of FY05-06 Funding Recommendations: This project has been repeatedly deferred since implementation of the experimental flows in FY03. In the current FY05-06 budget, it is deferred once again to FY06. Failure to implement this project will be contrary to the management objectives identified in the AMP strategic plan.

Status/Schedule: FY06 will be the first year of this project.

Expected Products/Deliverables: Report assessing economic impacts of experimental flows on anglers, whitewater boaters, and closely related industries.

Project B.6. Comprehensive Inventory of River-based Camp Sites in the CRE

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor						80,000
Logistics						40,000
Operations						5,000
GCMRC Salary						35,000
Project Total						160,000
% total outsourced*						87%

*Includes 50% of logistical costs.

Principal Investigators: To be determined

Statement of Problem: Campable areas in the Colorado River ecosystem include sand bars, smooth sandstone ledges, and occasionally rocky bars bordering the river margins. The limited numbers of campsites in the river corridor constrain the upward limits of the CRE's visitor carrying capacity. The kinds, qualities and spatial distribution of campsites in the river corridor also have a direct bearing on visitor experiential values. The relationship between operations of Glen Canyon Dam and camping opportunities in the river corridor has been studied over the course of the last three decades, using a variety of assumptions and approaches. Previous studies have shown that sand bar camp size and opportunities have decreased through time as sediment has been removed from the system. Despite more than 30 years of research on river corridor camp site issues, however, we still lack a comprehensive inventory of camping sites in the river corridor. A complete inventory of camp sites is necessary in order to fully assess the effects of

changes in camp site size, distribution, and quality over time. This proposed project will address this key deficiency by compiling the results of previous camp sites inventories into a GIS and integrating this legacy data with current information derived from a recent remote sensing initiative (Breedlove 2003) and an as-yet-to-be-completed field inventory.

Summary Project Description: This project will be comprised of several interrelated components:

- Compile aerial photo-based inventories from Weeden et al. (1975), Brian and Thomas (1984), and Kearsley and Warren (1993) and transfer the data to ortho photo images in a spatially referenced GIS.
- Evaluate quality and collection methods of pre-existing aerial photo data.
- Comprehensively inventory all campsites currently used in the river corridor through interviewing commercial guides and science outfitters to determine locations, then outline current camp sites areas on orthophotos in the field, using the pen tablet approach pioneered by Kaplinski et al. (2003). Record attributes of camp sites in linked data fields (e.g. bedrock ledges vs. open beach). Compile data on maximum group size using information derived from guides about current use levels at each site.
- Compare currently used camp sites with formerly identified sites to determine changes in type, distribution and (where possible) size of camp sites over the past thirty years.
- Compare currently used camp sites with campable area polygons developed by Breedlove (2003); assess limitations/benefits of using the remotely sensed data to track changes in varying types of camp sites through time.

MO's and IN's ADDRESSED: Goal 7, MO's 7.1 – 7.3

Consequences of FY05 - 06 Funding Recommendations: Although it would be desirable to complete a comprehensive camp site inventory immediately, restrictions on funding available in FY05 prohibit immediate implementation of this project. FY06 presents the first opportunity to implement new projects. This project should be considered a high priority activity in FY06.

Status/Schedule: FY01-06: This is a new scheduled to begin in FY06. It builds upon previous remote sensing work by Breedlove (2003) and recommendations of Kaplinski et al. (2003).

Expected Products/Deliverables: A series of GIS layers composed of previously inventoried camp sites tied to spatially referenced ortho-images, plus an analysis of the data to 1) document changes in type, distribution and size (where feasible) of camp sites over time, and 2) test

reliability of remotely-sensed sand areas for predicting camp site location and actual areal extent of camp sites.

Integration: This project integrates GIS-derived data with legacy data derived from conventional aerial photos and ties the physical attributes of camp sites to experiential parameters that are important for tracking effects of dam operations on visitor use values.

C. LOGISTICS OR SUPPORT SERVICES PROGRAM

Project C.1. Coordination and Support Program-Logistics Operations

LOGISTICS DESCRIPTION		FY01	FY02	FY03	FY04	FY05	FY06
Salary (includes benefits)							
Logistics Operations Specialist	1.0	55,000	51,300	65,000	67,000		
Logistics Assistant	1.0	30,000	30000	36000	37,000		
Logistics Summer Aid	1.0		17000	20000	17,000		
Contracts							
Logistics Contracts*		525,000	500000	361000	365,000		
Permitting Contract		54,000	57000	72000	76,000		
Services							
Helicopter Support		30,000	31000	36000	36,000		
Emergency Evacuation		6,000	6000	5000	5,000		
Supplies and Materials							
Logistics Support Supplies & Expenses*		5,000	5000	179000	190,000		
Equipment		30,000	65,000	31,000	32,000		
Subtotal all logistics costs		735,000	762,300	805,000	825,000		
Allocation to Projects		437,000	437,000	805,000	825,000	TBD**	TBD**
TOTAL		298,000	325,300	*0	*0	*0	*0

*All Logistics Operations costs are distributed to GCMRC projects based on a formula proportional to use of services. The formula takes into account contractor costs, trip size and length, and a percentage of operating expenses, salaries and permitting costs. Approximately 50% of logistical costs are outsourced to contracts.
**Determined by total projected Logistics Costs from projects.

Principal Investigators: Carol Fritzinger and Parke Steffensen

RIN'S Addressed by this Project: The Logistics Program provides support to the GCMRC science programs and the adaptive management program.

Program Description: Implementation of the GCMRC mission to provide credible, objective scientific information to the AMP begins with effective coordination of all technical and logistical support of research activities. The Research Coordination and Support Program staff functions as a team to facilitate collaboration with the Integrated Science and Cultural Programs

through effective communication with Program Managers, PI's and the Technical Support Services. The program encompasses the integration of 5 elements:

- Permitting
- Library Operations Coordination
- Survey Support Coordination
- Technical Support Coordination
- Logistics Operations

Program Staff address each of these elements in assessment of support requests from researchers to determine which tools and processes will best facilitate the most effective collection and delivery of information from research projects. Through the combined effort of the program elements the process of research support is executed as a complete and fully integrated support service. The process is initiated in the proposal review and permitting stage, continued through the support coordination stage and completed with information delivery and report. The process acts as an accountability checkpoint, failure to meet agreed data collection and delivery standards is addressed immediately and corrective solutions are sought to avoid any delay in project completion.

Summary Project Description: The GCMRC provides complete logistical support for 35-50 research, monitoring and administrative river trips through the Grand Canyon annually. These trips range in length from 7 to 21 days and from 4 to 36 people in size. Trips are comprised of a variety of motor and oar powered boats operated by contracted boat operators. Projects operating in the Glen Canyon reach of the Colorado River (Glen Canyon Dam to Lee's Ferry) are supported by a variety of motor powered boats operated by GCMRC researchers and contracted boat operators. Additionally, research activities on the Little Colorado River and at other locations outside of the Grand Canyon National Park boundaries are supported by helicopter services contracted with the Bureau of Reclamation. Ground based support for other research activities outside of the river corridor are also coordinated with the use of GCMRC leased vehicles.

The GCMRC uses a method of supporting trips in which government owned boats and river logistical equipment are used in conjunction with a contracted vendor who supplies Technical and Logistical Boat Operators. A concerted effort is made to match PI's with the best possible Boat Operators for their particular study. Food packs, trip supplies, and equipment are

organized, packed and maintained at the GCMRC warehouse. Put-in and take-out transportation is provided with the use of GSA leased vehicles and contracted shuttle drivers.

This logistical approach has evolved since the GCES phase to allow a detailed overview of trip particulars that most influence cost and efficiency, ultimately giving the GCMRC control over trip costs and productivity. Effective communication with PI's and sensitivity to and awareness of the challenges they face in implementing their studies enable the GCMRC to offer more customized (and therefore more cost-effective and productive) logistical support than other support strategies utilized previously. Retaining control over the process of supporting trips also facilitates compliance with NPS regulations and allows greater control over issues sensitive to the general public and the "recreational river community".

Schedule: The trip planning and scheduling process begins in the fall when the Logistics Coordinator, in cooperation with contracted PI's, Program Managers and the Research Coordination and Support Staff work together to generate a draft schedule of trips for the fiscal year. The schedule includes; launch and take-out dates, numbers of personnel and specific boat and boat operator requests for each trip. Researchers must submit a Trip Request Form a minimum of 60 days prior to the scheduled launch date. This form provides information for two purposes: 1) determine and schedule logistical and support services and 2) complete a GCNP River Trip Application in order to meet the GCNP 45 day deadline for submitting access permit applications. The schedule is implemented throughout the fiscal year. Project cost distribution is determined at the close of the fiscal year.

Consequences of FY05-06 Funding Recommendations: The Logistics Budget represents the funding required to support all research and monitoring projects in the 05/06 work plan. Any reduction in funding will result in inability to provide logistical support to projects as proposed.

Project C.2. Survey Operations

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor		0	0	33,000	0	0
Logistics (All)		0	0	12,200	45,200	45,200
Operations		35,000	36,000	36,800	36,800	36,800
GCMRC Salaries		35,550	41,180	44,000	44,000	44,000
Project Total		70,550	77,180	126,000	126,000	126,000
% total outsourced**		0	0	26%	0	0

* Control Network budget prior to FY2004 combined with survey operations
**Includes 50% of logistical costs

Principal Investigators: Keith Kohl, U.S. Geological Survey (WRD- GCMRC)

Rationale: All long term monitoring efforts require spatial positioning of data. The survey support offered by GCMRC allows for consistent data collection methods by trained personnel familiar with logistical constraints of Grand Canyon fieldwork. The department staff is technically trained to operate all survey equipment to minimize or eliminate field data collection mishaps. The department also owns necessary survey equipment, which minimizes or eliminates costly leasing fees. The survey department also develops and performs consistent storage and database protocols for all survey data collected in the CRE for simple integration into the GIS database.

Statement of Problem: All spatial data collected under the direction of the GCMRC requires referencing to the primary geodetic control network established by the National Geodetic Survey and the GCMRC. The geodetic control network is the framework for the entire Geographic Information System Database (GIS). The primary network has been expended to secondary and tertiary levels of control within the CRE in reaches of research and monitoring activities. Consistent methods and protocols have been developed and implemented for spatial data collection and its integration into the GIS. The trained GCMRC Survey staff supports research and monitoring activities by collecting survey data with these protocols, and by delivering the data in the formats consistent with data standards. The support staff also maintains survey equipment for field use including conventional total station equipment, static, kinematic and Real

Time Kinematic (RTK) GPS equipment, echo sounders, acoustic Doppler and bathymetry systems, and field maps for resource identification.

Summary Project Description: Survey support is provided for spatial measurement and referencing of scientific data collected through GCMRC research projects. Survey operations in support of programs within GCMRC can be divided into three areas:

1) Positioning of historically and newly collected spatial data.
2) Reference historical spatial data to modern control network.
3) Compile spatial reference data into a control point data base.
4) Quality Assurance/ Quality Control of remotely sensed spatial data.

It has been shown that horizontal positions can be efficiently attained with the use of GPS techniques. While the vertical component is more problematic, heights referencing the ellipsoid can be effectively calculated throughout much of the CRE. These horizontal and vertical coordinates are required for previously collected data sets prior to inclusion in the CRE Oracle database. Coordinates are also required for control in areas of future data collection to eliminate the need to translate and rotate surveys collected in local or historical coordinate systems. Substantial project cost savings are achieved when the geodetic control is established within study areas prior to field data collection in support of monitoring and research projects.

QA/QC is required for all remotely sensed spatial data sets. The Colorado River Ecosystem Elevation Database is designed to give positions and elevations at visible "hard points" along the river corridor. This dataset can be used to check accuracy of LiDAR and ISTARS remote sensing techniques, both on a canyon wide basis and for a local assessment of positional and elevational accuracies of each day's flight. With the high cost of remote sensing data collection, QA/QC is critical to analyzing the usefulness of each data subset. This elevation database can also be used to georeference scanned photos for 2-dimensional change detection.

Recommended Approach and Methods: Control points are established and spatial data is collected using both GPS and conventional survey methods. Surveys follow protocols developed by GCMRC with technical support from the National Geodetic Survey, Army Corps of Engineers, and the Federal Geodetic Data Committee.

Integration: All programs within the GCMRC require spatial data measurements. Integration with each program's requirements and the GIS database is imperative to the process of survey

data collection, post-processing, storage, and evaluation. The survey department is available to all GCMRC principal investigators and can often collect data for multiple projects during the same mission.

MO's and IN's ADDRESSED: 4.1, 4.2, 5.1, 5.2, 6.4, 7.3, 8.1, 8.2, 8.3, 8.4, 8.5, 9.3, 11.2, 12.2, 12.3, and 12.9

Consequences of FY05-06 Funding Recommendations: Funding will allow for more historical datasets to be integrated into the GIS database for accurate change detection with GIS tools. Additional funds will be preserved by attaining accurate positions and elevations of spatial data prior to integration into GIS database.

Status/Schedule: FY2001- Low Summer Steady Flows, Kanab Amber Snail, Channel Mapping

FY2002- Fine-grained Sediment Team, Cultural Mitigation, Kanab Amber Snail, Remote sensing support
FY2003- Remote sensing support, Cultural Mitigation, Kanab Amber Snail
FY2004- Physical resource historical data sets, Colorado River Ecosystem Elevation Database, Fine-grained Sediment Team, Kanab Amber Snail, Colorado River Ecosystem Elevation Database, remote sensing support
FY2005-6 Physical resource historical data sets, Cultural resource historical datasets, cultural mitigation, Kanab Amber Snail, Colorado River Ecosystem Elevation Database, remote sensing support

Project Goals and Objectives:

1) Supply GCMRC principal investigators with the necessary equipment, supplies, and survey knowledge to perform the spatial data collection required by their research.
2) Expand the Geodetic Control Network into necessary areas of the CRE in support of the Adaptive Management Program.
3) Create a Colorado River Ecosystem Elevation Database for georeferencing of past datasets and accuracy evaluation of remotely sensed data.
4) Publish updated control point coordinates, superceded coordinates, and associated error estimates for all network control. This will be done through the development of the GCMRC control point database and made available to Grand Canyon National Park and all CRE researchers.
5) Publish control point maps and make them available for all CRE field survey activities
6) Continue translating and rotating historical survey data sets to updated network control coordinates
7) Integrate the prioritized historical survey datasets into the CRE database
8) Educate principal investigators and researchers regarding the limits of accuracy and height systems with alternate survey methods.

Project C.3. Geodetic Control Network

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor				0	33,000	33,000
Logistics (All)				54,000	64,000	64,000
Operations				10,000	20,000	20,000
GCMRC Salaries				22,000	33,000	33,000
Project Total	*	*	*	86,000	150,000	150,000
% total outsourced**				0%	22%	22%

* Control Network budget prior to FY2004 combined with survey operations
**Includes 50% of logistical costs

Principal Investigators: Keith Kohl, Kristin Brown, U.S. Geological Survey (BRD- GCMRC)

Rationale: The geodetic control network serves as the foundation for all spatial measurements necessary for long term monitoring. This control network also serves as the spatial framework for the Geographic Information System (GIS). The referencing of spatial data must be consistent in order to perform accurate change detection. All spatial data collected within the CRE requires georeferencing to the primary geodetic control network established by the GCMRC and the National Geodetic Survey. While current remote sensing and long-term monitoring sites have been referenced to this network, additional GCMRC monitoring activities require expanded network control efforts.

Statement of Problem: The geodetic control network serves as the spatial framework for the entire Geographic Information System Database (GIS). Discrepancies of control point coordinates affect both the surveys that reference these coordinates and the spatial data analyses performed with available GIS tools. These discrepancies exist, mainly in the vertical component, due to complications of deflection of the vertical, local gravitational anomalies, satellite signal multipath errors, and the combination of conventional measurements, which reference gravity, with GPS measurements, which reference a geocentric ellipsoid. It is the geoid that provides the

connection between terrestrial and GPS surveys and it is the geoid that, at this time, is undefined within the complex topography of Grand Canyon.

Summary Project Description: The geodetic control network in Grand Canyon requires both survey operations for research and survey operations for program support. Research is required to better understand the vertical accuracies associated with the Grand Canyon control network. The National Geodetic Survey is pursuing height modernization efforts that will allow for more accurate height systems. Current NGS-funded geodesy research is concentrating on the gravitational effects on heights and geoid computations within the Grand Canyon. The Grand Canyon was selected as a study area to determine the effects of terrain in an extreme and computationally challenging topographic setting. Results from this research will immediately assist GCMRC in the accuracy assessment of CRE control and will potentially contribute to height modernization projects throughout the world.

It has been shown that horizontal positions can be efficiently attained with the use of GPS techniques. While the vertical component is more problematic, heights referencing the ellipsoid can be effectively calculated throughout much of the CRE. These horizontal and vertical coordinates are required for previously collected data sets prior to inclusion in the CRE Oracle database. Coordinates are also required for control in areas of future data collection to eliminate the need to translate and rotate surveys collected in local or historical coordinate systems. Substantial project cost savings are achieved when the geodetic control is established within study areas prior to field data collection in support of monitoring and research projects.

QA/QC is required for all remotely sensed spatial data sets. The Colorado River Ecosystem Elevation Database is designed to give positions and elevations at visible "hard points" along the river corridor. This dataset can be used to check accuracy of LiDAR and digital aerial photography (ISTAR) remote sensing techniques, both on a canyon wide basis and for a local assessment of positional and elevational accuracies of each day's flight. With the high cost of remote sensing data collection, QA/QC is critical to analyzing the usefulness of each data subset. Additionally, this elevation database can also be used to georeference scanned photos from previous missions to study change detection.

Recommended Approach/Methods: Control points are established using both GPS and conventional survey methods. GPS techniques utilize relative positioning where antennas and

receivers are placed at both known and unknown network positions. Distances are measured between the known and unknown points by time dependant calculations from GPS satellite data. Conventional survey techniques involve the use of a total station (a survey instrument which combines the horizontal and vertical angle measurement abilities of a transit with electronic distance measurements). Conventional traverse surveys begin at a known reference point, measure through a series of line-of-sight stations, and close at either the point of beginning or another known reference point. Both conventional and GPS measurements will be required for 1) coordinate determinations of positions and elevations throughout the CRE, and 2) realistic error estimates for each network control station.

Integration: Accurate spatial positioning of scientific data from the cultural, biological and physical programs is necessary for facilitating change detection methods. Historical data must be adjusted to reliable coordinates before integration into the database and before these resource assessments can be made. Often, past surveys that relate to current monitoring efforts have been referenced to local datums. These sites also require accurate positional and elevational data before the data can be entered into the GIS database for examination and change detection.

MO's and IN's ADDRESSED: 6.4, 7.3, 8.1, 8.2, 8.3, 8.4, 8.5, 9.3, 11.2, 12.2, 12.3, and 12.9

Consequences of FY05-06 Funding Recommendations: Funding will allow for more accurate change detection using GIS tools and utilize the expertise of the NGS and cooperators to create more accurate error estimates for all spatial data sets. Additional funds will be preserved by attaining accurate positions and elevations of spatial data prior to integration into GIS database.

Status/Schedule: The CRE geodetic control network schedule has been modified to reflect changes resulting from the development of the long-term monitoring reaches of the biological, cultural, and physical resource programs. Efforts have been concentrated to establish, verify and validate the coordinates of the control stations utilized in these monitoring studies. Additional efforts have added 9 stations to the primary rim control network and 36 secondary control stations extending the line-of-site network from Glen Canyon Dam to Bright Angel Creek. These efforts both increase accuracy of the entire network and minimize errors inherent with longer baselines (distances from known to unknown positions). Future survey operations will increase accuracy of CRE control points by expanding the river corridor network. These GPS data sets

will be combined with conventional traverse measurements to evaluate the effects of varying geoid undulations and to give realistic error estimates to all network control stations.

Project Goals and Objectives: The objective of this project is to develop a high-precision control network throughout the CRE. Control monuments will be established at consistent intervals throughout the CRE and at locations required for accurate positions and elevations of past, current, and future data sets. The goal of this project is the expansion of the control network into the necessary areas prior to spatial data collection required by the research activities. By having stable control monuments and accurate coordinates completed before spatial data acquisition begins, post-processing methods are reduced, and both human resources and money are conserved.

Expected Products: The products of the CRE control network project will be:

- A network of survey control points established in specific research areas and throughout the CRE, referenced to the primary control network established by the Grand Canyon Monitoring and Research Center and the National Geodetic Survey.
- Coordinates and realistic positional and height accuracy estimates for all network control stations will be available to the National Park Service, the GCMRC, and all cooperating agencies.
- Index maps showing the location of the network control stations.
- Creation of a Colorado River Ecosystem Elevation Database for georeferencing of past datasets and accuracy evaluation of remotely sensed data.
- GIS layers with control station information.

Timeline for Geodetic Control Network

2001	2002	2003	2004	2005
Primary Network Established, LSSF reaches surveyed	LTM reaches surveyed. Line-of-site network established to Bright Angel Creek	Densification of primary network. Accuracy assessment of previous control network	Accuracy assessment of all network control. Georeferencing of historical datasets upstream of Bright Angel Creek, CREED	Georeferencing of historical datasets throughout CRE, CREED

D. INFORMATION AND OUTREACH PROGRAM

PROJECT D.1. INFORMATION OFFICE

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	N/A	N/A	N/A	N/A	80,000	80,000
Logistics (All)	N/A	N/A	N/A	N/A	0	0
Operations	N/A	N/A	N/A	N/A	20,000	20,000
GCMRC Salaries	N/A	N/A	N/A	N/A	0	22,000
Project Total	N/A	N/A	N/A	N/A	100,000	122,000
% total outsourced*	N/A	N/A	N/A	N/A	66%	66%

*Includes 50% of logistical costs

Principal Investigators: Liszewski, U.S. Geological Survey (BRD)

Statement of Problem: The GCMRC is a science organization within the GCDAMP that produces data, analysis, and reports relating to the effects of the operations of Glen Canyon dam on the Colorado River Ecosystem (CRE). The GCMRC has extensive historical data and information collected over many years relating to the condition of resources in the Colorado River ecosystem. New data and information are being collected daily. Some of this data resides on mature DBMS systems but much of it remains on floppy disks or hard disks on personnel computers using PC-type spreadsheets and database formats. Some of these products go unnoticed and many are underutilized because they are not centrally located and cataloged, or are difficult to obtain.

The two distribution mechanisms used by GCMRC are its library and Website. For the most part, the library is fully functional with web accessible catalogs of all library content. However, limited library content is available on-line. To help remedy this, the library has embarked upon a project to digitize legacy hardcopy library content to facilitate distribution over the Internet.

Some digital data is currently available on the GCMRC FTP site. This data is often non-descript and difficult to navigate. It is the intent of the Information Office to integrate this data

into the GCMRC website with complete data descriptions and navigation tools. Data from other sources will be integrated into the GCMRC website as it becomes available.

Summary Project Description: The information office consolidates, catalogs, and digitizes these products for rapid and timely distribution to our stakeholders, cooperators, and the public through centrally located distribution mechanisms such as our library and website. Web development and maintenance services will be procured through contract.

These activities require a robust and efficient computing infrastructure. Therefore, system administration activities reside in the information office to facilitate its computing needs as well as general GCMRC office automation and data processing and analysis requirements.

The Information Office also coordinates GCMRC review activities.

MO's and IN's ADDRESSED: The GCMRC information office is intended to provide a centrally located distribution point for data and information relating to all GCMRC science activities.

Consequences of FY05-06 Funding Recommendations: The currently proposed budget for FY 2005 and 06 provides for the continued development of, and integration of new products into, the centrally located distribution points (i.e., library and website). Reduced funding will impair our ability to fully develop the infrastructure necessary to implement the distribution technologies and integrate new data and information as they become available. Digitizing hard copy legacy data will be delayed and therefore unavailable for distribution on the GCMRC website.

Status/Schedule: The GCMRC information office was formally established in FY 2004. Program development is expected to continue through 2005 at which point the program will enter into a maintenance mode that will primarily involve minor system tweaking and the integration of new data and information as it becomes available. It is anticipated that new development cycles will need to commence on 1 to 3 year intervals depending upon the changing needs of GCMRC science activities, user needs, and advances in technology.

Expected Products/Deliverables: The primary products of the information office are the library and website from which data, analysis, reports, and scientific publications can be obtained. These products include tabular and spatial data; reports, peer reviewed scientific

publications, fact sheets, presentations, and posters; slides, videos, and photographs (including aerial photos); maps, strategic and annual work plans, program and project descriptions, requests for proposals, personnel listings and events. Releasable electronic data and information will be freely available to stakeholders, cooperators, and the public through our website. Hardcopy data and information will be available through our library. Legacy hardcopy data will be digitized for distribution from our website on a time available basis.

Specific products include the following:

- Comprehensive and fully functional website with access to all non-sensitive digital data and information relating to the effects of dam operations on the CRE. Non-digital data and information will be cataloged electronically with instructions on how to obtain it.
- Comprehensive and fully functional library containing all hard copy and digital media containing data and information relating to the effects of dam operations on the CRE cataloged and accessible. Sensitive and non-releasable data and information will be archived and secured separately from releasable data and information.
- Peer review of reports, scientific publications, fact sheets, and presentations.
- Fully functional and integrated computing environment.

Timeline for project implementation and maintenance:

	2004	2005	2006
Competitive Solicitation Released for web development, March 2004	Contract solicitation - March	Contract modification - Spring	Contract modification - Spring
Project development – build web and library infrastructure	January through December	January through December	
Project maintenance – integration of new data and information	Annual, January through December	Annual, January through December	Annual, January through December

Project D.2. Systems Administration

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor	0	0	0	16,000	17,000	18,000
Logistics (All)	0	0	0	0	0	0
Operations	120,000	111,000	166,000	165,450	166,000	188,000
GCMRC Salaries	61,000	57,000	84,200	80,000	80,000	80,000
Project Total	181,000	168,000	250,200	261,450	263,000	286,000
% total outsourced	0%	0%	0%	6%	6%	6%

Principal Investigators: Blank, U.S. Geological Survey (BRD)

Statement of Problem: The GCMRC computing environment is a complex system of servers, workstations, laptops, printers, plotters, disk arrays, routers, hubs, switches, tape backups, copy and Fax machines, and audio-visual and telecommunications equipment. In addition, over 50 software applications are utilized by scientists and support personnel in carrying out the collective mission of the GCMRC. The computing environment currently consists of 12 servers, 65 workstations, 22 laptops, 6 network printers, 2 tape backup systems, and over 7 Terabytes of disk storage. These devices must work together in a reliable, seamless, and secure manner in order to facilitate the mission of GCMRC.

Summary Project Description: Systems administration supports the collective mission of GCMRC by providing a secure and standardized computing environment for scientists, managers, administrators, and support staff. Computer hardware is largely a combination of state-of-the-art PC (Intel) processors running the Microsoft Windows operating system. Each workstation has a core suite of software applications that include mainstream off-the-shelf integrated office products such as a word processor, spreadsheet, graphics, database, Internet browser, etc. Additional software needed for specialized scientific data processing is also available. To the extent possible, hardware and software is standardized throughout the GCMRC.

Standardization facilitates the inter-office exchange of information and reduces the administrative effort needed for hardware and software support to a sustainable level.

MO's and IN's ADDRESSED: Systems administration supports all GCMRC science and administrative programs.

Consequences of FY05-06 Funding Recommendations: Reduced funding will result in the possible loss of scientific data due to backup equipment failure and lack of storage capacity. Potential loss of productive work hours for scientists and management due to breakdowns in equipment. Loss of software licensing and upgrades, impacting scientific programs. Reduced updates and development on internal and external web sites.

Status/Schedule: FY01-06 – Initiated in its current design as a standardization and support effort for the entire GCMRC. FY's 2004-06, were identified to be years in which increased disk storage, increased web presence and public accessibility to information are priorities.

Expected Products/Deliverables: Specific products of GCMRC systems administration are:

- Desktop and servers - GCMRC's computing environment is based upon the PC platform, Microsoft Windows operating system, and Microsoft Office, office automation software. Systems maintenance is performed using a combination of warranty service, service contracts, and in-house service as needed to facilitate quick turnaround, minimize downtime, and reduce costs.
- Network environment- Computer interconnectivity is provided using TCP/IP network communication protocol running on a 1000baseT and 100baseT network media. Network traffic is arbitrated by 4 3COM switches and hubs operating at 100 Mbps and 1 Gbps.
- Internet connectivity– The GCMRC computer network is linked to the Internet through the Flagstaff Field Center GEOnet-3 router that provides a DS-3 (45 Mbps) virtual circuit to Menlo Park where it joins the U.S. Geological Survey's GEOnet network. Also located in Menlo Park is a network portal to the Internet operated by the U.S. Geological Survey and NASA through a peering partnership. GEOnet provides a secure Survey-wide networking environment that interconnects headquarter region, district, and field offices located throughout the United Sates.
- Intranet website– GCMRC's intranet offers a secure centralized medium for information exchange among GCMRC employees. Among things to be internally shared via the intranet are: standard operating procedures, personnel availability and contact info, vehicle and equipment loans, and an IT support system. The GCMRC intranet is served from a Windows 2000 Server utilizing ASP.
- Computer security – Network security is provided by firewalls, routers, system update server (SUS), systems management server (SMS) and antivirus (AV).

Firewalls and routers are configured and maintained to restrict outside access to authorized systems. Operating systems (OS) are updated to minimize vulnerabilities using SUS that automates a central delivery system for patch management. AV updates are downloaded from the web as released and pushed to all systems the same night.

- System back-up and disaster recovery – System back-up and disaster recovery is accomplished using dual LTO tape drives in a 30 slot carriage with a capacity of 3 Tbytes. Tapes are stored locally in a fire vault and archival tapes are stored off-site. Server disks are configured to run either a raid-5 array or mirrored for redundancy.
- Web and FTP Services – The GCMRC web site and FTP site serve to make the mission and findings of GCMRC accessible to the public. The sites offer our updated work plan, descriptions of our program areas, and various interactive stores of data including our Internet Map Server and our online library.
- Online discussion forums – GCMRC hosts on-line discussions forums for the AMWG, GCMRC, and the U.S. Geological Survey LiDAR discussion group. These forums provide a widely accessible medium for informal discussions and announcements relating to the respective topics.
- Troubleshooting and maintenance – helpdesk support is provided as requested/required. Requests are received via the web, email and telephone. Support is tracked in a searchable database with solutions to facilitate prioritization and resolution.
- Data storage – Over 7 Tbytes of on-line disk storage is provided by multiple servers with SCSI disk arrays. Server disk arrays are hot swappable to minimize downtime. GCMRC also utilizes Networked Attached Storage (NAS) devices. These devices are IDE drives connected to a SCSI backplane. NAS units are used to provide bulk storage capacity at less expense.

Project D.3. Library

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Out-sourced Science/Labor	0	0	15,249	15,250	17,000[1]	28,000
Logistics (All)	0	0	0	0	0	0
Operations	0	18,000	29,000	39,000	39,000	186,000
GCMRC Salaries	51,000	47,500	32,800	40,000	43,000	44,100
Project Total	51,000	65,500	77,049	94,250	99,000	286,100
% total outsourced	0%	0%	20%	16%	17%	10%

[1]This figure assumes an increase in payrate for a student contractor with a bachelor's degree.

Principal Investigators: Stephanie Wyse – GCMRC and Esther Quinn - Contractor

Statement of Problem: The scope and purpose of the library is to collect, archive and deliver materials that assist GCMRC in its efforts to administer long-term monitoring and research. Many of these materials are archival, meaning only one copy exists, and are at risk of loss or damage. The library program also coordinates GCMRC's peer review process to ensure the high quality of the scientific information it produces.

Summary Project Description: Library operations facilitate monitoring and research by providing a centralized repository for hard copy information such as books, reports, maps, photography, and videos. The library has undertaken a project to convert all materials in the library and make them accessible on the GCMRC website. Having materials available through the website will allow multiple users to access data concurrently from remote locations as well as protect one of a kind items from damage or loss. This project commenced in 2003 and will be completed in 2008. Independent scientific peer review at all levels of GCMRC scientific activities -- proposals, ongoing programs, publications, and other products -- provides a mechanism for ensuring the quality, credibility, and objectivity of GCMRC's scientific activities.

MO's and RIN's ADDRESSED: The library provides support to the GCMRC science programs and the adaptive management program and addresses all MO's and RIN's.

Consequences of FY05 Funding Recommendation: Additional funding during 2005 would allow the library scanning project to proceed ahead of schedule and increase the number of digital products available on the website in 2005. Additional funding requested in 2006 will be used for the purchase of additional hard drives for the web server. This will allow scanned materials to be posted on the GCMRC website, available immediately 24 hours a day as opposed to having to be specifically requested through the library. The library scanning project require 40 terabytes of storage space to allow all of the scanned materials to be accessible through the website. Funding for facilitating review process is allocated to the Independent Reviews Account.

Status/Schedule: FY2005 is year 3 of the six year scanning project. All other library activities are ongoing.

Expected Products/Deliverables: Specific products of the library include:

- On-line library catalog which provides access to more than 8000 publications.
- Catalog records of new materials.
- Monthly update of new reports received in the library.
- Review process for proposals and reports which includes a monthly report of the status of deliverables as it relates to the review process.
- Assistance to cooperators, stakeholders, media contacts and the public by providing access to reports, aerial photos, maps, slides and photos in hardcopy and digital form.
- Research in locating contemporary and legacy materials.
- A research facility for researchers, GMCRC employees, cooperators and the public.
- Access to: 17,652 aerial photographs, 9000 digital aerial images, 8000 hardcopy reports, 300 reports available on-line as pdfs, 198 videos in VHS Format 521 in broadcast format, 200 videos converted to digital format, 8000 slides scanned at high and low resolution, and 700 photos scanned at high and low resolution.

TIME LINE FOR PRODUCT COMPLETION FOR LIBRARY SCANNING PROJECT FY03-07

	2003	2004	2005	2006	2007
Work plan completed, contract staff hired and equipment purchased	End of FY2003				
Project Completion Schedule:					
Aerial Images		1000 photos scanned 3413 film frames scanned	1000 photos scanned 3413 film frames scanned	1000 photos scanned 3413 film frames scanned	1000 photos scanned 3413 film frames scanned
Texts		200 texts scanned	200 texts scanned	200 texts scanned	200 texts scanned
Videos		200 broadcast videos converted to digital format	200 broadcast videos converted to digital format	121 broadcast and 50 VHS videos converted to digital format	148 VHS videos converted to digital format
Slides		8000 slides scanned at high and low resolution	Metadata completed for 4000 slides		
Photos		700 photos scanned at high and low resolution	Metadata completed for 700 photos		
Flightline Maps					60 Arc Info Coverages

CHAPTER 3

ADMINISTRATION AND TECHNICAL SUPPORT SERVICES

INTRODUCTION

This chapter provides descriptions and budget information on GCMRC administration and technical support services. GCMRC administration includes sections on administrative operations, program planning and management, AMWG/TWG participation, and the independent review process. Technical support services include geographic information systems, systems administration, library operations, database management, survey operations, and logistics support. At the end of this chapter is a schedule for implementing the FY 2005 monitoring and research annual plan.

GCMRC ADMINISTRATION

The GCMRC is administered by a Chief and three program managers (integrated ecosystem science program (biology and physical sciences), or IESP, socio-cultural, and information technologies. The program managers oversee the individual resource areas and an extensive program of data analysis and management. GIS and information transfer, surveying, and evaluation of remote sensing technologies support program integration and evaluation of the effects of dam operations on the CRE.

In addition to their program management responsibilities, the program managers are also expected to remain subject area experts in their respective fields on the Colorado River ecosystem. It is important that GCMRC program managers and scientific staff maintain this expertise so they can provide high quality technical assistance in the form of expert analysis, opinion, and advice to the Chief, TWG and the AMWG as requested. This will include but is not limited to the annual State of the Canyon Resources (SCORE) Report, evaluation of the BHBF resource criteria, and preparing syntheses of current knowledge and other such activities that may be requested. The Socio-cultural Program Manager also functions as the Native American coordinator. The program managers supervise additional technical and support staff, and act as project lead with their cooperators.

The newly constituted information program has personnel with specific responsibility for systems administration, and library activities. A major focus of the new program will be outreach to our stakeholders emphasizing knowledge of, and access to data and tools available as a result of GCMRC monitoring and research activities. Under the new organization, data base management, GIS, remote sensing, and surveying activities are now merged with the IESP and the Logistics Program in an effort to align them more closely with the monitoring and research activities they support. For example, the surveying department is staffed by two full-time surveyors and a staff assistant who provide GCMRC and PIs with high quality, cost-effective, and timely support in the areas of terrestrial and bathymetric surveying. Having in-house capability ensures familiarity with the challenges of surveying in the canyon and promotes reproducible, quality data critical to sound monitoring and research programs. These personnel assure critical support to GCMRC monitoring and research program.

The GCMRC will continue to conduct logistics for its programs in FY 2005, with direct coordination with appropriate NPS offices. This approach has proven to be cost-effective. In addition to cost savings, by running the logistics program in-house, GCMRC is able to ensure compliance with all NPS directives, consolidate and coordinate river trips, and create a level playing field so all researchers have an equal chance at competing for proposals and successfully implementing their projects. All river trip logistics and permitting, helicopter support, rescue, etc., is overseen by the logistics coordinator in cooperation with the NPS. GCMRC expects to initiate between 35 and 45 river trips in FY 2005.

E. ADMINISTRATIVE AND MANAGEMENT

E.1. Administrative Operations

These costs are for salary and other operating expenses in support of administrative operations and management of GCMRC. Included is salary of the Chief and administrative staff, space and facilities, travel, training, vehicles, office supplies and equipment and maintenance. Also included are costs for USGS local network and Flagstaff Science Center support, and USGS regional services including contracting and personnel.

FUNDING HISTORY	FISCAL YEAR					
	2001	2002	2003	2004	2005	2006
Outsourced Admin costs				395,000	400,000	400,000
Logistics (All)						
Operations			340,500	154,000	160,000	160,000
GCMRC Salaries			243,500	71,000	78,000	78,000
Project Total			584,000	620,000	638,000	638,000
% total outsourced			0%	64%	63%	63%

E.2. Program Planning and Management

These costs are for salary and travel in support of program planning and management in the areas of Integrated Ecosystem Science, Cultural Resources, and Information Technologies.

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor						
Logistics (All)						
Operations			226,000	20,000	22,000	22,000
GCMRC Salaries			243,000	254,000	260,000	260,000
Project Total			584,000	274,000	282,000	282,000
% total outsourced			0%	0%	0%	0%

E.3. AMWG/TWG Participation

These costs are to cover salary and travel to attend and prepare for AMWG and TWG meetings.

FUNDING HISTORY	FISCAL YEAR					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor						
Logistics (All)						
Operations			12,000	12,000	12,350	12,350
GCMRC Salaries			26,500	33,000	34,000	34,000
Project Total			38,500	45,000	46,350	46,350
% total outsourced			0%	0%	0%	0%

E.4. Independent Review Panels

Introduction

Independent external review is at the heart of GCMRC's approach to program management and implementation. Together with the competitive process, independent external peer-review ensures the quality and objectivity of GCMRC's programs. Independent review panels are utilized to evaluate GCMRC's plans and activities. All proposals, reports, programs, etc., are subject to independent peer review according to GCMRC's peer-review protocols. Managing GCMRC's peer-review process requires 3 to 6 person-months and is the responsibility of the Librarian/Review Coordinator. The Review Coordinator reports to the Information Program Manager.

Peer Review

All of GCMRC's scientific activities undergo an independent, external peer-review. This is true for all proposals, whether unsolicited, solicited, or an in-house proposal. Similarly, all draft reports received by GCMRC undergo independent, external peer-review. The peer-review protocols developed by GCMRC meet or exceed the standards articulated by the Secretary of the Interior for the Department of the Interior.

Peer-review for proposals received by GCMRC in response to an RFP is conducted through a panel process, while peer-review for unsolicited and in-house proposals, as well as project reports is conducted through the mail. In all cases, the peer-reviewers are offered

anonymity and the individual and panel reviews, where applicable, are provided to the PIs along with comments from GCMRC. In addition, GCMRC conducts protocol evaluation panels (PEPs) to review and assess GCMRC's projects and methodologies. To date, PEPs have been held for remote sensing, physical, terrestrial, aquatic, cultural resources, and the water quality program. The survey and GIS support services PEP is scheduled for Winter 2001/2002. PEPs are described in Chapter 1 of this plan.

The GCMRC review process is handled by a report review coordinator to ensure that the peer-review process is conducted one-step removed from the GCMRC program managers to guard against any conflicts of interest, real or perceived. Strict conflict-of-interest guidelines are adhered to. GCMRC annually recruits new individuals to join the ranks of its peer-reviewers and maintains a database of almost 500 potential reviewers, organized by area of expertise. GCMRC peer-reviewers come from academia, Federal, State and Tribal government, non-governmental organizations, and the private sectors. Reviewers are selected on the basis of their record of scientific accomplishment and expertise.

Science Advisors

The GCMRC works with a group of Science Advisors (SAs) as one of its independent review panels. The SAs are advisory and not a decision-making body. It is an interdisciplinary group composed of scientists who are qualified, based on their record of publication in the peer-reviewed literature, or other demonstrable scientific achievements. An executive Director who provides leadership to the SAs and serves as the liaison officer to the AMWG and the GCMRC.

The SAs together and individually will be expected in FY 2005, among other things, to review and comment to the AMWG and GCMRC on: (1) GCMRC's annual work plan and budget proposal, (2) GCMRC's long-term monitoring and research plan, (3) the results of GCMRC's completed monitoring and research activities, (4) the results of any synthesis and assessment activities initiated by the GCMRC, and (5) any other activities (i.e., developing a core monitoring plan, enhancing opportunities for integrated science, and other program specific scientific advice) it is asked to address by the GCMRC Chief or the AMWG.

FUNDING HISTORY	Fiscal year					
	2001	2002	2003	2004	2005	2006
Outsourced Science/Labor			89,000	200,000	200,000	200,000
Logistics (All)						
Operations						
GCMRC Salaries			10,000	22,000	22,000	25,000
Project Total			99,000	222,000	222,000	225,000
% total outsourced			90%	90%	90%	90%

TASK GROUPS

Task groups have been established in areas where GCMRC seeks on-going dialogue and guidance for specific issues. Two task groups are described below; however, other task groups can be formed as needs arise.

A Cultural Resources Task Group operates to facilitate the incorporation of cultural concerns within all GCMRC program areas to assist the GCMRC in the development of a more integrated program that incorporates Native American perspectives in project development and work plans. The Task Group consists of the GCMRC Socio-cultural Resources Program Manager, Reclamation's Regional Archaeologist, NPS managers, Western Area Power Administration's Archaeologist, and Tribal representatives. In addition, a tribal task group functions to obtain guidance from tribal representatives in program development, and program and project implementation.

A Biological Opinion Task Group operates to ensure appropriate coordination between GCMRC and the monitoring and research needs of the Bureau and USFWS under various biological opinions. The Task Group consists of the GCMRC Biological Resources Program Manager and appropriate representatives of Reclamation, FWS, AGFD, Tribal governments, and other AMWG and TWG members. All proposed activities are reviewed by the TWG.

GCMRC BUDGET

The total FY2005 and FY2006 budget for the GCMRC are $10,083,610, and $13,779,610 respectively. These totals include $8,672,600 and $8,932,800 from AMP – Power Revenues, $282,000 from the Bureau of Reclamation Water Qualify fund in both years; and $1,482,000 requested from Federal appropriations in both years. In FY2006 an additional $3,400,000 is required to restore funding levels to those of FY2004 for Core Monitoring and ongoing Experimental Treatments, plus implementation of all new Humpback Chub Actions.

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