

**THE GRAND CANYON MONITORING AND RESEARCH CENTER**

**FISCAL YEAR 2004**

**MONITORING AND RESEARCH WORK PLAN**

by

THE GRAND CANYON MONITORING AND RESEARCH CENTER

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**GRAND CANYON MONITORING AND RESEARCH CENTER**  
**FY 2004 MONITORING AND RESEARCH WORK PLAN**

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# **CHAPTER 1**

## **THE GCMRC FY 2004 ANNUAL WORK PLAN**

### **INTRODUCTION**

The Fiscal Year 2004 (FY 2004) 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. 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)

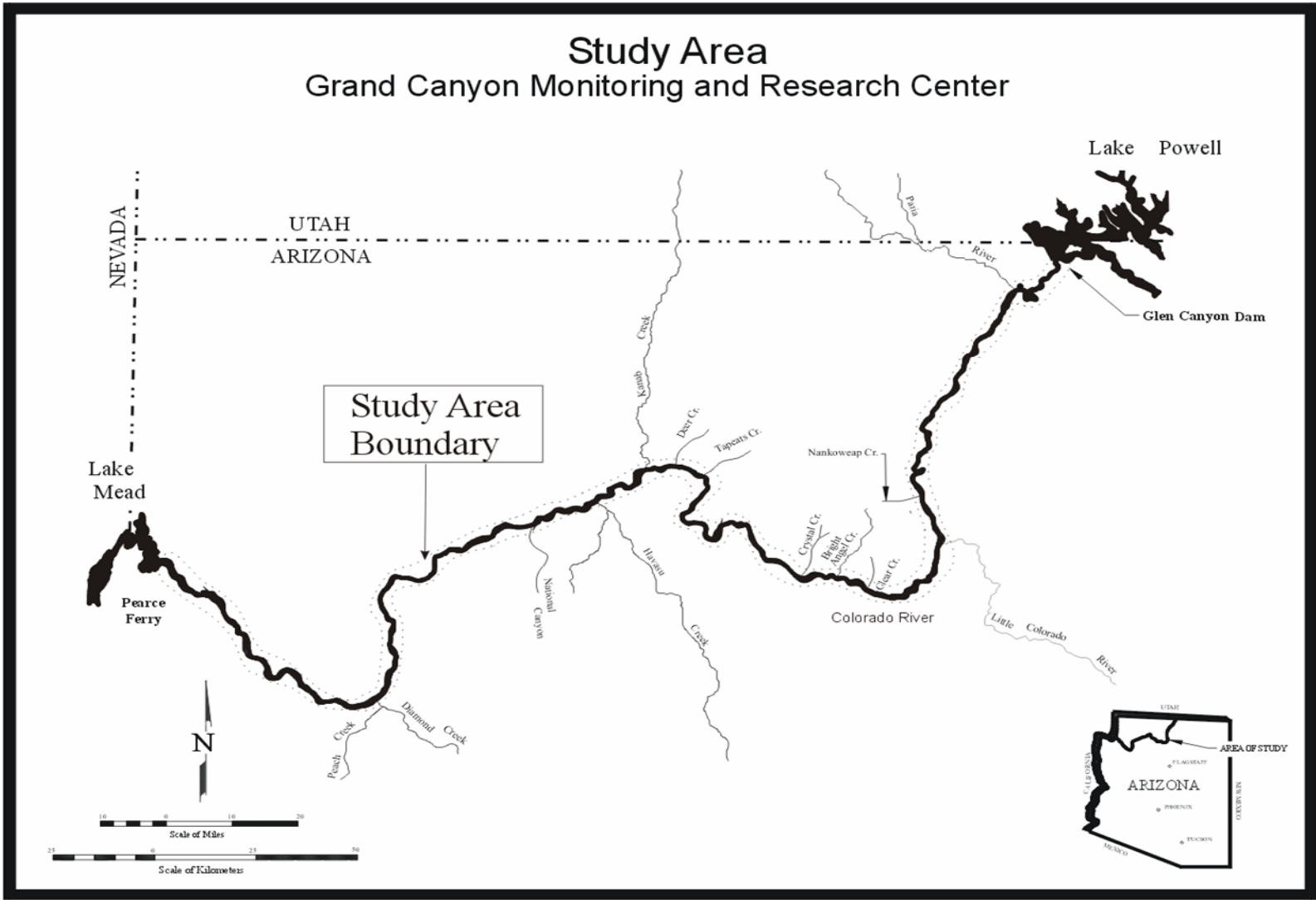


Figure 1.1. Map of Grand Canyon Monitoring and Research Center Study Area.

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](http://www.uc.usbr.gov/amp/amwg/02jan17/Attach_06.pdf)).

## **GRAND CANYON MONITORING AND RESEARCH CENTER (GCMRC)**

### **Mission**

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 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. Advocate 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.<sup>1</sup> The quality and objectivity of GCMRC research findings is ensured through competition and independent external scientific peer review.<sup>2</sup> All proposals, data, reports, etc., are reviewed by independent, external scientists as well as by the GCMRC science team.

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1 Operating Protocols for GCMRC, June, 1996.

2 GCMRC Peer Review Guidelines, October 26, 2001.

## GCMRC SCIENTIFIC ACTIVITIES

The FY 2004 Work Plan describes monitoring and research activities that address the management objectives (MOs) and information needs (INs)<sup>3</sup> 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 effect 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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<sup>3</sup> This Work Plan references the finalized 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 operates an information technologies program. The information technologies program is intended to ensure information management (e.g., DBMS, GIS, Library), data analysis (e.g., GIS), and data dissemination to managers and stakeholders and science organizations (e.g., WWW). 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.

## **CURRENT KNOWLEDGE**

### **Sediment and Stream Flow Resources:**

**Overview of Monitoring -** Existing management actions taken through WY 2002, under the Record of Decision 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 2001, 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.

**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 short-term 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.

**Fine Integrated Sediment Team (FIST)** - 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 2002 show dramatic declines 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.

**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 unengaged 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 735 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, 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.

**Sediment-Transport Modeling** – Research to develop a 1-dimensional sand routing model to predict the fate of tributary sand inputs, and a multi-dimensional model for sand-bar evolution was initiated in FY 2002, by a group composed of researchers from the USGS, Johns Hopkins University and Utah State University. This project is using a combination of field and laboratory methods, including flume studies, to refine an algorithm that estimates the degree of channel-bed winnowing that occurs following tributary flooding from the Paria and Little Colorado Rivers. This predictive capability shall allow managers to more accurately predict the rate at which new fine-sediment inputs are depleted (through downstream transport) following enrichment of the ecosystem's sand supply. This information can assist in developing experimental flow treatments intended to test additional hypotheses related to sand-bar conservation and

maintenance. Further refinement of the team's previous sand-bar simulation model shall also allow for better predictions about how new sand inputs are mobilized from the river's channel bed and deposited along channel margins within and outside of eddies. This type of simulation shall allow managers to more clearly identify the extent to which sand bars in specific river segments can be restored and maintained using BHBF's under a variety of flow and sediment-supply conditions.

**Results of Geomorphic Synthesis Research** – This research project was initiated in FY 1998, and was completed in FY 2003. The objective of this research was to provide managers with a comprehensive synthesis of all historical data on hydrology, sediment-transport and geomorphology related to the Colorado River ecosystem between Glen Canyon Dam (located about 15 miles upstream of Lees Ferry) and the Grand Canyon gage, located at river mile 87. This research was undertaken by members of the USGS in collaboration with Utah State University. Results are too numerous to include in this planning document, but are briefly summarized as -- **for Marble and Grand Canyon's:** 1a) Compression of the river's flood frequency following initial operation of the power plant (reduced low and high flows) was increased following implementation of the interim flow and ROD operations, resulting in higher sand transport occurring more of the time. As a result, new inputs of sand from downstream tributaries does not have a long residence time in the low-elevation portions of the main channel; 1b) Sand storage within main channel pools and eddies responds to changes in operations driven by upper basin hydrology and storage conditions within Lake Powell; 1c) The overall style of historical sand-bar change derived from sand-bar mapping (area changes only) within continuous river segments closely follows the time series for individual sand bars (measured for area and volume changes) throughout Marble Canyon from 1990 through 2001; 1d) Historical erosion of sand bars within Marble Canyon is most dramatic in terms of loss of bar volumes (vertical changes) rather than bar areas, and may have occurred mostly as a result of wind deflation. The condition of bars upstream of river mile 87, continues to be degraded and will likely remain so until such time that new sand inputs are effectively deposited at higher elevations along shorelines; 1e) Overall, since 1983, sand resources along the shorelines of the Colorado River ecosystem have been reduced by about 25 percent. **Glen Canyon:** 2a) In response to operation of Glen Canyon Dam,

the channel bed of this river segment has been deeply incised and has been armored owing to removal of most of the fine sediment and much of the gravel that resided there prior to dam construction. This information was derived from repeat measurements of cross-sections established by the Bureau of Reclamation (USBR) in the 1950s as well as sedimentology of the pre-dam versus 2000 condition of the channel bed; 2b) As a result of channel incision and armoring, the top-width of the channel (at flows of 5,000 to 8,000 cfs) has narrowed, probably as a result of sand being eroded down slope from higher channel margin deposits; 2c) Lateral retreat of pre-dam river terraces is only detectable from air-photo mapping at a limited number of sites; 2d) Scour of pools in the this segment of the river appears to be ongoing in response to dam operations, even in the post-EIS period.

**Advanced Conceptual Modeling Research** – This research effort was initiated in FY 2001, and is scheduled to be completed in FY 2004. The objective of the project was to develop longer-range simulation about how ongoing tributary inputs of sediment coarser than sand (63-2000 microns) might influence the physical and biological processes within the Colorado River ecosystem. Years 2-3, include field studies to provide data on food base dynamics at channel elements (coarse-grained gravel bars and cobble islands) under varied flow conditions, and under conditions of aggradation by coarse-sediment tributary inputs. Additional modeling efforts are being conducted by the USGS to simulate physical changes that occur within rapid/pool/run complexes following tributary debris flows. Such impacts are thought to force aggradation of rapids with only partial reworking from Glen Canyon Dam operations; the result being that the coarsest sediment is deposited within low-velocity pools between rapids and runs. Workshops are scheduled for FY 2003 and FY 2004, that incorporate the results from this project into the conceptual model of the Colorado River ecosystem developed in FY 1998-2000.

An important new component of this study was initiated in FY 2003, and consists of a trout redds mapping initiative focused in Glen Canyon. This work was undertaken as part of the fluctuating-flow experiment started in January 2003. This project is scheduled to continue downstream in Marble Canyon if the second year of the fluctuating-flow experiment is implemented in FY 2004. The objectives of this project are to identify the level of main stem spawning by rainbow trout in Glen, Marble and eastern Grand



Canyon, and to document the extent to which experimental fluctuating flows limit survival of early life stages of trout.

**Terrestrial Resources:** Specific terrestrial resources of interest to the adaptive management program include riparian vegetation, riparian breeding birds and waterfowl, Kanab ambersnail, and invertebrates, small mammals, and reptiles associated with the river corridor. As a whole, approaches for monitoring terrestrial biologic resources underwent review in late 1999 (KAS expert panel) and 2000 (Urqhart, 2000), in the form of expert panels and protocol review panels. Recommendations from these reviews were incorporated into 2001 monitoring and research plans and continue to be evaluated and implemented in 2004.

With respect to riparian vegetation, a review of previous 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. In most cases, change was detectable within five years of measurement. 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. Knowing the length of time needed to detect change is critical in addressing management objectives associated with the riparian communities identified by the adaptive management program.

Kearsley and Ayers' (2001) analysis also indicated that the minimum number of sites needed to detect change is between 30 and 70, depending on the type of vegetation (Kearsley and Ayers, 2001). The report also indicated that previous sites over-represented some types of vegetation (e.g., tamarisk) and under-represented others (e.g., seep willow). These analyses support recommendations from the terrestrial review panel (Urqhart, 2000) that recommended expanding riparian vegetation surveys from something greater than 11 sites, and include a randomized site selection within a GIS framework in order to detect change among vegetation communities. These data and

recommendations were incorporated into the monitoring and inventory program for terrestrial resources, resulting in expanded sampling coverage for vegetation within a random, reach-based sampling program that is linked to other terrestrial resources, specifically, birds as well as reptiles and mammals.

Riparian breeding birds, including southwest willow flycatcher, and overwintering waterfowl continue to be monitored using point-count and walking surveys. 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. Year-to-year variability exists for the 18 most common bird species that represented at least 10% of the total number of birds detected for years 1998-2000. Significant distributional shifts occurred for four species each year between 1998 and 2000, although these species were not the same each year. Several new winter records were reported for waterfowl during the 1998-2000 period, including Barrow's goldeneye, horned grebe, trumpeter swan, red-breasted merganser and long-tailed duck, among others. Variables affecting waterfowl numbers include turbidity and reach width. Diving species increase as turbidity declines and dabbler species increase with increasing reach width (Spence, 2001).

Initial studies associated with birds and invertebrate food sources (Yard and Cobb, 2001) indicate that abundance and composition changes occur in the arthropod community throughout the period that riparian birds are active in the river corridor. Arthropod abundances in both old and new high water zone vegetation decline between early May to early June. The leafhopper, an insect common on tamarisk is the most abundant arthropod, representing a significant contribution to the insect densities in both the old and new high water zones. However, removal of this leafhopper from the analysis indicates that insect densities become greater in the old high water zone (Yard and Cobb, 2001), suggesting that the old high water zone still provide a large portion of food resources to riparian birds within the Colorado River ecosystem. Arthropod richness did not differ between these zones. Lastly, birds found foraging in the old high water zone were significantly linked to the arthropod community found in the old high water zone, more than birds that forage in new high water zone vegetation. These data

provide potential to consider arthropods as indicators of bird abundance. Results of the two-year project will become available in 2002, following review of the submitted report.

Lastly, Kanab ambersnail monitoring at Vasey's Paradise has continued to follow the protocols begun 1997. Data collection efforts have been reduced from 4 trips per year to two trips: 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). Genetic analysis of the snail at Vasey's Paradise and other snails assumed to be related to KAS suggest that the Vasey's Paradise taxon is less related to the Three Lakes population than other populations collected within the Colorado Plateau and more closely allied with samples of *Oxyloma* species from Canada and the Great Plains (Stevens et al., 2000). While the genetic distance between the Three Lakes and Vasey's populations is greater than expected, these taxa are more similar morphologically than between Three Lakes and other snails sampled from the Kanab Creek drainage. More genetic and morphologic analysis of the *Oxyloma* complex resulting in taxonomic revision is needed to resolve management questions around the Vasey's Paradise taxon. This analysis will be pursued in a new RFP to be issued by GCMRC in late 2002.

**Aquatic Resources:** Aquatic resources continue to undergo review of methodologies and historic data and incorporation of new methods into monitoring the sport fishery, the native fish communities 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 also downstream of Lees Ferry. Recommendations include increasing random sampling efforts, strengthening efforts associated with integration across disciplines and developing modeling efforts. The aquatic foodbase program issued a new RFP in FY 2002 which resulted in only one proposal and was reissued in late FY 2002 to increase competition and encourage new approaches consistent with the PEP recommendations. As a result of cooperator sampling (NPS at Glen Canyon National Recreation Area) there has recently been confirmation of a new invasive aquatic species in the CRE. The New

Zealand Mud Snail, *Potamopyrgus antipodarum*, was first confirmed in the Glen Canyon reach and has now been documented throughout the CRE. This species attains very high densities in some stream and river systems and is known to occur in 5-6 populations in the U.S. The species will be the subject of future monitoring and research in the CRE. 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.

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. Current population estimates for the Lees Ferry trout indicate that the size of trout has declined from 400 mm in the early 1990s to an average of 325 mm in 1999, while the numbers of fish in the reach has increased. These data indicate that the fishery is strongly influenced by diel changes in flows and that growth is 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 (ca. 743,000 individuals) and brown trout (ca. 56,000 individuals) in the mainstem (AGFD, 2001) and for humpback chub in the LCR and its confluence with the mainstem (Coggins and Walters, 2001). Preliminary analysis of data associated with humpback chub in the LCR indicates that population numbers have declined since 1991 from approximately 6,500 (fish > 150 mm) to approximately 2100 (fish > 150mm) in 2000 (Coggins and Walters, 2002). This downward trend in

population abundance is based on an estimated decline in recruitment to the population beginning in 1992. Multiple hypotheses exist for the apparent recruitment decline including dam operations, tributary flooding, parasitism, predation/competition and mainstem temperature effects.

Monitoring efforts in FY 2004 and FY 2005 include beginning to establish population estimates for carp and increasing the tagging record started for humpback chub with values for flannelmouth sucker and bluehead suckers. Further work is needed to determine appropriate methods to quantify changes in small-bodied fish that are most effectively caught by seining return channels but that may not effectively represent their numbers within the river corridor. The FY 2002-03 downstream fish sampling efforts were the most extensive and expansive undertaken since GCMRC's effort to develop new monitoring protocols was implemented. This is also true for the LCR.

**Integrated Water Quality Program:** Downstream water quality 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 Water Quality Program presented to the TWG in 2002.

The Low Steady Summer Flows (LSSF) experiment during the summer of 2000 pre-empted much of the IWQP research originally slated for 2000-2001. These LSSF projects included thermal monitoring in the forebay, hypolimnion and inflows in Lake Powell and enhanced thermal monitoring in the mainstem and channel margins of the Colorado River in Grand Canyon.

Results for the LSSF were presented in the Science Symposium in April 2001, including talks entitled “Thermal Dynamics of Lake Powell and its Inflow: Patterns During the LSSF Experiment and Beyond” and “Main Channel and Near-Shore Warming of the Colorado River Under Low Steady Summer Flows.” Dilute and mixed conditions in Lake Powell during the summer of 2000 diminished the measurable effects of internal seiching (oscillation of lake strata) that influence the water quality properties of dam discharges. While this homogeneity reduced our ability to discern dam-operation induced

seiches associated with the steady releases, wind-driven seiches produced pronounced effects immediately following storm events that attenuated within 0.5 to 1 day. Oscillations were greatest at the surface, and synchronization was identified up to 90 km apart, from Wahweap to Oak Canyon.

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 instream 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.

The 30-year-plus database for Lake Powell is being automated for access through GCMRC's database system. These data are also being input to the CE Qual Water Quality model in cooperation with the USBR. Eventually there is the prospect that simulation modeling may replace some of the extensive field sampling effort on the reservoir. In addition GCMRC is increasing its cooperation with the Glen Canyon National Recreation Area (NPS) in an effort to reduce GCMRC costs for this program. Recent changes to the reservoir-monitoring program include the addition of several continuous thermal monitoring stations in the lake. Tidbit© thermistors are located at the inflow areas of the Colorado River (Sheep Canyon) and San Juan River (Mike's Canyon), logging temperature at 15-minute intervals. In addition, a Hydrolab Recorder monitors temperature, specific conductance, pH and dissolved oxygen at the Sheep Canyon buoy. Four specially designated water quality buoys have been installed at the Wahweap, Padre Bay, Oak and Escalante stations. These buoys assist in collection efforts at these deep-water stations as well as act as a platform for any deployments of continuous monitors. Chlorophyll sampling protocols have been amended under recommendations of the PEP. Preservation has shifted from the in-field dry-ice freezing method to the simpler and more effective desiccation with reusable silica gel crystals. Greater efforts to keep samples darkened during and after processing have been made. Greater vertical resolution

of the chlorophyll samples lake-wide has been implemented, along with some reduction in vertical resolution of the chemical samples throughout the lake, excepting inflow areas. TOC, total organic carbon, measurements have been added to DOC measurements already being taken in the inflow areas of the lake.

### **Socio-Cultural Resources:**

**Cultural Resources:** Cultural resources of interest to the AMP along the Colorado River corridor include archaeological sites and traditional cultural resources such as springs, landforms, sediment and mineral deposits, and traditional plant locations and animals. The goal of the cultural resource efforts is *in-situ* preservation with minimal impact to the integrity of the resources, and when preservation is not possible, treatment efforts as appropriate. Monitoring activities include site visits, photography, and remedial activities and tribal assessments of traditional cultural resources and the general health of the ecosystem through traditional perspectives.

Cultural resources are monitored regularly and during high flow events. Many of the archaeological resources along the river corridor are contained in the sediment deposits that form the alluvial terraces. Since the completion of Glen Canyon Dam, the sediment resource has declined, and the alluvial terraces continue to erode. A system-wide method for regenerating the river terraces and redistributing sediment is generally considered an essential component to maintaining integrity for cultural resources (Balsom, 1996).

**Previous 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 and the overall findings of the cultural resources studies strongly suggest 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 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). Recent research in the physical resources area (see pages 10 through 14) indicates that the timing of BHBFs relative to tributary inputs is the most beneficial.

Completed GCMRC projects provide additional information. These projects include a synthesis of data collected by the NPS and Tribal groups, mainstem flow and deposition modeling, and testing of a geomorphic erosional hypothesis. The data synthesis report (Neal et al., 2000) identifies data gaps in previously collected data. A stage flow and deposition modeling project provides information on estimated sediment deposition at selected archaeological resource locations given particular water releases and modeled sediment loads. These modeled data can be used to analyze available information on pre-dam processes that affected cultural site preservation. A draft report is currently under review and will be finalized soon (Wiele, 2001). A geomorphic report (Thompson and Potochnik, 2000) attempted to identify erosional processes that are related to dam operations versus naturally occurring processes. The results of this study indicate that questions remain in distinguishing resource impacts that are related to dam operations. Efforts to investigate and identify these processes are currently under discussion. Finally, a cultural resource protocol evaluation panel (PEP) was held during Spring 2000. 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 in 2001 and 2002 and some of those described in this plan reflect the PEP recommendations.

Ongoing Investigations: Current resource monitoring of archaeological and traditional resources suggests that archaeological resources continue to be impacted by physical impacts such as surface erosion and gulying in both the Grand and Glen Canyon areas. Some surface erosion is due to natural processes that are unrelated to dam operations. Other sediment loss from erosional processes is believed to be related to dam operations. Mainstem water levels and head cutting arroyos appear to impact archaeological sites at specific locations. Of the 91 sites monitored by the NPS, 83% (N=75) had physical impacts. Visitor impacts such as trailing and collection of artifacts have also been noted at archaeological sites and locations of traditional importance.



Approximately 28% (N=25) of the sites monitored had visitor impacts (Kunde et al., 2001).

Monitoring of traditional plant resources occurred by tribal groups under the Programmatic Agreement (PA) program. Graffiti at two rock art sites were observed by the Southern Paiute Consortium (Drye et al., 2001) and visitor impacts were observed at two important Navajo sites (Begay, 2001). Monitoring by the Southern Paiute Consortium indicated that plant resources at 75% (9 of 12) of the sites seemed to be flourishing and that there was no evidence of disturbance or impacts. Concerns continue to be expressed for the Goodding Willow at Granite Park relative to erosion at the base of the tree (Drye et al., 2001). An ethnobotanical report compiled and synthesized by the Hopi Tribe expressed concern for water releases and sediment availability to sustain important riparian resources for plants important for ceremonies that are directly related to the overall welfare and health of the Hopi people (Lomaomvaya et al., 2001). Finally, the Southern Paiute Consortium continues to implement its educational outreach program to tribal members who cannot visit the river corridor and to the public through workshops, training sessions and the production of a plant reference guidebook (Austin et al., 2000).

#### Recreational Resources:

Recreational resources encompass several elements including camping beaches, trout sport fishing, recreational river trips and safety, and recreational experiences. GCMRC has supported studies in all of these areas.

Previous Investigations. Beaches and 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). Most pre-dam beaches are now considerably smaller, and some have disappeared completely. Camping beaches are also being eroded through gullying induced by monsoon rainstorm runoff, a phenomenon

believed to be related to the lowered mainstem base levels as degraded beaches are not replenished by annual flooding.

In 1994, change in campable area was analyzed from an inventory of campsites using past aerial photographs (Kearsley et al., 1994). The effects of the 1996 controlled flood on campsites were evaluated and it was found that the increase in the number and size of campsites was of short duration. These data suggest that floods temporarily increase campsite number and size but then campsites will continue to erode slowly. The flood effects to campsites seem temporary but they appear to be the only feasible means of depositing sediment above normal fluctuations (Kearsley et al., 1999).

Recent and Ongoing Investigations: Recent GCMRC studies have assessed camping beaches, trout fishing activities and recreational river running and the related experiences and safety issues. An on-going effort is studying campsite assessment and monitoring protocols that are used for quantitative beach and sand bar measurements and the detection of area and volume change. The report on this work will be available in FY2003. In addition, annual monitoring of 34 campsite areas is on going. Interim results from this monitoring indicate that camping areas continue to slowly erode. However, the 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.

A previous study assessed recreational preferences relative to experiences and camping beaches (Stewart et al., 2000). Based on user surveys, this study indicates recreational preferences for camping beaches and activities such as white water rafting, day-use rafting in Glen Canyon, and fishing and recreation experiences.

Low Steady Summer Flows in summer, 2000, provided additional data on recreational experiences, travel times, safety and economic impacts to concessionaires. Draft reports have been received and are currently under review. These data will be available in FY 2003. Recreational fishing data was compiled and synthesized in FY 2001. The final draft report for this study is currently being reviewed and the results of this study will be available in FY 2003.

**Information Technologies Program (ITP):**

Data Base Management System (DBMS): The DBMS 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 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.

Geographic Information System (GIS): The GIS is the second 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 and analyze spatial

data. The ESRI Arc/Info spatial data base engine was selected for GCMRC spatial data development. Efforts are now underway to integrate this data into the oracle DBMS. Historical and current GCMRC and contributor data as well as recent remotely sensed imagery and topography data sets are now available on the GCMRC FTP site (accessible from the GCMRC web page or directly at <ftp.gcmrc.gov>) in the /data/basedata subdirectory.

GIS is an important analytical tool for change detection of biological, cultural, and physical data. The GCMRC is working to increase the GIS coverage of the CRE by using modern remote sensing techniques including light detection and ranging (LIDAR) mapping techniques for topography and airborne GPS control for digital orthophotography development.

Working with other IT programs, the GIS department has also developed data standards for consistent delivery of data and an archive structure to store all GIS layers, imagery, database tables, and library reports.

Library: The library is the third 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 hardcopy reports, maps, videos, and photographs as well as other miscellaneous documents. Although the nature of library materials is generally hardcopy, efforts are being made to catalog materials on-line. The Follet library catalog software was selected for this purpose. You can access the Follet library catalog from the GCMRC website at [www.gcmrc.gov](http://www.gcmrc.gov). Currently, all hardcopy reports and books pertaining to the CRE are searchable electronically using the on-line catalog. Other materials will be added as time permits. Efforts are underway to digitize historical library materials so that they may be distributed electronically via the Internet. The library has also implemented a consistent peer review process to help ensure the quality of scientific reports submitted in partial fulfillment of contract and cooperative agreement requirements. The GCMRC library continues to make strides in organization and accessibility. Accomplishments to date include the following:

- New materials are being cataloged as they arrive.
- Reports were peer reviewed before they were made available to the public.

- Electronic versions of reports were archived in the library and made available on the FTP (accessible from the GCMRC web page or directly at ftp.gcmrc.gov) site for electronic distribution to stakeholders and the public.
- An archive structure was created for electronic data that will be used in the Oracle database.

In addition to serving patrons, FY2004 activities will focus on converting historical library materials to electronic form for distribution via the Internet.

Surveying: The GCMRC survey department provides support to GCMRC scientists and investigators for spatially referencing data collected in the field. In addition, the survey department provides terrestrial and hydrographic base maps and maintains a network of survey control throughout the ecosystem.

Terrestrial 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 of the remaining river channel needs to be obtained as control is established. In FY2001, hydrographic channel data was collected for approximately 30 additional miles of the CRE. These data were processed in FY2002 and an additional 30 miles will be collected and processed by the end of FY2003.

Canyon control: Survey control in the Colorado River ecosystem is required to meet the demands of any spatial measurements for scientific monitoring and research. Survey control also supports the spatial positioning of hydrographic and bathymetric channel mapping as well as ground control for aerial mapping or remote sensing applications. We currently have approximately eight A order GPS grade base stations set on the rim of the Grand Canyon. This base station network is currently in good order to complete the control in the Canyon. We additionally have continuous traverse control (point-to-point line of sight) from GDC to RM 72. Downstream from RM 72 there is continuous traverse control that was surveyed for the GCES GIS sites. In addition there is continuous traverse control from the LCR confluence to Blue Springs, approximately 14 miles of the LCR. The GCMRC Survey department objective is to complete the continuous control network in the Canyon by end of calendar year 2006.

In early 2001, preliminary DTM data from LIDAR measurements showed some inconsistencies in comparable ground measurements. The ground measurements referenced control from the existing CRE control network. The LIDAR data referenced the newly established NGS rim control standard. The inconsistencies are a result of the unavailability of accurate GPS base stations when the original GCES control was

established. The remote sensing initiative is requiring an upgrade of the existing coordinate values. This will allow a comparison of remotely sensed data and CRE legacy data that can be accurately used for change detection. Furthermore, current data collection on the ground requires updated coordinate values for change detection.

In order to meet GCMRC's positioning needs, the existing control reference system must be continually enhanced to provide the high accuracy required for use with GPS and conventional measurements. In association with National Geodetic Survey, GCMRC has established a GPS control network of monumented points having three-dimensional positions. This control network is the positional infrastructure for all surveying, mapping, and remote sensing operations in the Grand Canyon that are implemented by GCMRC. Project objectives for the observations are to ensure 2-centimeter local accuracy and 5-centimeter accuracy overall. This additional work is described in the Development of a CRE Control Network section of Chapter 2.

Systems Administration: Systems Administration encompasses the entire computing and networking environment at the GCMRC. The core computing environment is, for the most part, fully implemented with the exception of the database management system, the Internet map server, and the World Wide Web server. It is anticipated that significant progress will be made in the non-fully implemented areas in 2002 and 2003 with the staff additions of a full-time system administrator and Oracle consultant.

Remote Sensing: There are currently two aspects to GCMRC remote sensing: (1) remotely sensed data collection, and (2) the remote sensing initiative entitled "*Evaluating ground-based and airborne remote sensing technologies.*" Remotely-sensed data collection currently consists of annual digital image collection of the entire Colorado River ecosystem around Memorial Day. The GCMRC intends to continue the annual acquisition of image data until resource programs determine that less frequent data can satisfy their monitoring requirements.

Accomplishments for remote sensing initiative include evaluations of various remote-sensing technologies that were deemed potential candidates for satisfying monitoring requirements of various GCMRC program elements. The program elements that were assessed included (1) mapping riparian vegetation, (2) mapping warm-water

fish habitats, (3) detecting and monitoring cultural resources, and (4) monitoring terrestrial sand bar deposits.

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 multispectral 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: We 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.

We 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. We are investigating 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 will be completed in FY2002. A report will be completed in FY2002 that presents recommended technologies for implementation within all GCMRC program areas. Remote sensing activities in FY2004 will largely consist of data collection in support of the biological, cultural, and physical science programs at GCMRC.

## **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 2003.

### **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 in 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 were discussed at the November 2001 TWG meeting and forwarded to AMWG for their approval in January 2002. 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 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. The PEP process for evaluating current and new alternative protocols in all program resources area was completed by the end of FY 2003. An additional PEP was conducted during winter 2003, 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 modify the FY 2004 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.

## CONTINGENCY PLANNING

The FY 2004 Work Plan is based on the assumption that the TCD, if built, will not be operated 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.

Three Department of the Interior agencies, the Bureau of Reclamation (Reclamation), National Park Service (NPS), and U.S. Geological Survey (USGS), have proposed and are implementing a series of experimental releases of water from Glen Canyon Dam and mechanical removal of non-native fish to help protect native fish, particularly the endangered humpback chub (collectively "proposed action"). The dam releases are also designed to conserve fine sediment in the Colorado River corridor in Grand Canyon National Park. Reclamation has responsibility for the dam operations aspects of the proposed action, while the NPS and Grand Canyon Monitoring and Research Center (GCMRC: USGS) have responsibility for the mechanical removal.

The purpose of the proposed action is: (1) to contribute to the conservation of endangered native fish, especially the humpback chub, by reducing populations of non-native fish who compete with and prey on native fish in the Colorado River between Glen Canyon Dam and Lake Mead; (2) to conserve fine sediments that form sandbars, beaches, and habitat for young native fish by altering dam operations; and (3) to improve the Lees Ferry sport fishery by reducing the overabundance of trout. These proposals are within the constraints established by applicable federal statutes (commonly known as the "Law of the River") and other applicable legal obligations.

The need for the proposed action arose because: (1) the Grand Canyon population of endangered humpback chub has declined to levels that threaten its viability and future existence, and (2) fine sediment has been exported to such an extent that camping beaches and sandbars, including those that form native fish rearing habitat, continue to be washed downstream and lost. These changes have occurred during operation of Glen Canyon Dam under the 1996 Record of Decision (ROD) by the Secretary of the Interior. They suggest that the predictions of resource responses to dam operations in the 1995 environmental impact statement were, in some respects, incorrect. The proposed action

should provide important information that will be used as additional operational and physical modifications are considered regarding future operation of Glen Canyon Dam

### **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. GCMRC hosted a scientific symposium in Spring 2001 that focused on the results of the Low-Steady Summer Flows from Summer 2000. A fourth science symposium is scheduled for fall 2003. GCMRC will host its fifth science symposium in 2005, to present the current status of knowledge on the CRE following Phase I of its long-term monitoring program.

The FY 2004 Work Plan is based on the assumption that the TCD, if built, will not be operated 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. With respect to implementation of endangered fish flows, the FY 2004 Work Plan is based on the assumption that, if implemented, the actual flows to be implemented will follow those in the plan prepared for GCMRC by SWCA, Inc. 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 Annual Work Plan and budget described in this document were reviewed by the TWG, which recommended at the May 16-17, 2002, meeting that the plan be recommended to the Secretary of the Interior by the AMWG. The total budget for the

AMP for FY 2004 is \$9,809,000, of which \$6,900,000 supports the science activities of GCMRC, \$1,409,000 funds the Programmatic Agreement, tribal consultation requirements and the administrative activities of Reclamation, and \$1,500,000 supports the experimental flow fund.

Of the \$6,900,000 GCRMC funds, \$6,800,000 would be provided from power revenues, and \$100,000 requested from Federal appropriations.

Of the \$1,409,000 funding the Programmatic Agreement, tribal participation and consultation, and Reclamation administration, \$934,000 would come from power revenues and \$475,000 would be requested from Federal appropriations.

Of the \$1,500,000 budgeted for experimental flows, \$500,000 would come from power revenues and \$1,000,000 would be requested from Federal appropriations.

### **Budget Review**

If the requested Federal appropriations do not occur, experimental flow activities will be prioritized and the work plan revised to remain within available funds. GCMRC will review the FY 2004 budget and identify core monitoring and research activities that may be deferred in order to accomplish the experimental flow work. The revised plan will be submitted to the TWG and the AMWG for input and approval.

## CHAPTER 2

### SCIENTIFIC ACTIVITIES

#### INTRODUCTION

This chapter provides descriptions of individual monitoring and research projects to be initiated or continued as part of the GCMRC's FY 2004 integrated science program. These scientific activities are grouped into the following categories: (A) Terrestrial Ecosystem; (B) Aquatic Ecosystem; (C) Integrated Terrestrial and Aquatic Ecosystem; and (D) Remote Sensing. The individual projects are designed to provide information that may be useful in setting targets for Management Objectives. The AMWG mission and vision, and goals and management objectives are found in Appendix One. Individual projects and their relationship to the management objectives listed in Appendix Two. Reference to Information Needs (INs) will be added once the INs are finalized. In addition, a master project schedule is included as Table 2.1 to provide an overview of all project activities.

Because the Information Needs are currently being reviewed, the priorities may change when this work plan is implemented. In addition, resource ad-hoc groups may meet and suggest work plan modifications prior to plan implementation. Each of these projects are classified as: (1) Ongoing - meaning a continuation of efforts initiated during FY 2002 or earlier, or (2) New - meaning that the project represents initiation of long-term monitoring using current or new alternative methods and sampling design or a new research effort.

Additional information in Table 2.2 details funding sources and Table 2.3 shows how total project costs and staff participation are estimated to be distributed across the GCMRC program. A key element in developing an ecosystem science design for long-term monitoring and research is the team approach to project design and oversight being advanced by GCMRC in the FY 2004 Work Plan.

**TABLE 2.1. Master Project Schedule**

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
<b>A. TERRESTRIAL ECOSYSTEMS ACTIVITIES</b>					
<b>ONGOING PROJECTS</b>					
1. Terrestrial Ecosystem Monitoring	Initiated	ongoing	ongoing	Final Year, New RFP	
1. - Cultural Monitoring Component	Initiated	ongoing	ongoing	final year/ reassessment	
2. Kanab Ambersnail Monitoring	Ongoing	ongoing	ongoing		
3. New Research in Terrestrial Ecosystems	end of project	New Project TBD	eliminated	eliminated	
4. Cultural Data Base Plan				Initiated	
5. Kanab Ambersnail Taxonomy			Initiated		
<b>B. AQUATIC ECOSYSTEMS ACTIVITIES</b>					
<b>ONGOING PROJECTS</b>					
1.& 2. Monitoring Aquatic Foodbase	End of Project	New RFP/design	ongoing	ongoing	
3. Monitoring Downstream Fish	Monitoring review/development	ongoing	final year	New RFP	
4. Monitoring Lees Ferry Trout Fishery	Initiated	ongoing	ongoing	ongoing	
5. IWQP Downstream Activities	final year for interim plan	review/implementation	ongoing	ongoing	
<b>C. INTEGRATED TERRES &amp; AQUATIC ECO</b>					
<b>ONGOING PROJECTS</b>					
1. Monitoring Fine-Grain Sediment Storage	Initiated	ongoing	ongoing	ongoing	End Phase 1
1. - Recreational Component - Beaches	Ongoing	ongoing	ongoing	ongoing	End Phase 1
2. Monitoring Streamflow Fine-Sediment Transport	Initiated	ongoing	ongoing	ongoing	End Phase 1
3. Monitoring Coarse-Grained Sediment	Initiated	ongoing	ongoing	ongoing	End Phase 1
4. A/B. Sediment-Transport Modeling	Start delayed until 2002	Initiated	ongoing	final year review	verification
5. Control Network	Ongoing	ongoing	ongoing	ongoing	completed
6. Channel/Hydrographic Mapping	Initiated	ongoing	ongoing	ongoing	ongoing

<b>D. OTHER SCIENCE ACTIVITIES</b>					
<b>ONGOING PROJECTS</b>					
1. Unsolicited Proposals		New projects	New project		
1. - Adopt-a-Beach	Ongoing	ongoing	ongoing	ongoing	ongoing
2. AMWG/TWG Requests			ongoing		
3. In-House Research			New project		
4. Tribal Outreach Activities			New project	ongoing	
5. Public Outreach/Involvement Plan Imple.			New project	ongoing	
6. Cultural Resource Synthesis & Status Report			New project	ongoing	ongoing
<b>NEW PROJECTS</b>					
7. Cultural Affiliation Study				Initiated	
8. Experimental Flows			Initial year (treatment 1)	ongoing	



TABLE 2.2. GCD AMP FY-2004 FUNDING NEEDS AND SOURCES

<b>SUMMARY FUNDING (PARTS I, II, &amp; III)</b>		AMP Power Revenues	Appropriations	TOTAL
Part I.	Bureau of Reclamation	934,000	475,000	1,409,000
Part II.	GCMRC	6,800,000	100,000	6,900,000
Part III.	Experimental Flows	500,000	1,000,000	1,500,000
Subtotal		8,234,000	1,575,000	9,809,000

<b>PART I. BUREAU OF RECLAMATION</b>	AMP Power Revenues	DOI Tribal Appropriations
<b>I. PROGRAM ADMINISTRATION</b>		
<u>A. ADAPTIVE MANAGEMENT WORK GROUP</u>		
1 Personnel Costs	178,000	
2 AMWG Member Travel Reimbursement	13,000	
3 Reclamation Travel	18,000	
4 Facilitation Contract	25,000	
5 Other	9,000	
<u>B. TECHNICAL WORK GROUP</u>		
1 Personnel Costs	81,000	
2 TWG Member Travel Reimbursement	15,000	
3 Reclamation Travel	17,000	
4 TWG Chair Reimbursement	25,000	
5 Other	2,000	
<u>C. SCIENCE ADVISORS</u>	0	
<u>D. COMPLIANCE DOCUMENTS</u>	26,000	
<u>E. TEMPERATURE CONTROL DEVICE</u>	0	
<u>F. CONTRACT ADMINISTRATION</u>	25,000	
<b>II. TRIBAL CONSULTATION</b>		
<u>A. COOPERATIVE AGREEMENTS WITH TRIBES</u>		
1 Hopi Tribe		80,000
2 Hualapai Tribe		80,000
3 Navajo Nation		80,000
4 Pueblo of Zuni		80,000
5 Southern Paiute		80,000
<u>B. RIVER TRIP LOGISTICS COSTS TO GCMRC</u>		
1 Hopi Tribe		15,000
2 Hualapai Tribe		15,000
3 Navajo Nation		15,000
4 Pueblo of Zuni		15,000
5 Southern Paiute		15,000
<b>III. PROGRAMMATIC AGREEMENT FOR CULTURAL RESOURCES</b>		
<u>A. WORK PLAN ACTIVITIES</u>		
1 Completion of HPP	50,000	
2 Reclamation Administration	50,000	
3 Treatment & Monitoring Implementation	400,000	
<b>TOTAL BOR EXPENSES:</b>	<b>934,000</b>	<b>475,000</b>

<b>PART II. GCMRC</b>	<b>AMP Power Revenues</b>	<b>USGS Appropriation</b>
<b>I. SCIENCE PROJECTS</b>		
<u>A. TERRESTRIAL ECOSYSTEM ACTIVITIES</u>		
1. Terrestrial Ecosystem Monitoring & Cultural Component	438,000	
2. Kanab Ambersnail Monitoring	79,000	
3. Cultural Data Base Plan	24,000	
4. Terrestrial Habitat Map & Inventory	88,000	
5. Kanab Ambersnail Taxonomy	25,000	100,000
<u>B. AQUATIC ECOSYSTEM ACTIVITIES</u>		
1. Aquatic Foodbase	233,000	
2. Status and Trends of Downstream Fish	740,000	
3. Status and Trends of the Lee's Ferry Trout Fishery	161,000	
4. Integrated Water Quality Monitoring - Downstream	179,000	
<u>C. INTEGRATED ECOSYSTEM ACTIVITIES</u>		
1. Fine-Grained Sediment Storage	385,000	
2. Streamflow and Fine-Sediment Transport	470,000	
3. Coarse-Grained Sediment Inputs	135,000	
4. Sediment Transport Modeling	231,000	
5. Control Network	86,000	
6. Channel/Hydrographic Mapping	128,000	
<u>D. OTHER SCIENCE ACTIVITIES</u>		
1. Unsolicited Proposals	38,000	
Adopt-a-Beach	10,000	
2. AMWG/TWG Requests	60,000	
3. In-House Research	16,000	
4. Tribal Outreach	45,000	
5. Public Outreach Involvement Plan Implementation	21,000	
6. Cultural Resource Synthesis & Status Report	10,000	
7. Cultural Affiliation Study	64,000	
8. Experimental Flows - Salary Contribution	38,000	
<b>II. ADMINISTRATIVE &amp; TECHNICAL SUPPORT SERVICES</b>		
<u>E. ADMINISTRATIVE &amp; MANAGEMENT</u>		
1. Administrative Operations	620,000	
2. Program Planning & Management	274,000	
3. AMWG/TWG Participation	45,000	
4. Independent Reviews	172,000	
<u>F. TECHNICAL SUPPORT SERVICES</u>		
1. Geographic Information Systems	160,000	
2. Data Base Management	128,000	
3. Library Operations	79,000	
4. Survey Operations	126,000	
5. Systems Administration	242,000	
6. Aerial Photography (previously in Remote Sensing)	363,000	
7. Logistics (Distributed to Projects)		
USGS Assessment 15%	887,000	
<b>TOTAL</b>	<b>6,800,000</b>	<b>100,000</b>

<b>PART III. EXPERIMENTAL FLOWS</b>	<b>AMP Power Revenues</b>	<b>USGS Appropriations</b>
Bureau of Reclamation	500,000	
GCMRC		1,000,000
Subtotal	500,000	1,000,000

**TABLE 2.3. Summary Table of Projected FY 2004 Budget**

ID	Project Descriptions	Salary	Operating Expenses	Biology Program Costs	Cultural Program Costs	Physical Program Costs	IT Program Costs	Logistics Support	Survey Support	GIS Support	TOTAL PROJECT COST
<b>SCIENTIFIC ACTIVITIES</b>											
<b>A</b>	<b>Terrestrial Ecosystem Activities</b>										
1	Terrestrial Ecosystem Mon; Cultural Comp.	49,000		107,000	89,000			190,000		3,000	438,000
2	Monitoring Kanab Ambersnail	14,000		21,000				37,000	7,000		79,000
3	Cultural Data Base Plan	7,000			17,000						24,000
4	Terrestrial Habitat Map & Inventory	28,000		60,000							88,000
5	Kanab Ambersnail Taxonomy	3,000		122,000							125,000
<b>B</b>	<b>Aquatic Ecosystem Activities</b>										
1	Monitoring Aquatic Foodbase	74,000		144,000				15,000			233,000
2	Status & Trends of Downstream Fish	48,000		551,000				141,000			740,000
3	Status & Trends of Lee's Ferry Trout	16,000		123,000				22,000			161,000
4	IWQP - Downstream	100,000		43,000				36,000			179,000
<b>C</b>	<b>Integrated Activities</b>										
1	Fine-Grained Sediment Storage	31,000		0	25,000	259,000		57,000	10,000	3,000	385,000
2	Streamflow & Fine-Sediment Transport	58,000		0		373,000		39,000			470,000
3	Coarse-Grained Sediment Inputs	12,000				71,000		47,000	3,000	2,000	135,000
4	Sediment Transport Modeling	12,000			18,000	177,000		12,000	10,000	2,000	231,000
5	Control Network							54,000	32,000		86,000
6	Hydrographic Mapping							90,000	38,000		128,000
<b>D</b>	<b>Other Research Activities</b>										
1	Unsolicited Proposals	3,000		35,000		0					38,000
	Adopt-a-Beach				10,000						10,000
2	AMWG/TWG Requests	10,000	50,000								60,000
3	In-House Research	0	16,000		0						16,000
4	Tribal Outreach	15,000			30,000						45,000
5	Public Outreach Involvement Plan Imple.	11,000			10,000						21,000
6	Cultural Synthesis & Status Report	4,000			6,000						10,000
7	Cultural Affiliation Study	14,000			50,000						64,000
8	Experimental Flows	38,000									38,000
	Subtotal:	547,000	66,000	1,206,000	255,000	880,000	0	740,000	100,000	10,000	3,804,000

**TABLE 2.3. Summary Table of Projected FY 2004 Budget (Cont'd)**

ID	Project Descriptions	Salary	Operating Expenses	Biology Program Costs	Cultural Program Costs	Physical Program Costs	IT Program Costs	Logistics Support	Survey Support	GIS Support	TOTAL PROJECT COST
<b>ADMINISTRATIVE &amp; TECHNICAL SUPPORT SERVICES</b>											
<b>E</b>	<b>Administrative &amp; Management</b>										
1	Administrative Operations	71,000	549,000								620,000
2	Program Planning & Management	254,000	20,000								274,000
3	AMWG/TWG Participation	33,000	12,000								45,000
4	Independent Reviews	22,000	150,000								172,000
<b>F</b>	<b>Technical Support Services</b>										
1	Geographic Information System	96,000					64,000				160,000
2	Data Base Management System	86,000					42,000				128,000
3	Library Operations	40,000					39,000				79,000
4	Survey Operations	35,000					91,000				126,000
5	Systems Administration	85,000					157,000				242,000
6	Aerial Photography	22,000					300,000		10,000	31,000	363,000
7	Logistics (distributed to projects)										
	Subtotal:	1,291,000	797,000	1,206,000	255,000	880,000	693,000	740,000	110,000	41,000	6,013,000
	DOI Overhead 15%	0.15									887,000
	<b>TOTAL</b>	<b>1,291,000</b>	<b>797,000</b>	<b>1,206,000</b>	<b>255,000</b>	<b>880,000</b>	<b>693,000</b>	<b>740,000</b>	<b>110,000</b>	<b>41,000</b>	<b>6,900,000</b>

## ***A. TERRESTRIAL ECOSYSTEM ACTIVITIES***

### **ONGOING PROJECTS:**

#### **PROJECT TITLE AND ID: A.1. TERRESTRIAL ECOSYSTEM MONITORING**

**Rationale/Problem Statement:** The terrestrial ecosystem within the Colorado River Ecosystem (CRE) is comprised of habitat that varies from open beaches to debris fans to 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 (BOR, 1995). These plant communities or the space absent of vegetation influence or define the concomitant animal and insect 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.

Plant communities and the space occupied or utilized by their associated animal and insect species constitute resources that provide recreational and intrinsic benefit, are of cultural value to tribes (e.g., some 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 and inter-specific interactions. Elements addressed in this monitoring program are habitat structure and composition and distribution of plants as they relate primarily to bird abundance and distribution and to the river corridor itself within the zone affected by dam operations. Other aspects addressed include linkages to distribution, abundance and composition of birds, insects, and vegetation.

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.

**Integration:** The primary goal of this project is to document significant changes in the abundance and distribution of terrestrial vegetation and secondarily the animals, including waterfowl, nesting avifauna, raptors, and other culturally important birds and coordinate these with information on the vegetation and insect communities. Other animals that are sampled are identified as links to these resources and will aid in discriminating between natural variation and the effects of operations on these resources. Other parameters that are collected under separately funded projects and that can be incorporated into analysis and interpretation of terrestrial ecosystem monitoring include discharge, camping beach area and fine sediment monitoring.

**Protocol Evaluation Panel:** The terrestrial biology PEP (Urquhart et al., 2000), recommended that terrestrial resources, (i.e., flora, fauna and physical habitat) be sampled in an integrated fashion. This recommendation was echoed by the physical and cultural PEPs, as well as the NRC (1999). In addition, the terrestrial biology PEP recommended that vegetation sampling sites be expanded and that additional elements (i.e., insects, lizards, small mammals) be sampled at the same time. The recommendation for expanding vegetation sampling comes from the viewpoint that the 11 sites historically monitored do not adequately reflect change along the channel margin, a similar recommendation associated with sediment came from the physical review panel. The inclusion of other elements to be sampled, like insects and small mammals, was recommended because single species monitoring (e.g., on SWWF, or species of concern) may fail to determine the variable that is affecting a change in a resource. For example, it may be that ROD flows reduce shoreline insects by destabilizing their habitat. These species may be a food source for riparian birds as well as native fish. By counting only birds or fish and seeing a decline or an increase in these species one cannot attribute that change to either natural variation or to dam operations.

Additionally, these other links can also serve as a metric for the level of impact a camping site may experience: increased abundances of mice or harvester ants (pogo ant) at a site may be an indication of a degraded, highly disturbed camp which feeds into recreational interests and human health issues. The conceptual model also supports multi-species monitoring for the CRE (Walters and Korman, 2000). The model is based on trophic cascades and linkages and recognizes that linkages are not unidirectional, but have interactions within trophic levels and between trophic levels.

**General 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.

**Project Goals and Objectives:** To annually 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 cultural, recreational and biological resources relative to annual operations of Glen Canyon Dam and fine-sediment monitoring data. Objectives of the project include:

- Understand how yearly operational patterns affect vegetation composition and structure in bird survey patch sites.
- Understand how composition and structure of patches influences bird abundance and distribution.
- Understand how vegetation composition affects invertebrate abundance and composition as a food base for avifauna and other vertebrates.
- Understand how vegetation composition and density changes relative to stage/discharge relationship and to geomorphic reach system-wide.
- Included in this work is an effort to merge tribal perspectives into the status of resources in the CRE.

**MOs Addressed:** This project is associated with management objectives listed under goal 6, specifically 6.1, 6.2., 6.3., 6.4., 6.5., 6.7.

**Expected Products:** Annual delivery of data on changes in species abundance and distribution that result from interactions between available habitat and dam operations. Report delivery about the status of species abundance, distribution and compositional change. Data delivery and exchange for integration with campsite monitoring regarding change of useable avifaunal habitat and campable beach habitat. FY 2004 products will include:

- Annual and final report
- Fact sheet
- Annual data delivery
- Coordination meetings with participating tribes and Park

**Recommended Approach/Methods:**

Sampling: The Biological PEP recommended expanding terrestrial flora and fauna surveys and to initiate monitoring utilizing randomly selected sampling sites based on a complete georeferenced map of the river corridor, requiring a two to three year effort (Urquhart et al., 2000). We have proposed a mapping project that will result in a georeferenced map of the river corridor at the same time that we take a phased approach to the expanded and integrated monitoring recommended by the PEP. Although we discuss at some length herein the integration of terrestrial vegetation analyses and mapping with faunal surveys, the principal objective of this project remains collecting vegetation data to allow detection of change over time and to delineate the species composition of the vegetation.

Sample sites: A georeferenced map provides the ability to randomly select sampling sites and to determine variables that predict “good,” “marginal” and “poor” habitat. Such a map would also allow the development of predictive responses and as a means of validating the conceptual model of how the CRE functions. Sampling for abundance and distribution of organisms will be coordinated so the data that is collected is representative of the overall river corridor and not of particular sites. This program will utilize randomly selected sampling sites, although some sites will be fixed by their nature (e.g., TCP). The initial sampling sites will be selected from historic bird survey sites (110 total sites are available). Each year 64 sites will be visited. The sites visited in FY 2004 will overlap with but not be the same sites visited in FY 2001 or FY 2002. Vegetation structure measurements will be



linked to bird sites, therefore the sites visited for vegetation structure and composition in FY 2004 will similarly overlap with but not be the same as those sampled in FY 2001 or FY 2002. The sites sampled for vegetation structure will also represent an increase of at least 53 sampling areas beyond the existing 11 vegetation mapping/monitoring sites (Kearsley and Ayers, 1999). Sites where linkage data are collected will be fewer in number (16 sites) due to logistics, and will exhibit a similar year-to-year rotational approach as described above.

The sites to be sampled will be identified in a manner that can be incorporated into a georeferenced relational mapping effort. These sample sites will have GPS coordinates established when possible (depending on satellite availability within the canyon) so they can be added to the GIS system and linked to a river corridor map when it is available. By gathering these data (bird, vegetation, foodbase links) collectively and examining trends of bird abundance and composition through time, for example, and within a GIS environment, we begin to fit together pieces that identify preferred habitat and better understand the implications (i.e., risk assessment) of management actions.

**Sampling:** Faunal monitoring data will be collected using primarily field-based survey measurements that include point-counts, walking surveys and live trapping for small mammals (Spence et al., 1998, Sogge et al., 1998, sample book). Surveys will consist of 5 12-18 day trips between the months of January through June and a fall trip in September. Survey sites, which include point-count stations, will occur in designated patches along the river within geomorphic reaches. A minimum of 57 patches will be visited each year below Lees Ferry, with 7 patches being visited above Lees Ferry. This number of samples is sufficient to characterize abundance and distribution of 15 most common bird, including Lucy's warbler (sensitive species elsewhere), blue grosbeaks, and yellow breasted chats (Spence et al., 1998). Other species will also be counted; however, to expect to monitor birds that occur rarely or are sporadically distributed (i.e., site specific) in addition to corridor-wide surveys is unrealistic given the funding available. The exception to this case is the southwestern willow flycatcher--which is a listed species. In this case we will conduct more intensive surveys to determine presence or absence, estimate habitat use, and assess breeding success of any observed breeding pairs. The birds listed above plus others may be considered surrogates or metrics of breeding bird habitat given that they occur in large enough numbers to detect changes in abundance.

Vegetation will be measured in a manner that captures composition and structure of habitats sampled for birds (Mills et al., 1991). Data regarding annual changes in plant species abundance and distribution will be collected at sites that may be randomized or at designated monitoring sites depending on the resource in question (e.g., a TCP or an exotic perennial that is locally abundant or fixed vs. carex sp. or dogbane that are widespread in their distribution) and may include pre-dam river terraces where appropriate. Methods may include line transects along elevational gradients to the river, or relieve patches that visually estimate % cover and species list for samples. Available habitat associated with vegetation change and campsite areas will be extracted from campsite monitoring data. Structural and compositional habitat data collection will be scheduled to coincide with nesting avifaunal monitoring (April, May). Data collection associated with linkages will be conducted seasonally (e.g., January, April/May, September) and in concert with avifaunal monitoring. Under contingency plans, additional measurements of vegetated habitat will occur in the event of large-scale flow experiments (e.g., BHBF and SASF).

The foregoing sampling strategies result in the following sampling framework:

- Bird habitat patch (minimum 100 m). 50-60 patches in spring. Vegetation structure and composition is recorded for each patch measured.
- Bird/lizard walking transect within vegetation patches 50-60 patches/3 times/year. Birds encountered or heard are recorded. 15 to 20 most common birds are tracked. SWWF is also monitored.
- Overwintering and waterfowl survey in February.
- Small mammal, invertebrate sampling at camping sites 4 times per year to determine relative densities and seasonal changes of foodbase.
- Vegetation density transects for reach-based estimates of vegetation cover and system-wide change. Transects at 60k, 45k, 35k, 25k and 15k cfs stages. 60 sites per year.

**Lower Grand Canyon:** GCMRC will continue efforts to determine appropriate means of obtaining data from agencies and other parties involved in monitoring terrestrial resources in the lower Grand Canyon. Possibilities for joint sampling efforts and coordination will be explored. GCMRC funds terrestrial monitoring activities through its cultural resources program with the Hualapai Tribe in this area. GCMRC needs to develop or access data in this area, particularly related to southwestern willow flycatcher in order to provide a complete picture of status and trends for the AMP.

**Tribal Participation:** Tribal perspectives for terrestrial resources that are significant to the tribes will be included in this monitoring effort. This may be represented by transferring the information to the tribe for interpretation and subsequent reporting, augmenting monitoring methods with tribal monitoring methods and monitors, or by other means. These efforts are funded at levels in addition to those already designated for this program and administered under a separate contract or agreement. This component of the project is discussed in detail in the following section.

**Status:** Ongoing. Originally Approved and Implemented in FY 2001.

**External Project Awards:** Mike Kearsley, Northern Arizona University and Helen Yard, Helen Yard Consulting. Three-year duration.

**Project Accomplishments:** FY 2002 was the second year of this project. As of this writing, the project had completed its second year of fieldwork and was part way through the field schedule for FY 2003.

**Schedule:** This long-term monitoring was initiated in FY 2001 and will continue annually through at least FY 2004, although field work will be significantly scaled back in FY 2004 to allow for completion of data analysis and report.

<b>Oct-December</b>	<b>January-March</b>	<b>April-June</b>	<b>July-September</b>
Analysis & report writing.	Review of project & RFP development.	Field surveys (2)	Release RFP, Analysis, Submission of Final Reports.

**Budget: \$438,000**

<b>TERRESTRIAL ECOSYSTEM MONITORING</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay Periods:			
Biology Program Manager	1.00	4,450	5,150	5,000
Biologist - Terrestrial	13.10	12,000	14,600	41,000
Biology Student	0.00	0	1,800	0
Cultural Program Manager	1.00	8,900	4,500	3,000
Physical Program Manager	0.00	1,780	1,700	0
Database Manager	0.00	7,400	0	0
Contracts				
Biology		184,000	200,000	101,000
Cultural		77,000	125,000	89,000
Technical Support Services				
Logistics		88,200	208,000	190,000
GIS	1.00	3,000	4,000	3,000
Operating Expenses			5,000	6,000
<b>TOTAL</b>		<b>386,730</b>	<b>569,750</b>	<b>438,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**PROJECT TITLE AND ID: A.1. TERRESTRIAL ECOSYSTEM MONITORING - Cultural Component - Tribal Participation**

**Rationale/Problem Statement:** The 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 (BOR, 1995). These plant communities or 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 may evaluate the resources differently. This project attempts to obtain and merge information from both sources to assess the resources more comprehensively.

**Integration:** The primary goal of the tribal component of this project is to document significant changes in the abundance and distribution of terrestrial animals including waterfowl, nesting avifauna, raptors, and other culturally important birds and coordinate these with information on the vegetation communities from western and tribal perspectives through the combined assessment of scientists and tribal representatives. See the biological project description for the integration of this project across physical, cultural and recreational resource areas.

**General Project Description:** The purpose 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 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. The project is multidisciplinary and includes Native American perspectives in ecosystem monitoring and interpretation. See biological component for full project description.

**Tribal Participation Component:** Tribal perspectives for terrestrial resources that are significant to the tribes are included in this monitoring effort. Tasks to incorporate tribal perspectives include transferring information to the tribe for interpretation and subsequent reporting, augmenting monitoring methods with tribal monitoring methods and monitors, or by other means. These efforts are funded at levels in addition to those already designated for this program and administered under a separate contract or agreement. Tribal participation for FY 2004 is specified at \$ 129,000 to incorporate all five AMP participating tribal groups.

This project was initiated in FY 2001 with additional approved funding in FY 2002 and FY 2003.

**Project Goals and Objectives:** The goal of this project is to integrate western and tribal perspectives on the monitoring and assessment of terrestrial resources in the CRE. Specific objectives are to: 1) Provide tribal perspectives on biological resource data collection methods relative to western science and tribal methodologies; 2) Identify impacts to resources from tribal perspectives; and 3) Provide recommendations for future monitoring of biological resources, data comparability and integrative mechanisms.

**MOs Addressed:** This project addresses the cultural resource MO 11.2.

**Expected Products:** Project products include: 1) Participation in data discussion meetings, presentation of preliminary data and provide information on the assessment of the condition of resources; 2) Participation in late fall/early winter meeting to discuss tribal data, collection methods, and a tribal interpretation of the information; and 3) Provide a brief written report to include tribal perspectives on data methodologies, tribal methodologies, data results, and recommendations for future monitoring activities.

**Recommended Approach/Methods:** Tribal groups develop work statements to accomplish the overall goals of the biological monitoring project. Work methodologies may differ as appropriate to the tribal group and the needs of the project. To date, methods range from intense field monitoring to data development and off-site interpretation.

**Status:** This project is ongoing and was originally approved and implemented in FY 2001.

**External Project Awards:** Awards have been made under this project to the Hopi Tribe, the Hualapai Tribe, and the Southern Paiute Consortium in FY 2001 and 2002. Awards are anticipated to all five AMP participating tribes in FY 2004 based on their expressed interest.

**Project Accomplishments:** To date, tribal representatives have participated in field monitoring trips and participated in field methodologies and assessment. Two workshops/meetings have been held to discuss tribal data and perspectives with the

biological scientists. The first annual summary report was submitted to the biological PI by the tribes.

**Schedule:** This project was initiated in FY 2001. The final year of this project is FY 2004 at which time the project will be reassess and a new RFP will be announced.

<b>Winter</b>	<b>Spring</b>	<b>Summer</b>	<b>Fall</b>	<b>December</b>
<b>Agreements drafted - Oct. - Dec.</b>	<b>Data analysis &amp; reporting</b>	<b>Data Collection &amp; analysis</b>	<b>Data analysis &amp; reporting</b>	<b>Report delivery</b>

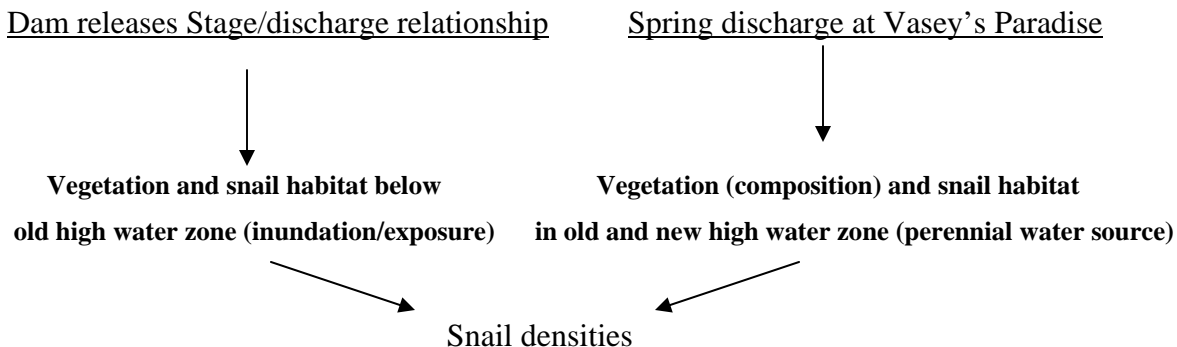
**Budget:** For budget see Terrestrial Monitoring Project A-1 above.

**PROJECT TITLE AND ID: A.2. MONITORING KANAB AMBERSNAIL AND HABITAT AT VASEY'S PARADISE**

**Rationale/Problem Statement:** Kanab ambersnail is a federally listed endangered species occurring in one location in Grand Canyon: Vasey's Paradise. While the taxonomic ranking of this taxon 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 (Diagram 1). Monitoring of quality, area and distribution occurs on a more detailed scale due to the limited nature of the habitat and surveys for animals are limited to snails. These surveys occur more than once per year. The relationships between operations from Glen Canyon Dam, habitat quality and its use by Kanab ambersnail at Vasey's Paradise are 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.

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.



**Diagram 1.** Illustration of the interactions stage discharge, habitat and snail densities have at Vasey's Paradise. While the dam and the spring are responsible for habitat, stage discharge relationship has the effect of exposing or inundating habitat, while the springs affect moisture gradients at the spring and influence plant composition.

**Integration:** Vasey's Paradise is a site that has is a unique physical feature that has biological, cultural and recreational value. In addition, the location is a sensitive cultural resource to Native American stakeholders. The primary goal for this monitoring project is to document significant changes in snail densities and size classes and available habitat at Vasey's Paradise resulting from interactions of dam operations and these variables.

**General Project Description:** Data collection and analysis that permits the monitoring of the Kanab ambersnail habitat up to the old high water zone and provides population estimates of the snail within this area.

**Project Goals and Objectives:** To determine the abundance of Kanab ambersnails that inhabit the Vasey's Paradise Springs vegetation and to determine how snail densities change relative to time and 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. These data will be related to available habitat changes relative to annual operations of Glen Canyon Dam and life history requirement of the species of concern. 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.

MOs Addressed: This project addresses MOs 5.1 and 5.2.

**Expected Products:**

- Yearly report of status and trend of Kanab ambersnail and habitat change.
- Trip reports following each trip providing area estimates of vegetation and general description of status of snail at V.P.
- Fact sheet.

**Recommended Approach/Methods:** Kanab ambersnail monitoring data will be collected using primarily field-based survey methods for snail densities and available habitat. Habitat will be measured when possible using remotely sensed methods to minimize impact to the site. Available habitat values are used for biological opinion consultation associated with special high releases (e.g., Experimental High Flows). Estimates for snail densities in difficult to access areas of habitat will receive increased attention in an effort to more reliably extrapolate data from more accessible areas. Data regarding annual changes in species abundance and distribution will be collected and may include pre-dam river vegetated habitat. Collection of available habitat and snail density will be conducted in the spring and fall to assess overwintering survival and subsequent recruitment. Issues pertaining to potential seasonal biases in population estimates will be addressed. These trips will be coordinated with population translocation site surveys located downstream. Specific methods and approaches include:

Population estimates:

- Sampling in the spring for over winter survival and in the fall for recruitment
- Sub-sampling vegetation patches for snails and developing estimates using boot strapping methods.

Habitat estimates:

- Traditional survey of perimeter of habitat and areas subsequently generated.
- Estimation of habitat available or affected by discharges > 30,000 cfs.
- Investigate feasibility of photogrammetry for habitat estimates.

Project consultation will be conducted with Native American stakeholders. Under contingency plans, additional measurements of habitat will occur in the event of large-scale flow experiments (e.g., BHBF and SASF).

**Status:** Ongoing.

**External Project Awards:** Cooperative agreement with Arizona Game and Fish Department and coordination with Kanab ambersnail working group.

**Project Accomplishments:** Yearly population estimates for the snail.

**Schedule:** This long-term monitoring was initiated in FY 2001 and will be continued annually through at least FY 2005 through contract and (or) cooperative agreements.

<b>Oct-December</b>	<b>January-March</b>	<b>April-June</b>	<b>July-September</b>
Data delivery, analysis.	Report delivery.	Data collection/survey	Data collection/survey

**Budget:** \$79,000

<b>KANAB AMBERSNAIL MONITORING</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay Periods:			
Biology Program Manager	1.00	4,450	5,150	5,000
Biologist - Terrestrial	3.00	6,000	7,300	9,000
Biology Student	0.00	850	0	0
Cultural Program Manager	0.00	4,450	0	0
Contracts				
Biology		10,000	30,000	21,000
Technical Support Services				
Logistics		39,200	33,000	37,000
Survey - Surveyor		4,300		
Survey - Surveying Technician	3.00	11,400	5,900	7,000
GIS				
<b>TOTAL</b>		<b>80,650</b>	<b>81,350</b>	<b>79,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**PROJECT TITLE AND ID: A.3. CULTURAL DATA BASE PLAN**

**Rationale/Problem Statement:** Cultural resource data currently exists in a number of locations, including federal agency and tribal databases. Consolidation of data will assist the AMP assessment efforts.

Initial efforts in FY 2001 include identification of existing and available data within the NPS units and within the tribal groups. Assessment of the type and extent of data and existing data structures and systems will also be made. Issues of data sensitivity and appropriate dissemination will also be addressed.

**Integration:** To achieve an ecosystem-level of understanding of the relationships between resources of the CRE and Glen Canyon Dam operations, integration of long-term monitoring between physical, cultural, biological, and recreational resources is required. This project will provide a means to consolidate the cultural resource data to assist in an ecosystem assessment of the resources.

**General Project Description:** This project was originally approved in the FY 2002 but has been delayed until FY 2004, owing to completion of the research design project for the HPP. The overall objective of this project is to consolidate cultural data for utilization by the AMP.

**Project Goals and Objectives:**

- Provide a plan and structure to consolidate cultural resource data that is currently held in various locations.
- Provide a methodology for the appropriate transfer of data
- Address issues of data sensitivity and confidentiality

**MOs Addressed:** This project addresses cultural resource management objectives and information needs (MO4) and implements recommendations by the cultural PEP.

**Expected Products/Deliverables:**

- Database plan for the continued consolidation of existing and new data for the AMP
- Project is one component of the Historic Preservation Plan

- Public dissemination of information, as appropriate.

**Recommended Approach/Methods:** Efforts in FY 2004 will include, but are not limited to, formulating the appropriate data structure, given the existing types of available data and data structures, address data links with NPS and tribal locations, data compatibility with existing databases and GCMRC data bases, and data security. Development of the database plan will require close coordination and interface with all cultural resource entities.

**Status:** Approved in FY 2002 but delayed until FY 2004.

**External Project Awards:** There have been no external awards to date.

**Project Accomplishments:** There are no accomplishments to date, as this project has not been initiated.

**Schedule:** The project duration is anticipated to be one year. The estimated cost of the project is \$24,000 for GCMRC's portion. The BOR will contribute approximately \$25,000, for a total project cost of \$49,000.

**Budget:** \$24,000

<b>CULTURAL DATABASE PLAN</b>	<b>New in Fy-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits) Pay Periods:			
Cultural Program Manager 2.00	13,350		7,000
Computer Specialist (DBMS)	3,700		
Contracts			
Cultural	25,000		17,000
<b>TOTAL</b>	<b>42,050</b>	<b>0</b>	<b>24,000</b>

**PROJECT TITLE AND ID:** A.4. TERRESTRIAL HABITAT MAP AND INVENTORY

**Rationale/Problem Statement:** 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. Terrestrial mapping usually produces a digital terrain model (DTM) in combination with the XYZ position of features and artifacts. Periodic mapping of the same areas can be used for change detection of resources. Attributes associated with a coverage type can also be used as a predictive tool for monitoring and research.

Mapping requires a combination of field surveys and remotely-sensed data (photogrammetry, LIDAR). Field surveys yield a very high precision DTM with a contour resolution of 25 to 50 centimeters (cm). The accuracy is dependent on the geodetic control available. Photogrammetry data, as in our current GIS sites, are sub-meter precision and are displayed at one half-meter contour. It is an objective of GCMRC to establish a sub-meter accuracy terrestrial topographic base map of the entire river corridor to support long-term monitoring. This is only feasible using remotely-sensed data such as photogrammetry or LIDAR. Coverages that identify vegetation communities would be layers applied to the topographic base map.

We currently have sub-meter accuracy terrestrial topographic coverage of approximately 80 miles of the CRE in 17 areas of concentrated scientific effort that we refer to as GIS sites. Coverages for vegetation communities have not been inventoried in a system-wide sense (within all GIS sites) since 1992 (Waring, 1993). In the absence of a system-wide topographic map being available, an updated coverage of the vegetation communities within the existing geo-reference sites would provide information about the total area of vegetation within these GIS sites and can form the basis for expansion throughout the canyon as the system-wide topographic base map is developed.

**Integration:** To achieve ecosystem-level scientific understanding of the relationships between resources of the CRE and Glen Canyon Dam operations, integration of long-term monitoring between physical, cultural, biological, and recreational resources is required. The inventory and mapping of system-wide vegetation communities provides information about changes in open and vegetated areas (camping beaches) and changes in the old and new high water vegetative communities as a whole (e.g., how have marsh community areas changed since 1992?). The primary goal for this project is to document compositional changes in the vegetated terrestrial habitat at an 80 mile coverage, at least, to complement field based surveys that occur at a fine scale.

**General Project Description:** This project will develop the first comprehensive map of terrestrial and riparian vegetation in the CRE that allows characterization of community level attributes and provides the opportunity to track changes over time. Data collection and analysis that permits the development of a geo-referenced, GIS based map of the terrestrial environment including physical (geomorphic at least Holocene deposits) and biological coverages (vegetation communities within the old and new high water zone).

**Project Goals and Objectives:** To measure, record and map terrestrial habitat throughout the river ecosystem, including the various geomorphic features and substrates, and vegetation communities. These data will be related to available habitat relative to annual operations of Glen Canyon Dam and compared with change since 1992, and earlier years as permissible with existing data. Specific objectives of the project include:

- Provide a baseline of vegetated and open terrestrial habitat that can be used for long-term, community-based change detection.
- To provide a vegetation map of the river corridor that uses a uniform hierarchical vegetation classification system that is compatible with NPS park units and AMP program purposes.
- Develop a spatial database of sampled and un-sampled areas to help quantify characters that define good vs. bad habitat for terrestrial invertebrates and vertebrates.
- The vegetation data will be compared to 1996, 1992 and earlier year data to detect and study changes.

**MOs Addressed:** This project addresses MOs under Goal 6 including 6.1, 6.2, 6.3., 6.4., and 6.5.

**Expected Products:**

- Vegetation coverage for GIS network.
- Randomized sampling design for terrestrial resource survey.

**Recommended Approach/Methods:** The overall mapping effort will use photo interpretation and ground-truth methodologies. The vegetation community designation will use methods that conform to national vegetation mapping standards. Finer scale community delineation may occur for some community associations. Digital overflight data (CIR)

provided by GCMRC for the vegetation mapping project will be used to construct a comprehensive GIS based map of the entire CRE at a resolution of less than 0.5 meters.

The project will incorporate the National Vegetation Classification Standards, Standard Field Methodologies and Accuracy Assessment Procedures developed in cooperation by the National Biological Survey and National Park Service and the Nature Conservancy (NBS/NPS 1994). Similar mapping efforts were completed for the Gray Ranch in New Mexico, the Yampa River in Colorado, and the Badlands in South Dakota (NBS/NPS 1994).

The National Park Service has undertaken a program of inventory and monitoring of its National Parks (NPS-75). Part of this effort includes developing vegetation maps for the park lands. The NPS Vegetation Mapping Project uses standard field methods and classification schemes for all parks. The minimum mapping unit for the NPS effort is 0.5 hectares and a scale of 1:24,000. The minimum mapping unit for GCMRC's purposes is 100 m or smaller and at a scale of at least 1:5000. Our efforts will be more detailed but, will provide the minimum information required by the NPS mapping effort, as well.

**Classification System for the CRE.** Spence et al. (1995) provided an outline for a preliminary classification for the Colorado Plateau that was presented to the series level. An example of a series from this classification scheme for the CRE would be coyote willow with a vegetation association of seep willow and horsetails. This would map vegetation at a scale that has been utilized since 1996 (Kearsley and Ayers 1996). To meet National Vegetation Classification Standards, the series and associations that will form the basis for polygon delineation on the vegetation map will use existing vegetation plot data (Kearsley and Ayers 1996) to verify associations or to redefine associations for this effort. Previous associations (Kearsley and Ayers 1996) were developed using multivariate analysis (e.g., TWINSPAN, Hill 1979) and this will be done again for this effort. Results will be compared with existing associations for the river corridor, signatures identified from previous aerial photography and the needs of the National Park Service as well as the Adaptive Management Program.

Examples of the classification hierarchy is:

1. WOODLAND
  2. Juniper woodland alliance
    - a. Juniper/rice grass alliance
    - b. Ponderosa Pine/Juniper alliance

The latter two (a and b) would be the level at which a polygon would be developed and given a unique number for that particular polygon. In the CRE alliances include coyote willow and seep willow/horsetails, based on previous TWINSPAN Analysis (Kearsley and Ayers 1996). The minimum amount of area that this association has to cover in order to be included into a polygon with this designation could be 100 m or about 25 m square. The minimum mapping area, or size of the polygon still needs to be determined. A product of this mapping project will be a vegetation description/field key for associations in the Colorado River ecosystem.

**Status:**

External Project Awards: Contractor supported by IT program in FY 2002

Project Accomplishments: None to report/new start in FY 2002-03

**Schedule:** This project was initiated in FY 2002 and will be a two and one-half year effort. This project may be amended in scale of effort and duration based on the outcome of the CIR digital overflight data collection in FY 2002. Current plans call for this project and a revised map to be reactivated and repeated every five years to assess change in the CRE riparian vegetation community. In the area pertaining to cultural resources, the project may also be revised based on the recommendations of a cultural resource research design that addresses numerous issues, including geomorphic research issues. This will be done prior to the completion of the proposed project.



**Budget: \$88,000**

<b>TERRESTRIAL HABITAT MAP AND INVENTORY</b>			<b>New in FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay Periods:			
Biology Program Manager	0.00		5,150	0
Biologist - Terrestrial	9.00		43,800	28,000
Physical Program Manager	0.00		1,700	0
Contracts				
Biology				60,000
Technical Support Services				
Logistics			8,000	0
GIS	0.00		12,000	0
<b>TOTAL</b>			<b>70,650</b>	<b>88,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**PROJECT TITLE AND ID: A.5. KANAB AMBERSNAIL TAXONOMY**

**Rationale/Problem Statement:** Kanab ambersnail is a federally listed endangered species occurring in one location in Grand Canyon: Vasey's Paradise. The taxonomic ranking of this taxon is currently unresolved, but it is currently considered a taxon that is endemic to Vasey's Paradise, within the Colorado River ecosystem. 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 (Diagram 1). Furthermore 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 and discharges as well as accessibility to this site by humans.

**Integration:** Vasey's Paradise is a site that is a unique physical feature that has biological, cultural and recreational value. The primary goal for this research project is to expand on the genetic and morphological and ecological information associated with this and related snail

taxa to provide more management tools associated with mitigation or other management strategies of this resource at this site.

**General 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 multivariate morphologic and geographic methods of analysis as well as modern genetic analysis that may include mitochondrial DNA or Amplified Fragment Length Polymorphisms (AFLP's).

**Project Goals & Objectives:** The purpose of this project is to examine and resolve the taxonomic relationship of the snail at Vasey's Paradise relative to Kanab ambersnail associated at its type locality and to other outgroups. The objective of this project is to:

- Understand the relationship of *Oxyloma haydeni* complex and the status of the taxon at Vasey's Paradise within this complex.

**MOs Addressed:** Responds to MO 5.1.

**Expected Products:**

- Yearly progress reports and a final report. Final products to be determined through RFP development process.

**Recommended Approaches/Methods:** Utilize a phylogenetic approach to resolve the taxonomy of the complex including morphological, geographical, genetic characters for phylogenetic tree construction. This project will require surveys and collection of snails outside of the Colorado River ecosystem to ensure a thorough understanding of the ecology and life history of the Kanab ambersnail at Vasey's Paradise relative to other snail populations and species. GCMRC developed and issued an RFP in late FY02. Pending peer review, a research award may be made in FY03. This project is being advanced in priority due to concerns expressed by the TWG. GCMRC will receive additional funds from USGS appropriations in the amount of approximately \$300,000 over a 3-year period.

**Status:**

External Project Awards: New Project.

Project Accomplishments: New Project.

**Schedule:**

<b>Oct-December</b>	<b>January-March</b>	<b>April-June</b>	<b>July-September</b>
Release and award RFP	Collection permit process and field surveys/initiate lab work on existing specimens		Field surveys Lab extractions/analysis

**Budget: \$25,000** (Estimated cost of \$100,000 for external contract.) Funding provided by the Biological Resources Discipline, USGS.

<b>KANAB AMBERSNAIL TAXONOMY</b>		<b>New in FY-2003</b>	<b>FY-2004</b>
Salary	Pay Periods:		
Biologist - Terrestrial	1.00		3,000
Contracts			
Biology		70,000	22,000
<b>TOTAL</b>		<b>70,000</b>	<b>25,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

<b>USGS Appropriations</b>	<b>FY-2003</b>	<b>FY-2004</b>
Contracts	30,000	100,000
<b>TOTAL</b>	<b>30,000</b>	<b>100,000</b>

Note: USGS-BRD will fund project from appropriations FY03 - FY05

## ***B. AQUATIC ECOSYSTEM ACTIVITIES***

### **ONGOING PROJECTS:**

#### **PROJECT TITLE AND ID: B.1. MONITORING AQUATIC FOODBASE**

**Rationale/Problem Statement:** The aquatic foodbase refers to the phyto-benthic community (algae, macrophytes and invertebrates) that is utilized by consumers such as fish, birds. Like the vegetative communities on land, the algae and macrophytes either form habitat that is utilized by invertebrates and vertebrates, or provide a source of food to these and other organisms as consumers. The composition, density and structure of the foodbase are affected by dam operations (volume, water quality of discharge), colonizing substrate (sand or cobble) as well as top down effects (overpopulation, overgrazing). The condition of the aquatic foodbase is fundamentally the basis for the status of higher-level species such as trout, waterfowl, and native fish (see Diagram 2). The relationships between basic productivity, benthic invertebrate communities, and higher trophic level organisms is complex. The occupation and use of habitats or resources by all organisms is dependent on their quality, distribution and availability. The relationships between operations from Glen Canyon Dam, nutrient levels, natural fine and coarse-sediment inputs that form substrate for aquatic habitats and their colonization and use along the Colorado River ecosystem resources are 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.

Monitoring of phytobenthic communities and evaluating their quality for utilization: (1) allows managers to assess the status of this community throughout the Colorado River ecosystem; (2) provides data that allows identification and interpretation of linkages between physical and biotic variables; (3) provides data on the effect of periodic management of sediment through high flows under the Record of Decision on the phytobenthic community and higher trophic levels.

**Dam releases (discharge volume & reservoir water quality at penstocks or other outlets)**

↓  
Available habitat and nutrients for colonization or utilization by algae and aquatic plants

**Sediment input & turbidity** → ↓

Productivity and composition of vegetation provide habitat or are direct food source for invertebrates and vertebrates

↕  
Higher trophic level organisms consume invertebrate foodbase (fish, waterfowl)

↕  
**Human interactions by way of recreation (catch & release, harvest)**

**Diagram 2.** Illustration of the links between operations, water quality, available aquatic habitat, productivity and consumption by higher-level organisms. There are both bottom-up (sediment and water) and top-down (harvesting, population densities) interactions that affect this resource.

**Integration:** To achieve ecosystem-level scientific understanding of the relationships between resources of the Colorado River and Glen Canyon Dam operations, integration of long-term monitoring between physical, cultural, biological, and recreational resources is required. The primary goal is to document significant changes in the composition, structure and volume/density of the phyto-benthic community within the main channel resulting from interactions of dam operations, changes in sediment supply (substrate) within the context of the Colorado River's geomorphic framework that may affect higher trophic level organisms.

**General Project Description:** The collection of data that monitors the influences of Glen Canyon Dam operations on the productivity and quality of the aquatic foodbase (phyto-benthic community) in the CRE as it relates to higher trophic level needs. Develops linkages between elements of the aquatic foodbase and higher trophic level organisms of direct management concern.

**Project Goals and Objectives:** The project serves two purposes: 1. to collect organic carbon (invertebrates to dissolve organic carbon) to characterize carbon production and usage

in the aquatic system on a yearly and seasonal basis relative to discharge and abiotic factors (suspended sediment, turbidity, pH, temperature, DO). 2. to sample for benthic organism to document composition along the river corridor. Monitoring of phytobenthic communities and evaluating their quality for utilization: (1) allows managers to assess the status of this community throughout the Colorado River ecosystem; (2) provides data that allows identification and interpretation of linkages between physical and biotic variables; (3) provides data on the effect of periodic management of sediment through high flows under the Record of Decision on the phytobenthic community and higher trophic levels.

FY 2004 Objectives: To understand the relationship of organic carbon inputs from heterotrophic and autotrophic sources and their relative contribution to carbon budget in the aquatic system on a temporal and spatial scale. To begin to understand how carbon values relate to fish community densities and distributions. To determine the composition and density of benthos along the river corridor and describe these data relative to previously collected data.

MOs Addressed: The aquatic foodbase monitoring and evaluation project provides information needs related to MOs 1.2, 1.4, 1.5.

**Expected Products:**

- Quarterly and annual report on productivity and benthic composition, linked with water quality data collection
- Fact sheet in association with water quality data
- Data delivery on quarterly basis.
- A synthesis report and peer-reviewed publication on the past 10 years of food base monitoring and research in the CRE.

**Recommended Approach/Methods:** The methods for monitoring the phyto-benthic community underwent protocol review (PEP) in March of 2001. The review also included the downstream fish monitoring program and elements of the water quality program. The panel participated in a downstream river trip along with PI's to see first hand logistic constraints of the system. The PEP report discussed existing sites, sampling methodology visitation of tributary mouths and integration of sampling with fishery monitoring. The results of that panel review are being used to determine the methods and approaches for long-

term monitoring of this resource. It is anticipated that much of the new protocol for this project will be completed in FY 2004.

One element that will be incorporated is developing a tighter link between sampling of the aquatic vegetation and invertebrates and fish. Sampling currently takes place at fixed locations. Future sampling may become randomized. Additionally, the Glen Canyon area—which is currently not included with downstream sampling—will be included into the sampling domain. The intent is to effectively measure and characterize changes in available river channel habitat and the benthic communities' composition and structure as prescribed. Structural and compositional data collected may be scheduled to coincide with important seasonal changes or projected changes in operations. Under contingency plans, additional measurements of the phyto-benthic community will occur in the event of large-scale flow experiments (e.g., BHBF and SASF).

As a result of cooperator sampling (NPS at Glen Canyon National Recreation Area) there has recently been confirmation of a new invasive aquatic species in the CRE. The New Zealand Mud Snail, *Potamopyrgus antipodarum*, was first confirmed in the Glen Canyon reach and has now been documented throughout the CRE. This species attains very high densities in some stream and river systems and is known to occur in 5-6 populations in the U.S. The species will be the subject of future monitoring and research in the CRE.

**Status:** Implemented in FY 2002. Likely to be revised based on PEP recommendations.

**External Project Awards:** Unknown at this time.

**Project Accomplishments:** Unknown at this time.

**Schedule:** While long-term monitoring was revised in FY 2002 to reflect the PEP and subsequent TWG recommendations, the current phyto-benthic monitoring contains elements that are similar to projected long-term monitoring goals. Integration of current and future monitoring techniques will be initiated in FY 2003 and continued annually through at least FY 2005 through cooperative agreements determined through competitive RFP, or through GCMRC staff work.

Oct-December	January-March	April-June	July-Sept
Analysis and report delivery for previous two quarters		Analysis and report delivery for previous two quarters	

**Budget: \$233,000**

<b>AQUATIC FOODBASE</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay Periods:			
Biology Program Manager	1.00	4,450	5,150	5,000
Biologist - Aquatic	12.10	3,000	38,400	34,000
Biologist - Fisheries-1	11.10			32,000
Hydrologist - Limnologist	1.00		4,800	3,000
Biologist - Terrestrial	0.00	3,000	0	0
Ecologist	0.00	6,000	0	0
Biology Student	0.00		3,600	0
Hydrologic Technician	0.00		2,600	0
Physical Program Manager	0.00	1,780	0	0
Contracts				
Biology		235,000	180,000	136,000
Technical Support Services				
Logistics		58,800	14,000	15,000
Other Operating Expenses			8,000	8,000
<b>TOTAL</b>		<b>312,030</b>	<b>256,550</b>	<b>233,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

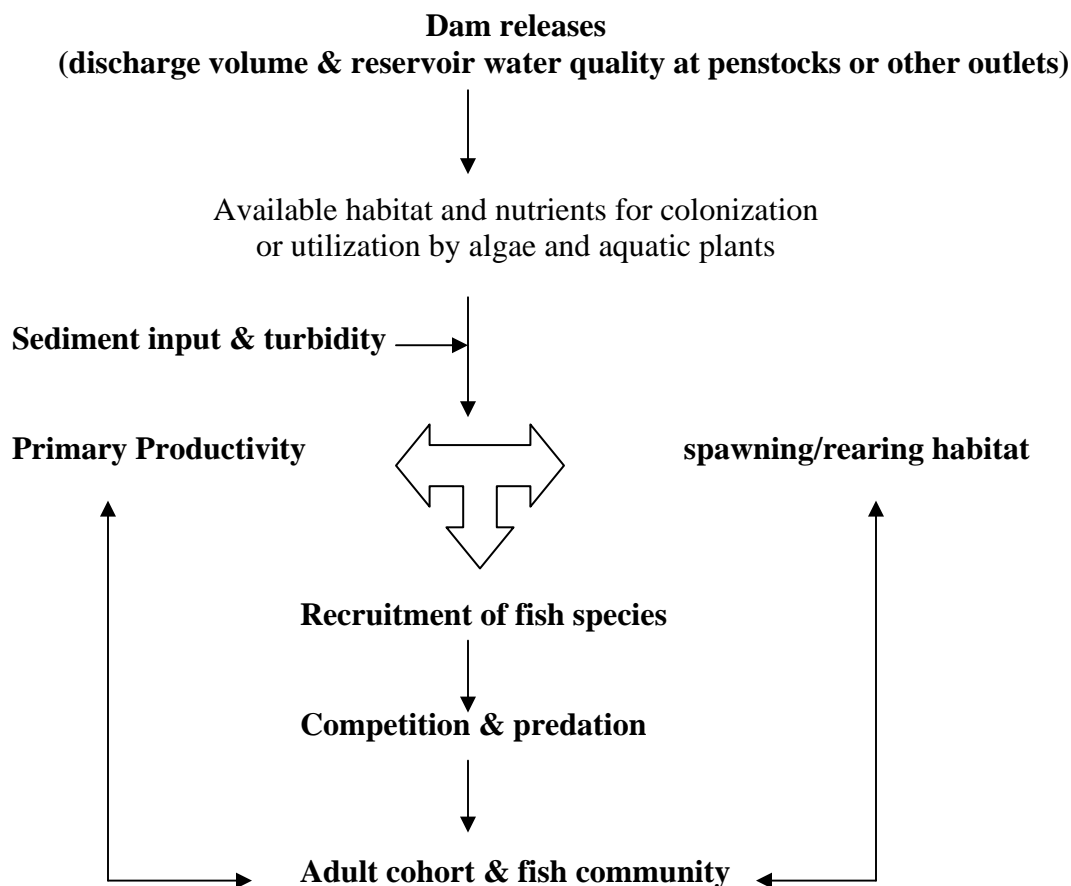
**PROJECT TITLE AND ID: B.2. MONITORING OF THE STATUS AND TRENDS OF DOWNSTREAM FISH COMMUNITY**

**Rationale/Problem Statement:** 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 striped bass. 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. Community traits such as spawning and recruitment are influenced by the quality of substrate, water, and food. Competitive interactions between fish species may also account for species abundance and distribution. The relationships



between operations from Glen Canyon Dam (e.g. water temperature, natural fine and coarse-sediment inputs that form substrate for aquatic habitats and their colonization) and use by fish along the Colorado River ecosystem resources are a management concern (Diagram 3). 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.

Monitoring of the fish community: (1) allows managers to assess the status of this community throughout the Colorado River ecosystem; (2) may provides data that allows identification and interpretation of linkages between physical and biotic variables; (3) provides data on the effect of periodic management of sediment and flow under the Record of Decision on the fish community and the resources on which it depends.



**Diagram 3.** Illustration of interactions and linkages between discharge, habitat, productivity, and the fish community. There are bottom-up effects associated with operations, habitat and productivity and top-down, or fish species interactions that also come into play in this system.

**Integration:** To achieve ecosystem-level scientific understanding of the relationships between resources of the Colorado River and Glen Canyon Dam operations, integration of long-term monitoring between physical, cultural, biological, and recreational resources is required. The primary goal is to document significant changes in the abundance and distribution of the fish community within the main channel resulting from interactions of dam operations, changes in sediment supply (substrate), fish community and potentially the phyto-benthic community within the Colorado River ecosystem.

**General Project Description:** Collection of data that monitors abundance and distribution of native and non-native fish to allow determination of the influences of Glen Canyon Dam operations on the fish community in the Colorado River ecosystem, includes those native fish found (e.g., Flannelmouth suckers) in the Glen Canyon reach.

**Project Goals and Objectives:** To annually measure, assess and report abundance and distribution of the fish community. These data will be related to changes relative to annual operations of Glen Canyon Dam, sediment inputs (coarse and fine) monitoring data, and food base monitoring data downstream of the dam. This project is an integrated effort involving personnel from the USFWS, SWCA, the AGFD, and GCMRC to collect data that monitors the status and trends of native and non-native fishes in the mainstem, including those native fish found (e.g., Flannelmouth suckers) in the Glen Canyon reach.

**FY 2004 Objectives:**

- Provide population estimates or CPUE for adult native fish (HBC, FMS, BHS).
- Determine potential cohort strength for Humpback chub at age 1.5 (> 120 mm).
- Determine population estimates for rainbow and brown trout in mainstem below Paria riffle
- Track distribution and relative abundance of these (above) and other fish species including carp, catfish, and other potential warm water competitors.
- Develop joint estimation procedures for HBC population in mainstem Colorado River near LCR confluence in spring sampling.

**MOs Addressed:** Addresses Goal 2, MOs 2.1, 2.2, 2.3, 2.8, Goal 4.

**Expected Products:**

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

**Recommended Approach/Methods:** Fish community data will be measured using field-based survey measurements to provide population estimates for those fish that exist in sufficient numbers to characterize change in the fish community. Those species likely to be estimated are humpback chub, flannelmouth sucker, rainbow trout, brown trout and carp. This project will generally employ a stock assessment approach which estimates recruitment to the adult (reproducing) population in combination with instantaneous population estimates for some species and index sampling based on catch per unit effort to estimate distribution and abundance of less numerous species.

Parameters of interest with respect to humpback chub are population estimates in the Little Colorado River (LCR) and spawning success and recruitment in the LCR, and distribution of adults and juveniles in the mainstem. Similar information will be needed for each species and will include sampling flannelmouth sucker spawning sites in Glen Canyon and at the Paria River mouth. Data collected (shocking effort) in Glen Canyon for the trout system will be incorporated into downstream monitoring. And the shocking effort in Glen Canyon will help in the calibration of this gear-type downstream. If additional gear types need to be deployed in the Glen Canyon reach for flannelmouth sucker, it will be this project that will be responsible for deployment and data collection. Field data associated with the fish community will be scheduled to coincide with important life history stages (e.g., spawning/overwintering survival, fall recruitment). The project will use mark recapture techniques for YOY to adult for native fish and depletion as well as mark/recapture for brown and rainbow fish.

Randomized sampling for general survey of fish abundance and distribution Under contingency plans, additional measurements of the fish community will occur in the event of large-scale flow experiments (e.g., BHBF and SASF).

**Status:** Implemented in FY 2002. Will be revised based on PEP recommendations.

**External Project Awards:** Cooperative agreement with Arizona Game and Fish Department, U.S. Fish and Wildlife Service, GCMRC and SWCA Inc. Final year of effort for design of monitoring was 2003. Project work in FY 2004 will implement new monitoring framework.

**Project Accomplishments:** Completion of historic data analysis and development of recommendations for long-term monitoring of fish in the Colorado River ecosystem.

**Schedule:** Integration of current and future monitoring techniques were initiated in FY 2002 and will continue annually through at least FY 2004 through contract and (or) cooperative agreements. An RFP will be released in summer of 2004 for long term monitoring to be conducted from FY 2004-2009.

<b>Oct-December</b>	<b>January-March</b>	<b>April-June</b>	<b>July-September</b>
Development of field schedule, yearly proposed activities	Implementation of field schedule, delivery of previous year's report	Field collection, data analysis. Development of monitoring recommendations. RFP release.	Field collection, data analysis.

**Budget: \$740,000**

<b>STATUS &amp; TRENDS OF DOWNSTREAM FISH</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
	Pay Periods:			
Salary (includes benefits)				
Biology Program Manager	4.00	4,450	10,300	18,000
Biologist - Aquatic		6,000	0	0
Biologist - Fisheries -	212.10		48,000	28,000
Biologist – Terrestrial		3,000	0	0
Ecologist		9,000	0	0
Biology Student	0.00	3,400	10,800	0
Physical Program Manager	0.00	1,780	1,700	0
Hydrology Technician	1.00			2,000
Contracts				
Biology		469,000	570,000	521,000
Biology Student				14,000
Technical Support Services				
Logistics		176,200	153,000	141,000
Other Operating Expenses				
<b>TOTAL</b>		<b>672,830</b>	<b>808,800</b>	<b>740,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**PROJECT TITLE AND ID: B.3. MONITORING OF THE STATUS AND TRENDS OF THE LEES FERRY TROUT FISHERY**

**Rationale/Problem Statement:** 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 and catfish. 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, natural fine and coarse-sediment inputs that form substrate for aquatic habitats and their colonization and use by trout in the Glen Canyon portion of the Colorado River ecosystem resources are a management concern (Diagram 3).

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.

Monitoring of the rainbow trout population: (1) allows managers to assess the status of this population in Glen Canyon; (2) provides data that allows identification and interpretation of linkages between physical and biotic variables; (3) provides data on the effect of periodic management of flows under the Record of Decision on the trout population in Glen Canyon and the resources it depends on including the phyto-benthic community.

**Integration:** To achieve ecosystem-level scientific understanding of the relationships between resources of the Colorado River and Glen Canyon Dam operations, integration of long-term monitoring between physical, cultural, biological, and recreational resources is required. The primary goal is to document significant changes in the abundance, age structure and condition of the trout population in Glen Canyon resulting from interactions to dam operations, changes in sediment supply (substrate), and the phyto-benthic community within the Colorado River ecosystem. These data are used to augment downstream fish community monitoring.

**General Project Description:** Monitoring the influences of Glen Canyon Dam operations on the Lees Ferry trout fishery in the Colorado River ecosystem.

**Project Goals and Objectives:** To annually measure, assess and report on abundance, age structure and condition of the rainbow trout population in Glen Canyon. These data will be related to changes relative to annual operations of Glen Canyon Dam and phyto-benthic monitoring data downstream of the dam. The purpose of this project is to collect data to determine that proportional stock density, condition and population estimates of age II+ rainbow trout in Lees Ferry/Glen Canyon Reach as it relates to Glen Canyon Dam operations.

**FY 2004 Objectives:** Sample in such a manner to provide population estimates for age II+ trout annually. Determine relative densities of trout in relationship to habitat sampled to refine population estimates. Continue to input data into stock assessment model to

establish status and trends for trout in Glen Canyon reach. Determine annual growth rates of trout and incorporate into status of fishery.

MOs Addressed: This project addresses Goal 4 and M.O. 4.1.

**Expected Products:**

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

**Recommended Approach/Methods:** The trout population data will be collected using a field-based survey method that characterizes changes in the trout fishery in Glen Canyon (see Lees Ferry Protocol document: [www.gcmrc.gov](http://www.gcmrc.gov)). Underwater transects using SCUBA and snorkeling will be implemented in FY03 to improve understanding of trout distribution and expansion of electrofishing estimates for total population estimates. Annual changes in trout size class distribution, recruitment and condition will be measured at monitoring sites. Populations change data associated with food or habitat resources will be extracted from phyto-benthic and sediment monitoring data. Field data associated with the trout population will be scheduled to coincide with important life history stages (e.g., winter spawning, summer recruitment). Under contingency plans, additional measurements of the trout population will occur in the event of large-scale flow experiments.

**Status:** Ongoing from FY 2001.

External Project Awards: Cooperative agreement with Arizona Game and Fish Department. Final year of three-year project will be FY2003, new RFP will be issued for work in FY2004.

Project Accomplishments: Incorporation of random sites into sampling design at Lees Ferry. Calibration of CPUE of Lees Ferry trout to downstream effort. Incorporation of snorkel survey effort into monitoring.

**Schedule:** Long-term monitoring was initiated in FY 2001 and will be continued annually through at least FY 2004 through contract and (or) cooperative agreements.

<b>Oct-December</b>	<b>January-March</b>	<b>April-June</b>	<b>July-September</b>
Data collection, field effort coordination, Report delivery	Report review, Field work	Field work RFP Release	Field work

**Budget: \$161,000**

<b>LEES FERRY TROUT FISHERY</b>			<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
<b>Description</b>					
Salary (includes benefits)	Pay Periods:				
Biological Program Manager	1.00		4,450	5,150	5,800
Biologist - Aquatic			3,000	0	0
Biologist - Terrestrial			3,000	0	0
Ecologist			6,000	0	0
Biologist – Fisheries – 1	2.00				6,000
Biologist - Fisheries - 2	2.00				5,000
Biology Student	0.00			1,800	0
Physical Program Manager	0.00		1,780	1,700	0
Contracts					
Biology			90,000	110,000	113,000
Technical Support Services					
Logistics			19,600	20,000	22,000
Other Operating Expenses					
<b>TOTAL</b>			<b>137,830</b>	<b>155,050</b>	<b>161,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**PROJECT TITLE AND ID: B.4. INTEGRATED WATER QUALITY MONITORING: DOWNSTREAM ACTIVITIES**

**Rationale/Problem Statement:** Water quality in the CRE has the potential to control or alter the composition and abundance of all biological components of the ecosystem from primary producers through fishes. Primary factors likely to influence these trophic levels are temperature, turbidity, and nutrient levels. A principal recommendation of the IWQP PEP was to focus water quality measurement efforts on downstream resources and to do so in a manner that clearly links water quality with the biotic community.



**Integration:** This program will be heavily integrated with the sediment transport studies in the physical sciences and with the sampling for aquatic foodbase and downstream fisheries efforts. Specific parameters and integration strategies are being developed in FY 2002-03. The likely areas of integration will include nutrient and organic carbon measurements. This project will also implement measures of instream metabolism to estimate primary productivity as well as evaluate the efficacy of linking stable isotope work on fish diet being conducted as part of the experimental flows treatment.

**General Project Description:** This project collects data on water quality factors in the CRE.

**Project Goals and Objectives:** To collect data that characterizes the physical, chemical and biological quality of water from GC Dam discharge and downstream as they relate to operations of Glen Canyon Dam and to higher trophic level interactions including primary production and carbon cycling within the aquatic ecosystem

**FY 2004 Objectives:** To understand how standard water quality parameters change longitudinally downstream and in relation to discharge. To determine if changes are additive downstream or are characteristic by reach To collect data in a manner that compliments and is available to make linkages with primary productivity and carbon cycling in the aquatic ecosystem.

**MOs Addressed:** Addresses Goal 7, MO 7.1, 7.2.

**Expected Products:**

- Quarterly and annual report of water quality with links to energy budget
- Fact sheet for water quality and productivity
- Data delivery on a quarterly basis.

**Recommended Approaches/Methods:** These are currently being developed as part of the IWQP five-year plan.

**Status:** On-going. This project was initiated as a separate water quality monitoring effort in FY 2002 to begin an increased focus on water quality work in the CRE and to allow better

integration with other biological and physical resource programs. GCMRC staff will conduct this project internally, although some analyses may be contracted.

External Project Awards: None

Project Accomplishments: Substantial temperature data was gathered during the LSSF experiments throughout the mainstem and in FY 2001. FY 2002 began a process of integration with fisheries and foodbase work and responsiveness to the Aquatic PEP Report.

Schedule: Sampling regimes and schedules are being developed as part of the IWQP five-year plan.

Budget: \$179,000

<b>INTEGRATED WATER QUALITY MONITORING - DOWNSTREAM</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)				
Biology Program Manager	1.00	6,230	5,150	5,000
Biologist - Aquatic	2.00	3,000	12,800	6,000
Hydrologist	0.00	29,000	24,000	0
Hydrologist - Limnologist	17.10	29,000	19,200	53,000
Hydrologic Technician	18.00	12,000	10,400	36,000
Ecologist		1,200	0	0
Biology Student		850	0	0
Contracts				
Biology		84,000	46,000	43,000
Technical Support Services				
Logistics		15,700	32,000	36,000
<b>TOTAL</b>		<b>180,980</b>	<b>149,550</b>	<b>179,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

## ***C. INTEGRATED TERRESTRIAL AND AQUATIC ECOSYSTEM ACTIVITIES***

### **ONGOING PROJECTS:**

#### **PROJECT TITLE AND ID: C.1a. INTEGRATED LONG-TERM MONITORING OF FINE-GRAINED SEDIMENT STORAGE THROUGHOUT THE MAIN CHANNEL**

**Rationale/Problem Statement:** 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.

**Integration:** Fine-sediment deposits along the main channel form many physical habitats for both terrestrial and aquatic organisms of the ecosystem. Fine-grained deposits are also sources and sinks for nutrients, recreational campsites and settings for in-situ preservation of cultural resources, with emphasis on role of aeolian processes. 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 physical and socio-cultural program managers.

**General 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.

**Project Goals and Objectives:** The *primary goal* is to collect annual and biennial measurements, report and evaluate system-wide relative changes in the morphology, volume and grain-size characteristics of fine-sediment deposits in aquatic and terrestrial settings of the main channel. These monitoring data will mostly be comprised of field measurements made using standard hydrographic and surveying methods within 45 previously monitored sand bars, as well as within six integrated monitoring reaches. Of particular concern are deposits within the first 240 miles downstream of the dam related to near-shore, terrestrial habitats, and recreational campsites, and areas where cultural resources occur. Habitats influenced by dam operations and fine-sediment storage include: aquatic near-shore habitats important to fish (backwaters and sandy shorelines that support vegetation), channel environments where benthic organisms occur and are affected by fine-sediment flux (cobble bars, debris fans and talus shorelines), terrestrial habitats that support riparian vegetation and associated fauna, terrestrial substrates used by recreational backcountry visitors, and terrestrial substrates that support and preserve cultural resources (frequently inundated sand bars and up to the tops of pre-dam river terraces).

*Secondary goals* shall be to relate changes in fine-sediment storage to dam operations, and to the distribution and condition of physical habitats of the aquatic and terrestrial ecosystem related to biological and socio-cultural resources of concern. These physical resource data provide information needed to interpret changes in cultural, recreational and biological resources relative to annual operations of Glen Canyon Dam.

Specific monitoring objectives of the project include change detection data:

- For pre-dam river terraces needed to determine the ongoing stability or erosion of these relict fine-sediment deposits of the pre-dam river associated cultural resources (biennial measurements),
- For near-shore aquatic and terrestrial substrates and associated fauna related to biological and cultural resources (biennial measurements),
- On grain-size (relative texture) and abundance (relative volume) of fine-sediments available for use in restoring and preserving sediment-dependent resources through periodic flow manipulation (biennial measurements),
- Availability and quality of recreational campsites in critical reaches and system-wide (annual measurements),
- Sand bar volume and area above 25,000 cfs at 45 previously monitored deposits (annual measurements),
- On the system-wide, channel-bed distribution of fine- versus coarse-sediment substrates (biennial measurements).

MOs Addressed: This integrated long-term monitoring project shall provide data related to the fine-sediment management objectives associated with Goal #8, as listed within Appendix Two. Within twelve integrated reaches, annual-to-biennial surveys of fine-sediment deposits of the main channel shall provide information on the condition of both terrestrial and aquatic sand bar morphologies and grain-size characteristics, including return-current channels (backwaters) and riparian plant substrates. In addition, fine-grained terraces that are relicts of the pre-dam system shall be monitored to detect lateral erosion, and any trends will be evaluated relative to historical changes in terraces determined through current synthesis research. The study reaches were selected in a way that: 1) compliments efforts to track the fine-sediment mass balance (including many existing study sites from the EIS period), 2) overlaps with terrestrial biological-cultural-recreational monitoring, and 3) coincides with aquatic study areas associated with native and non-native fishes. A system-wide subset of terrestrial sand bars will also be evaluated for recreational camping suitability at elevations above the 25,000 cfs stage.

**Expected Products:** Annual-to-biennial data on main channel topographic and grain-size changes of fine-sediment deposits that result from interactions between sediment supply and dam operations. Also required, shall be a system-wide, GIS-based map of the main channel documenting the distribution of channel-bed substrates, with specific emphasis on fine-versus coarse-sediment and bedrock. Annual progress reports based on change-detection data for fine-sediment deposits documenting relationships between the above physical data sets and related Colorado River ecosystem attributes. A final report on sand storage changes within study sites following year-5 monitoring shall be provided by the integrated study team. Emphasis shall be on relationships between fine-sediment distribution and near-shore aquatic and terrestrial habitats where vegetation and associated fauna, recreation and cultural resources are of management and scientific concern. Please see current Fact Sheets and publications on this project, available through the GCMRC web site.

**Expected products from this project include:**

- Annual progress reports on status of the monitoring project, and annual reports describing achievement of goals (e.g., time series depicting changes in the volume, area and grain-size distributions of fine-sediment storage, changes in pre-dam terraces related to cultural preservation sites, or changes in recreation camping beach availability above the 25,000 cfs stage),
- Annual GIS data sets related to change detection analyses related to main channel storage of fine sediment that result from tributary events, and interactions with dam operations,
- Annual technical presentations at GCMRC Science Symposia or Technical Workgroup meetings on the project's progress and results,
- Annual color *Fact Sheets* that summarize long-term monitoring trends in fine-sediment storage through the main channel of the Colorado River ecosystem,
- Participation in conceptual modeling workshops and related planning meetings that are periodically convened by GCMRC program staff and other cooperators,
- Final report, including interpretive results derived from monitoring and all data

**Recommended Approach/Methods:** Fine-grained sediment storage data will be measured throughout integrated monitoring reaches on a biennial schedule using a combination of remote and ground-based topographic survey and sedimentology measurements that characterize changes in grain-size, morphology and storage volume changes in fine-sediment deposits at prescribed long-term monitoring sites. Although more frequent sand storage measurements might be warranted on the basis of fine-sediment dynamics, the reduced FY

2004 science budget can only support biennial reach-scale measurements in six of the eleven originally designated monitoring reaches. To maintain continuity with previous monitoring, 45 pre-existing sand bar monitoring sites above and below Phantom Ranch will be surveyed on an annual schedule above river stage, with special emphasis on volumetric and area changes above the 25,000 cfs stage.

Campsite areas will be included within monitoring reaches as a subset of deposits monitored, and may eventually include a sub-sample of as many as fifty campsite areas located within reaches designated as “critical.” Campsite assessments shall be conducted annually within critical reaches using a combination of new technologies (computer mapping tablets) and existing survey methods to document campable areas at elevations above 25,000 cfs. Campsites outside of critical reaches will be monitored on a biennial schedule.

A suite of channel-substrate mapping methods shall be used within integrated monitoring reaches on a biennial schedule in the spring season to map the distribution of fine versus coarse sediment and bedrock channel-bed substrates. However, the spatial and temporal need for these data is still being evaluated as part of the long-term monitoring plan for sediment and ecological resources.

Under contingency plans, additional measurements of fine-sediment storage, channel-bed substrates and grain-size characteristics shall be conducted using additional fiscal resources in the event of large-scale flow experiments (e.g., BHBF and SASF).

**Status:** This is an ongoing monitoring project that was originally approved and implemented through a competitive solicitation process in FY 2001.

**External Project Awards:** Management and Cooperative agreements were established with two groups within the USGS, and two universities to accomplish this monitoring during FY 2001 and 2002: 1) Water Resources Discipline, 2) Geologic Discipline, 3) Northern Arizona University and 4) Utah State University. Additional funds were expended internally by the GCMRC to support student-staff salaries, accomplish tasks related to supporting field data collection, laboratory analyses of sediment samples, and replacement and repair of field and laboratory equipment and instrumentation. Projected funding for the FY 2004, portion of this project is shown in the budget table below.

**Project Accomplishments:** During water years 2001 through 2003, the project has supplied the GCMRC monitoring program with sand bar deposit topography and grain-size

data throughout the ecosystem, as well as annual data on changes in camping areas. The project has also been working toward completion of a decade-scale comparison (1990 to 2000) of changes in sand deposits within key reaches related to return-current channels (backwaters) and pre-dam river terrace deposits. New advances include methods for capturing very high-resolution data for channel-bed topography, bed substrates, as well as digital imagery of substrate grain-size distributions. This project is also producing digital ortho-photogrammetry data for sand bar area and volume at 45 pre-existing study sites. The purpose of this work is to extend the time series of those sites from 10 years (1991-2001) to 17 years (1984-2001). In addition, this project is also exploring new ways to use LIDAR data and ortho-rectified remote imagery to enhance the efficiency of change-detection mapping of sandy deposits.

**Schedule:** This ongoing, long-term monitoring program will enter its fourth year in FY 2004, and will be continued through FY 2005, under the modified budget and work plan, through annual modification of the FY 2001 agreements. During FY 2005, this monitoring program's scope, methods and accomplishments shall be evaluated through an additional PEP-SEDS review. During the external review process, special focus will be placed on the level of integration achieved with biological, cultural and recreational resource management issues, as well as revised management objectives and information needs. The monitoring project shall be continued as phase II, from FY 2006 through 2010, following the PEP review, and approval of funding.



### Integrated Fine-Sediment Storage Monitoring Project Time Line 2001-2005:

	2001	2002	2003	2004	2005
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
Integrated, Reach-Based Field Data Collection/Analysis (12 reaches), plus Selected Camping Areas & Sand bars	Planning for Reaches, plus Collect <u>Annual</u> Camp Areas & Sandbars	Collect <u>Biennial</u> Reach Data, plus <u>Annual</u> Camp Areas & Sandbars	Processing Reach Data, plus <u>Annual</u> Camp Areas & Sandbars	Collect <u>Biennial</u> Reach Data, plus <u>Annual</u> Camp Areas & Sandbars	Processing Reach Data, plus Collect <u>Annual</u> Camp Areas & Sandbars
Report and Data Delivery	Semiannual and Annual	Semiannual and Annual	Semiannual and Annual	Semiannual and Annual	Draft Final Reports
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
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

### Budget: \$459,000

FINE-GRAINED SEDIMENT STORAGE		FY-2002	FY-2003	FY-2004
Salary (includes benefits)	Pay periods:			
Physical Program Manager	4.10	8,900	8,500	16,000
Physical Resources Student	9.00		5,200	12,000
Biological Scientist		1,780	0	0
Ecologist		1,200	0	0
Cultural Program Manager	1.00	1,780	4,500	3,000
Contracts				
Biology		31,000	32,000	0
Cultural		87,000	75,000	91,000
Physical		230,000	237,000	259,000
Technical Support Services				
Logistics		117,600	52,000	57,000
Survey (Surveyor)	3.00	12,900	8,200	10,000
GIS	1.00		4,000	3,000
<b>TOTAL</b>		<b>492,160</b>	<b>426,400</b>	<b>\$459,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

Notes: The reduced budget (16 percent) for this core-monitoring project will limit the emphasis on integration of physical and biological data. Additionally, biennial measurements in FY 2004 shall be made in only 8 of the 11 originally designated monitoring reaches with emphasis on the upper one-third of the ecosystem. Funds reprogrammed from D.6 and D.7 shall be used to support additional studies on the role of aeolian processes near archaeological preservation sites.

**PROJECT TITLE AND ID: C.1b. LONG -TERM MONITORING OF FINE-GRAINED SEDIMENT STORAGE THROUGHOUT THE MAIN CHANNEL - Recreational Component - Monitoring Camping Beaches**

**Rationale/Problem Statement:** 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 sediment 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.

**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. They also comprise 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.

**General Project Description:** This component of the long-term sediment monitoring studies recreational camping beaches to determine if and how they are affected by flow releases. These beaches provide needed locations for recreational enthusiasts within the river corridor. Various flow regimes may affect the distribution, size, and availability of beaches.

**Project Goals and Objectives:**

- Record and monitor beach conditions and changes at selected beach locations within narrow and wide reaches throughout the river corridor.
- Provide an annual assessment of beach changes or stability to the AMP stakeholders and the NPS.
- Provide recommendations on the sources of beach change or stability and methodologies for assessing and monitoring beaches

**MOs Addressed:** This project addresses recreational management objectives MO 9.3.

**Expected Products:**

- Data collection at specified beach locations on an annual basis
- Coordinate beach monitoring efforts with sandbar monitoring, river terraces and other sediment data
- Provide an annual report incorporating camping beaches within larger sediment storage reports.

**Recommended Approach/Methods:** Fine-grained sediment storage data will be measured throughout monitoring reaches upstream of Phantom Ranch annually using a combination of remote and ground-based topographic survey and sedimentology measurements that characterize changes in grain-size, morphology and storage volume changes in fine-sediment deposits at prescribed long-term monitoring sites. Existing monitoring reaches above and below Phantom Ranch will be surveyed on an annual schedule, with special emphasis on reaches where relations between physical habitat and endangered native fishes are of interest (second population of humpback chub), or in years when changes in fine-grained sediment storage are influenced by flood flows.

Campsite areas will be included within monitoring reaches as a subset of deposits monitored, and may include a sub-sample located within reaches designated as “critical.” Campsite assessments shall be conducted annually within critical reaches using existing survey methods to document campable areas at elevations above 25,000 cfs. Campsites outside of critical reaches will be monitored on a biennial schedule. These data shall be related to stages up to at least 45,000 cfs, and possibly higher.

**Status:** This project was initiated in FY 2001 and is scheduled to continue through FY 2005, when it will be reassessed. The estimated cost for FY 2004 for the recreational component is \$25,000.

**External Project Awards:** The recreational component of this project has been awarded to Northern Arizona University, Department of Geology.

**Project Accomplishments:** Campsites are monitored on an annual basis through intensive field assessments. Annual reports are submitted providing an evaluation of the campsites.

**Schedule:** This is an on-going long-term monitoring project for the assessment of campsites. The final year of the project is FY 2005, when it will be reassessed.

<b>Fall</b>	<b>Winter</b>	<b>Spring</b>	<b>Summer</b>
<b>Annual October monitoring trip</b>	<b>Data analysis</b>	<b>Data analysis &amp; report write up</b>	<b>September report Delivery to AMP</b>

**Budget:**

See project C-1a (sediment component) above for budget information.

**PROJECT TITLE AND ID: C.2. INTEGRATED LONG-TERM MONITORING OF STREAM FLOW AND FINE-SEDIMENT TRANSPORT IN THE MAIN CHANNEL COLORADO, PARIA AND LITTLE COLORADO RIVERS**

**Rationale/Problem Statement:** Glen Canyon Dam operations, as prescribed by the Secretary's Record of Decision, and their relationship with downstream resources of management concern, are the primary focus of the ongoing Glen Canyon adaptive management program. It is therefore necessary that discharges from the dam be measured and reported, as well as data on suspended-sediment transport. Owing to the key role played by fine sediments throughout the ecosystem, it is also necessary to monitor key tributary stream flows and associated fine-sediment inputs that occur downstream from the dam. These combined data provide the basis for monitoring the ecosystem's mass balance of fine sediment relative to dam operations. Recent findings by USGS researchers on the relationships between ROD dam operations and fine-sediment dynamics of the ecosystem (please see *Current Knowledge* section for details) support increased efforts to monitor the monthly to seasonal flux of fine sediment into and out of the ecosystem.

Inflows from the Paria and Little Colorado Rivers are a major source of both inorganic and organic fine-sediments that support physical and biological habitats of the ecosystem. Therefore, field measurements of these inputs are required for tracking the system-wide fine-sediment and nutrient budgets. In addition, monitoring the export of fine-sediment out of the ecosystem is another vital component of the system-wide sediment and nutrient budgets related to estimating the residence time for inputs. Residence time and fate

of nutrients and fine inorganic sediments is related to dam operations, and influences the stability and characteristics of physical habitats, as well as biological processes.

During FY 2004, new methods will continue to be tested for monitoring influx versus of efflux of nutrients, in addition to fine inorganic sediment. To achieve this objective, several automated pumping samplers are planned for installation at key sites within major and lesser tributaries, as well as at sites along the main channel of the Colorado River. In addition, the USGS has reactivated one gaging station on the Paria River within southern Utah. Telemetry stage/discharge data from this station will allow sediment scientists a better chance to anticipate the occurrence and timing of floods that reach Lees Ferry. This advance information on Paria River sand inputs will better ensure the collection of “event” samples on this key tributary, and may provide some early notice to dam managers about the timing of new sand inputs that enter the Colorado River ecosystem.

Monitoring stream flow and suspended-sediment transport: (1) allows managers to track the status of fine-sediment flux into and out of the ecosystem on a seasonal to annual basis; (2) provides data that allow development of a 1-dimensional model for routing fine sediment through the main channel related to tributary sediment inputs “events” that can dramatically influence Colorado River ecosystem resources in both aquatic and terrestrial habitats; (3) provides data that supports interpretation of other monitoring data on the availability and grain-size of fine-grained sediment stored within geomorphic environments of the main channel; and 4) provides an opportunity to begin tracking a mass balance for suspended and dissolved organic and inorganic constituents of the ecosystem’s nutrient budget.

**Integration:** Stream flow is the fundamental parameter linking dam operations with changing conditions of downstream resources. Main channel and tributary stream flows play an integral part in driving sediment transport and dynamics of the nutrient budget, and thus in relating dam operations to changes in downstream resources linked to the sediment budget. Stream flow also links with nutrient flux between Lake Powell, the Paria and Little Colorado River and hundreds of *lesser* tributaries downstream from the dam that input both organic and inorganic constituents. Data on stream flow, sediment transport and quality of water need to be documented consistently throughout the ecosystem so that trends in non-physical

resources downstream of the dam can be linked back to dam operations, or to non-dam related factors.

**General Project Description:** This ongoing monitoring and research project represents the core of the long-term monitoring effort for fine-sediment, stream flow and downstream water quality resources. The project is intended to document: (1) discharges from Glen Canyon Dam at the existing Glen Canyon stream gage; (2) stream flows and fine-sediment inputs entering the Colorado River ecosystem from the Paria and Little Colorado Rivers at existing stream gages; (3) combined stream flows and fine-sediment transport along the main channel at the existing stream gages immediately below Glen Canyon Dam, at Lees Ferry and Grand Canyon (river miles -14, 0, and 87, respectively); (4) evaluations of model-derived estimates of fine-sediment inputs from the Paria and Little Colorado Rivers with sediment-transport field measurements; (5) model-reach characteristics before and after major tributary floods and evaluate channel changes with respect to model variables and modeling assumptions associated with those variables; (6) “event” data for stream flow floods and associated fine-sediment inputs that occur in *lesser* but significant drainage areas in Glen and Marble Canyons; (7) quality of water data from the above sites that contribute to biological program needs, particularly those needed for development of a system-wide nutrient budget.

**Project Goals and Objectives:** The major emphasis of this project will be to document the flux of stream flow, fine-grained sediments and nutrients system-wide through an existing network of USGS operated stream gages and numerical models developed for the gaged tributaries.

The *primary goal* is to document the flux of fine inorganic sediment into and out of the main channel of the ecosystem and relate this flux to data on annually collected system-wide storage of fine-sediment in the main channel. *Secondary goals* include improved understanding of stream flow and sediment-transport processes in gaged tributaries and along the main channel; continued data collection that supports flow and sediment model development and verification; and a consistent process for segregating sediment samples into their respective organic and inorganic components to support development of a nutrient budget-with an emphasis on Carbon and Phosphate. Both inorganic and organic components of the fine-sediment budget are known to influence organisms of the food base, as well as

physical habitats of the aquatic and terrestrial ecosystem, such as aquatic near-shore habitats important to fish, terrestrial habitats that support riparian vegetation and associated fauna, terrestrial substrates used by recreational backcountry visitors, and terrestrial substrates that support and preserve cultural resources.

These physical resource data shall be related to changes in cultural, recreational and biological resources relative to annual operations of Glen Canyon Dam and fine-sediment inputs downstream of the dam.

Specific monitoring objectives of the project:

- Measurement of unit-value discharge and fine-sediment transport along the main channel Colorado River between Glen Canyon Dam and Phantom Ranch, located at river miles –15 and 87, respectively,
- Measurement of unit-value discharge and fine-sediment transport of the Paria and Little Colorado Rivers, located at river miles 1 and 61, respectively,
- Characterize grain-size of channel-bed and transported fine sediments where discharge measurements are made, as well as at key intermediate locations,
- Monitor channel attributes of the Paria and Little Colorado Rivers within selected modeling reaches, and compare these data with assumptions associated with flow and sediment input model performance estimated for these tributaries,
- Evaluate and report on annual flux of fine sediment with respect to data for similar periods on status of channel-storage component of system-wide fine-sediment budget,
- Monitor and evaluate system-wide nutrient flux between Lake Powell, key tributaries and downstream reaches below Glen Canyon Dam.

MOs Addressed: This integrated physical resource monitoring project provides information needs related to management objectives lists specific MOs. Management objectives and information needs associated with long-term monitoring of dam operations, fine-grained sediment flux and stream flow throughout the main channel shall be obtained through this project by a combination of internal activities, as well as through a management agreement with the Water Resources Discipline (WRD). Additionally, key water quality parameters related to main channel, and gaged tributaries shall be obtained through the existing USGS stream gage network in support of biological management objectives and information needs.

**Expected Products:** Annual data reports on main channel and gaged tributary stream flows and sediment transport that reflect tributary inputs and interactions between those inputs and

dam operations. These measurements will reflect fine-sediment export from the Colorado River ecosystem (as determined at the Grand Canyon gage, as well as at one location upstream of the Little Colorado River confluence). Annual data and interpretive report(s) on stream flow and sediment transport relationships between tributary inputs and the main channel of management and scientific concern. Of particular concern will be reports and presentations to the GCMRC and Science Advisors assessing the performance of geomorphically based flow and sediment models for the Paria and Little Colorado Rivers.

Stream flow will be measured and reported in 15-minute unit values, and posted along with daily mean values on the USGS web site. Suspended-sediment and bed-sediment, and water quality samples will be collected and analyzed throughout the monitoring period on a daily to weekly basis and reported annually through the USGS web site. Monitoring of tributary model reaches shall be conducted periodically as needed relative to flows that have potential for changing channel characteristics related to model parameters and assumptions.

**Recommended Approach/Methods:** Ongoing measurement of stream flow, water quality, suspended-sediment concentration and grain-size, and bed-sediment grain-size characteristics at five main channel locations downstream of Glen Canyon Dam, and on established gages located on the Paria and Little Colorado Rivers. These measurements will be made using standard protocols established and maintained by USGS at similar monitoring sites nationwide. USGS personnel using standard methods at the GCMRC Sediment Laboratory will conduct analyses of sediment and water samples, and other laboratories as needed for nutrient budget purposes.

Motorized trips will be conducted to maintain five existing main channel stream gage sites, and to deploy intensive sediment sampling teams at above sites on a seasonal basis. Under contingency plans, additional measurements of stream flow, suspended and bed sediment concentration and grain-size characteristics will occur in the event of large-scale flow experiments.

**Status:** This is an ongoing monitoring project that was originally approved and implemented through an internally-negotiated management agreement between the GCMRC and Water Resources and Geologic Disciplines of the USGS during FY 2001. Collection of suspended-



sediment and water quality samples shall occur as a joint collaboration between the GCMRC and the WRD, as specified in the FY 2004 version of the management agreement.

External Project Awards: Management agreements were established with two non-GCMRC groups within the USGS to accomplish this monitoring effort during FY 2001 and 2002: 1) Water Resources Discipline and 2) Geologic Discipline. Additional funds were expended internally by the GCMRC to accomplish tasks related to supporting field data collection, laboratory analyses of sediment samples, and replacement and repair of field and laboratory equipment and instrumentation. Projected funding for the FY 2004, portion of this project is shown in the budget table below.

Project Accomplishments: During water years 2001 through 2003, the project has supplied the GCMRC monitoring program with hourly unit values of stage, discharge, temperature, specific conductivity and suspended-sediment data related to operations from Glen Canyon Dam. In addition, during the first three years of this monitoring project, additional intensive sediment-transport monitoring protocols were evaluated for the main channel and several of its tributaries. These protocols support the minimum data collection requirements for estimating the monthly mass balance of fine sediment throughout the ecosystem. Daily-to-weekly sediment data have been collected at both the Grand Canyon and Above Diamond Creek gages. Owing to budget reductions, support for surface-water data will be eliminated, and weekly suspended-sediment sampling at the above-Diamond Creek station may be discontinued in FY2004 and beyond. Stream flow and water quality data are available through the USGS - WRD web site, while sediment data are available through the GCMRC's ftp site. Stream flow and sediment monitoring protocols have been improved for both the Paria and Little Colorado Rivers, and additional monitoring instrumentation has been installed within several "lesser" tributaries within Glen and Upper Marble Canyons. Internal planning between the GCMRC and the WRD occurred during FY 2002, to develop monitoring protocols for collection and analyses of water quality samples obtained from the main channel of the ecosystem and key tributaries.

New Initiatives to Improve Monitoring: Improvements in data collection are intended to reduce uncertainties in estimates of fine-sediment influx (tributaries) and efflux (main channel) tied to the system-wide mass balance. Preliminary FY 2002, evaluations of suspended-sediment data collected using *Laser In-Situ Scattering and Transmissometry*

(LISST) technology indicates that such instruments have the potential to greatly improve estimates of the monthly mass of fine sediment exported from the ecosystem under ROD operations. Evaluation, and potential implementation, of the LISST technology is scheduled to continue through FY 2005. In addition, automated pumping samplers were installed and maintained in FY 2003, and beyond (pending available funds) at key sites throughout the ecosystem to further improve sand mass balance estimates. Finally, added “advance alert” instrumentation was installed and operated (pending availability of funds) in the upper Paria River drainage areas, so that dam operators may gain increased planning time for combining peak power-plant releases with significant fine-sediment inputs from this key tributary. Please see budget tables for additional details on the costs associated with these new initiatives.

**Schedule:** This long-term monitoring program will enter its fourth year in FY 2004, and will be continued annually through at least FY 2005, through an annually through modification of management agreements with the Water Resources and Geologic Disciplines of USGS. Status of the monitoring program methods, temporal and spatial scale shall be evaluated through a PEP-SEDS approach during year 5; with special focus on the level of integration with biological resource management and information needs. This project shall be ongoing in FY 2006 through 2010, following a second PEP-SEDS review, and approval of funding.

## Integrated Stream Flow and Sediment-Transport Monitoring Project Time Line

**2001 - 2005:**

	2001	2002	2003	2004	2005
Project Conducted Internally Within USGS, on Basis of Management Objectives & IN's	Two New Management Agreements, Signed, 2001	Renewed as Modification of MA's, Fall 2001	Renewed as Modification of MA's, Fall 2002	Renewed as Modification of MA's, Fall 2003	Renewed as Modification of MA's, Fall 2004
Data Collection and Analyses for Fine-Sediment Mass Balance	Flow & SS Collected, Hourly to Weekly, w/ Ongoing Analysis	Flow & SS Collected, Hourly to Weekly w/ Ongoing Analysis	Flow & SS Collected, Hourly to Weekly w/ Ongoing Analysis	Flow & SS Collected, Hourly to Weekly w/ Ongoing Analysis	Flow & SS Collected, Hourly to Weekly w/ Ongoing Analysis
Report/Data Delivery	Quarterly to Semi-annual and Annual	Quarterly to Semi-annual and Annual	Quarterly to Semi-annual and Annual	Quarterly to Semi-annual and Annual	Preparation, Draft Final Reports
Project Technical Coordination and Review/Evaluation	Monthly to Annually by GCMRC	Monthly to Annually by GCMRC	Monthly to Annually by GCMRC	Monthly to Annually by GCMRC	Externally Reviewed by PEP & SA's
Schedule for Project Progress and Completion	Annual Progress Report	Annual Progress Report	Annual Progress Report	Annual Progress Report	Final Reports by June 30, 2006

**Budget: \$470,000**

<b>STREAMFLOW AND FINE-SEDIMENT TRANSPORT</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay Periods:			
Physical Program Manager	10.00	8,900	21,250	38,000
Physical Research Student	15.10	11,900	15,600	20,000
Biology Program Manager		1,780	0	0
Ecologist		1,200	0	0
Cultural Program Manager		1,780	0	0
Contracts				
Biology		72,000	74,000	0
Physical		408,000	420,000	373,000
Technical Support Services				
Logistics		98,000	44,000	39,000
Survey		4,300	0	0
<b>TOTAL</b>		<b>607,860</b>	<b>574,850</b>	<b>470,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

Notes: Owing to the reduced budget (20 percent) of this core-monitoring project, support for surface-water measurements shall be eliminated for the above-Diamond Creek streamgage. In addition, weekly suspended-sediment sampling at the above site may need to be reduced to summer season only, or completely eliminated. These reductions will result in reduced certainty of fine-sediment efflux from the western portion of the ecosystem (downstream of river mile 87). The budget reductions will also reduce the level of participation by certain WRD scientists in the mass-balance project compared to FY2001-2003.

**PROJECT TITLE AND ID: C.3. INTEGRATED LONG-TERM MONITORING OF COARSE-GRAINED SEDIMENT INPUTS, STORAGE AND IMPACTS TO PHYSICAL HABITATS**

**Rationale/Problem Statement:** 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. Coarse-grained sediment inputs also include organic particles, such as woody matter that add to the ecosystem's Carbon budget.

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).

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.

**Integration:** 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.

**General 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.

**Project Goals and Objectives:** The *primary goal* is to annually document and evaluate coarse-sediment inputs from tributary debris flows and floods. *Secondary goals* include evaluating annual coarse-sediment inputs to: local and system-wide changes in aquatic and terrestrial physical habitats, storage settings for fine-sediment deposits, impacts to campsites caused by debris-flow deposits, changes to navigational characteristics of rapids, etc.

Specific monitoring objectives of the project include change detection:

- Distribution and abundance of coarse substrates associated with biological habitats,
- Quality of recreational campsites and navigational conditions in rapids,
- For conditions and potential for fine-sediment storage in pools and rapids.

MOs Addressed: This integrated long-term monitoring project provides data related to management objectives 8.1, 8.2, 8.3, 8.4, 8.5, and 8.6. Information shall be provided on changes in the navigational characteristics of rapids, degradation of terrestrial sand bars, enhancement of sand-storage potential within upper pools and recirculation zones (eddies), distribution of cobble bars, and other aspects of physical habitat characteristics related to channel geomorphology.

**Expected Products:** Annual data on coarse-sediment inputs to main channel that result from tributary events, and interactions between coarse-sediment storage and dam operations. Annual progress report(s) that include information on ecological linkages between the above data sets and related Colorado River ecosystem resources. Progress reports shall also include information about changing physical-habitat conditions relating to biological, recreational resources and main-channel fine-sediment storage and mass balance.

Expected products from this project include:

- Semi-annual progress reports on status of project, and annual reports describing achievement of goals (for example, incorporation of historical data into conceptual sub-model for geomorphic framework during year one),
- Annual data on coarse-sediment inputs to main channel that result from tributary events, and interactions between coarse-sediment storage and dam operations,
- Periodic interpretive reports on progress of the monitoring project, as well as collaborative efforts with GCMRC conceptual modeling group(s) toward simulating ecological linkages between the above data sets and related Colorado River ecosystem resources, including changing conditions of biological habitats, recreational resources and main-channel fine-sediment storage,
- Annual GIS data sets related to change detection analyses related to inputs and related impacts of coarse-sediment that result from tributary events, and interactions with dam operations,
- Annual technical presentations at GCMRC Science Symposia or Technical Workgroup meetings on the project's progress and results,
- Annual color *Fact Sheets* that summarize long-term monitoring trends in fine-sediment storage through the main channel of the Colorado River ecosystem,

- Participation in conceptual modeling workshops and related planning meetings that are periodically convened by GCMRC program staff and other cooperators.

**Recommended Approach/Methods:** A combination of remotely and field-based survey measurements documenting annual impacts from tributary debris flows and floods on the texture and topography of debris fans of the main channel, substrates of the terrestrial and aquatic habitats, and characteristics of rapids and campsites. These data shall be used in combination with annual channel-substrate mapping data collected as part of the long-term monitoring of fine-sediment storage to assess the magnitude of pre- versus post-tributary event impacts.

**Status:** This is an ongoing monitoring project that was originally approved and implemented through a competitive solicitation process in FY 2001.

**External Project Awards:** A new management agreement was established with one group within the USGS to accomplish this monitoring during FY 2001 and 2002: 1) Water Resources Discipline; funded at approximately \$70,000.00 per year. Additional funds were expended internally by the GCMRC to support student-staff salaries, accomplish tasks related to supporting field data collection, laboratory analyses of sediment samples, and replacement and repair of field and laboratory equipment and instrumentation. Projected funding for the FY 2004, portion of this project is shown in the budget table below.

**Project Accomplishments:** During water years 2001 and 2002, the project has supplied the GCMRC monitoring program with new information of debris-flow impacts that occurred at several sites throughout the ecosystem during 1999 through 2001. In addition, two USGS color *Fact Sheets* and one USGS *Water Resources Research Investigation Report* (Webb et al., 2001) were published during FY 2001, that describe the protocols of this long-term monitoring project, as well as recent findings on debris-flow impacts, and estimates of total sediment contributions annually from all 768 lesser tributaries.

**Schedule:** This long-term monitoring program will be continued into its fourth year in FY 2004, and will be continued annually through at least FY 2005 through an annually renewal of the management agreement with the WRD. Status of the monitoring program methods, temporal and spatial scale shall be evaluated through a PEP-SEDS approach during years 4-

5; with special focus on the level of integration with biological resource management and information needs. This project shall be ongoing in FY 2006 through 2010, following the next PEP-SEDS, and approval of funding.

### **Integrated Coarse-Sediment Monitoring of Inputs and Impacts Project Time**

#### **Line 2001 - 2005:**

	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>
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

#### **Budget: \$135,000**

<b>COARSE GRAINED SEDIMENT INPUTS</b>	<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits) Pay periods:			
Physical Program Manager 3.0	8,900	8,500	11,000
Biology Program Manager	1,780	0	0
Ecologist	1,200	0	0
Cultural Program Manager	1,780	0	0
Physical Research Student 1.0		1,300	1,000
Contracts			
Physical	77000	79000	71,000
Technical Support Services			
Logistics	35300	43000	47,000
Survey 1.0	4,300	4,100	3,000
GIS 0.5		2,000	2,000
<b>TOTAL</b>	<b>130,260</b>	<b>137,900</b>	<b>135,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**Note:** Owing to budget reductions (9 percent for external support), the integrated components of this core monitoring project (coarse sediment inputs and influence on fisheries habitats and non-native spawning) will be reduced.



**PROJECT TITLE AND ID: C.4.A. INTEGRATED STREAM FLOW AND SUSPENDED-SEDIMENT TRANSPORT MODELING WITHIN THE COLORADO RIVER ECOSYSTEM (An Ongoing Two-Part Research Project)**

**Part A: *MODELING REACH-AVERAGED SAND BAR EVOLUTION IN RESPONSE TO A RANGE OF DISCHARGE AND SEDIMENT CONDITIONS ALONG THE MAIN CHANNEL***

**Note:** Originally proposed as two separate research efforts in the FY 2001 annual plan, these two modeling projects described below have been combined into one effort and initiated in FY 2002. The main reasons for combining the two projects was to promote scientific integration in the models development, as well as cost efficiency among the two projects, as they are intimately related to one another. The start date of this research project was delayed owing to a need by the GCMRC to seek increased competition during the solicitation process.

**Rationale/Problem Statement:** One useful method that has been used to screen options for managing fine-grained sediment deposits along the main channel has been development of a conceptual model that includes flow routing and sedimentation sub-routines. Unfortunately, the existing model lacks the capability to predict sand bar deposition and erosion locally at sites where 3-D bar morphology and process-rate information is needed (fate of backwater habitats, for example). By selecting representative sub-reaches in which process-based sediment-transport and stream flow modeling can be developed, estimates of sand bar responses can be predicted in ways that allow for 3-D bar morphologies to be better anticipated under changing flow and sediment supply conditions.

Predicting sand bar size and morphology is critical for anticipating how sand bars supporting physical habitats will respond over short and long periods to a range of sediment supply conditions and experimental dam operations, such as the current treatment. This modeling capability also allows for large-scale flow experiments, especially those intended for sand bar restoration, to be evaluated in advance of conducting field tests. Screening of large-scale experiments through preliminary modeling is one way to assess and minimize risks associated with alternative flood-flows, such as BHBFs of variable duration and floods in excess of 45,000 cfs under varied sediment supply conditions. In addition, sand bar simulations allow managers and scientists opportunities to better design flood experiments related to key hypotheses that need to be addressed, such as short and longer-term impacts to

the system's fine-sediment budget, distribution and characteristics of camping beaches, abundance and availability of backwater habitats, and potential for fine-sediment deposition along river terraces containing cultural resources.

**Integration:** Sand bar distribution, size and morphology are related to habitat types thought to be important to biological organisms of the ecosystem, such as early life stages of the Humpback chub. Dam operations affect not only the fine-sediment budget of the system, but also the individual characteristics of sand bars that support habitat types, such as backwaters. In addition, sand bar characteristics also affect recreational campsites and settings where cultural resources are preserved. As a result, being able to predict how the range of dam operations and sediment conditions relate to sand bar abundance and morphologies can help promote integrated understanding of how physical and non-physical resources are related to dam releases.

**General Project Description (Part A):** Development of a sediment-transport model capable of predicting 3-dimensional sand bar evolution under a range of dam operations and sediment supply conditions in selected geomorphic reaches of the main channel. The model development shall be conducted in a way that results in predictions of reach-averaged sand bar responses within geomorphic reaches identified by GCMRC and Ecometric Research, Inc., in advance of the project (FY 2000 activity). The model will also be able to simulate changing bar conditions at specific sites of concern, provided that high-resolution channel geometry is available for the reach or site of interest.

**Part A Project Goals and Objectives:** The *primary goal* is to advance the understanding of sediment and flow processes along the main channel, while developing reach-averaged estimates of sand bar deposition and erosion under varied sediment supply conditions and dam operations up to 100,000 cfs. These estimates shall be based on selected portions of individual geomorphic reaches defined on the basis of average channel attributes and (or) proximity to points of major sediment inputs.

*Secondary goals* are: to produce data on estimated exchanges of fine-sediment transfer between eddies and the main channel for use in development of a 1-dimensional sand-transport model for routing fine sediment inputs through the main channel to Upper

Lake Mead; to evaluate evolution of specific sand bar types related to backwaters and other physical habitats; to better estimate sand bar building flows related to distribution of camping areas, and to assess sand-bar deposition and erosion potential along pre-dam terraces where arroyo development threatens *in-situ* preservation of cultural resources. Because all flood flows must be routed through the relatively sediment-depleted Glen Canyon reach, it is crucial to conduct simulations to determine whether such flows are likely to erode pre-dam river terraces.

**MOs Addressed:** This integrated physical resource research project shall provide information related to predicting influences of dam operations on fine sediment and related resources as described in management objectives 8.1, 8.2, 8.3, 8.4, 8.5, and 8.6. This research project shall provide: (1) greater understanding of flow and depositional processes related to sand bar evolution; (2) predictive insight into the fate of individual sand bar types and site-specific morphologies under a range of hypothetical conditions; and (3) sand-storage exchange data between eddies and the main channel within key reaches where 1-dimensional fine-sediment export predictions are needed.

**Expected Products:** Numerical model code and documentation on model development and use within study reaches of the main channel. Model output data on flow and sediment-transport simulations for a range of conditions as specified by the GCMRC. Interpretive report(s) on model theory and assumptions related to sediment storage changes along geomorphic reaches related to dam operations and fine-sediment flux.

**Recommended Approach/Methods:** Limited development and verification of similar modeling capability has been previously undertaken by the U.S. Geological Survey, for the reach between river mile 61 and 72 below Glen Canyon Dam. Results of these activities indicate good correspondence with documented floods in 1993 and 1996 that have resulted in bar building in this reach. Methods similar to these are currently being used in the same reach to support information needs related to the cultural resources program. It is assumed that such methods will likely be successful when applied to other geomorphic reaches throughout the ecosystem.

**PROJECT TITLE AND ID: C.4.B. INTEGRATED STREAM FLOW AND SUSPENDED-SEDIMENT TRANSPORT MODELING WITHIN THE COLORADO RIVER ECOSYSTEM (Cont.)**

**Part B: *DEVELOPMENT OF A ONE-DIMENSIONAL FINE SEDIMENT-ROUTING MODEL ALONG THE MAIN CHANNEL***

**Rationale/Problem Statement:** At present, the instability of bed-storage grain-size distributions and related sediment-transport rating curves for measurement sites on the main channel (Lees Ferry, above confluence with Little Colorado River, Grand Canyon, and above Diamond Creek) make it impossible to estimate changes in the ecosystem's fine-sediment budget over time frames of interest to managers (hours to seasons). To document changes in the storage of fine sediment in critical reaches, the current approach is to make relatively intensive field measurements for suspended-sediment transport. Such measurements are difficult to obtain for extended periods, costly to analyze, and are often associated with errors large enough that long-term sediment budgeting has little meaning. Development of a fine-sediment routing model that can track the fate of tributary inputs over hours to weeks can provide rapid evaluation of short-term changes in the system-wide flux of fine sediment needed to evaluate the influence of dam operations.

**Integration:** The ability to accurately estimate the export of fine sediment from the ecosystem following tributary floods is vital for predicting the potential for restoration of sediment-dependent resources through controlled floods. A major premise of the management program is that downstream resources may be preserved and sustained when a positive fine-sediment budget is maintained-one where sand supplies are available for manipulation through controlled floods. Sediment routing models allow for evaluations on how effective current dam operations are at maintaining a positive supply of stored fines in the main channel. This information is another source of information that can be used to relate non-physical resources back to dam operations.

**General Project Description (Part B):** A research program to develop an efficient numerical method for evaluating the influence of dam operations on tributary sediment inputs (sand and silt/clay) and the related fine-sediment budget. A numerical method of routing

fine-sediment through the ecosystem is needed to track the fate of channel-stored sediment over short periods following tributary floods from the Paria and Little Colorado Rivers. This capability is also needed to make advance estimates of fine-sediment export from the ecosystem that result from planned or unplanned flood flows, as well as to simulate impacts of alternative dam operations. Because the grain-size distribution of channel-stored fine sediments directly impacts transport rates, this model will focus on tracking sediment loads in 1-dimension (tied to existing flow-routing model) for several size classes of sand, as well as silt and clay.

**Part B Project Goals and Objectives:** The *primary goal* is to obtain a 1-dimensional sediment routing model that links stream flow to suspended transport of fine sediment between, at a minimum, Glen Canyon Dam and the Grand Canyon stream gage near Phantom Ranch. *Secondary goals* include improved understanding of relationships between suspended-sediment transport and grain-size evolution of fines stored on the channel bed; improved ability to track fine-sediment budget within critical reaches for periods of weeks to months following gaged tributary floods; improved estimates of the residence time for storage of fine inputs in main channel eddies and pools relative to ROD dam operations.

**MOs Addressed:** This sediment-transport research project provides information needs related to predictions about how dam operations influence fine sediment and related resources, as described in management objectives 8.1, 8.2, 8.3, 8.4, 8.5, and 8.6. Successful development of this model and predictive capability has the potential for allowing managers to more quickly assess the system-wide influences of dam operations on fine-sediment inputs from gaged tributaries, while reducing the need for intensive field measurements and delays caused by laboratory analyses of sediment-transport samples.

**Expected Products:** Numerical model code and documentation on 1-D routing model development and use within the main channel below Glen Canyon Dam. Model output data on flow and sediment-transport simulations. Interpretive report(s) on model theory, linkages with results of 3-D eddy and sand bar simulations, and descriptions of the key model assumptions related to numerical estimation of fine-sediment flux along critical reaches related to dam operations and gaged tributary fine-sediment flux.

**Recommended Approach/Methods:** Conceptually, this sediment routing model shall combine the existing stream flow routing model (USGS) with results from 3-D sand bar evolution simulations, as well as existing reach-averaged channel geometry data, sediment-transport theory, and ongoing sediment-transport and stream flow monitoring data collected as part of core long-term monitoring of stream flow and sediment. Input data for model simulations will include unit-value discharge data from Glen Canyon Dam and associated downstream gage network site, fine-sediment input data from the Paria and Little Colorado Rivers (existing flow-based sediment models), and estimated antecedent conditions of grain size for main channel bed storage.

The model's initial development will be followed by an intensive verification period in which stream flow, suspended-sediment concentration and grain size, and bed grain-size distribution data (above the confluence of the Little Colorado River and Grand Canyon gages) will be compared with model simulation outputs. The length of this required verification period will be dependent on the desired range of dam operations for which the model is intended to be used, and level of tributary flood activity that occurs following model development.

**Status:** An ongoing research project that was originally approved and implemented through a competitive solicitation process during FY 2002.

**External Project Awards:** Management and Cooperative agreements are scheduled to be established (pending final approval) with three groups, the USGS and two universities, to initiate this research during FY 2002-03: 1) Water Resources Discipline, 2) The Johns Hopkins University and 3) Utah State University. Additional funds were expended internally by the GCMRC to support student-staff salaries, accomplish tasks related to supporting field data collection, laboratory analyses of sediment samples, and replacement and repair of field and laboratory equipment and instrumentation. Projected funding for the FY 2004, portion of this project is shown in the budget table contained in the following section.

**Project Accomplishments:** In the first two years of the project technical coordination meetings were held between the research team and the GCMRC. In addition, initial reaches were identified for model simulation, full-channel geometry data sets were assembled, geomorphic reaches were identified, and plans were made for conducting flume experiments at The University of Minnesota.

**Part B Schedule:** This research was initiated in FY 2002, through release of a competitive solicitation and will likely continue as a research effort through at FY 2004. The post-development verification may last an additional period of several years, but will be supported through collection of ongoing stream flow and sediment-transport data at main channel gage sites. Emphasis for development of sediment routing prediction will be on critical upstream reaches where fine-sediments and related physical habitats are of most interest - Glen Canyon Dam to river mile 87 (Grand Canyon gage). Ultimately, the point at which sediment export is simulated may extend down to Diamond Creek. This project shall be supported through long-term monitoring program for stream flow and sediment transport (USGS, Arizona District). Additional sediment-transport data needs within Lower Marble Canyon for this project resulted in an expansion of long-term monitoring in FY 2002, under elements of project C.2. Eventually, the successful development of this sediment routing model may reduce the need for intensive suspended-sediment sampling of the main channel that is currently required to track the fine-sediment flux following large floods on the Paria and Little Colorado Rivers.

### **Integrated Sand Bar Evolution and Fine-Sediment Routing Modeling Project**

#### **Time Line 2002 - 2004:**

	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>
RFP Development/Release (April 2001)	Award of Agreements in Fall 2001	Initial Funding is Ongoing	Modified in Fall 2003	Model Development Completed
Data Collection/Analysis	Annually	Annually	Annually	Finalizing GUI's
Report/Data Delivery	Annually by December 31	Annually by December 31	Draft Reports by December 31	Revising Final Reports
Project Review/Evaluation	Annually by GCMRC & SA's	Annually by GCMRC & SA's	Annually by GCMRC & SA's	Externally Reviewed by PEP and SA's
Schedule for Project Completion	Progress Report 12/02	Progress Report 12/03	Progress Report 12/04	Finalize Reports by 12/05

**Budget: \$231,000**

<b>SEDIMENT TRANSPORT MODELING</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay periods:			
Physical Scientist	3.0	8,900	8,500	11,000
Biology Program Manager		1,780	0	0
Biologist - Terrestrial		3,000	0	0
Cultural Program Manager		1,780	0	0
Physical Research Student	1.0		1,300	1,000
Contracts				
Cultural		26,00	17000	18,000
Physical		179,00	184000	177,000
Technical Support Services				
Logistics		16,00	10000	12,000
Survey (Surveyor)	3.0	17,200	8,200	10,000
GIS	0.5		2,000	2,000
<b>TOTAL</b>		<b>233,660</b>	<b>231,000</b>	<b>231,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**PROJECT TITLE AND ID: C.5. DEVELOPMENT OF A COLORADO RIVER ECOSYSTEM CONTROL NETWORK**

**Rationale/Problem Statement:** Currently, about half of the CRE has geographic control that has met the needs of near and long-term monitoring and research plan. However, the existing control network requires the coordinates to be upgraded to the NGS rim control standard as well as set control in the remainder of the CRE. Upgraded survey control is required throughout the CRE to fully implement the monitoring and research plan.

**Integration:** Accurate spatial positioning of scientific data facilitates integration across resource areas by providing common geographic framework to store and analyze data. Many resource monitoring programs depend upon changes in the spatial distribution of resources as the basis of their monitoring strategy. Spatial analysis tools such as a GIS depend upon accurate geo-referencing of data to provide meaningful analysis. Without geographic control, geo-referencing of resource data and subsequent spatial analysis is impractical.



**General Project Description:** GCMRC researchers and contractors requiring data collection in the Colorado River Ecosystem (CRE) need geographic control to spatially position their data. Geographic control is the infrastructure to any mapping product. Public Land Survey Township and Range polygons, digital elevation models (DEM), or orthophotos are common types of geographic control. However, the most common reference to control pertains to survey control points that consists of well-defined and monumented location within the study areas. Survey control points typically represent the highest accuracy possible given the available technology. GPS or conventional survey technology is generally used to establish control points.

**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 a line-of-sight interval depending upon terrain.

**MOs Addressed:** The survey control network is fundamental to spatially positioning all scientific data collected as part of the GCDAMP. This project supports MOs identified in all integrated terrestrial and aquatic ecosystem activities.

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

- A network of survey control points established at line-of-sight intervals in the CRE from the GCD to the headwaters of Lake Mead.
- A report describing the methods, its construction, and control identifiers and locations.
- An index map showing the location of control points using the 2000 orthophotography as a backdrop.

**Recommended Approach/Methods:** Control points will be established using two industry standard survey methods, GPS and conventional survey practices. In the CRE, conventional survey practices means the use of a total station and one or more survey targets.

Conventional traverse control involves starting at a known reference point, then setting a series of line-of-sight points and closing out at the point of beginning or another known reference point. Conventional survey methods will always be required to fill-in where satellite visibility is too obstructive for GPS. Conventional methods are used for all types of location surveys including topography and site location.

GPS technology will be used to set accurate control as well as a basis for remote sensing and ground topography. GPS is utilized to establish high order control points in the Canyon. This requires that a receiver or receivers be placed at known control points on the rim or in the canyon. Then additional receivers are used to set new points.

PEP Recommendations: The preliminary physical science PEP conducted in the summer of 1998 has recommended the continued development of a control network in their list of action items. In addition, all cultural, biological, physical, and remote sensing PEP's recommended scientific activities that require a control network throughout the canyon.

**Status:** Ongoing. Originally approved and implemented in FY 2000.

External Project Awards: None.

Project Accomplishments:

- Collected geodetic GPS (Global Positioning System) control data to upgrade river corridor control to NGS (National Geodetic Survey) rim control standards. Areas of survey work include: RM 30-55, 60-65, and 120-130 and long-term monitoring reaches.
- Established new NGS rim control standards on two new strategic rim control points during an NGS co-observation. These points include Eminence Break and Desert View.
- Control trip in August 2001. Collected geodetic GPS control data to upgrade river corridor control to NGS rim control standards. Areas of survey work include all of the LSSF (Low Steady Summer Flows) control points used so that they may be adjusted and used for comparison of remotely sensed data.

**Schedule:** The CRE control network schedule has been modified to reflect changes in the long term monitoring sites of the biological, cultural, and physical resource programs to be implemented in 2002.

**Project Timeline 2000 - 2004**

	2000	2001	2002	2003	2004
RM 72-90 plus select points in GIS areas	January-December				
RM -15-72 less select points in GIS areas		January-December			
RM 93-99, 120-123, 133-138, 143-145, 179-181, 207-210, 225-230 and 273-276 (old GIS sites)			January-December		
RM 99-120, 138-143 and 145-179				January-December	
RM 181-207 and 210-225					January-December
Completed					December

**Budget: \$86,000**

<b>CONTROL NETWORK</b>		<b>New in FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Technical Support Services	Pay Periods:			
Logistics			49,000	54,000
Surveyor	3.00	6,880	13,120	10,000
Surveying Technician	10.10	11,400	23,600	22,000
GIS				
<b>TOTAL</b>		<b>18,280</b>	<b>85,720</b>	<b>86,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**PROJECT TITLE AND ID: C.6. DEVELOPMENT OF COLORADO RIVER ECOSYSTEM HYDROGRAPHIC MAPPING PROGRAM**

**Rationale/Problem Statement:** Hydrographic mapping is the best method currently available to measure sub-aqueous topography.

**Integration:** Hydrographic technology is used in the Grand Canyon primarily to measure changes in the river channel. The primary changes that occur are due to the movement of sediment. These changes are monitored by hydro-acoustic measurements that are accurately positioned over the course of the river channel. The hydrographic data collection method is designed to develop required monitoring and research products such as topographic maps, digital terrain models, sediment aggregation and degradation, hydrologic stage discharge

modeling, and cross-section analysis. These products support the following projects: system wide channel mapping, fine-grained sediment storage, coarse-grained sediment, streamflow and fine-grained sediment transport, modeling reach-averaged sand bar evolution, and aquatic bio-monitoring.

**General Project Description:** The hydrographic mapping program facilitates all monitoring efforts requiring sub-aqueous measurements. The two areas of hydrographic mapping consist of an ongoing system-wide channel map and a repeatable reach monitoring for annual change detection.

**Project Goals and Objectives:** The objective of the project is to develop:

- Complete mapping sections of river between GCD and Phantom Ranch in 2003.
- Monitor approximately 30 miles of river channel annually for repeatable change detection of the river channel.

**MOs Addressed:** Hydrographic channel mapping addresses MOs associated with the Physical Science Program's Sand Storage Change Detection Monitoring and Channel Modeling project.

**Expected Products:** The products of the hydrographic channel-mapping project will be:

- A complete hydrographic channel map of the CR to Phantom Ranch at a resolution that would allow a contour interval of a quarter-meter without interpolation in 2002.
- A DEM of the CR channel bottom from the GCD to Phantom Ranch in 2002.
- A report describing the hydrographic mapping and data processing methods used in the map and DEM production.

Products will conform to GCMRC data standards and be integrated with terrestrial base maps produced as part of the terrestrial mapping project (i.e., the LIDAR mapping). The combined terrestrial and hydrographic maps and DEMs will provide the three-dimensional canyon geometry required for accurate change detection.

**Recommended Approach:** The multibeam approach will be used for most of the data collection because of its higher resolution and productivity. Multibeam technology is the only method available to accomplish the objectives within the projected time frame.

**Status:** Ongoing. Originally approved and implemented in FY 2000.

**External Project Awards:** None.

**Project Accomplishments:** Completed 30 miles of hydrographic channel mapping of the CRE in 2001. It is anticipated that an additional 20 mile of channel mapping will be completed in 2002 and 40 miles in 2003.

**Schedule:** The hydrographic channel mapping schedule of the CRE has been modified to reflect changes in the long term monitoring sites of the biological, cultural, and physical resource programs to be implemented in 2002.

**Project Timeline 2000 - 2004**

	2000	2001	2002		2004
RM 1-3, 7.5-8, 8.5-12, 16, 22, 29-31, 42-45, 60-65 and 68	January-December				
RM 31-42 and 45-60		January-December			
RM -2.2 - 0.0, 1.1-2.8, 3-7, 21.9-23.6, 29.4-32, 42.5-45.4, 54.4, 56.1, 63.3-66.2, 68-75, 86.4-87.9, 87-90, 119.1-123, 207.3-208.9, and 224.3-225			January-December		
RM 99-120, 138-143, 145-160 and 162-165				January-December	
RM 181-207, 210-225					January-December

**Budget: \$128,000**

<b>CHANNEL MAPPING</b>		<b>New in FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Technical Support Services				
Logistics			82,000	90,000
Surveyor	8.10	15,480	24,600	27,000
Surveying Technician	5.00	17,100	11,800	11,000
<b>TOTAL</b>		<b>32,580</b>	<b>118,400</b>	<b>128,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

## ***D. OTHER SCIENCE ACTIVITIES***

### **ONGOING PROJECTS:**

#### **PROJECT TITLE AND ID: D.1. UNSOLICITED PROPOSALS**

The GCMRC proposes to retain \$35,000 in FY 2004 to support unsolicited proposals. This will allow for flexibility in the program and help ensure that GCMRC can address critical issues in a timely fashion. It will also provide GCMRC the ability to fund truly outstanding proposals that addresses a key concern that may be overlooked in the research planning process. All unsolicited proposals will be discussed with the TWG and will undergo independent, external peer review prior to funding.

The GCMRC encourages Tribal groups to submit proposals for projects that address resource issues related to Management Objectives. Because these groups define their resource issues from tribal perspectives and formulate their work proposals, the GCMRC considers these submittals as unsolicited proposals. These proposals are reviewed by internal and external peer reviewers to evaluate the proposed project methodologies relative to the project objectives. Unsolicited proposals may be submitted to the GCMRC at any time. At the present time, the ongoing Adopt-a-Beach project is anticipated for FY 2004. The project description and budget follow.

#### **ADOPT-A-BEACH PROJECT**

**Rationale/Problem Statement:** Recreational beaches can be impacted by flows and unexpected debris flows. Regularly scheduled field monitoring generally occurs on quarterly and biannual basis and impacts can be experienced during this time. Volunteer river guides are monitoring beaches on a constant basis and can provide immediate information on impacts.

**Integration:** To achieve an ecosystem-level understanding of the relationships between resources of the CRE and Glen Canyon Dam operations, integration of long-term monitoring between physical, cultural, biological, and recreational resources is required. This project

will provide a means to provide immediate information concerning a recreational and physical resources and impacts to assist in the ecosystem assessment of the resources.

**General Project Description:** Through volunteer efforts, this project collects repeat photographic data on changes at selected beaches throughout the CRE. Project data supplements quantitative data collected under other protocols. Data are collected through out the river season and presently consist of several years of archived data. The project personnel disseminate data at educational and other public workshops.

**Project Goals and Objectives:**

- Collect repeat photographic data at selected beach locations ranging from 3 to 10 photographic sets
- Provide qualitative data to assist in focusing quantitative efforts
- Provide volunteer efforts to assist the AMP in resource monitoring

**MOs Addressed:** This project addresses recreational resource management objectives MO 9.3.

**Expected Products:**

- Photographic data collection of selected beach locations
- Integrative data report on beach changes relative to flow regimes
- Education and data dissemination to recreational community

**Recommended Approach/Methods:** Repeat photographic monitoring of selected beaches provides immediate information on impacts to these resources. Photo locations and methods are standardized. Qualitative data provide a mechanism to focus more labor intensive and costly assessments.

**Status:** This project is ongoing and was originally approved and implemented in 1996.

**External Project Awards:** Annual awards have been made to the Grand Canyon River Guides (GCRG) for this project, subject to acceptance of their unsolicited proposals.

**Project Accomplishments:** An annual report is submitted to the GCMRC by the GCRG. In addition, the project data are disseminated at the annual Guides training session prior to the river season, through the Boatman's Quarterly journal, and at workshops and the GCMRC science symposium.

**Schedule:** This project is ongoing on an annual basis, subject to receipt and acceptance of an unsolicited proposal. A project review will be scheduled prior to FY 2004 funding to evaluate integration and utility with other GCMRC projects.

<b>Fall</b>	<b>Winter</b>	<b>Spring</b>	<b>Summer</b>
<b>Data compilation and analysis</b>	<b>Data analysis and report write up</b>	<b>Workshops Data dissemination</b>	<b>Report delivery and new data collection</b>

The following budget refers to all unsolicited proposals in FY 2004.

**Budget: \$48,000**

<b>UNSOLICITED PROPOSALS</b>	<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits) Pay periods:			
Cultural Program Manager 1.00		4,500	3,000
Contracts			
Biology	72,000	49,000	35,000
Physical			0
Cultural	51,000		
Adopt-A-Beach		10,000	10,000
<b>TOTAL</b>	<b>123,000</b>	<b>63,500</b>	<b>48,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**PROJECT TITLE AND ID: D.2. AMWG & TWG REQUESTS (IN TARGETS)**

In addition, GCMRC historically budgets funding that can be used in support of requests that arise from the AMWG and TWG during the course of the year. In FY 2004 GCMRC proposes to use this \$60,000 to continue the development of target levels for the Management Objectives begun in FY 2002. This has been identified as an important activity during the development of the revised Information Needs. This will be a collaborative process where GCMRC brings scientific information that establishes a range within which a target can be established and the TWG, on behalf of the AMWG, makes a recommendation regarding where within the range the target should be established.



**Budget: \$60,000**

<b>AMWG &amp; TWG REQUESTS</b>	<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits) Pay periods:			
Chief 1.00		7,700	5,000
Biology Program Manager 1.00		5,150	5,000
Contracts	61,000	63,000	50,000
<b>TOTAL</b>	<b>61,000</b>	<b>75,850</b>	<b>60,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**PROJECT TITLE AND ID: D.3. IN-HOUSE RESEARCH**

The GCMRC supports in-house research by GCMRC Program Managers and scientific staff. In-house research is supported as a means of ensuring that GCMRC program managers and scientific staff remain subject area experts in their respective fields through the conduct of their own research on the Colorado River ecosystem. Funds totaling \$16,000 will be available to support these activities in FY 2004. This also ensures that they are able to provide the highest quality of technical assistance in the form of expert analysis, opinion, and advice to the Chief, TWG and the AMWG as requested. In-house research may be in the form of original research or synthesis. In all cases, GCMRC in-house research proposals undergo the same independent external review as all GCMRC proposals.

**Budget: \$16,000**

<b>IN-HOUSE RESEARCH</b>	<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)			
Contracts - Cultural		5,000	
Operating Expenses	20,000	21,000	16,000
<b>TOTAL</b>	<b>20,000</b>	<b>26,000</b>	<b>16,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**PROJECT TITLE AND ID: D.4. TRIBAL OUTREACH: TRIBAL TRAINING, SCIENCE/TRIBAL PERSPECTIVES INTEGRATION/TRIBAL INTERNS**

**Rationale/Problem Statement:** Dissemination of information collected within the GCMRC cultural resource program for the benefit of the Adaptive Management Program Stakeholders and the interested public. This project implements the recommendations of the Cultural Resource PEP to coordinate with AMP stakeholders and the Native American representatives to disseminate information.

**Integration:** To achieve an ecosystem-level of understanding of the relationships between resources of the Colorado River and Glen Canyon Dam operations, integration of long-term monitoring between physical, cultural, biological, and recreational resources is required. This project will provide a means to disseminate cultural resource information concerning the ecosystem resources.

**General Project Description:** Incorporation of Tribal stakeholder perspectives within the AMP/GCMRC project development, implementation and activities. The project provides a mechanism for the integration of tribal perspectives within western science projects including the use of tribal interns for projects and activities at GCMRC and with AMP stakeholders. Tribal outreach activities may address several AMP activities rather than a specific project.

**Project Goals and Objectives:**

- Increase tribal participation within AMP project development and implementation
- Increase tribal participation within AMP project activities
- Utilize tribal interns to assist in project development, implementation and activities
- Link project with other public outreach/involvement efforts

**MOs Addressed:** This project addresses cultural resource management objectives MO 11.1 and 11.2.

**Expected Products:**

- Conduct workshops at GCMRC provide training to tribal stakeholders on technological issues, specific legislative issues, and other AMP specific issues.
- Utilize tribal interns within GCMRC and AMP stakeholders to assist with project development, implementation and activities.
- Provide AMP with report of activities of this project and recommendations for future activities

**Recommended Approach/Methods:** Methods include, but are not limited to, recruiting tribal interns to participate in GCMRC program and activities and conducting workshops and trainings for tribal stakeholders.

**Status:** This project is a continuation of work approved in FY 2003 and provides a mechanism to fund numerous types of activities as they are suggested. The estimated cost in FY04 is \$45,000.

**External Project Awards:** There have been no external awards to date.

**Project Accomplishments:** There are no accomplishments to date, as this project has not been initiated.

**Schedule - Project Time Line FY 2004:**

<b>Fall</b>	<b>Winter</b>	<b>Spring</b>	<b>Summer</b>
<b>Initiate efforts to recruit tribal interns. Schedule workshops and trainings</b>	<b>Conduct workshops, trainings, utilize interns</b>	<b>Continue workshops, use of interns</b>	<b>Report write up to AMP</b>

**Budget: \$45,000**

<b>TRIBAL OUTREACH</b>		<b>New in FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay periods:		
Cultural Program Manager	2.00	4,500	7,000
Cultural Assistant	6.00		8,000
Other Operating Expenses			
Tribal Participation and Workshops		40,000	30,000
<b>TOTAL</b>		<b>44,500</b>	<b>45,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**PROJECT TITLE AND ID: D.5. PUBLIC OUTREACH / INVOLVEMENT PLAN IMPLEMENTATION**

**Rationale/Problem Statement:** Implementation of a project to disseminate information collected within the program for the benefit of the Adaptive Management Program Stakeholders and the interested public.

**Integration:** To achieve an ecosystem-level of understanding of the relationships between resources of the Colorado River and Glen Canyon Dam operations, integration of long-term monitoring between physical, cultural, biological, and recreational resources is required. This project will provide a means to disseminate information concerning the ecosystem resources.

**General Project Description:** Implementation of a plan to disseminate information collected within the cultural resource program and other resource areas for the benefit of the Adaptive Management Program Stakeholders and the interested public. In conjunction with an ad hoc group of the AMWG and pursuant to Executive Orders relative to Tribal consultation, GCMRC is developing public outreach activities. To coordinate GCMRC's overall public outreach efforts and the public outreach efforts under Reclamation's Programmatic Agreement program, a public outreach/involvement plan is necessary. This project will implement the public outreach plan that was approved in FY 2003. Plan implementation will address cultural sensitive data and the dissemination processes will be discussed with Native American groups prior to project implementation. This project implements the recommendations of the Cultural Resource PEP to coordinate public outreach efforts by AMP stakeholders, including Native American representatives to disseminate information. This plan forms a portion of the overall Historic Preservation Plan suite of documents. Project is also funded by Reclamation.

**Project Goals and Objectives:**

- Implement a plan to guide and coordinate dissemination of cultural material

- Implement a plan to coordinate dissemination of material from other resource areas.
- Incorporate and address issues concerning culturally sensitive data and dissemination processes with Native American groups and other concerned parties
- Implement mechanisms for information dissemination and education.
- Implement for participation of the stakeholders in the dissemination process.

**MOs Addressed:** This project addresses cultural resource management objectives MOs 11.1, 11.2, 11.3.

**Expected Products:**

- Implement Public outreach/involvement plan
- Identification of current outreach efforts and future mechanisms for information dissemination include presentations, workshop materials, and scoping efforts to expand dissemination efforts

**Recommended Approach/Methods:** An RFP was issued for the outreach plan development in FY 2003. This project will implement the recommendations of that plan.

**Status:** The development of the outreach plan was approved in FY 2003. This project, plan implementation is new for FY 2004. This is a new project proposed for FY 2004 for the duration of one year. The estimated cost for the project is \$ 21,000.

**External Project Awards:** There have been no awards to date, as this project will be awarded in FY 2004.

**Project Accomplishments:** There are no accomplishments to date, as this project has not been awarded.

**Schedule - Project Time Line FY 2004:**

<b>Fall</b>	<b>Winter</b>	<b>Spring</b>	<b>Summer</b>
<b>RFP drafted and released (October 2002)</b>	<b>Project awarded</b>	<b>Workshops for plan implementation</b>	<b>Report on plan implementation</b>

**Budget: \$21,000**

<b>PUBLIC OUTREACH INVOLVEMENT PLAN IMPLEMENTATION</b>		<b>New in FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay period:		
Cultural Program Manager	1.00	4,500	3,000
Cultural Assistant0	6.00		8,000
Contracts			
Cultural		30,000	10,000
<b>TOTAL</b>		<b>34,500</b>	<b>21,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**\$0**

Project eliminated in FY04, funds reprogrammed to Project C.1, Aeolian Process Studies Near Archaeological Sites.

**\$0**

Project eliminated in FY04, funds reprogrammed to Project C.1, Aeolian Process Studies Near Archaeological Sites.

**PROJECT TITLE AND ID: D.8. EXPERIMENTAL FLOWS**

Discussions concerning experimental flow treatments are ongoing. To date, specific treatments have been proposed for FY 2004. An overview of the long-term experimental flows program is provided here and a preliminary budget figure which may support some but not all of the additional research and monitoring required is presented.

**General Project Description:** In response to the AMWG motion passed on January 18, 2002, the Grand Canyon Monitoring and Research Center (GCMRC) is recommending a program of annual experimental treatments spanning a multi-year time period rather than a single year flow scenario. The decision to expand from the specific directive of the motion to develop a single year flow scenario is motivated by the desire of GCMRC to forward a recommendation that embraces a defensible experimental design and is consistent with the principles of ecosystem science and adaptive management. If the experimental design proposed in this document is adopted by the AMWG, each treatment (e.g., high fluctuating flows from January through March) is proposed for two years. If the monitoring program

measures unintended or adverse affects from a treatment, a proposal to end the treatment will be considered.

The notion that the evaluation of a single experimental flow scenario evaluated for a single year will lead to improved learning in an adaptive management framework has been repeatedly criticized. These criticisms are founded, most basically, in the recognition that an experiment without control, replication, or evaluation is not an experiment. Additionally, it has been shown that scientists have a very bad track record for predicting the outcome of single treatment evaluations, and that relying on this tact usually leads to costly mistakes. Based on these premises, GCMRC provides below a discussion of what it believes are the critical elements of a good experimental design and what general steps are required in order to execute an experiment likely to yield increased understanding of processes shaping key resources in Grand Canyon.

An experiment fundamentally relies on three elements: control, treatment replication, and treatment evaluation. The first element, control, is necessary so that the response of the key indicator variable (e.g., sediment storage) to a treatment event (e.g., Beach Habitat Building Flow) can be compared to the state of the key indicator variable during a non-treatment event (e.g., Record of Decision flow). In this way, the state of the key indicator variable during a non-treatment event is the so-called control or “baseline condition”. The difference between a baseline condition and the treatment response is essentially the fundamental measure of a treatment effect. It is the cumulative affects of individual treatments, when taken together that comprise an experiment.

The second element, treatment replication, is of paramount importance in the context of a large-scale field experiment conducted in a complicated system like the Colorado River ecosystem. This is most easily recognized by considering the suite of non-treatment factors that could be responsible for inducing a response in the indicator variable. For example, consider that humpback chub recruitment is likely mediated by a host of factors both within the Little Colorado River and in the mainstem Colorado River. If we seek to understand the relationship between humpback chub recruitment and one potential controlling factor such as competition/predation with rainbow trout, we must necessarily manipulate the abundance of rainbow trout. However, if poor humpback chub recruitment occurs under the current baseline condition of high rainbow trout abundance, and high humpback chub recruitment

occurs under a treatment condition where rainbow trout abundance is lowered, we cannot necessarily conclude that competition/predation with rainbow trout is the controlling factor. This is because there may be some other factor responsible for the high humpback chub recruitment. The only way to have a chance of disentangling this situation is to have multiple treatments (replication) of high and low rainbow trout abundance and evaluate whether the relationship to humpback chub recruitment is robust across these different treatments.

The third element, treatment evaluation, is commonly referred to as monitoring. A robust monitoring program is perhaps the most critical element in a multi-year experiment since it is the mechanism that evaluates the state of the key indicator variable (e.g., sediment storage or humpback chub recruitment). The precision of the treatment evaluation is usually the most important factor in determining the likelihood that an experiment will yield valid results.

GCMRC is confident that monitoring programs for sediment and key fish species are robust enough to consider implementing multi-year experiments. Furthermore, declines in sediment and fish resources detailed in the following document illustrate the need for experimentation in order to discover policy options to reverse these disturbing trends.

GCMRC recommends the initiation of a long-term experiment beginning in year one with the treatment recommended in this document. The year one treatment is consistent with the AMWG motion. GCMRC also recommends a process for developing subsequent year treatments in consultation with the Technical Work Group, Science Advisors, and experts in the field of adaptive management and experimental design. GCMRC has included a draft series of treatments that could be implemented over a 16-0year timeframe as a point of departure for discussions with these groups.

We would suggest that monitoring and research mechanisms be in place to scientifically evaluate, on a yearly basis, the response of both the targeted resources, as well as interactions with other secondary resources in this ecosystem. Having such an evaluation mechanism would allow for a means to assess and determine whether or not to: (1) discontinue a specific treatment if observed to be deleterious; (2) prescribe a management prescription; and (3) include other factors for future testing. However, we also suggest caution in the use of such an evaluation method so as to avoid truncating an experiment



prematurely without due cause. The following table illustrates various choices along with treatment elements designed to benefit native fishes in the context in which they would be considered in a longer term adaptive management experiment.

**Table 2.4. Experimental Design, Long-Term Sequence of Treatments**

<b>Water Year</b>	<b>Fluctuating Flows (Jan – Mar)</b>	<b>Mechanical Removal (Aug – Dec)</b>	<b>Stable Fall Flows (Aug – Dec)</b>	<b>TCD (Future)</b>	<b>BHBF (Jan – Jul)</b>
WY2002-03	Yes	Yes	Yes	No	?
WY2003-04	Yes	Yes	No	No	?
WY2004-05	No	Yes	Yes	No	?
WY2005-06	No	Yes	No	No	?
WY2006-07	No	No	Yes	No	?
WY2007-08	No	No	No	No	?
WY2008-09	Yes	No	Yes	No	?
WY2009-10	Yes	No	No	No	?
WY2010-11	Yes	Yes	Yes	Yes	?
WY2011-12	Yes	Yes	No	Yes	?
WY2012-13	No	Yes	Yes	Yes	?
WY2013-14	No	Yes	No	Yes	?
WY2014-15	No	No	Yes	Yes	?
WY2015-16	No	No	No	Yes	?
WY2016-17	Yes	No	Yes	Yes	?
WY2017-18	Yes	No	No	Yes	?

**IN REPOSE TO THESE RECOMMENDATIONS THE FOLLOWING PROPOSED EXPERIMENTAL RELEASES FROM GLEN CANYON DAM AND REMOVAL OF NON-NATIVE FISH WAS ADOPTED BY THE SECRETARY OF THE INTERIOR IN DECEMBER OF 2002 AND IMPLEMENTATION WAS BEGUN IN JANUARY OF 2003.**

Three Department of the Interior agencies, the Bureau of Reclamation (Reclamation), National Park Service (NPS), and U.S. Geological Survey (USGS), are proposing a series of experimental releases of water from Glen Canyon Dam and mechanical removal of non-native fish to help protect native fish, particularly the endangered humpback chub (collectively “proposed action”). The dam releases are also designed to conserve fine sediment in the Colorado River corridor in Grand Canyon National Park. Reclamation has responsibility for the dam operations aspects of the proposed action, while the NPS and Grand Canyon Monitoring and Research Center (GCMRC: USGS) have responsibility for the mechanical removal.

The purpose of the proposed action is: (1) to contribute to the conservation of endangered native fish, especially the humpback chub, by reducing populations of non-native fish who compete with and prey on native fish in the Colorado River between Glen Canyon Dam and Lake Mead; (2) to conserve fine sediments that form sandbars, beaches, and habitat for young native fish by altering dam operations; and (3) to improve the Lees Ferry sport fishery by reducing the overabundance of trout. These proposals are within the constraints established by applicable federal statutes (commonly known as the “Law of the River”) and other applicable legal obligations.

The need for the proposed action arises because: (1) the Grand Canyon population of endangered humpback chub has declined to levels that threaten its viability and future existence, and (2) fine sediment has been exported to such an extent that camping beaches and sandbars, including those that form native fish rearing habitat, continue to be washed downstream and lost. These changes have occurred during operation of Glen Canyon Dam under the 1996 Record of Decision (ROD) by the Secretary of the Interior. They suggest that the predictions of resource responses to dam operations in the 1995 environmental impact statement were, in some respects, incorrect. The proposed action would provide important information that will be used as additional operational and physical modifications are considered regarding future operation of Glen Canyon Dam.

The proposed action was deemed necessary by the Glen Canyon Dam Adaptive Management Program (GCDAMP), which is comprised of 25 member agencies, Native American tribes, and organizations, because endangered species and sandbars in the Grand Canyon have not responded as well as predicted to past management actions regarding the operation of Glen Canyon Dam. The proposed action is the product of years of scientific study and would implement the recommendation of an independent advisory committee, the Adaptive Management Work Group, that has been studying the natural and cultural resources of the Grand Canyon since 1997. It is multi-faceted and complex, and has been designed to protect both the endangered species and the important beach habitat found in the Grand Canyon.

## **PROPOSED ACTION**

**The Proposed Action consists of two major elements:**

1. A set of hydrological scenarios and experimental dam releases that are triggered by minimum sediment inputs to the Colorado River from tributaries; and
2. Reduction of non-native fish populations, primarily rainbow and brown trout, through mechanical removal and experimental releases from Glen Canyon Dam.

Experimental Flows— Proposed dam operations include five types of releases, in addition to ROD operational flows, that would occur within four hydrological scenarios over a period of at least two water years. The five proposed release types are:

- 8,000 cfs steady flows,
- 6,500-9,000 cfs fluctuating flows,
- 5,000-20,000 cfs fluctuating non-native fish suppression flows<sup>4</sup>,
- 31,000-33,000 cfs habitat maintenance flow, and
- 42,000-45,000 cfs high flows. The magnitude of these short-term releases would not exceed 45,000 cfs but they would vary below this level depending on Lake Powell elevation and generator availability.

The order in which the releases would occur depends on the amount of sediment inputs from the Paria River or ungaged tributaries in Glen Canyon and upper Marble Canyon. However, under the proposed action the fluctuating non-native fish suppression flows would occur independent of sediment availability.

The first release scenario is called the *autumn sediment input scenario*. It would occur if three conditions are met. First, if at least 500,000 metric tons of fine sediment enters the Colorado River from the Paria River and ungaged upper Marble Canyon tributaries between July 1 and October 31, then dam releases would change from current ROD operations to a series of alternating 2-week long steady 8,000 cfs releases and 2-week long 6,500-9,000 cfs fluctuating releases. If the minimum sediment input does not occur, dam releases would continue to follow the prescription of the ROD.

Second, if at least 1,000,000 metric tons of fine sediment enter Marble Canyon by October 31, the alternating steady and fluctuating releases would continue. If the minimum sediment input does not occur by that date, dam releases would follow the prescription of the ROD. By December 1, a comparison would be made of the effectiveness of sediment conservation by the 8,000 cfs steady releases and the 6,500-9,000 cfs low fluctuating

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<sup>4</sup> Maximum flow, upramp and downramp rates could be adjusted through the adaptive management and environmental compliance process during the second year of non-native suppression flows if the proposed action is not achieving the objectives of the experiment or is creating unanticipated adverse effects.

releases. The action agencies within the Department of the Interior would decide which flow is most effective at sediment conservation and discontinue the less effective release.

Third, if at least 800,000 metric tons of sediment input are retained in the Colorado River between Glen Canyon Dam and the Little Colorado River by January 1 of the ensuing year, then a powerplant and jet tube total release between 42,000-45,000 cfs would occur in the first week of January in an effort to “bank” the conserved sediment at higher elevations within the Grand Canyon. This high flow would last for approximately 60 hours. Upramp rates for this release would be 4,000 cfs/hour for the first two hours, then 1,500 cfs/hour up to powerplant capacity, then opening one bypass tube in two steps over the course of six hours until reaching jet tube capacity. The downramp rate would be 1,500 cfs/hour from maximum releases (42,000-45,000 cfs) to 8,000 cfs and this would take about 22 hours to achieve. A steady release of 8,000 cfs would be continued for a period not to exceed 10 days during which time aerial photography and surveying would occur to document the effect of the high flow test on sediment conservation and other resources.

If the minimum sediment accumulation does not occur by January 1, dam releases would change to fluctuating non-native fish suppression releases between 5,000 cfs and 20,000 cfs with an upramp rate of 5,000 cfs/hour and a downramp rate of 2,500 cfs/hour. The fluctuating non-native fish suppression flows would continue from January through March unless a minimum sediment input of 800,000 metric tons is received.<sup>5</sup>

If the minimum tributary sediment input of 800,000 metric tons occurs in the months of January-March during fluctuating non-native fish suppression flows, the *winter sediment input scenario* would begin with the release of 42,000-45,000 cfs. This release would have the same features as the high flow test under the autumn sediment input scenario, including the succeeding period of 8,000 cfs steady releases for aerial photography and surveying. It would interrupt the non-native fish suppression flows, but they would be resumed through the end of March following the high flow test and ensuing steady releases.

The third hydrologic scenario is the *no sediment input scenario*. In this scenario, the minimum sediment inputs necessary to trigger the autumn sediment scenario or the winter

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<sup>5</sup> These fluctuating non-native fish suppression flows were designed to mimic pre-1990 daily fluctuations and ramp rates. Pre-1990 flows limited natural recruitment of rainbow and brown trout. The proposed downramp rate of 2,500 cfs/hour was also selected to test the validity of the beach seepage model used to formulate the ROD downramp constraints.

sediment input scenario do not occur. Under these conditions ROD operations would continue until at least July 1 of that water year, except for the January to March period of fluctuating non-native fish suppression flows. Dam releases after July 1 would depend on tributary sediment inputs. If minimum tributary inputs occur and the first scenario has been completed, the fourth hydrological scenario would be initiated. If they do not occur, ROD operations would continue.

The fourth hydrological scenario is the *habitat maintenance flow scenario*. This scenario would be implemented only under two conditions: (1) the autumn sediment input scenario must have been completed, and (2) a minimum tributary sediment input of 500,000 metric tons must occur between July 1-December 31.<sup>6</sup> This scenario is similar to the winter sediment scenario in that a high flow would immediately follow the tributary input, but in this case the dam release would be limited to powerplant capacity, last two days, and have 4,000 cfs/hr upramp rates and 1,500 cfs/hr downramp rates.

Total flow, including tributary inputs and dam releases, during this scenario will be limited to 45,000 cfs. It is estimated that the Paria River flow necessary to provide the minimum sediment input would be approximately 2,500 cfs, though in rare events Paria River flows could be as high as 12,000 cfs. Thus, the combined powerplant capacity and tributary flow would be in the approximate range of 33,500 cfs (31,000 cfs dam release + 2,500 cfs tributary inflow) to 43,000 cfs (31,000 dam release + 12,000 cfs tributary flow). If the combined flows would exceed 45,000 cfs, then dam releases would be reduced to constrain total flow to 45,000 cfs or less. The close association in timing of the sediment input and the ensuing dam release would be facilitated through installation of additional gages on the Paria River to serve as an early warning system announcing the inflow.

The habitat maintenance flow would be followed by ROD operations with daily fluctuations until January 1 unless another minimum 500,000 metric ton input occurred, in which case the powerplant capacity releases would be repeated, followed again by ROD operations. On January 1, if there was a minimum sediment retention of 800,000 metric tons in the reach of the Colorado River between Glen Canyon Dam and the Little Colorado River, a high flow of 42,000-45,000 cfs would be released from the dam having the same features as

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<sup>6</sup> If the minimum sediment input trigger does not occur during the first or ensuing years of proposed action operations, the autumn sediment input scenario would continue to receive the highest priority for completion in the following year.

that under the autumn sediment input scenario or winter sediment input scenario. If the minimum amount of sediment is not retained above the Little Colorado River, fluctuating non-native fish suppression releases would be initiated following the January 1 evaluation. These releases would continue until April 1 unless additional sediment was received by the Colorado River sufficient to bring the sediment retained up to the 800,000 metric ton minimum. This amount of additional sediment in the system would trigger a two-day 42,000-45,000 cfs high flow having the same features as in the winter sediment input scenario. Following this high flow, the non-native fish suppression flows fluctuating between 5,000-20,000 cfs would continue through March 31. Dam releases would then revert to those prescribed under ROD operations.

Although the proposal is focused on water years 2003 and 2004, it could take an indeterminate number of years to implement the sediment conservation portion of the proposed action due to the necessary sediment input triggering involved. To ensure that development of a program of experimental flows benefits the resources of concern, the Adaptive Management Work Group has directed GCMRC to report back at six-month intervals on relevant resource conditions.

**Mechanical Removal of Non-Native Fish**—A second key component of the proposed action is assisting native fish through mechanical removal of non-native fish. Non-native fish removal is targeted at reducing adult rainbow and brown trout and other non-native fish in the Colorado River near the confluence of the Little Colorado River. The area around the confluence of the Colorado and Little Colorado rivers has the highest abundance of adult and juvenile humpback chub in the Colorado River mainstem. To help the humpback chub in this reach, an area located approximately five miles upstream (RM 56.4) to four miles downstream (RM 65.8) from the confluence of the Little Colorado and Colorado rivers has been proposed as the “depletion reach.” The proposed depletion effort (i.e., the removal of non-native fish by electrofishing techniques) would be uniformly distributed within this 9.4 mile reach and repeated six times a year in the 2003-2004 water years.

Each year for two years, GCMRC is proposing to conduct three depletion trips from January to March and three depletion trips from July to September.<sup>7</sup> During each 10-day

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<sup>7</sup> The exact timing of these trips could be adjusted through the adaptive management process to minimize adverse effects to humpback chub. The effort would also yield information regarding abundance of young-of-

field trip there would be five passes through the reach using four electrofishing boats that concurrently sample the river on opposing sides. Following each trip, the data would be used to construct abundance estimates for rainbow and brown trout present at the beginning of each trip. Comparisons among trip population estimates and trip catchability coefficients would be analyzed to evaluate if mechanical removal is an effective means to control undesirable fish species. Additionally, electrofishing and hoopnet collections would be used to measure juvenile humpback chub relative abundance and any potential adverse effects on adult humpback chub.

A fish anesthetic will be used to euthanize the non-native fish. The proposed disposal mechanism for non-native fish would be to transport the fish out of the Grand Canyon. In response to concerns expressed by Native American tribes, remains of the non-native fish will be used as fertilizer on gardens tended by tribal members.

#### MITIGATION MEASURES

The following measures have been agreed upon to remove or mitigate potentially negative effects of the proposed action.

No mechanical removal of non-native fish by electrofishing will occur within 50 feet of the point (line) of the confluence of the Little Colorado River and Colorado River.

Non-native fish euthanized during mechanical removal activities will be preserved and transported out of Grand Canyon to lands of the Hualapai tribe where they will be used as fertilizer in gardens maintained by the tribe for food.

Approximately 25% of the vegetation and Kanab ambersnails that could be washed downstream by the experimental high flow under the autumn sediment input scenario will instead be removed from the path of the flood and then replaced after the flood has passed.

A number of young-of-year humpback chub, not to exceed 300, that might otherwise be carried into the Colorado River and suffer a high rate of mortality will be translocated out of the lower Little Colorado River to the perennial reach above the series of travertine falls called Atomizer Falls. This reach does not contain the endangered fish, probably because the

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year humpback chub and complement existing monitoring efforts.

falls are too high, but research using caged humpback chub indicates that they can survive there.



**Budget: \$-500,000**

<b>EXPERIMENTAL FLOWS</b>		<b>New in FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay periods:		w/o sediment	w/sediment
Biologist Fisheries-1	12			35,000
Biologist Fisheries-2	12			28,000
Biologist Aquatic	12			34,000
1 Mass Balance of Fine Sediment		113,000	255,000	420,000
2 FIST		20,000	490,000	500,000
4 Primary Productivity, Carbon Flux ...		125,000	30,000	25,000
5 Temperatures & Habitat Use Mon....		0	0	200,000
6 Modeling EHF Sand-Bar Responses		0	0	62,000
7 Coarse-Sediment & Conceptual Mon.		0	0	49,000
8 Kanab Ambersnail Population		0	10,000	10,000
9 Foodbase Impacts of EHF Flows		0	0	50,000
13 Monitoring of Rainbow Trout Adult		24,000	66,000	0
14 Distribution of Spawning Redds		0	132,000	100,000
15 Determination of the Mechanism Acct ...		0	0	125,000
16 Food Base Impacts of Fluctuating Flows		0	60,000	60,000
17 Mechanical Removal		95,000	635,000	551,000
19 Rainbow Trout Diet Analysis		32,000	164,000	123,000
20 Predation of Humpback Chub...		0	58,000	58,000
22 Sediment Deposition in Arroyos		0	25,000	25,000
25 Impacts to Concessionaires/Anglers		0	0	0
27 Changes in Camping Beaches		0	20,000	25,000
29 Administrative Support		2,000	5,000	5,000
30 Technical Support				
Computer Support - .5 Student		0	23,000	21,000
Survey Costs - Equipment		0	55,000	32,000
<b>Subtotal</b>		<b>411,000</b>	<b>2,028,000</b>	<b>2,538,000</b>
<b>Funding Sources:</b>				
Funding from Reclamation		500,000	500,000	500,000
Funding from Appropriations			500,000	1,000,000
Agency Contributions				500,000
GCMRC Salary Contribution				38,000
<b>TOTAL</b>		<b>411,000</b>	<b>2,028,000</b>	<b>-500,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

## **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 2004 monitoring and research annual plan.

#### **GCMRC ADMINISTRATION**

The GCMRC is administered by a Chief and four program managers (physical, biological, 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 through the conduct of their own research 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 Information Technologies program has personnel with specific responsibility for systems administration, data base management, GIS, remote sensing, and surveying activities. These personnel assure critical support to GCMRC monitoring and research program. 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.

The GCMRC will continue to conduct logistics for its programs in FY 2004, 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 2004.

## **E. ADMINISTRATIVE AND MANAGEMENT**

### **E.1. Administrative Operations**

The Administrative Operations budget provides for Center leadership, facilities, various operating expenses, and other direct costs for GCMRC activities. Other administrative functions are provided by the Southwest Biological Science Center (SBSC), which is the USGS cost center that supports the GCMRC. SBSC provides financial, budget, and acquisitions support and is funded through the USGS assessment. At the time SBSC was established in October 2002, several positions including the administrative officer, administrative assistant, one-half of the secretary and a part-time student assistant were transferred from GCMRC to SBSC to form a centralized administrative support center. These positions are no longer paid directly through GCMRC funds but are now supported through the USGS assessment. As a result of the

reorganization, GCMRC continues to receive the full range of Administrative Services without additional cost to project funds.

**Budget: \$620,000**

<b>ADMINISTRATIVE OPERATIONS</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay periods:	425,280		
Chief	10.00		38,500	46,000
Secretary <sup>(1)</sup>	13.05		40,320	25,000
Administrative Officer <sup>(1)</sup>	0.00		63,920	0
Administrative Assistant <sup>(1)</sup>	0.00		34,000	0
Student Assistant - Secretary <sup>(2)</sup>	0.00		14,000	0
Student Assistant - Staff <sup>(1)</sup>	0.00		8,400	0
Awards		20,000	25,000	25,000
Travel		25,000	34,000	34,000
Space and Telecommunications		184,000	186,000	190,000
Vehicle Lease & Maintenance		32,000	32,000	50,000
Training & Conference Attendance		18,000	18,000	18,000
Contract: Clerical Assistance <sup>(2)</sup>				15,000
Supplies and Materials		48,000	51,000	57,000
Equipment		20,000	20,000	20,000
Travel & Network Support - USGS FSC		65,000	65,000	70,000
Flagstaff Field Center Management		128,000	125,000	70,000
<b>TOTAL</b>		<b>965,280</b>	<b>755,140</b>	<b>620,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

<sup>(1)</sup> Decreases are a result of the USGS assessment. The administrative officer, administrative assistant, staff student assistant, and 1/2 of the secretary positions have been transferred to the Southwest Biological Science Center and will be funded by the assessment. Administrative support will be provided by the Southwest Biological Science Center Administrative Services Group.

<sup>(2)</sup> Secretary assistant employee position will be replaced with a student services contract.

## **E.2. Program Planning and Management**

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

**Budget: \$274,000**

<b>PROGRAM PLANNING &amp; MANAGEMENT</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay periods:			
Chief	10.00	30,400	77,000	46,000
Secretary		3,440	0	0
Administrative Officer		4,880	2,720	0
Administrative Student			5,600	0
Biology Program Manager	15.10	31,150	41,200	69,000
Biologist - Terrestrial		21,000	0	0
Biologist - Aquatic		33,000	0	0
Biologist - Fisheries			3,200	0
Ecologist		19,200	0	0
Biology Student		10,200	0	0
Physical Program Manager	5.00	19,580	17,000	19,000
Physical Research Student		5,100	0	0
Cultural Program Manager	16.10	15,130	45,000	55,000
Economist - Harpman (TSC)		12,000	0	0
Cultural Student		17,000	26,000	0
IT Program Manager	18.10	49,840	57,120	65,000
Surveyor			4,100	0
GIS			4,000	0
Travel		24,000	19,000	20,000
<b>TOTAL</b>		<b>295,920</b>	<b>301,940</b>	<b>274,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**Note:** GCMRC Chief and Program Managers charge time here. All other employees will charge time to projects.

### E.3. AMWG/TWG Participation

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

**Budget: \$45,000**

<b>AMWG/TWG PARTICIPATION</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay periods:			
Chief	3.00	45,600	15,400	14,000
Secretary	0.00	1,720	1,680	0
Administrative Officer	0.00	1,220	1,360	0
Biology Program Manager	1.00	4,450	5,150	5,000
Physical Program Manager	1.00	4,450	4,250	4,000
Cultural Program Manager	1.00	4,450	4,500	3,000
IT Program Manager	1.00	7,120	4,200	4,000
Biologist - Fisheries	1.00		3,200	3,000
Surveyor		3,440	0	0
GIS Specialist		2,400	0	0
Database Manager		2,960	0	0
Travel		12,000	12,000	12,000
<b>TOTAL</b>		<b>89,810</b>	<b>51,740</b>	<b>45,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

### 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 directly to the Chief.

### 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, survey and GIS support services.

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 established a group of Science Advisors (SAs) in FY 2002 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. GCMRC has designated a person to serve as the 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., program specific scientific advice) it is asked to address by the GCMRC Chief or the AMWG.

**Budget: \$172,000**

<b>INDEPENDENT REVIEW PANELS</b>	<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits) Pay periods:			
Chief 2.10	15,200	15,400	10,000
Cultural Program Manager 0.00		4,500	0
Technical Information Specialist 6.10		8,200	12,000
Activities			
RFP Review	66,000	68,000	60,000
SAB Review	82,000	84,000	60,000
Technical Report Review	26,000	27,000	25,000
Unsolicited & In-House Reviews	5,000	5,000	5,000
<b>TOTAL</b>	<b>194,200</b>	<b>212,100</b>	<b>172,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**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.

## **F. TECHNICAL SUPPORT SERVICES**

### **Information Technologies**

The goal of the Information Technology Program (ITP) 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: 1) 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 (Figure 3.1). 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 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 ITP 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 ITP.

### **Information Technology Program Functions**

To satisfy the information needs of the GCDAMP in FY2004, the IT program 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 function of the IT 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. IT 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 IT 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 IT 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.

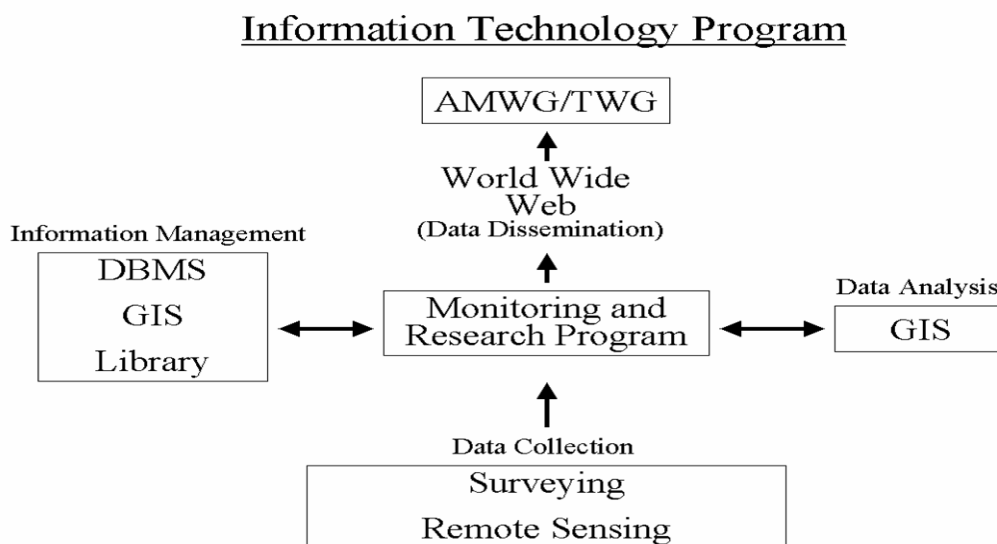


Figure 3.1. – Schematic illustrating the relationship of various Information Technology Program functions to the GCMRC monitoring and research program and the AMWG and TWG.

### **F.1. Geographic Information Systems**

The purpose of the GCMRC GIS program is to provide storage and analysis capabilities to for spatial datasets to the GCMRC staff and stakeholders. GIS is an important analytical tool for change detection of biological, cultural, and physical data.

The GCES program developed up to 20 thematic coverages associated with spatial relationships of biological, cultural and cultural resources at 17 GIS sites within the Colorado River ecosystem (CRE). Tabular attribute data exists as part of these data sets. These data sets are known as “base data”. In addition, other GIS data sets which were constructed as part of past GCES-supported investigations and delivered as part of a final product. These data sets are known as “contributor data”. Efforts are now underway to catalog, describe, and distribute base and contributor data. The GCMRC is working to increase the GIS coverage of the CRE by using modern light detection and ranging (LIDAR) mapping techniques.

Ongoing GIS activities are:

- Administer GIS data systems
- Service GIS map, data, and analysis request
- Integrate current year monitoring data into data systems
- Coordinate collection of remotely sensed data sets

FY2004 GIS activities are:

- Internet map server development project

#### Internet map server development project

The purpose of this project is to develop an easy-to-use, internet-accessible, graphic interface to the GCMRC monitoring and research GIS layers and Oracle database files. The Internet Map Server (IMS) runs inside a standard Internet browser allowing a broad range of users, from GCMRC staff to cooperators to the general public, to display, query, and download GIS layers and Oracle database tables. This project is intended to increase the accessibility, usability, and value of the existing and future GCMRC data collection efforts. This is a three-year project scheduled to begin in FY2002. In FY2004, a pilot internet map server will be deployed with limited mapping, query, and downloading functionality.

**Budget: \$160,000**

<b>GEOGRAPHIC INFORMATION SYSTEM</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay periods:			
GIS Specialist	13.10	33,600	36,000	41,000
GIS Assistant	26.10	40,850	48,000	55,000
GIS Student	0.00	17,000	12,000	0
Travel		4,000	5,000	5,000
Services		8,000	8,000	10,000
Contract - GIS Student Services				14,000
Supplies and Materials		11,000	12,000	10,000
Equipment		35,000	29,000	25,000
<b>TOTAL</b>		<b>149,450</b>	<b>150,000</b>	<b>160,000</b>

**F.2. Data Base Management System**

The purpose of the GCMRC DBMS is to store and deliver all tabular and other electronic non-spatial information 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. Some data resides on mature DBMS systems but much of it is stored on floppy disks or hard disks on personal computers using PC-type spreadsheets and database formats. Although the objective of the information technology program is to provide a centralized database management system (DBMS), it is our policy not to duplicate fully developed and accessible data warehousing already provided by other entities. In these circumstances it is preferable to interrogate the off-site database remotely when possible. However, the GCMRC will act as a clearinghouse of data owned by other entities in the case where remote database interrogation is not possible. 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. 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.

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. Important features of the DBMS are:

1. All data is being ecologically integrated. Meaning that data is being stored in a consistent format relative to time, space, researcher, and discipline. This is essential for comprehensive ecological analysis. Appropriate data standards and protocols have been, or in some cases, will be developed to regulate this feature.
2. Spatial data is being geographically integrated. Although the database does not contain a spatial data analysis engine, the GIS used by the GCMRC will be highly integrated with, and dependent upon, the database for storing attribute data associated with spatial features. Data contained in the database is being spatially referenced within the database where appropriate.
3. Public data will be freely available. Sensitive data will be protected. User accessibility is being configured item-by-item.
4. The database will be searchable over the Internet using browser interfaces. Intuitive browser interfaces will be the primary method used to interrogate the database.

The GCMRC data base development is occurring over an 18-month period ending in FY2004.

**Ongoing Activities:**

- Administer the database
- Service data requests
- Integrate current year data into data system

**FY2004 Activities:**

- Database development project

### Database development project

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. Currently, an ARC/INFO based Geographic Information System (GIS) is used for spatial data storage, analysis, and data transfer of information to users. In conjunction, a centralized integrated, relational database will be developed to facilitate exchange of information among projects. The software selected for this relational database is Oracle. The data base management project is a 18 month project that began in FY2001 and is scheduled to be completed in FY2003. It is anticipated that the development and implementation phase of the database will be completed near the end of FY2002. Activities in FY2003 will largely focus on fine-tuning the database system and conducting training and workshops.

### **Budget: \$128,000**

<b>DATABASE MANAGEMENT</b>	<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits) Pay periods:			
Data Base Manager 26.10	56,240	67,000	86,000
Travel	3,000	1,000	2,000
Contracts (Oracle)	10,000	10,000	10,000
Services	3,000	5,000	5,000
Supplies and Materials	10,000	10,000	11,000
Equipment	19,000	20,000	14,000
<b>TOTAL</b>	<b>101,240</b>	<b>113,000</b>	<b>128,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

### **F.3. 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.

**Budget: \$79,000**

<b>LIBRARY</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay period:			
Technical Info. Spec	20.00	47,500	32,800	40,000
Travel		1,500	2,000	2,000
Services		1,500	1,000	1,000
Supplies and Materials		10,000	26,000	36,000
Equipment		5,000		
<b>TOTAL</b>		<b>65,500</b>	<b>61,800</b>	<b>79,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

#### **F.4. Survey Operations**

The Survey department's mission is to provide survey support for spatial measurement and referencing of scientific data collected in the Colorado River ecosystem by GCMRC programs. This support may be in the form of precise measurement of geographic coordinates of a sample collected in the Canyon or in the generation of topographic maps used for erosion monitoring of terraces adjacent to the Colorado River. The Survey department is also responsible for establishing and maintaining accurate geographic control in the Canyon that is essential for accurate geo-referencing of remotely sensed data and change detection of resource data using modern image processing and GIS technologies. These technologies are critical to the integration and analysis of the diverse scientific data that have been collected in the Canyon over the past 15 years. Products of the Survey department include precise sample location coordinates, topographic maps, river channel maps and cross sections, digital elevation models, and digital terrain models. This information provides the basis for spatial analysis of data within the ecosystem using GIS software that in turn provides area and volumetric change detection capabilities.

The Survey department is responsible for the development of sound topographic and mapping control required to build accurate spatial data sets that can be used for reliable change detection. David Evan's and Associates and Banner and Associates were hired in 1990 to establish a reliable geodetic control network. In 1991 Joseph Mihalko (NPS surveyor) occupied the Banner ground control points for a soil mapping project by the USGS. He found that the control points did not meet their claimed accuracy and precision. As a result, GCES established a survey department to correct all previously established survey control as well as meet research needs of the future.

The Survey department uses a variety of technology to assist in accomplishing its mission in a timely, cost effective manner that utilizes a minimum amount of personnel. These technologies include global positioning systems, multibeam acoustic technology, and conventional total station survey technology.

Ongoing activities are:

- Administer the survey program
- Service survey work requests
- Provide survey, control, and GPS support to remote sensing data collection activities

FY2004 activities are:

- Survey control network
- Hydrographic channel mapping

#### Survey control network

The survey control network is fundamental to spatially positioning all scientific data collected as part of the GCDAMP. Currently, only about a quarter of the CRE has adequate geographic control that meets the needs of near and long-term monitoring and research plan and fewer have been upgraded to the rim control standard. Survey control is required throughout the remainder of the CRE to fully implement the long-term monitoring and research activities.

Accurate spatial positioning of scientific data facilitates integration across resource areas by providing common geographic framework to store and analyze data. Many resource monitoring programs depend upon changes in the spatial distribution of

resources as the basis of their monitoring strategy. Spatial analysis tools such as a GIS depend upon accurate geo-referencing of data to provide meaningful analysis. Without geographic control, geo-referencing of resource data and subsequent spatial analysis is impractical. The survey control network project is a five-year project that began in 2000 and is scheduled to be complete in 2006 to the upgraded rim control standard.

#### Hydrographic channel mapping

The hydrographic mapping program is intended to facilitate all monitoring efforts requiring sub-aqueous measurements. The two areas of hydrographic mapping consist of an ongoing system-wide channel map and a repeatable reach monitoring for annual change detection. Hydrographic mapping is the only method currently available to measure sub-aqueous topography. Hydrographic technology is used in the Grand Canyon primarily to measure changes in the river channel. The primary changes that occur are due to the movement of sediment. These changes are monitored by hydro-acoustic measurements that are accurately positioned over the course of the river channel. The hydrographic data collection method is designed to develop required monitoring and research products such as topographic maps, digital terrain models, sediment aggregation and degradation, hydrologic stage discharge modeling, and cross-section analysis. These products support the following projects: system wide channel mapping, fine-grained sediment storage, coarse-grained sediment, streamflow and fine-grained sediment transport, modeling reach-averaged sand bar evolution, and aquatic bio-monitoring. The hydrographic channel-mapping project is a five-year project that began in FY2000 and is scheduled to be complete in FY2004.

**Budget: \$126,000**

<b>SURVEY OPERATIONS</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay period:			
Surveyor	5.00	4,300	11,480	17,000
Surveying Technician	8.00	14,250	17,700	18,000
Survey Student	0.00	17,000	12,000	0
Travel		2,000	5,000	5,000
Services		6,000	4,000	4,000
Contract for Survey Student Services				14,000
Supplies and Materials		27,000	27,000	68,000
<b>TOTAL</b>		<b>70,550</b>	<b>77,180</b>	<b>126,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**F.5. 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

**Budget: \$242,000**

<b>SYSTEMS ADMINISTRATION</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay period:			
IT Program Manager	1.00	4,450	4,200	4,000
Systems Administrator	26.10	57,000	74,000	81,000
Travel		2,500	4,000	4,000
Services		3,500	5,000	5,000
Supplies and Materials		25,000	33,000	35,000
Equipment		80,000	130,000	113,000
<b>TOTAL</b>		<b>172,450</b>	<b>250,200</b>	<b>242,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**F.6. Aerial Photography**

GCMRC annually collects digital imagery and topography data in support of biological, cultural, and physical resource monitoring projects. These data sets are utilized for multiple monitoring and research projects and provide spatial integration of multiple resource parameters. Digital imagery and topography data sets include orthorectified digital imagery, orthorectified multispectral imagery, LIDAR, and photogrammetry products. These data sets enable GCMRC to expand the coverage of resource monitoring projects in the CRE in a more cost-effective manner while in many cases reducing the environmental impact. Resource monitoring in the CRE is inherently difficult and expensive due to the remote nature of the canyon environment. Aerial imagery, LIDAR, and photogrammetry provide alternative methods of collecting monitoring data over large areas with reduced numbers of expensive and invasive river trips.

The GCMRC has been collecting annual aerial photography of the CRE for over 20 years in support of research and monitoring activities related to the operations of the Glen Canyon dam. Until recently, the product delivered has been nine-by-nine inch contact prints of black-and-white or color-infrared film at an approximate scale of 1/4800. Photographs have been delivered without any rectification or geopositioning

information. While useful for many past monitoring and research activities in the CRE, these products are largely being supplanted by high-resolution, calibrated, multispectral digital products that include pointing and positioning parameters that allow cost-effective rectification and geopositioning. These products have much more utility, and have resulted in increased productivity, capability, and efficiency in almost all resource programs. In addition these data sets allow improved image analysis using automated computerized techniques. Simultaneous acquisition of LIDAR or photogrammetric data provides high accuracy topographic information in areas where terrestrial volume information is desired.

The GCMRC remote sensing initiative evaluated new technologies to support resource monitoring in the CRE during 2000 – 2002. Over 106 airborne and spaceborne sensors and two waterborne sensors were considered. Many of these sensors were eliminated based upon the demanding data specifications required by the resource monitoring programs. Ten sensors, or sensor configurations, were field tested for suitability in the CRE. The following applications of remotely sensed data products have been identified from the initiative:

#### Orthorectified digital imagery

- Georeferencing of historical and future scientific data
- Monitoring terrestrial, fine grained sediment movement and storage, e.g., sand bars and river terraces
- Monitoring terrestrial, coarse-grained sediment changes, e.g., cobble bars and debris-fans
- Monitoring size and quality of camping beaches throughout the corridor
- Development of a Colorado River centerline
- Development of an accurate river guide in terms of mileage and waters edge at specific stages
- Potentially, monitoring effects of runoff and dam releases on archeological structures
- Potentially, mapping/monitoring aquatic food base and water quality throughout the corridor

#### Multispectral digital imagery

- Mapping terrestrial vegetation types throughout the corridor at five-year intervals and annual monitoring of terrestrial vegetation habitat as in selected reaches
- Monitoring aquatic flux and storage of sediment within the main channel
- Surface water temperature
- Channel morphology
- Potentially, suspended sediment monitoring

#### LIDAR and photogrammetry

- Topographic basemaps
- Orthorectification of imagery
- Monitoring terrestrial, fine grained sediment movement and storage, e.g., sand bars and river terraces
- Monitoring terrestrial, coarse grained sediment changes, e.g., cobble bars and debris fans
- Characterizing and monitoring terrestrial vegetation habitats for birds and insects
- 3-d visualization
- Overflight mission planning

The collection of aerial imagery, LIDAR, and photogrammetry is accomplished through a contract utilizing a request for proposal process. Imagery, LIDAR, and photogrammetry needs of the science programs are determined annually in advance and incorporated into the statement of work from which an RFP will be generated. Currently aerial overflights are scheduled to collect imagery, LIDAR, and photogrammetry over the Memorial Day weekend when power demand is low to reduce the impact on power utilities. Data sets are collected at steady dam release of either 8,000 or 15,000 cfs depending on the inflow into Lake Powell to provided spatial and temporal comparability.



**Budget: \$363,000**

<b>TECHNICAL SUPPORT SERVICES</b>		<b>FY-2003</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay Periods:			
IT Program Manager	6.00		18,480	22,000
Contracts				
Aerial Photography			282,000	200,000
Lidar			130,000	100,000
Technical Support Services				
Survey	3.00	8,600	8,200	10,000
GIS Specialist	10.00	12,000	16,000	31,000
<b>TOTAL</b>		<b>20,600</b>	<b>454,680</b>	<b>363,000</b>

Pay periods are bi-weekly. One year has 26.1 pay periods.

**F.7. Logistics**

GCMRC provides all logistical support for monitoring and research projects conducted by contracted Principal Investigators (PIs) whose work is administered by GCMRC Program Managers in physical, biological and social-cultural resource programs. GCMRC staff initiate some of their own in-house scientific activities, which require logistical support, including; the Integrated Water Quality Program, administrative trips for groups such as the TWG, AMWG, Science Advisors and program PEP panels. The GCMRC also supports logistical needs for the Bureau of Reclamation's activities conducted by Native American groups under the Programmatic Agreement program and activities conducted to meet Reclamation's needs concerning endangered species. In addition, GCMRC provides logistics support for any contingency plans or experimental floods.

To meet these responsibilities, the GCMRC Logistics Staff, consisting of a full time Logistical Coordinator and Warehouse Manager and a seasonally employed Warehouse Assistant, facilitates support of approximately 35-45 downriver trips annually on the Colorado River through Grand Canyon. These trips range from four to thirty-six people in size, five to twenty-one days in length, and are comprised of a variety of combinations of oar and motor-powered boats. Additionally, logistical support is provided for research activities on the Glen Canyon reach of the Colorado River (Glen Canyon Dam to Lees Ferry), the Little Colorado River and occasionally Lake Powell and Lake Mead.

The GCMRC uses a “partial in-house” method of supporting trips in which government-owned boats and river logistical equipment are used in conjunction with two contracted vendors who supply Boat Operators. Food packs and river put-in and take-out transportation are generally provided in-house but may alternatively be supplied by one of three contracted vendors when needs exceed GCMRC resources. The “in-house” approach allows better oversight over trip particulars that most influence cost (number of boats and Boat Operators, food packs, shuttle services) and ultimately gives the GCMRC greater control over trip costs than other support strategies used in past years.

In addition, the GCMRC Logistics Coordinator and Program Managers are able to accommodate scientists who may be leaders in their field, but new to the Colorado River Ecosystem. Effective communication with PIs, and sensitivity to and awareness of the challenges they face in implementing their studies, enable the GCMRC to offer more tailored (and therefore more cost-effective and productive) logistical support than any subcontracted vendor. Retaining more control over the process of supporting trips also facilitates better compliance with NPS regulations, allows greater control over issues sensitive to the recreational river community and enables the GCMRC to match PIs with the best Boat Operators for their particular study.

Trip planning begins in the fall when the Logistics Coordinator in cooperation with contracted PIs and GCMRC Program Managers and staff generate a draft schedule of trips for the next fiscal year. The schedule includes; launch and take-out dates, numbers of required personnel and specific boat and boat operator needs for each trip. Individual trip itineraries are firmed up as soon thereafter as possible, and *must* be finalized 60 days prior to launch date and submitted to the Logistics Coordinator in order to meet the 45 day deadline for submitting launch permit application packets for each trip to the GCNP/NPS. Arrangements for operations services (Logistical and Technical Boat Operators) and support services (foodpacks, put-in/take-out transportation, equipment rentals) are made two to four weeks prior to each trip launch date.

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

**Budget: \$742,000**

<b>LOGISTICS</b>		<b>FY-2002</b>	<b>FY-2003</b>	<b>FY-2004</b>
Salary (includes benefits)	Pay periods:			
Logistics Operations Specialist	26.1	51,300	65,000	65,000
Logistics Assistant	26.1	30000	36000	44,000
Logistics Summer Aid	0.0	17000	20000	0
Travel				
Contracts				
Logistics Contracts*		500000	361000	320,000
Permitting Contract		57000	72000	76,000
Logistics Summer Aid Contract Svcs				14,000
Services				
Helicopter Support		31000	36000	30,000
Emergency Evacuation		6000	5000	5,000
Supplies and Materials				
Logistics Support Supplies & Expenses*		5000	179000	156,000
Equipment		65,000	31,000	32,000
Subtotal all logistics costs		762,300	805,000	742,000
Allocation to Projects		437,000	805,000	
<b>TOTAL</b>		325,300	0	742,000

Pay periods are bi-weekly. One year has 26.1 pay periods.

Note: Logistics costs are allocated to projects.

## GCMRC PROGRAM SCHEDULE

The tentative schedule for implementation of the FY 2004 Monitoring and Research Annual Plan is as follows:

May 2003	Draft FY 2004 Annual Plan for review by TWG/AMWG
July 2003	AMWG review of FY 2004 Annual Plan and recommendations for implementation. AMWG review and approval of revised Information Needs
October 2003	Review of FY 2002 program accomplishments and the revised “State of the Colorado River Ecosystem Resources” report with the TWG.
October 2003	Develop Logistics Plan for FY 2004 program
Oct./Nov. 2003	Release of RFPs for FY 2004
December 2003	Final Reports on FY 2003 programs with all contract deliverables
December 2003	Receipt of Proposals for FY 2004 program
January 2004	AMWG review of FY 2005 Annual Plan and recommendations for implementation
January 2004	Panel Review of FY 2004 Proposals
February 2004	Notification of Intent for FY 2004 Awards
March 2004	FY 2004 Awards
April 2004	First Progress Report due on FY 2003 program activities
July 2004	Second Progress Report due on FY 2003 program activities
September 2004	Draft Final Reports due on FY 2003 program activities

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## **APPENDIX ONE**

### **AMWG VISION AND MISSION**

(Adopted July 6, 2000)

The Grand Canyon is a homeland for some, sacred to many, and a national treasure for all. In honor of past generations, and on behalf of those of the present and future, we envision an ecosystem where the resources and natural processes are in harmony under a stewardship worthy of the Grand Canyon.

We advise the Secretary of the Interior on how best to protect, mitigate adverse impacts to, and improve the integrity of the Colorado River ecosystem affected by Glen Canyon Dam, including natural biological diversity (emphasizing native biodiversity), traditional cultural properties, spiritual values, and cultural, physical, and recreational resources through the operation of Glen Canyon Dam and other means.

We do so in keeping with the federal trust responsibilities to Indian tribes, in compliance with applicable federal, state, and tribal laws, including the water delivery obligations of the Law of the River, and with due consideration to the economic value of power resources.

This will be accomplished through our long-term partnership utilizing the best available scientific and other information through an adaptive ecosystem management process.

### **AMWG PRINCIPLES**

The Glen Canyon Dam Adaptive Management Work Group embraces the following Principles. They guided development of the Goals and Objectives for the Glen Canyon Dam Adaptive Management Program (GCDAMP). These Principles are:

1. The Goals represent a set of desired outcomes that together will accomplish our Vision and achieve the purpose of the Grand Canyon Protection Act. Some of the Objectives and actions that fall under these Goals may not be the responsibility of the GCDAMP, and may be funded by other sources, but are included here for completeness.
2. The construction of Glen Canyon Dam and the introduction of non-native species have irreversibly changed the Colorado River ecosystem.
3. Much remains unknown about the Colorado River ecosystem below Glen Canyon Dam and how to achieve GCDAMP ecosystem Goals.
4. The Colorado River ecosystem is a managed ecosystem. An ecosystem management approach, in lieu of an issues, species, or resources approach, will

guide our efforts. Management efforts will prevent any further human-induced extirpation or extinction of native species.

5. An adaptive management approach will be used to achieve GCDAMP ecosystem Goals, through experimentation and monitoring, to meet the intent of the Grand Canyon Protection Act, the Environmental Impact Statement, and the Record of Decision.
6. Dam operations and management actions will be tried that attempt to return ecosystem patterns and processes to their range of natural variability. When this is not appropriate, experiments will be conducted to test other approaches.
7. Because management actions to achieve a goal may benefit one resource or value and adversely affect another, those action alternatives that benefit all resources and values will be pursued first. When this is not possible, actions that have a neutral impact, or as a last resort, actions that minimize negative impacts on other resources will be pursued, consistent with the final Glen Canyon Dam Environmental Impact Statement and the Record of Decision.
8. Recognizing the diverse perspectives and spiritual values of the stakeholders, the unique aesthetic value of the Grand Canyon will be respected and enhanced.
9. Recognizing the diverse perspectives and spiritual values of the stakeholders, the unique aesthetic value of the Grand Canyon will be respected and enhanced.

### **AMWG MANAGEMENT OBJECTIVES**

#### **Goal 1. Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels.**

**M.O. 1.1** Maintain or attain primary producers: (algae, macrophytes, diatoms) in the Glen Canyon Reach.

**M.O. 1.2** Maintain or attain benthic invertebrates in the Glen Canyon Reach

**M.O. 1.3** Maintain or attain primary producers (algae, macrophytes, diatoms) in the mainstem and tributaries (to the extent primary producers in the tributaries are influenced by dam operations) below the Paria.

**M.O. 1.4** Maintain or attain benthic invertebrates in the mainstem and tributaries (to the extent benthic invertebrates in the tributaries are influenced by dam operations) below the Paria.

**M.O. 1.5** Maintain or attain drift (Diptera, CPOM, FPOM, DOC) in the mainstem and tributaries (to the extent drift in the tributaries is influenced by dam operations).

**Goal 2. Maintain or attain viable populations of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to associated critical habitat.**

**M.O. 2.1** Maintain or attain humpback chub (>150 mm) abundance in the LCR and other aggregations at appropriate target levels for viable populations and to remove jeopardy.

**M.O. 2.2** Maintain or attain HBC (51-150mm) year class strength in the LCR and other aggregations at appropriate target levels for viable populations and to remove jeopardy.

**M.O. 2.3** Maintain or attain HBC (>200mm) recruiting adults in the LCR and other aggregations at appropriate target levels for viable populations and to remove jeopardy.

**M.O. 2.4** Establish viable HBC spawning aggregations in the CRE below GCD to remove jeopardy.

**M.O. 2.5** Attain HBC and other native fish condition and disease/parasite numbers in LCR and other aggregations at an appropriate target level for viable populations and to remove jeopardy.

**M.O. 2.6** Reduce native fish mortality due to non-native fish predation as a percentage of overall mortality in the LCR and mainstem to increase native fish recruitment.

**M.O. 2.7** Attain Razorback sucker abundance in the CRE below GCD.

**M.O. 2.8** Maintain (FMS, BHS and SPD) abundance and distribution in the CRE below GCD for viable populations.

**Goal 3. Restore populations of extirpated species, as feasible and advisable.**

**M.O. 3.1** Restore Colorado pikeminnow, bonytail, and roundtail chub, and river otter abundances in the CRE as feasible and advisable.

**Goal 4. Maintain a wild reproducing population of rainbow trout above the Paria River, to the extent practicable and consistent with the maintenance of viable populations of native fish.**

**M.O. 4.1** Maintain or attain RBT abundance, proportional stock density, length at age, condition, spawning habitat, natural recruitment, and prevent or control whirling disease and other parasitic infections.

**M.O. 4.2** Limit Lees Ferry RBT distribution below the Paria River of the CRE to reduce competition or predation on downstream native fish.

**Goal 5. Maintain or attain viable populations of Kanab ambersnail.**

**M.O. 5.1** Attain and maintain KAS population at Vasey's Paradise from the current level to the target level.

**M.O. 5.2** Maintain KAS habitat at Vasey's Paradise from the current level to the target level.

**Goal 6. Protect or improve the biotic riparian and spring communities, including T&E species and their critical habitat.**

**M.O. 6.1** Maintain marsh community abundance, composition and area in the CRE in such a manner that native species are not lost.

**M.O. 6.2** Maintain NHWZ community patch number and distribution, composition and area to be no lower than values estimated for 1984.

**M.O. 6.3** Maintain OHWZ community abundance, composition and distribution in the CRE.

**M.O. 6.4** Maintain sand beach community abundance, composition and distribution in the CRE from 1984 (Is this the right benchmark year?)

**M.O. 6.5** Reduce invasive non-native species abundance and distribution.

**M.O. 6.6** Maintain spring and seep habitat.

**M.O. 6.7** Maintain riparian habitat in the CRE capable of supporting Southwest Willow Flycatcher.

**Goal 7. Establish water temperature, quality and flow dynamics to achieve GCDAMP ecosystem goals.**

**M.O. 7.1** Attain water temperature ranges and seasonal variability in the mainstem for biological resources (e.g., native fish, foodbase and trout).

**M.O. 7.2** Maintain water quality in the mainstem of the CRE.

**M.O. 7.3** Maintain flow dynamics associated with power plant operations, BHBF and habitat maintenance flows.

**Goal 8: Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.**

**M.O. 8.1** Maintain or attain fine sediment abundance, grain-size, distribution in the main channel below 5,000 cfs

**M.O. 8.2** Maintain or attain fine sediment abundance, grain-size, distribution within channel margins (not eddies) from 5,000 to 25,000 cfs

**M.O. 8.3** Maintain or attain fine sediment abundance, grain-size, distribution, within eddies below 5,000 cfs

**M.O. 8.4** Maintain or attain fine sediment abundance, grain-size, distribution within eddies between 5,000 to 25,000 cfs

**M.O. 8.5** Maintain or attain fine sediment abundance, grain-size, distribution, shorelines between 25,000 cfs and uppermost effects of maximum dam release

**M.O. 8.6** Maintain or attain coarse sediment (greater than 2mm) abundance, grain-size and distribution throughout the Colorado River Ecosystem needed to achieve other resource goals

**GOAL 9: Maintain or improve the quality of recreational experiences for users of the Colorado River Ecosystem, within the framework of GCDAMP ecosystem goals.**

**M.O. 9.1** Maintain or improve the quality and range of opportunities in Glen and Grand Canyons within the capacity of the Colorado River Ecosystem to absorb visitor impacts consistent with the NPS and tribal river corridor Management Plans.

**M.O. 9.2** Maintain or improve the quality and range of opportunities in Glen and Grand Canyons in consideration of visitor safety, and the inherent risk of river-related recreational activities.

**M.O. 9.3** Increase the size, quality and distribution of camping beaches in critical and non-critical reaches in the mainstem within the capacity of the Colorado River Ecosystem to absorb visitor impacts consistent with NPS and tribal river corridor Management Plans.

**M.O. 9.4** Maintain or enhance the wilderness experience in the CRE in consideration of existing management plans.

**M.O. 9.5** Maintain or enhance visitor experiences as a result of GCDAMP research and monitoring activities.

**Goal 10: Maintain power production capacity and energy generation, and increase where feasible and advisable, within the framework of GCDAMP ecosystem goals.**

**M.O. 10.1** Maintain or increase power with respect to marketable capacity and energy at Glen Canyon dam

**M.O. 10.2** Maintain or increase power within the existing emergency criteria for Western Area Power Administration systems.

**M.O. 10.3** Maintain or increase power within the existing emergency criteria for the western interconnected electrical system.

**M.O. 10.4** Maintain or increase power regulation at Glen Canyon dam.

**Goal 11: Preserve, protect, manage and treat cultural resources for the inspiration and benefit of past, present and future generations.**

**M.O. 11.1** Preserve the National Register integrity of register-eligible properties in the area of potential effect via protection, management, and/or treatment (e.g., data recovery) for the purpose of federal agency compliance with NHPA, and AMP and AMWG compliance with GCPA.

**M.O. 11.2** Preserve resource integrity and cultural values of traditionally important resources within the Colorado River Ecosystem.

**M.O. 11.3** Protect and maintain physical access to traditional cultural resources through meaningful consultation on AMP activities that might restrict or block physical access by Native American religious and traditional practitioners.

**Goal 12: Maintain a high quality monitoring, research, and adaptive management program.**

**M.O. 12.1** Maintain or attain socio-economic data about tribal and spiritual values for adequate decision-making.

**M.O. 12.2:** Attain or improve monitoring and research programs to achieve the appropriate scale and sampling design needed to support science-based adaptive management recommendations.

**M.O. 12.3** Integrate and synthesize cultural and environmental data to increase an understanding of the past and for ongoing interactions of humans within the CRE.

**M.O. 12.4** Attain or maintain an integrated and synthesized “ecosystem-science”-based adaptive management program.

**M.O. 12.4a** Maintain or attain the participation of externally-funded investigators

**M.O. 12.5** Foster effective two-way communication between scientists, external reviewers, managers, decision-makers and the public.

**M.O. 12.5a** Build AMP public support through effective public outreach.

**M.O. 12.5b** Attain and maintain effective communication and coordination with other resource management programs in the Colorado River basin to ensure inclusion of their values and perspectives into the AMP and vice versa.

**M.O. 12.6** Attain and maintain an effective adaptive management program, composed of informed stakeholders.

**M.O. 12.6a** Maintain or attain funding from multiple sources

**M.O. 12.7** Attain and maintain effective tribal consultation to ensure inclusion of tribal values and perspectives into the AMP.

**M.O. 12.8** Attain and maintain tribal participation in the AMP research and long-term monitoring activities.

**M.O. 12.9** Conduct experimental flows and other management actions for flow dynamics in the mainstem to gain critical understanding of ecosystem function under different dam operations, e.g., BHBF's, HMF's, biological opinion flows, and financial exception criteria flows.

**M.O. 12.10** Maintain or attain adequate funding from power revenues, foundations and corporations, appropriations, and State agencies to meet AMP program goals.

**M.O. 12.11** Maintain or attain participation from externally funded investigators that can help address the information needs and meet AMP program goals.



**APPENDIX TWO**

**FY2004 PROJECT TITLES AND ASSOCIATED MANAGEMENT OBJECTIVES.**

<b>A. TERRESTRIAL ECOSYSTEM ACTIVITIES</b>
<b>Project Title and ID: A.1. Terrestrial Ecosystem Monitoring</b>
<b>Status: Ongoing, originally initiated in FY2001.</b>
MANAGEMENT OBJECTIVE
<p><b><u>MO 6.1:</u></b> Maintain marsh community abundance, composition and area in the CRE in such a manner that native species are not lost.</p> <p><b><u>MO 6.2:</u></b> Maintain NHWZ community patch number and distribution, composition and area to be no lower than values estimated for 1984.</p> <p><b><u>MO 6.3:</u></b> Maintain OHWZ community abundance, composition and distribution in the CRE.</p> <p><b><u>MO 6.4:</u></b> Maintain sand beach community abundance, composition and distribution in the CRE from 1984 (Is this the right benchmark year?)</p> <p><b><u>MO 6.5:</u></b> Reduce invasive non-native species abundance and distribution.</p> <p><b><u>MO 6.7:</u></b> Maintain riparian habitat in the CRE capable of supporting Southwest Willow Flycatcher.</p>
<b>Project Title and ID: A.1. Terrestrial Ecosystem Monitoring-Cultural Component – Tribal Participation.</b>
<b>Status: Ongoing, originally initiated in FY 2001</b>
<b><u>MO 11.2:</u></b> Preserve resource integrity and cultural values of traditionally important resources within the Colorado River Ecosystem.
<b>Project Title and ID: A.2. Monitoring Kanab Ambersnail and Habitat at Vasey’s Paradise</b>
<b>Status: Ongoing.</b>
<p><b><u>MO 5.1:</u></b> Attain and maintain KAS population at Vasey’s Paradise from the current level to the target level.</p> <p><b><u>MO 5.2:</u></b> Maintain KAS habitat at Vasey’s Paradise from the current level to the target level.</p>

<b>Project Title and ID: A.3. Cultural data base plan implementation</b>
<b>Status: Continuation of project funded in FY 2002.</b>
<b>MO 11.1:</b> Preserve the National Register integrity of register-eligible properties in the area of potential effect via protection, management, and/or treatment (e.g., data recovery for the purpose of federal agency compliance with NHPA, and AMP and AMWG compliance with GCPA).
<b>Project Title and ID: A.5. Kanab Ambersnail Taxonomy</b>
<b>Status: New Project.</b>
<b>MO 5.1:</b> Attain and maintain KAS population at Vasey's Paradise from the current level to the target level.

## B. AQUATIC ECOSYSTEM ACTIVITIES

**Project Title and ID: B.1. Monitoring aquatic foodbase and evaluating its quality for utilization**

**Status: Ongoing. Originally approved and implemented in FY2001.**

**MO 1.2:** Maintain or attain benthic invertebrates in the Glen Canyon Reach.

**MO 1.4:** Maintain or attain benthic invertebrates in the mainstem and tributaries (to the extent benthic invertebrates in the tributaries are influenced by dam operations) below the Paria.

**MO 1.5:** Maintain or attain drift (Diptera, CPOM, FPOM, DOC) in the mainstem and tributaries (to the extent drift in the tributaries is influenced by dam operations).

**Project Title and ID: B.2. Monitoring of the status and trends of the downstream fish community**

**Status: Ongoing. Originally approved and implemented in FY2001.**

**MO 2.1:** Maintain or attain humpback chub (>150 mm) abundance in the LCR and other aggregations at appropriate target levels for viable populations and to remove jeopardy.

**MO 2.2:** Maintain or attain HBC (51-150mm) year class strength in the LCR and other aggregations at appropriate target levels for viable populations and to remove jeopardy.

**MO 2.3:** Maintain or attain HBC (>200mm) recruiting adults in the LCR and other aggregations at appropriate target levels for viable populations and to remove jeopardy.

**MO 2.8:** Maintain (FMS, BHS and SPD) abundance and distribution in the CRE below GCD for viable populations.

**Project Title and ID: B.3. Monitoring the status and trends of the Lees Ferry Fishery**

**Status: Ongoing. Originally approved and implemented in FY2001.**

**MO 4.1:** Maintain or attain RBT abundance, proportional stock density, length at age, condition, spawning habitat, natural recruitment, and prevent or control whirling disease and other parasitic infections.

**Project Title and ID: B.4. Integrated Water Quality Monitoring: Downstream Activities**

**Status: Ongoing, initiated in FY 2002.**

**MO 7.1:** Attain water temperature ranges and seasonal variability in the mainstem for biological resources (e.g., native fish, foodbase and trout).

**MO 7.2:** Maintain water quality in the mainstem of the CRE.

**MO 2.6:** Reduce native fish mortality due to non-native fish predation as a percentage of overall mortality in the LCR and mainstem to increase native fish recruitment.

## C. INTEGRATED TERRESTRIAL AND AQUATIC ECOSYSTEM ACTIVITIES

**Project Title and ID: C.1a Long-term monitoring of fine-grained sediment storage throughout the main channel**

**Status: Ongoing. Originally approved and implemented in FY2001.**

**MO 8.1:** Maintain or attain fine sediment abundance, grain-size, distribution in the main channel below 5,000 cfs.

**MO 8.2:** Maintain or attain fine sediment abundance, grain-size, distribution within channel margins (not eddies) from 5,000 to 25,000 cfs.

**MO 8.3:** Maintain or attain fine sediment abundance, grain-size, distribution, within eddies below 5,000 cfs.

**MO 8.4:** Maintain or attain fine sediment abundance, grain-size, distribution within eddies between 5,000 to 25,000 cfs.

**MO 8.5:** Maintain or attain fine sediment abundance, grain-size, distribution, shorelines between 25,000 cfs and uppermost effects of maximum dam release.

**MO 8.6:** Maintain or attain coarse sediment (greater than 2mm) abundance, grain-size and distribution throughout the Colorado River Ecosystem needed to achieve other resource goals.

**Project Title and ID: C.1b Long-term monitoring of fine-grained sediment storage throughout the main channel – Recreational component – monitoring camping beaches**

**Status: Ongoing.**

**MO 9.3:** Increase the size, quality and distribution of camping beaches in critical and non-critical reaches in the mainstem within the capacity of the Colorado River Ecosystem to absorb visitor impacts consistent with NPS and tribal river corridor Management Plans.

**Project Title and ID: C.2. Long-term streamflow and fine sediment transport in the main channel Colorado, Paria and Little Colorado Rivers**

**Status: Ongoing. Approved and implemented in FY2001 through a sole source award to the USGS.**

**MO 8.1:** Maintain or attain fine sediment abundance, grain-size, distribution in the main channel below 5,000 cfs.

**MO 8.2:** Maintain or attain fine sediment abundance, grain-size, distribution within channel margins (not eddies) from 5,000 to 25,000 cfs.

**MO 8.3:** Maintain or attain fine sediment abundance, grain-size, distribution, within eddies below 5,000 cfs.

**MO 8.4:** Maintain or attain fine sediment abundance, grain-size, distribution within eddies between 5,000 to 25,000 cfs.

**MO 8.5:** Maintain or attain fine sediment abundance, grain-size, distribution, shorelines between 25,000 cfs and uppermost effects of maximum dam release.

**MO 8.6:** Maintain or attain coarse sediment (greater than 2mm) abundance, grain-size and distribution throughout the Colorado River Ecosystem needed to achieve other resource goals.

<p><b>Project Title and ID: C.3. Long-term monitoring of coarse-sediment inputs, storage and impacts to physical habitats</b></p>
<p><b>Status: Ongoing. Originally approved and implemented in FY2001.</b></p>
<p><b>MO 8.1:</b> Maintain or attain fine sediment abundance, grain-size, distribution in the main channel below 5,000 cfs.</p> <p><b>MO 8.2:</b> Maintain or attain fine sediment abundance, grain-size, distribution within channel margins (not eddies) from 5,000 to 25,000 cfs.</p> <p><b>MO 8.3:</b> Maintain or attain fine sediment abundance, grain-size, distribution, within eddies below 5,000 cfs.</p> <p><b>MO 8.4:</b> Maintain or attain fine sediment abundance, grain-size, distribution within eddies between 5,000 to 25,000 cfs.</p> <p><b>MO 8.5:</b> Maintain or attain fine sediment abundance, grain-size, distribution, shorelines between 25,000 cfs and uppermost effects of maximum dam release.</p> <p><b>MO 8.6:</b> Maintain or attain coarse sediment (greater than 2mm) abundance, grain-size and distribution throughout the Colorado River Ecosystem needed to achieve other resource goals.</p>
<p><b>Project Title and ID: C.4.A. Modeling reach-averaged sandbar evolution in response to discharge and sediment conditions</b></p>
<p><b>Status: Initiated in FY 2002.</b></p>
<p><b>MO 8.1:</b> Maintain or attain fine sediment abundance, grain-size, distribution in the main channel below 5,000 cfs.</p> <p><b>MO 8.2:</b> Maintain or attain fine sediment abundance, grain-size, distribution within channel margins (not eddies) from 5,000 to 25,000 cfs.</p> <p><b>MO 8.3:</b> Maintain or attain fine sediment abundance, grain-size, distribution, within eddies below 5,000 cfs.</p> <p><b>MO 8.4:</b> Maintain or attain fine sediment abundance, grain-size, distribution within eddies between 5,000 to 25,000 cfs.</p> <p><b>MO 8.5:</b> Maintain or attain fine sediment abundance, grain-size, distribution, shorelines between 25,000 cfs and uppermost effects of maximum dam release.</p> <p><b>MO 8.6:</b> Maintain or attain coarse sediment (greater than 2mm) abundance, grain-size and distribution throughout the Colorado River Ecosystem needed to achieve other resource goals.</p>

<p><b>Project Title and ID: C.4.B. Development of one-dimensional fine sediment routing model along the main channel</b></p>
<p><b>Status: Initiated in FY 2002.</b></p>
<p><b>MO 8.1:</b> Maintain or attain fine sediment abundance, grain-size, distribution in the main channel below 5,000 cfs.</p> <p><b>MO 8.2:</b> Maintain or attain fine sediment abundance, grain-size, distribution within channel margins (not eddies) from 5,000 to 25,000 cfs.</p> <p><b>MO 8.3:</b> Maintain or attain fine sediment abundance, grain-size, distribution, within eddies below 5,000 cfs.</p> <p><b>MO 8.4:</b> Maintain or attain fine sediment abundance, grain-size, distribution within eddies between 5,000 to 25,000 cfs.</p> <p><b>MO 8.5:</b> Maintain or attain fine sediment abundance, grain-size, distribution, shorelines between 25,000 cfs and uppermost effects of maximum dam release.</p> <p><b>MO 8.6:</b> Maintain or attain coarse sediment (greater than 2mm) abundance, grain-size and distribution throughout the Colorado River Ecosystem needed to achieve other resource goals.</p>
<p><b>Project Title and ID: C.5. Development of a CRE Control network</b></p>
<p><b>Status: Ongoing. Originally approved and implemented in FY2000.</b></p>
<p><b>MOs:</b> Address MOs under Goals.</p> <p><b>Goal 1.</b> Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels.</p> <p><b>Goal 2:</b> Maintain or attain viable populations of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to associated critical habitat.</p> <p><b>Goal 4:</b> Maintain a wild reproducing population of rainbow trout above the Paria River, to the extent practicable and consistent with the maintenance of viable populations of native fish.</p> <p><b>Goal 5:</b> Maintain or attain viable populations of Kanab ambersnail.</p> <p><b>Goal 8:</b> Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.</p> <p><b>Goal 9:</b> Maintain or improve the quality of recreational experiences for users of the Colorado River Ecosystem, within the framework of GCDAMP ecosystem goals.</p> <p><b>Goal 11:</b> Preserve, protect, manage and treat cultural resources for the inspiration and benefit of past, present and future generations.</p>

<p><b>Project Title and ID: C.6. Development of CRE Hydrographic Mapping Program</b></p>
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<p><b>Status: Ongoing. Originally approved and implemented in FY2000.</b></p>
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**MOs:** Address MOs under Goals.

**Goal 1:** Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels.

**Goal 2:** Maintain or attain viable populations of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to associated critical habitat.

**Goal 4:** Maintain a wild reproducing population of rainbow trout above the Paria River, to the extent practicable and consistent with the maintenance of viable populations of native fish.

**Goal 5:** Maintain or attain viable populations of Kanab ambersnail.

**Goal 8:** Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.

**Goal 9:** Maintain or improve the quality of recreational experiences for users of the Colorado River Ecosystem, within the framework of GCDAMP ecosystem goals.

**Goal 11:** Preserve, protect, manage and treat cultural resources for the inspiration and benefit of past, present and future generations.

## D. OTHER SCIENCE ACTIVITIES

### **Project Title and ID: D.1. UNSOLICITED PROPOSAL: Adopt-a-Beach project**

**Status: Ongoing.**

**MO 9.3:** Increase the size, quality and distribution of camping beaches in critical and non-critical reaches in the mainstem within the capacity of the Colorado River Ecosystem to absorb visitor impacts consistent with NPS and tribal river corridor Management Plans.

### **Project Title and ID: D.4. Tribal Outreach Activities**

**Status: New Project.**

**MO 11.1:** Preserve the National Register integrity of register-eligible properties in the area of potential effect via protection, management, and/or treatment (e.g., data recovery for the purpose of federal agency compliance with NHPA, and AMP and AMWG compliance with GCPA).

**MO 11.2:** Preserve resource integrity and cultural values of traditionally important resources within the Colorado River Ecosystem.

### **Project Title and ID: D.5. Public Outreach Involvement Plan**

**Status: New Project.**

**MO 11.1:** Preserve the National Register integrity of register-eligible properties in the area of potential effect via protection, management, and/or treatment (e.g., data recovery for the purpose of federal agency compliance with NHPA, and AMP and AMWG compliance with GCPA).

**MO 11.2:** Preserve resource integrity and cultural values of traditionally important resources within the Colorado River Ecosystem.

**MO 11.3:** Protect and maintain physical access to traditional cultural resources through meaningful consultation on AMP activities that might restrict or block physical access by Native American religious and traditional practitioners.

### **Project Title and ID: D.6. Cultural resource synthesis and status report**

**Status: New Project.**

**MO 11.1:** Preserve the National Register integrity of register-eligible properties in the area of potential effect via protection, management, and/or treatment (e.g., data recovery for the purpose of federal agency compliance with NHPA, and AMP and AMWG compliance with GCPA).

**MO 11.2:** Preserve resource integrity and cultural values of traditionally important resources within the Colorado River Ecosystem.



**Project Title and ID: D.7. Cultural affiliation study**

**Status: New Project (To be provided by Ruth Lambert, Program Manager for Cultural Resources)**

**Project Title and ID: D.8. Experimental flows**

**Status: New Project (To be provided by Steve Gloss, Program for Aquatic Ecosystem Activities)**

**APPENDIX THREE**

**GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM  
Project Descriptions for Fiscal Year 2004**

**I. PROGRAM ADMINISTRATION**

- A. Adaptive Management Work Group (AMWG): This includes personnel costs required to administer the Adaptive Management Program (AMP), travel funds to reimburse members/alternates for attendance at AMWG, ad hoc, and other meetings, and a facilitation contract for meeting management and/or special ad hoc assignments.
- B. Technical Work Group (TWG): This includes personnel costs needed to administer the TWG, travel funds to reimburse members/alternates for attendance at TWG, ad hoc, and other meetings required in the completion of AMWG/TWG assignments, as well as reimbursement for the TWG Chairperson.
- C. Compliance Documents: This covers funding for preparation of compliance documents for AMP-proposed actions in order to comply with ESA, NEPA, and NHPA.
- D. Contract Administration: These are Reclamation personnel costs needed to administer the AMWG facilitation, TWG Chairperson, and Programmatic Agreement contracts.

**II. TRIBAL CONSULTATION**

- A. Cooperative Agreements with Tribes: Five tribes with demonstrated interests in effects of Glen Canyon Dam operations on resources of tribal concern will continue to be funded through cooperative agreements. The agreements provide \$80,000 per tribe (or consortium of tribes) annually. Funds cover salary, benefits, travel, and indirect costs to enable one official tribal representative to attend meetings wherein government-to-government consultation occurs on AMP activities, issues, and proposals. Funds also ensure the tribal representative maintain communication within their tribes regarding the AMP.
- B. Tribal Monitoring Trips: Each of the five tribes is allocated \$15,000 to monitor effects of dam operation or other management actions on resources of tribal concern. Tribes report their observations to the AMP and the Secretary. The funds are transferred from Reclamation to the GCMRC to pay for river guides, boats, fuel, food, etc.

**III. PROGRAMMATIC AGREEMENT**

- A-1. Completion of Historic Preservation Plan: Total \$50,000
- A-2. Reclamation Administrative Costs for the PA: A total of \$50,000 is allotted for salary, benefits, travel, and indirect costs of administering the PA program and tribal cooperative agreements.

- A-3. Treatment and Monitoring Implementation: The treatments and monitoring plan will be completed in FY03, so planned actions to resolve adverse effects of dam operations should begin in FY04. Costs are estimated at \$400,000.

#### IV. EXPERIMENTAL FLOW FUND

The TWG Experimental Flow Fund Ad Hoc Group has developed an integrated program of experimentation that addresses current information needs related to sediment conservation, riparian vegetation management, and Biological Opinion compliance. The Experimental Flow Fund would finance this program. A financial carry-over account has been established in Reclamation for these funds. Funds would be accumulated each year until there is a sufficient account balance to support the scientific objectives. Appropriated dollars are also being requested through the USGS to supplement this fund.

#### V. GCMRC SCIENTIFIC ACTIVITIES

Scientific Activities. Project descriptions and budget estimates have been built using information from current and draft information needs, recommendations contained in PEP reports, and existing monitoring and research activities that have been funded as multi-year projects. It is expected that as the revision to existing information needs and the AMP Strategic Plan is completed, the details for a given project may be revised. We believe the bottom-line budget figure presented here is a reasonable estimate of the funds needed for FY 2004 given existing information.

Project costs include contract costs, salaries for GCMRC staff, logistics, GIS and survey support, and other operational costs.

- A-1. Monitoring & Inventory of Terrestrial Resources & Tribal Participation: Integrated biological monitoring of vegetation linking birds, foodbase and vegetative structure on reach and river-wide scale, using bird patch size as minimum sampling unit. Also linking hydrology to vegetation composition change and implementing PEP recommended sampling scheme for long-term monitoring of status and trends. New RFP in FY 2004 to include expanded effort in Lower Grand Canyon, downstream of Diamond Creek.
- Tribal Participation: Intended to provide support to participating tribes to work with biologists on terrestrial monitoring to incorporate tribal perspectives within the integrated terrestrial resources monitoring program.
- A-2. Monitoring Kanab Ambersnail: Sampling and estimating population status of snails at Vaseys Paradise. Includes measurement of habitat and refinement of sampling procedures. Logistics support for supplemental population surveys.
- A-3. Cultural Data Base Plan. Development of cultural resource database plan as stipulated in the PEP recommendation and a component of the Historic Preservation Plan stipulated in

the PA agreement. Plan development was postponed due to development of other HPP components.

- A-4. Terrestrial Habitat Map and Inventory: A two-and-a-half year effort to map the vegetation along the Colorado River corridor to support spatial monitoring of physical, biological and cultural resources. The map will use remote sensing and field checking for accuracy of interpretation. The mapped vegetation communities will become layers that can be applied to the topographic base map for the river corridor.
- A-5. Kanab Ambersnail Taxonomy: Second year of multi-year project to resolve taxonomic issues associated with *Oxyloma* complex. This project will use a combination of molecular genetics techniques and morphometric measurements to determine the most appropriate taxonomic classification of snails at Vasey's Paradise. This will be done in the context of resolving the taxonomy for this species that will include examining related snails outside the Colorado River ecosystem.
- B-1. Aquatic Foodbase Monitoring - External: Data collection and analysis of algae and benthos to measure response to operations. This will be the second year of a three year contract to improve the statistical rigor of prior foodbase monitoring and done in a repeatable way to allow for determination of status and trends. Increased emphasis in Glen Canyon and in association with gauging stations in Grand Canyon. The project is integrated with downstream water quality, in house foodbase work, and measurements taken by the physical resources program. Project is responsive to aquatic PEP report.
- B-1. Aquatic Foodbase Monitoring – In House: This project was new in FY02 and represents an effort to better understand and establish trends in the dynamics and availability of aquatic food resources for higher organisms. The project will monitor and establish trends for the flux of organic carbon in the riverine portion of the CRE by measuring different size fractions of carbon from dissolved to particulate (including invertebrate drift) at fixed stations. The monitoring is closely coupled with downstream water quality work and measurements taken in the physical resources program.
- B-2. Monitoring Downstream Fish: New RFP to be issued for FY04 work. Data collection and analysis of fish populations in the mainstem and Little Colorado River likely involving 4 LCR trips and 6 mainstem trips that include 2 trips for estimates of trout (rainbow, brown) and 3 trips to develop native fish abundance estimates and for synoptic surveys to detect distribution changes. This project is intended to provide statistically reliable status and trend information for key native and non-native fish in the CRE. Initial efforts will be included to expand the sampling effort in the lower Grand Canyon, below Diamond Creek.
- B-3. Monitoring Lees Ferry Trout: New RFP for work in FY04 involving population estimates for Lees Ferry trout fishery including proportional stock density and condition factor of fish. Establishes status and trend information for the Lees Ferry trout fishery.
- B-4. IWQP Downstream Activities: Water quality monitoring in the CRE downstream of Glen Canyon dam. Monitoring provides status and trend information with respect to temperature

and nutrient dynamics and is designed to integrate with foodbase monitoring efforts to improve understanding of the relationships between water quality and biological resources. Includes development of downstream water quality model to interface with Lake Powell model.

- C-1. **Monitoring of Fine-Grained Sediment Storage:** This project is designed to annually assess the spatial distribution of sand- and finer-sized material stored within the main channel of the Colorado River ecosystem; specifically related to storage in eddy complexes and main-channel pools. Monitoring data shall reflect the relative changes in total volume of sediment and grain-size distribution within a subset of representative reaches throughout the ecosystem, with emphasis on the first 100 miles below the dam. These data support information needs on the state of the available fine-sediment supply in the system subject to influence of dam operations. Related elements of this project include documenting changes in high-elevation sand storage (above 25,000 cfs) related to available campable areas, evolution of sand bar grain-size distribution, changes in the spatial distribution of channel-bed substrates, changes in the number and size of return-current channels within eddy complexes (backwater habitats) and changes in the size of pre-dam river terraces.
- C-2. **Monitoring Streamflow and Fine-Sediment:** This project provides data on streamflow and suspended-sediment transport on the gaged tributaries that provide fine-sediment to ecosystem (influx), and on suspended-sediment transport through critical reaches of the main channel of the Colorado River ecosystem (efflux). It has one research component related to advancing development of a protocol for tracking the fine-sediment budget in real time through a variety of integrated and remotely sensed input data.
- 2 (a) **Formal Evaluation of Technologies for Continuous, In-Situ Suspended-Sediment Transport Monitoring:** One-year evaluation of in-situ instrumentation aimed at tracking continuous suspended-sediment transport (reach-scale export) between Glen Canyon Dam and Diamond Creek using laser-diffraction technologies (LISST). Initial evaluation will be conducted using installation of LISST-25 instrument at the Grand Canyon stream gage. Grain-size and concentration data for suspended sediment conditions derived from LISST will be verified using the daily-to-weekly samples collected as part of long-term monitoring. This evaluation will be conducted in collaboration between the GCMRC and the WRD of USGS.
- 2 (b) **Advance Warning for Anticipating Paria River Sediment Inputs:** This consists mostly of hardware required for instrumentation of the Upper Paria River watershed so that sediment inputs to the main channel of the Colorado River can be better anticipated. The need for this system relates to a desire by managers to have sufficient lead time to allow high flows from Glen Canyon Dam to be released during or immediately following large sand inputs. This network would likely provide from 12-18 hours of advance notice before large Paria River floods reach the main channel.
- C-3. **Monitoring Coarse-Grained Sediment:** This project provides data on tributary inputs of coarse sediment introduced by debris flows annually, and information about how these

inputs change the geomorphology of the main channel settings where sand storage, recreational, food base and fisheries resources exist.

- C-4. One-dimensional Fine Sediment Routing and Sand-Bar Evolution Models: This project results in a numerical simulation for routing sand inputs from the Paria and Little Colorado Rivers, downstream through main channel storage settings below Glen Canyon Dam, including eddy complexes and main channel pools. The simulation uses modeled information on sand inputs, in combination with predictions of travel time and historical and model-derived local conditions of sand bar deposition and erosion.
- C-5. Control Network: The objective of this project is to develop a high precision survey control network throughout the CRE that can be used to georeference and geographically integrate field and remotely sensed monitoring and research data. The project will provide a suitable rim control network and line-of-site floor control network throughout the CRE with accuracies suitable for existing and projected GCMRC natural and cultural resource projects.
- C-6. Channel Mapping: The objective of this project is to develop a sub-aqueous topographic basemap of the Colorado River channel throughout the CRE at a resolution suitable for habitat mapping and monitoring of sediment load transported on the channel bottom.
- D-1. Unsolicited Proposals: The GCMRC proposes to retain funds in support of unsolicited proposals that will allow for flexibility in the program and help ensure that GCMRC can address critical issues in a timely fashion. It will also provide GCMRC the ability to fund truly outstanding proposals that address a key concern that may be overlooked in the research planning process. All unsolicited proposals will be discussed with the TWG and will undergo independent, external peer review prior to funding.
- D-2. AMWG/TWG Requests: GCMRC budgets funding that can be used in support of requests that arise from the AMWG and TWG during the course of the year.
- D-3. In-house Research: The GCMRC supports in-house research by GCMRC Program Managers and scientific staff. In-house research is supported as a means of ensuring that GCMRC program managers and scientific staff remain subject area experts in their respective fields through the conduct of their own research on the Colorado River ecosystem. This also ensures that they are able to provide the highest quality of technical assistance in the form of expert analysis, opinion, and advice to the Chief, TWG and the AMWG as requested. In-house research may be in the form of original research or synthesis. In all cases, GCMRC in-house research proposals undergo the same independent external review as all GCMRC proposals.
- D-4. Tribal Training, Science/Tribal Perspectives Integration/Tribal Interns: Follow-on workshops for tribal training, science/tribal perspective integration workshop implementation, and use of tribal student interns. Purpose of work is to increase tribal participation within AMP for project development and implementation.

- D-5. Public Outreach Involvement Plan Implementation: Implementation of public outreach/involvement plan developed during FY 03 as stipulated in the PA agreement and recommended by the cultural PEP. Originally recommended as cultural plan, but as recommended by several stakeholders expanded to include all AMP resources.
- D-6. Cultural Resources Synthesis and Status Report: Incorporates data and reports developed by AMP cultural representatives to provide a general synthetic knowledge gained from projects and integrated across resource areas. Developed in-house by GCMRC with collaboration with AMP cultural representatives. Project provides current information within SCORE report.
- D-7. Cultural Affiliation Study: An ethnographic project that is a companion plan to the Research Design Plan contracted in FY-01. This project forms a component of the Historic Preservation Plan and provides information on tribal histories and affiliation to the project area.

## VI. GCMRC ADMINISTRATIVE & TECHNICAL SUPPORT

- 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. Includes salaries for GCMRC staff not otherwise assigned to project costs.
- E-2. Program Planning and Management: These costs are for salary and travel in support of program planning and management in the areas of Biological, Physical, and Cultural Resources, and Information Technologies.
- E-3. AMWG/TWG Participation: These costs are to cover salary and travel to attend and prepare for AMWG and TWG meetings.
- E-4. Independent Review Panels: Independent external review is at the heart of GCMRC's approach to program management and implementation. Independent external peer-review ensures the quality and objectivity of GCMRC's programs. All proposals, reports, programs, etc., are subject to independent peer review according to GCMRC's peer-review protocols. These costs cover all of the expenses related to the peer-review process, the Science Advisors, Protocol Evaluation Panels and the salary of the Review Coordinator. The Review Coordinator reports directly to the Chief.
- F-1. Geographic Information Systems: The GIS is a core information technology used by the GCMRC. Its purpose is to provide spatial analysis capabilities to GCMRC staff and stakeholders and maintain a library of GIS thematic coverages of the study area. The GIS is an important analytical tool for change detection of biological, cultural, and physical data relating to the operations of Glen Canyon Dam.

- F-2. **Data Base Management:** The purpose of the DBMS is to store and deliver tabular and other electronic data pertaining to the CRE. 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. The GCMRC data base management systems will, to the extent possible, integrate these vast and disparate data sets into a single ecologically integrated database that can be accessed by stakeholders, scientists, and the public interested in analyzing data pertaining to the Colorado River Ecosystem.
- F-3. **Library Operations:** Library operations are a core information technology used by the GCMRC ITP. Its purpose is to facilitate 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 those materials that assist the center in its efforts to administer long-term monitoring and research.
- F-4. **Survey Operations:** The Survey department's mission is to provide survey support for spatial measurement and referencing of scientific data collected in the Colorado River ecosystem by GCMRC programs. This support may be in the form of precise measurement of geographic coordinates of a sample collected in the Canyon or in the generation of topographic maps used for erosion monitoring of terraces adjacent to the Colorado River. The Survey department is also responsible for establishing and maintaining accurate geographic control in the Canyon that is essential for accurate geo-referencing of remotely sensed data and change detection of resource data using modern image processing and GIS technologies. These technologies are critical to the integration and analysis of the diverse scientific data that have been collected in the Canyon over the past 15 years.
- F-5: **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 of the PC type 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. The system administrator develops, implements, and troubleshoots the infrastructure necessary to support the complex computer environment at GCMRC.
- F-6: **Aerial Photography:**
- (a) The GCMRC has been collecting annual aerial photography of the CRE for over ten years in support of biological, cultural, and physical research and monitoring activities related to the operations of the Glen Canyon dam. Until recently, the photography product delivered has been a nine by nine inch contact prints of black and white or color infrared



film at an approximate scale of 1/4800. Photographs have been delivered without any rectification or geopositioning information. While useful for many past monitoring and research activities in the CRE, these products are largely being supplanted by high resolution multispectral digital products that include pointing and positioning parameters that allow convenient rectification and geopositioning. These products have much more utility and allow improved image analysis using automated computerized techniques. In addition, with the addition of LIDAR equipment, high accuracy topographic information can be acquired simultaneously in areas where volume information is desired.

(b) The Grand Canyon Monitoring and Research Center's library collection includes almost 32,000 aerial photographs of the Colorado River spanning a period of 65 years. 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.

F-7. Logistics: GCMRC provides all logistical support for monitoring and research projects conducted by contracted Principal Investigators whose work is administered by GCMRC Program Managers in physical, biological and social-cultural resource programs. GCMRC staff initiate some of their own in-house scientific activities, which require logistical support, including; the Integrated Water Quality Program, administrative trips for groups such as the TWG, AMWG, Science Advisors and program PEP panels. The GCMRC also supports logistical needs for the Bureau of Reclamation's activities conducted by Native American groups under the Programmatic Agreement program and activities conducted to meet Reclamation's needs concerning endangered species. In addition, GCMRC provides logistics support for any contingency plans or experimental floods. GCMRC logistics costs are accounted for under the specific projects, which they support.