THE GRAND CANYON MONITORING AND RESEARCH CENTER

LONG-TERM MONITORING AND RESEARCH STRATEGIC PLAN

Lawrence D. Garrett[1/]
Barry D. Gold
Ruth E. Lambert

EXECUTIVE SUMMARY

INTRODUCTION

This Long-Term Monitoring and Research Strategic Plan (the Strategic Plan) is designed to implement the adaptive management and ecosystem science approaches called for in the Grand Canyon Protection Act (GCPA) and Glen Canyon Dam Environmental Impact Statement (GCDEIS). The areas of monitoring, research, and information technology outlined for physical, biological, cultural and socioeconomic resources will be implemented over a five-year period. Within each of these years an annual monitoring and research plan will be developed and implemented to assure appropriate progress on critical elements of the Strategic Plan.

All elements of the Strategic Plan, and all monitoring programs, research projects and information technologies drafted into annual plans will incorporate the ecosystem

---

[1]/Lawrence D. Garrett, Barry D. Gold and Ruth E. Lambert are respectively Center Chief, Biological Resources Program Manager and Cultural Resources Program Manager of the Grand Canyon Monitoring and Research Center (GCMRC).

science paradigm and be developed cooperatively with the Adaptive Management Work Group (AMWG), utilizing adaptive management procedures. All programs proposed relate to determined or potential resource impacts primarily in the Colorado River corridor between Glen Canyon Dam and Lake Mead resulting from "The effects of the Secretary's actions."[2]/

The Strategic Plan and annual monitoring and research plans will build upon the rich history of monitoring and research investigations developed by the Bureau of Reclamation (BOR) and other organizations. Although the first scientific efforts in geomorphology, biology and ethnography in the Canyon were developed by John Wesley Powell in his scientific expedition of 1869, the majority of scientific accomplishment in the corridor between Glen Canyon Dam and Lake Mead has been accomplished under the guidance of BOR since 1982. Since that time, the BOR Glen Canyon Environmental Studies Program (GCES) has initiated a significant number of research studies and monitoring activities to determine baseline conditions and associated change in many physical, biological, cultural and socioeconomic resources.

Over a period of thirteen years, the GCES developed extensive databases in many different resource areas. Further scientific analysis in many of these areas permitted identification of some of the important attributes associated with changes in critical resources. Significant opportunity now exists to conduct extensive analysis of these

---

[2]/As specified in the 1992 Grand Canyon Protection Act, the GCDEIS, and the Record of Decision (ROD).

collected data and research to improve understanding of critical attributes affecting specific resources and the interrelationships of resource attributes in the riverine corridor.

Independent reviews of past research in the Colorado River corridor primarily between Glen Canyon Dam and Lake Mead have concluded that several actions need to be taken to ensure progressive future monitoring and science programs. These include:

1. Implementation of an adaptive management process to facilitate close interaction of science and management in applying potential new management criterion and evaluating impacts of those criterion in shorter time periods.
2. Development of a conceptual model of the Colorado River ecosystem primarily between Glen Canyon Dam and Lake Mead which can be used to more clearly define critical attributes within resource categories, critical attribute linkages across resource categories, and interdependencies of resource attributes.
3. An extensive synthesis of all past knowledge associated with original baseline resource conditions in the Colorado River ecosystem, riverine resource changes associated with construction of the Glen Canyon Dam, and changes associated with "The effects of the Secretary's actions."
4. Ecosystem analyses to improve understanding of the most critical attributes that drive individual resources and groups of resources, and the interdependencies of attributes within and across resources.

5. Development of predictive models of ecosystem function and interaction.

PURPOSE AND SCOPE OF GCMRC AND THE LONG-TERM PLAN

The GCPA and GCDEIS direct the Secretary of 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 Grand Canyon Monitoring and Research Center (GCMRC) and the goals of this long-term strategic plan are to determine short- and long-term ecosystem resource impacts of "The effect of the Secretary's actions" and other information needs specified by the AMWG. The GCMRC will work cooperatively with the AMWG, utilizing the adaptive management process and implementing monitoring and scientific investigations within an ecosystem science framework.

Long-term monitoring will occur in all resources of concern to determine changes in resource attributes from some desirable level. Research will be used to 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.

In addition to monitoring and research activities, the GCMRC will develop information technologies to assure information archiving and transfer to managers and stakeholders and science organizations. Specific protocols will be developed to ensure

sensitive information such as location of endangered species and cultural resource sites are maintained in confidence.

The physical scope of the research area to be investigated by the GCMRC includes primarily the Colorado River mainstem corridor and associated riparian and terrace zones from the forebay of Glen Canyon Dam to the upper reaches of Lake Mead, normally identified as Separation Canyon, a distance of approximately 278 river miles. The research scope includes limited investigations into side tributaries such as the Little Colorado and Paria Rivers. It also includes resource impacts to inundation levels associated with a flow of 100,000 cfs from the dam.

An assessment of water quality in Lake Powell will be completed in FY97, and any future monitoring and research investigations in either Lake Powell or Lake Mead must be directly associated with impacts resulting from "The effects of the Secretary's actions." In general, resource impacts may result from "The effects of the Secretary's actions" as specified in the GCPA, GCDEIS, and the ROD, and/or identified for evaluation by the AMWG.

STAKEHOLDER INFORMATION NEEDS AND CRITICAL RESOURCE ATTRIBUTES

The Strategic Plan is by design established to respond to the general objectives and information needs of managers and stakeholders regarding the Colorado River corridor and its resources. Objectives and information needs of stakeholders are specified in nine

differing resource areas including hydropower, water, sediment, fish and aquatic, riparian vegetation, threatened and endangered species, terrestrial wildlife, cultural, and recreation.

Within each of the above resource areas specific objectives have been developed cooperatively by the BOR, and representatives of the AMWG and are reviewed in the text and specified in Appendix A. Detailed information needs for specific objectives and resource areas were then defined by representatives of the AMWG working cooperatively with the GCMRC. These are also presented in the text and Appendix A.

Objectives and information needs specified by stakeholders are the basis for development of both monitoring and research programs, and these are referenced in discussions of monitoring and research programs. Appendix A contains "resource sheets" which represent a matrix linking stakeholder objectives and information needs to potential monitoring and research statements.

ENSURING QUALITY INDEPENDENT SCIENCE

The GCMRC is established to provide high quality independent science assessments to the AMWG. To accomplish these goals, stringent protocols regarding science-planning, competition, peer-review, administration and publication have been established.

An independent Science Advisory Board will oversight scientific planning and methodologies adopted by the center. The selection of this interdisciplinary group of advisors will be based on their standing and accomplishments in the science community.

The GCMRC will solicit extensive involvement of stakeholders and scientists in defining research agendas and methods. However, it will ensure unbiased programs by independently developing needed monitoring and research projects which will be awarded through competitive science procedures.

Quality science programming and objective and unbiased research findings will be ensured through rigorous scientific peer review protocols. All proposals, data, reports, etc. will be reviewed by external anonymous scientists as well as the GCMRC science team.

PROPOSED MONITORING AND SCIENCE PROGRAMS

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

1. **Conceptual modeling and synthesis of existing knowledge.**
2. **Physical resource program.**
3. **Cultural resource program.**
4. **Biological resource program.**
5. **Socioeconomic resource program.**
6. **Information technology program.**

Each of these areas represent components of the Strategic Plan where important information will be developed to respond to objectives and information needs specified by stakeholders.

Conceptual Modeling and Synthesis of Existing Knowledge

The conceptual modeling and synthesis of existing knowledge represents two primary activities, and will be completed in the first two to three years of the Strategic Plan. The first component, will be development of a conceptual model of the Colorado River ecosystem, and the various resource attributes that respond to variable operations of Glen Canyon Dam. The second component will be a focused detailed assessment of all past research associated with the riverine corridor's resources before and after Dam construction, as well as other western riverine corridors yet undamed, and of similar character and structure to the Colorado River mainstem. These syntheses are also addressed in the individual resource program areas.

Development of a conceptual model and completion of a "state-of-the-science" synthesis is critical to understanding this riverine ecosystem and associated impacts from differing Dam operations. It will include extensive integrated data assessment and interpretation, as well as the first comprehensive transfer of information to stakeholders regarding the potential impacts of differing Dam operations on ecosystems and associated resources.

Physical Resources Program

Water and sediment are the two primary resources of concern in the physical resources area. Monitoring and research efforts will concentrate on four aspects of these physical resources as follows:

1. Dam discharges and instream flows.

2. Sediment balance and processes.

3. Interrelationship of mainstem water and sediment and side channel inflows.

4. Interaction of mainstem water and sediment and Lake Mead resources.

The Biological Resources Program

Monitoring and research activity for biological resources is intended to develop information about the structure and function of the Colorado River ecosystem as well as the impacts of differing Dam operations on the ecosystem and associated flora and fauna. The effort will provide the knowledge base required to implement ecosystem management strategies within an adaptive management framework. It is key that relationships between the biotic and abiotic components of the Colorado River ecosystem be addressed to predict impacts on critical biological resources.

Monitoring and research activities are proposed in several different areas. These include assessments of aquatic food base, native and non-native fish species, wildlife and other riparian invertebrates and vertebrates.

The Strategic Plan contains proposals to evaluate the status and trends of native fish populations in the Colorado River ecosystem and seek to collect data that can be used to assess the native and non-native fish communities response to Dam operations resulting from the Secretary's actions. Native fish species of concern are the humpback chub, razorback sucker, flannel mouth sucker, blue head sucker and speckled dase.

Monitoring of the non-native trout fisheries in the Lees Ferry reach is proposed to concentrate on growth, survivorship, and changes in population structure, including the contribution from natural reproduction over time.

Changes in the three primary riparian zones along the river is proposed to be monitored including, the old high water zone, new high water zone, and near shoreline wetland communities. Proposals to monitor faunal assemblages will be aligned to sampling of riparian vegetation habitat changes. Proposals to monitor and conduct research on terrestrial invertebrates along the riverine corridor are also included.

It is proposed that avifauna monitoring emphasize listed species such as the Bald Eagle, Southwestern willow flycatcher and Peregrine Falcon. It may also include wintering and breeding water fowl, riparian obligate species, resident non-obligate species and migrant species in a biogeographic/geomorhpic/seasonal context.

As appropriate the biological resources monitoring and research program will consider and address information needs of the biological opinion.

The Cultural Resources Program

The cultural resources program is charged with designing and implementing monitoring and research activities that assess cultural resource impacts related to dam operations. The program will accommodate both ongoing activities of the Programmatic Agreement (PA), and new programs proposed to address needs of the AMWG.

Activities necessary to the PA will be incorporated into the cultural resources program at the request of the agency and Native American tribal members of the AMWG.

Monitoring and research information needs and activities from the PA are expected to be a major component of the GCMRC's cultural resource program.

The Strategic Plan incorporates a more comprehensive perspective of cultural resources than those outlined in the PA. This perspective is derived from objectives and information needs specified by agencies, Native American tribes and other stakeholders, relating to cultural resources and their association with other resources in the Colorado River corridor.

The cultural resources program for the GCMRC will accommodate three primary components: **a core program, a tribal projects element, and a cooperative programming aspect.** Further, the program manager is responsible in coordinating with other program managers to incorporate Native American concerns within these programs.

Objectives and information needs specified by the stakeholders have been utilized to incorporate the following monitoring and research proposals in the Strategic Plan.

1. Develop data and monitoring systems to assess impacts.
2. Develop data to assess risk of damage and loss of cultural resources from varying flow regimes.
3. Develop tribal monitoring programs for evaluation of impacts to cultural resources.
4. Develop a predictive model of geomorphic processes that are related to archeological site erosion.

5. Develop mitigating strategies related to documented dam impacts to size by monitoring assessments.

6. Characterize resource values through scientific study.

The Socioeconomic Resources Program

There are many socioeconomic resources associated with the Colorado River corridor including recreation, electric power and water. Further, due to the vastness and geological distinctiveness of the Grand Canyon, the Grand Canyon National Park has acquired national and international recognition and all of the resources in the Grand Canyon are considered to be significant to the public.

The objectives of long-term monitoring and research will be to determine whether recreation is enhanced and safety improved when comparing current or proposed dam operations to historical dam operations, and whether changes in recreational patterns resulting from the dam operations have any affect on the Canyon's downstream recreation resources.

In the Lees Ferry reach, monitoring methods will be established to characterize changes in sport fish recreation (trout) relative to the Secretary's actions regarding dam operations. Elements of this program will be developed with stakeholders including fishing guides and associations such as Trout Unlimited.

Continued monitoring and research is needed to assess changes in camping beach areas associated with the effects of the Secretary's actions. Monitoring changes in beach

areas will be conducted by using primarily remotely sensed data and cooperative programs with boating guides and their associations.

Hydropower supply is an integral part of the economy of the region. Changes in power operations result from changes in annual dam operations, and they affect power supply and its costs. Actual power generation will be monitored on a hourly basis to assess the consequences of changing dam operations on power economics. Power generation is also a method for estimating water discharge rates and volumes. A Cost Benefit Analysis (CBA) model is proposed, to evaluate all associated market and non-market costs and benefits, including intrinsic or existence values of key resources.

Information Technology

Extensive data and information currently exists in the GCMRC relating to resource levels, quality, and relationship to other resources. Potentially equal amounts of data and information exists within museums, universities, agencies, etc. However, much of this information has not been evaluated, to assess the interrelationship of resource attributes and differing flow regimes.

Several areas of focus will be implemented through the information technology program, including the following:

1. Development of protocols for data collection, processing and use.
2. Development of extensive databases across all resources and a database management system.

3. Development of a robust geographic information system to accommodate multiple layers associated with all resources of interest to stakeholders.
4. Development of databases associated with remotely sensed data, here to date not incorporated in the GCES database system.
5. Stakeholder direct access to selected data and information in the database management system and GIS.
6. Development of outreach programs to transport data and information to stakeholders and train stakeholders in utilization of data and models incorporated in the information technology program.

SCHEDULE AND BUDGET

The strategic plan outlined in this document addresses monitoring and research activities for a five year period: fiscal years 1998 to 2002. Each year in May, an annual operating plan will be drafted to guide implementation of specific elements of the Strategic Plan. It will be reviewed by the technical working group (TWG), and AMWG before approval by the Secretary of Interior.

This Strategic Plan is designed to guide specific monitoring and research through three fundamental phases.

1. Development of conceptual ecosystem models, synthesis of existing knowledge, and determination of key attributes associating resource impacts to dam operations.

2. Definition of integrated impact of key attributes within a resource set and across all resources.

3. Development of decision support guidelines and models to assist managers and interested stakeholders to understand resource interactions, impacts of dam operations on resources and procedures for mitigating impacts.

Phase I will require fiscal years 1997, 1998, and 1999, for completion. Fiscal years 1997 and 1998 will be utilized to develop conceptual models of the Colorado River ecosystem. Fiscal years 1998 and 1999 will involve comprehensive synthesis of past research information across all resources.

Phase II, which will be implemented in fiscal year 1998, is not expected to be completed during the first five year implementation of the Strategic Plan. This relates to the significant lack of knowledge on key driving attributes for many physical, cultural and biological resources. Significant results will be obtained for some resources, including physical and cultural resources.

Phase III of the monitoring and research program will be implemented in fiscal year 1999, primarily for predictive models in the cultural and physical resource areas. However, it is anticipated that useful operational algorithms and models in many of the biological resources areas will require most of a second five year strategic plan. Development of a comprehensive and robust decision support system (dss) is not anticipated until the end of the second five year strategic plan.

Budget for this five year strategic plan is anticipated at approximately seven million dollars per year. Of the total seven million dollar per year annual budget allocation, approximately 5.3 million will be placed into on the ground research programs. Approximately one-half million is required by the upper Colorado region of BOR to administer the adaptive management program, and approximately 1.2 million is required to operate all the center's administrative and service programming including logistics and computer support.