REPORT TO CONGRESS: OPERATIONS OF GLEN CANYON DAM PURSUANT TO THE GRAND CANYON PROTECTION ACT OF 1992

WATER YEARS 1999 – 2001

Secretary of the Interior

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REPORT TO CONGRESS: OPERATIONS OF GLEN CANYON DAM PURSUANT TO THE GRAND CANYON PROTECTION ACT OF 1992

WATER YEARS 1999 – 2001

REPORT TO CONGRESS

Section 1804(c)(2) of the Grand Canyon Protection Act (GCPA) of 1992 requires the Secretary of the Interior (Secretary) to:

> . . . transmit to the Congress and to the Governors of the Colorado River Basin States a report, separate from and in addition to the report specified in section 602(b) of the Colorado River Basin Project Act of 1968, on the preceding year and the projected year operations undertaken pursuant to this Act.

This report responds to the above-cited reporting requirements. The report focuses on Glen Canyon Dam operations for water years 1999 through 2001, projected dam operations for water year 2002, and Adaptive Management Program activities for 2001.

HISTORY OF GLEN CANYON DAM

Glen Canyon Dam was authorized for construction by the Colorado River Storage Project Act of 1956 (Public Law 84-485). The underlying project purposes are defined by Section 1 of the Act (43 United States Code [U.S.C.] § 620) which authorized the Secretary to "construct, operate, and maintain" Glen Canyon Dam:

> . . . for the purposes, among others, of regulating the flow of the Colorado River, storing water for beneficial consumptive use, making it possible for the States of the Upper Basin to utilize, consistently with the provisions of the Colorado River Compact, the apportionments made to and among them in the Colorado River Compact and the Upper Colorado River Basin Compact, respectively, providing for the reclamation of arid and semiarid land, for the control of floods, and for the generation of hydroelectric power, as an incident of the foregoing purposes . . . .

In 1968 Congress enacted the Colorado River Basin Project Act (43 U.S.C. § 1501 et seq.). This Act provided for a program for further comprehensive development of Colorado River Basin water resources. Section 1501(a) states:

> This program is declared to be for the purposes, among others, of regulating the flow of the Colorado River; controlling floods; improving navigation; providing for the storage and delivery of the waters of the Colorado River for reclamation of lands,

including supplemental water supplies, and for municipal, industrial, and other beneficial purposes; improving water quality; providing for basic public outdoor recreation facilities; improving conditions for fish and wildlife; and the generation and sale of electrical power as an incident of the foregoing purposes.

Glen Canyon Dam, completed in 1963, was built and is operated by the Bureau of Reclamation (Reclamation). The 710-foot dam backs up water for 186 miles to form Lake Powell, the second largest reservoir in the United States, and the key storage unit of the Colorado River Storage Project. Lake Powell holds approximately 26.2 million acre-feet (maf) of Colorado River water. The reservoir is not only a national recreation area, but a huge "savings bank" of water that allows development in the Upper Basin states of Wyoming, Colorado, New Mexico, and Utah, and can be drawn upon during dry years to make Colorado River Compact deliveries.

Glen Canyon Powerplant has eight electric generators that can operate at a combined output of 1,296,000 kilowatts. The hydroelectric power produced at Glen Canyon Powerplant is sold to approximately 1.7 million people in cities and towns in Arizona, Colorado, Utah, Wyoming, New Mexico, and Nevada. Glen Canyon Powerplant produces approximately five billion kilowatt-hours of hydroelectric power a year — enough electricity to completely supply the annual electrical needs of about 400,000 households.

A NEED FOR SCIENTIFIC EVALUATION

As a result of the construction and operation of Glen Canyon Dam, the Colorado River ecosystem below the dam changed significantly from its pre-dam character. Before Glen Canyon Dam was built, the Colorado River was a sediment-laden river that fluctuated according to the seasons, rainfall, and inflows from side canyons. After the dam was built, water releases from the dam, which occur at 200-230 feet below the surface of Lake Powell, run clear and cold (47°F to 52°F) without the spring time floods that once transported sediment, built beaches, and restored critical habitat for endangered species. Downstream from the dam, a new ecosystem emerged consisting of a mixture of native and non-native plant and animal communities.

From 1964 to 1991, Glen Canyon Dam was operated to meet the fluctuating demand for electrical power. Since the need for power varies greatly depending on the time of day and season, releases of water from Glen Canyon Dam were adjusted daily, and at times hourly, to respond to changes in electrical demand. This type of operation, known as "peaking," meant that the river level below the dam could rise and fall by as much as 14 feet a day.

Recognizing that this type of operation was impacting the downstream Colorado River environment, Reclamation launched the Glen Canyon Environmental Studies Program in 1982. By the late 1980s, sufficient scientific evidence had been gathered to demonstrate that significant positive and negative impacts on the downstream environmental and cultural resources were occurring as a result of daily fluctuating releases from the dam.
Those findings, in conjunction with the intent to rewind the generators at Glen Canyon Dam, led to a July 1989 decision by the Secretary directing Reclamation to prepare an environmental

impact statement (EIS) on the operation of Glen Canyon Dam. This document would provide the necessary information and analysis for a Secretarial decision on how to best operate the dam to balance competing interests, meet statutory requirements for protection of downstream resources, generate hydropower, and protect Native American interests. Because Glen Canyon Dam was constructed prior to enactment of the National Environmental Policy Act of 1969, no environmental impact studies were required on the construction or existence of the dam.

From 1990 to 1991, various flow regimes were tested to determine their impact on the downstream environment. In November 1991, the Secretary adopted interim operating criteria that limited minimum and maximum flows and daily powerplant fluctuations to protect downstream resources. After 1991, flows generally ranged between 5,000 and 20,000 cfs until the Secretary signed final operating criteria in February 1997. With the signing of the final operating criteria, Glen Canyon Dam releases do not exceed 25,000 cfs except during high inflow years and occasionally when higher releases are required in response to power system emergencies.

Grand Canyon Protection Act

In addition to the Secretary's 1989 decision to reevaluate Glen Canyon Dam operations, in October 1992, the President signed into law the Reclamation Projects Authorization and Adjustments Act, Public Law 102-575. Responding to continued concerns over potential impacts of Glen Canyon Dam operations on downstream resources, Congress included the GCPA as Title 18 of the Reclamation Projects Authorization and Adjustments Act. Section 1802(a) of the GCPA requires the Secretary to operate Glen Canyon Dam:

> . . . in accordance with the additional criteria and operating plans specified in section 1804 and exercise other authorities under existing law in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established, including, but not limited to natural and cultural resources and visitor use.

In addition, the GCPA directs the Secretary to implement Section 1802 in a manner fully consistent with all existing laws and compacts that govern allocation, appropriation, development, and exportation of the waters of the Colorado River Basin. Section 1803 of the GCPA validated the interim operating criteria adopted by the Secretary in 1991 and provided for consultation, a deviation process, and a method for termination upon adoption of final operating criteria.

Section 1804 of the GCPA required preparation of an EIS on operations, adoption of operating criteria and plans, reports to Congress, and reallocation of costs. The EIS requirement merely validated the Secretary's earlier direction to Reclamation and provided specific time frames for preparation and submittal.
Section 1805 of the GCPA directs the Secretary 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." Section 1805 also states that:

> Long-term monitoring of Glen Canyon Dam shall include any necessary research and studies to determine the effect of the Secretary's actions under section 1804(c) on the natural, recreational, and cultural resources of Grand Canyon National Park and Glen Canyon National Recreational Area.

The passage of the GCPA of 1992 represented a shift in the nation's environmental values. As the demand for water and power continued to increase throughout the West, this demand now had to be balanced with more diverse and potentially competing needs.

Glen Canyon Dam Environmental Impact Statement and Record of Decision

In accordance with the Secretary's 1989 request to prepare an EIS and requirements of the GCPA of 1992, a draft EIS was filed with the Environmental Protection Agency in 1994. The final EIS was filed with the Environmental Protection Agency in March 1995 and a Record of Decision (ROD) was signed by the Secretary in October 1996.

The signing of the ROD began a new chapter in the history of Glen Canyon Dam. In addition to meeting traditional water and power needs, the dam was to be operated in a more environmentally sensitive manner. The ROD set flow parameters concerning minimum and maximum releases from Glen Canyon Dam and limited the rate at which flows could fluctuate. The ROD also changed the triggering mechanism for conducting beach/habitat-building flows.[1] In addition, the ROD established the Glen Canyon Dam Adaptive Management Program (AMP) to respond to future monitoring and research findings.

Following the signing of the ROD, the Secretary, in February 1997, adopted a formal set of operating criteria to protect the Colorado River ecosystem and the Grand Canyon (see Operating Criteria for Glen Canyon Dam in Accordance with the GCPA of 1992 – Appendix A). This terminated the 1991 interim operating criteria.

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM

The GCPA directed the Secretary to establish long-term research and monitoring programs for the natural, recreational, and socio-cultural resources of Grand Canyon National Park and Glen

Canyon National Recreation Area. Recognizing the complexity of this task, the ROD directed Reclamation and other interested agencies, tribes, organizations, and individuals to use an adaptive management approach. The objective of the Glen Canyon Dam AMP is to use

[1]Scheduled high releases (above powerplant capacity) designed to rebuild sandbars, deposit nutrients, restore backwater habitats for endangered species, and provide some of the dynamics of a natural ecosystem.

scientific data, produced through research and monitoring, to refine dam operations. In addition, the AMP uses other management actions to accomplish the intent of the GCPA. The program calls for the continued interaction of stakeholders, managers, and scientists to monitor the effects of current dam operations on the Colorado River ecosystem.

The Glen Canyon Dam AMP is managed by Reclamation and with power revenues it annually funds approximately $8 million of adaptive management, scientific research, and resource protection activities in Glen and Grand Canyons. The National Academy of Sciences has called this particular adaptive management effort "a science policy experiment of local, regional, national, and international importance." (National Research Council, 1999)

The adaptive management approach being taken to manage Glen Canyon Dam operations and the resources affected by dam operations is as follows:

- The AMP focus is on the Colorado River ecosystem;
- The AMP evaluates how well the preferred alternative of the EIS ROD and other management actions meet the goals of the GCPA and the mix of resource benefits defined in the EIS ROD;
- Models are developed to reveal the potential effects of policies, activities, or practices that are being considered for implementation;
- Questions are formulated as testable hypotheses regarding the expected responses or linkages of the Colorado River ecosystem to dam operations and other management actions;
- Experiments are conducted to test hypotheses and answer questions;
- Management activities reveal, through monitoring and evaluation of results, the accuracy or completeness of the earlier predictions; and
- New knowledge and information produced through experimentation are incorporated into management discussions and recommendations to the Secretary.

Positions and Organizations Within the Glen Canyon Dam Adaptive Management Program

With the signing of the ROD for the Glen Canyon Dam EIS and establishment of the Glen Canyon Dam AMP, the following positions and organizations were created to contribute to the adaptive management process:

- Secretary of the Interior's Designee
- Adaptive Management Work Group (AMWG)
- Technical Work Group (TWG)
- Grand Canyon Monitoring and Research Center (GCMRC)
- Independent Review Panels (IRPs)

The roles, functions, and relationships of these positions and organizations are schematically characterized in Fig. 1 and are described in detail below based on descriptions in the Glen Canyon Dam EIS and ROD:

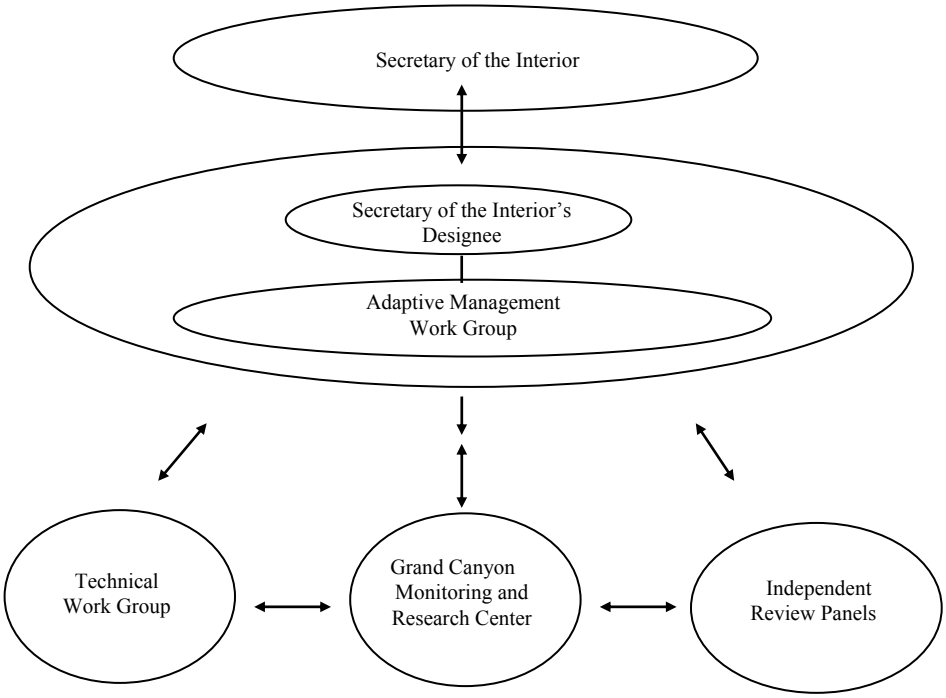

Figure 1.—Organizational Components of the Glen Canyon Dam Adaptive Management Program.

Secretary of the Interior's Designee

The Secretary's Designee serves as the principal contact for the Glen Canyon Dam AMP and as the focal point for issues and decisions associated with the program. The Designee's responsibilities are:

- Chairs the AMWG;
- Ensures that the Department of the Interior complies with its obligations under the GCPA, EIS, and ROD;
- Ensures that the Department of the Interior fulfills its trust responsibilities to American Indian tribes with interests or assets affected by the program; and
- Reviews, modifies, accepts, or remands recommendations from the AMWG in making decisions about any changes in dam operation and other management actions and forwards the approved recommendations to the Secretary.

Adaptive Management Work Group

The AMWG is a Federal Advisory Committee chartered by the Secretary consisting of a group of stakeholders that are federal and state resource managers, Native American tribes, power marketers, environmental groups, recreationists, and other interested stakeholders (see Glen

Canyon Dam AMWG Charter – Appendix B). The Secretary appoints the AMWG members. The AMWG is chaired by the Secretary's Designee and was established to develop, evaluate, and recommend alternative operation strategies for Glen Canyon Dam, and make recommendations to the Secretary. The AMWG does not displace federal agency legal authority and responsibility to manage resources in the best interests of both the environment and society. Responsibilities of the AMWG are:

- Provides the framework for Glen Canyon Dam AMP policy, goals, direction, and priorities;
- Develops recommendations to the Secretary for modifying operating criteria and other resource management actions, policies, or procedures;
- Facilitates coordination and input from interested parties;
- Reviews and forwards the annual report to the Secretary and his/her Designee on current and projected year operations;
- Reviews and forwards annual budget proposals; and
- Ensures coordination of operating criteria changes in the Annual Operating Plan for Colorado River Reservoirs and other ongoing activities.

In addition to creation of the AMWG, the TWG, GCMRC, and IRPs were created to play vital roles as part of the adaptive management process providing technical, scientific, and oversight support to the AMP.

Technical Work Group

The TWG is comprised of technical representatives of AMWG members and operates at the direction of the AMWG. The TWG's main function is to provide technical assistance to the AMWG. TWG functions may include:

- Developing, with the GCMRC, criteria and standards for monitoring and research programs and providing periodic reviews and updates of these;
- Developing, with the GCMRC, resource management questions (i.e., information needs);
- Reviewing and commenting on the scientific studies conducted or proposed by the program;
- Providing a forum for discussion by TWG members, external scientists, the public, and other interested persons;
- Providing information as necessary for preparing annual resource reports and other reports as required by the AMWG; and
- Reviewing strategic plans, annual work plans, long-term and annual budgets, and other assignments from the AMWG.

Grand Canyon Monitoring and Research Center

The GCMRC was established November 11, 1995, by the Assistant Secretary for Water and Science. The GCMRC was created to fulfill a mandate in the GCPA for establishment and implementation of a long-term monitoring and research program and serves as the science center for the Glen Canyon Dam AMP. The GCMRC leads the monitoring and research of the Colorado River ecosystem and facilitates communication and information exchange between scientists and members of the TWG and AMWG. Other functions of the GCMRC are:

- Advocate quality, objective science, and the use of that science in the adaptive management decision process;
- Provide scientific information about resources in the Colorado River ecosystem;
- Support the Secretary's Designee and the AMWG in a technical advisory role;
- Develop research designs and proposals for implementing (by the GCMRC or its contractors) monitoring and research activities in support of information needs;
- Coordinate review of the monitoring and research program with the IRPs;
- Coordinate, prepare, and distribute technical reports and documentation for review and as final products;
- Prepare and forward technical management recommendations and annual reports, as specified in Section 1804 of the GCPA, to the TWG;
- Manage data collected as part of the AMP and serve as a repository for other information about the Colorado River ecosystem;
- Administer research proposals through a competitive contract process, as appropriate;
- Develop, with the TWG, criteria and standards for monitoring and research programs;
- Develop, with the TWG, resource management questions (i.e., information needs); and
- Produce the State of the Colorado River Ecosystem Report.

Independent Review Panels

The IRPs, as called for in the Glen Canyon Dam EIS, are comprised of qualified individuals not otherwise participating in the long-term monitoring and research studies. The panels include peer reviewers, science advisors, and protocol evaluation panels whose primary responsibility is to assess the quality of research, monitoring, or science being conducted by the AMP and to make recommendations to improve it. Responsibilities of the panels include:

- Reviewing Glen Canyon Dam AMP monitoring and research programs and protocols;
- Providing reports based on their review to the GCMRC, TWG, and AMWG;
- Making recommendations and providing advice to the AMWG, TWG, and GCMRC regarding science activities;
- Assessing proposed research plans and programs, technical reports and publications, and other program accomplishments; and
- Conducting five-year reviews of GCMRC monitoring and research protocols.

Summary of the Glen Canyon Dam Adaptive Management Program

The AMP was developed and designed to provide an organization and process, using a collaborative, science-based integration of monitoring and research information, to make formal recommendations to the Secretary. These recommendations must recognize the environmental commitments of the Glen Canyon Dam EIS and ROD, and comply with the GCPA. The AMP must also remain in compliance with the Law of the River[2] and relevant environmental statutes, regulations, and policies. With all of these demands, the AMWG constructed a vision and mission statement for the AMP, including principles and goals, to guide its activities (see Appendix C).

GLEN CANYON DAM OPERATIONS

In water years 1999 through 2001, Glen Canyon Dam was operated in compliance with the ROD, *Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act of September 30, 1968* (Coordinated Long-Range Operating Criteria), and the GCPA. Operations for water years 1999, 2000, 2001, and projected water year operations for 2002, are described in detail below:

Glen Canyon Dam Operations – Water Year 1999

In water year 1999, aggregate runoff in the Colorado River Basin was near normal. The distribution of precipitation and snowpack accumulation throughout the water year, however, was quite varied. Near average precipitation was observed in the early months of water year 1999. Basinwide snowpack on February 1, 1999, was 89 percent of average. However, changes in basin hydrology occurred in the late winter. Very dry and abnormally warm weather occurred in February and March of 1999, resulting in reduced basinwide snowpack and inflow projections.
By April 1, 1999, basinwide snowpack had fallen to 71 percent of average and the April inflow forecast issued by the National Weather Service called for only 62 percent of average April through July unregulated inflow into Lake Powell. This warm dry pattern was reversed, however, as April and May were cooler than average months with abundant precipitation. April was particularly wet, with precipitation in the Upper Colorado River Basin more than twice the average. By mid-May, basinwide snowpack had risen to levels moderately above average.

The Upper Colorado River Basin also experienced a very strong summer monsoon season. Precipitation and inflow were much above average in August and September of 1999. The end

[2]Compacts, federal and state laws, court decisions and decrees, contracts, treaties, and regulatory guidelines that govern operation of the Colorado River.

result was a near average April through July snowmelt runoff in the Upper Colorado River Basin, with above average inflow to Lake Powell for the entire water year owing to the effects of the summer monsoon.

In water year 1999, April through July unregulated inflow into Lake Powell was 7.79 maf, or 100 percent of average. Water year 1999 unregulated inflow was 13.1 maf, or 112 percent of average. This inflow resulted in a gain of 0.593 maf of storage in Lake Powell. Lake Powell essentially filled in water year 1999, reaching a peak elevation of 3694.72 feet on July 16, 1999 (5.3 feet from full). Because of the summer monsoon, Lake Powell stayed nearly full though the end of water year 1999.

In water year 1999, a total of 11.4 maf of water was released from Glen Canyon Dam. Releases from Glen Canyon Dam in 1999 were made consistent with Article II(3) of the Coordinated Long-Range Operating Criteria for equalization of storage between Lake Mead and Lake Powell or for the avoidance of spills. Daily and hourly releases in 1999 were made within the parameters of the ROD for the Glen Canyon Dam EIS and the Operating Criteria for Glen Canyon Dam (62 Fed. Reg. 9447, March 3, 1997). Monitoring and research activities were conducted through the Glen Canyon Dam AMP on the effects of Glen Canyon Dam operations.

Monthly releases from Glen Canyon Dam varied in water year 1999, in large part due to changes in forecasted inflow. Monthly releases of 800,000 to 900,000 acre-feet were made from October 1998 through March 1999. Releases in April 1999 were reduced to 700,000 acre-feet, as forecasted inflow to Lake Powell was reduced due to below average basinwide snowpack. However, April and May of 1999 were months with much greater than average precipitation, and releases were increased in May to accommodate the additional runoff. From May 1999 through September 1999, releases varied between 980,000 acre-feet and 1,150,000 acre-feet.

Inflow to Lake Powell was unusually high in the late summer months of 1999 due to the summer monsoon. Unregulated inflow into Lake Powell in August 1999 was 196 percent of average, while September 1999 unregulated inflow was also high at 176 percent of average. These high summer inflows combined with a nearly full reservoir resulted in releases being maintained at relatively high levels through the end of 1999.

Glen Canyon Dam Operations – Water Year 2000

As water year 2000 began, a shift to a drier pattern in the Colorado River Basin took place. The strong summer monsoon, and above average precipitation and runoff that was experienced in August and September of 1999, was followed by very dry weather in October, November, and December 1999. By January 1, 2000, hydrologic conditions in the basin appeared bleak, with basinwide snowpack at only 43 percent of average.

The January inflow forecast issued by the National Weather Service called for only 52 percent of average April through July unregulated inflow into Lake Powell. While this forecast turned out to be very close to the observed inflow for the year, a moderately wet pattern, followed by a very

dry pattern, were yet to play out in the Colorado River Basin in water year 2000. In January, February, and March of 1999, hydrologic conditions in the basin were moderately wet, with basinwide precipitation about 130 percent of average during these three months.

By April 2000, the hydrologic picture in the Upper Colorado Basin looked quite different than it did three months earlier. Basinwide snowpack on April 1, 2000, was 91 percent of average and the April inflow forecast issued by the National Weather Service called for 85 percent of average April through July unregulated inflow into Lake Powell. However, another reversal in basinwide hydrology took place in April. Basinwide precipitation in the months of April, May, June, and July was only 60 percent of average. Many snow recording sites recorded a record loss of snow during the month of April 2000. The National Weather Service significantly reduced the April through July inflow forecast in May, with the forecast calling for only 69 percent of average. Inflow projections were further reduced in June and July as it became apparent that inflow was not keeping pace with earlier projections.

April through July unregulated inflow into Lake Powell in water year 2000 was 4.37 maf, only 56 percent of average. Water year 2000 unregulated inflow was 7.45 maf, only 63 percent of average. Lake Powell began water year 2000 nearly full with 23.0 maf of storage (95 percent of capacity). Only in the high water years of 1983 and 1984 was storage higher in Lake Powell on October 1. The below average inflow in water year 2000 resulted in a decrease of 2.06 maf of storage in Lake Powell. Lake Powell reached a seasonal peak elevation of 3683.4 feet on June 30, 2000 (16.6 feet from full).

The low April through July inflow forecast to Lake Powell issued in January of 2000 (4.0 maf or 52 percent of average) resulted in Reclamation's monthly operations study, the 24-Month Study, showing an annual release from Glen Canyon Dam of only 8.3 maf. The operation at that time was still controlled by storage equalization between Lake Mead and Lake Powell, as required under Article II(3) of the Coordinated Long-Range Operating Criteria, but was very close to being governed by the minimum objective release of 8.23 maf. Because of this, Reclamation began planning for the implementation of experimental flows as required by the Biological Opinion on the Operation of Glen Canyon Dam (Biological Opinion).

The Biological Opinion was issued by the U.S. Fish and Wildlife Service in December 1994. One of the elements of the reasonable and prudent alternative in the Biological Opinion is a "program of experimental flows . . . to include high steady flows in the spring and low steady flows in the summer and fall during low water years (releases of approximately 8.23 maf)." Since the issuance of the 1994 Biological Opinion, hydrologic conditions caused the operation of Glen Canyon Dam to be controlled either by storage equalization between Lakes Mead and Powell or by spill avoidance. None of the years 1995 through 1999 were years with dry basin hydrology, and releases were not governed by the minimum objective release of 8.23 maf from Lake Powell in accordance with Article II(2) of the Coordinated Long-Range Operating Criteria. In January of 2000, it appeared that water year 2000 would likely be an 8.23 maf release year. Planning for the implementation of experimental flows was influenced by changing hydrology. January, February, and March were months with above average precipitation in the Colorado

River Basin, with forecasted inflow to Lake Powell increasing sequentially each month. Forecasted inflow stayed below average, but increased from 52 percent of average in January to 85 percent of average in April, resulting in planned water year releases of about 9.50 maf, with equalization of storage between Lake Mead and Lake Powell governing the operation. Reclamation continued with the planning for a test release despite the changes in forecasted inflow. This test release proposal was called a low steady summer flow (LSSF) release.

The LSSF test releases were begun in April. From April through May, releases of 13,500 cubic feet per second (cfs) or higher were made to create impounded flow conditions in the Little Colorado River at its confluence with the Colorado River. In addition, as part of the test releases, a four-day powerplant capacity release of approximately 30,000 cfs was made from May 3 through May 5. Releases in June, July, August, and most of September were at 8,000 cfs. Hour-to-hour load following did not take place during the LSSF, and except for the effects of automatic generation control, where releases vary by up to 1,000 cfs of that pre-scheduled, releases during the LSSF were steady.

Even though 2000 was not a minimum objective release year, Reclamation executed the LSSF test release pattern because the unusual hydrologic conditions required release volumes in the second half of water year 2000 to be similar to those seen in a minimum objective release year. Knowledge was gained about the effects of such releases on the endangered humpback chub and other native fish, and will help better prepare Reclamation to pursue the elements of the reasonable and prudent alternative under minimum objective release conditions. Conducting this experiment was consistent with Reclamation's plan to implement the elements of the reasonable and prudent alternative from the Biological Opinion.

In water year 2000, a total of 9.5 maf of water was released from Glen Canyon Dam. Daily and hourly releases in 2000 were made within the parameters of the ROD for the Glen Canyon Dam EIS and the Operating Criteria for Glen Canyon Dam (62 Fed. Reg. 9447, March 3, 1997), with the exception of four days (May 3, May 7, September 5, and September 9, 2000) where the LSSF test releases required that daily fluctuation rates be exceeded. Monitoring and research activities were conducted through the Glen Canyon Dam AMP on the effects of Glen Canyon Dam operations.

The information shown in Fig. 2 depicts the daily average releases from Glen Canyon Dam from April 2000 through September 2000 as part of the LSSF.

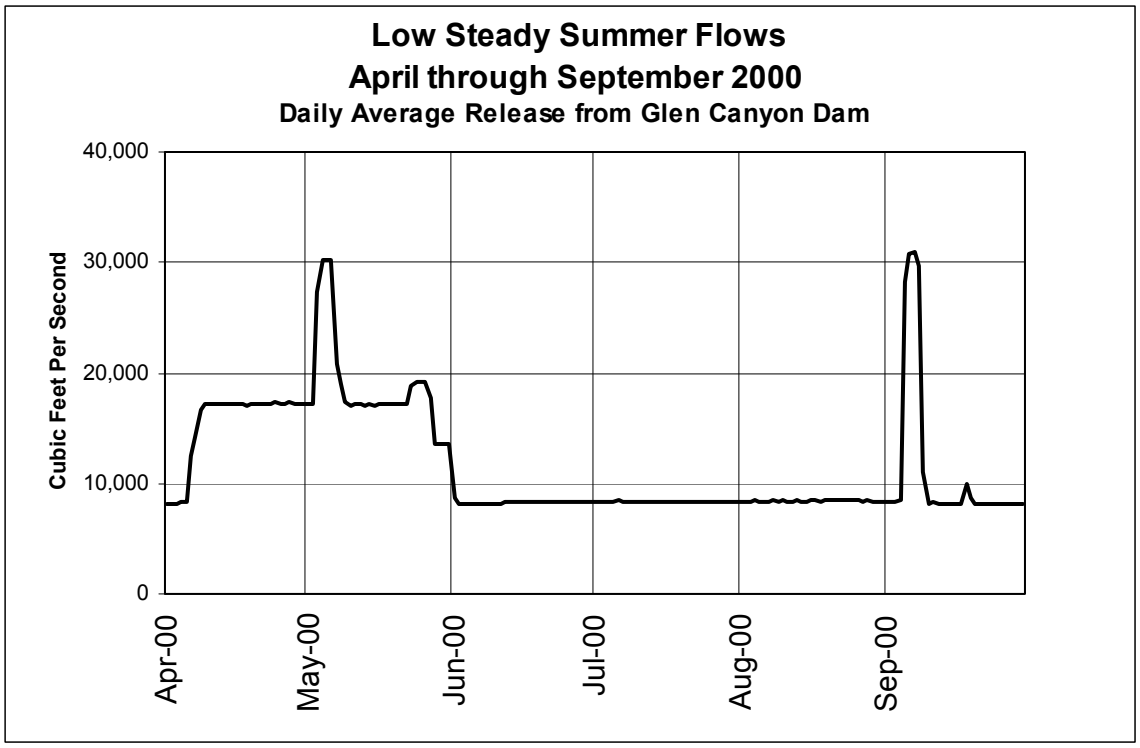

Figure 2.—Daily Average Release from Glen Canyon Dam During Low Steady Summer Flows (April – September 2000).

Glen Canyon Dam Operations – Water Year 2001

Water year 2001 was the second consecutive year with dry hydrologic conditions in the Colorado River Basin. While water year 2001 ended up being drier than normal in the basin, hydrologic conditions appeared favorable as water year 2001 began. Upper Colorado River Basinwide snowpack on January 1, 2001, was 92 percent of average with near normal runoff forecasted at the time.

Drier than normal conditions, with below average precipitation, were observed in the late winter and spring. During the April through July runoff period, warm and windy weather compounded the situation, contributing to a loss of snowpack and reducing runoff efficiency.

Unregulated April through July inflow to Lake Powell in 2001 ended up being only 4.30 maf, or 56 percent of average. This was nearly identical to the 4.37 maf of April through July unregulated inflow observed in water year 2000. Water year 2001 unregulated inflow was 6.96 maf, or 59 percent of average. This below average inflow resulted in a decrease of approximately 1.80 maf of storage in Lake Powell. Lake Powell reached a peak elevation of 3673.0 feet on July 1, 2001 (27.0 feet from full). Lake Powell ended water year 2001 with 19.1

maf of storage (79 percent of capacity).

In water year 2001, a total of 8.23 maf of water was released from Glen Canyon Dam. From October 2000 through June 2001, releases from Glen Canyon Dam were scheduled to achieve equalization of storage between Lake Mead and Lake Powell by the end of water year 2001 in accordance with Article II(3) of the Coordinated Long-Range Operating Criteria. Early season forecasts called for near normal inflows to Lake Powell requiring that the operation be governed by equalization.

Hydrologic conditions became drier as water year 2001 progressed and forecasted inflow to Lake Powell dropped to lower and lower levels through the late winter and spring months. By July 2001, forecasted inflow had dropped to 4.30 maf or 56 percent of average. This forecast was sufficiently low enough that storage equalization no longer became the governing criterion in the operation. From July 2001 through the end of the water year, releases were scheduled to maintain the minimum objective release from Lake Powell of 8.23 maf for water year 2001 in accordance with Article II(2) of the Coordinated Long-Range Operating Criteria.

Daily and hourly releases in 2001 were made within the parameters of the ROD for the Glen Canyon Dam EIS and the Operating Criteria for Glen Canyon Dam (62 Fed. Reg. 9447, March 3, 1997). Monitoring and research activities were conducted through the Glen Canyon Dam AMP on the effects of Glen Canyon Dam operations.

Due to the fact that water year 2001 began with Lake Powell below capacity as a result of a dry year in 2000, releases from Glen Canyon Dam were scheduled throughout the year anticipating the possibility that water year 2001 would be a minimum objective release year. The month with the highest release volume was January 2001 at which time the release was 850,000 acre-feet.

For seven days during water year 2001, Glen Canyon Dam responded to Stage III power emergencies in California. These responses occurred on February 15, March 19, March 20, May 7, May 8, May 31, and July 2. During most of these responses, generation was increased by about 300 megawatts (approximately 7,000 cfs) above that pre-scheduled. Ascending ramp rates and daily fluctuations exceeded the parameters of the ROD for the Glen Canyon Dam EIS preferred alternative on each of these occasions. However, emergency exception criteria cited in the ROD allows powerplant operations to exceed the parameters of the preferred alternative when necessary to respond to emergency situations. On each of the days that Glen Canyon Dam responded to the Stage III power emergencies, there was insufficient available generation capacity on the interconnected power system.

No experimental flows from Glen Canyon Dam were conducted in water year 2001.

Glen Canyon Dam Projected Plan of Operations – Water Year 2002

During water year 2002, releases from Glen Canyon Dam are scheduled to be 8.23 maf, the minimum objective release. Precipitation and snowpack in the Colorado River Basin in the first half of water year 2002 have been below average, requiring that scheduled releases be the minimum objective volume of 8.23 maf. Should hydrologic conditions in the Upper Colorado River Basin change, and inflow projections increase significantly, releases greater than 8.23 maf could be required to equalize the storage between Lake Mead and Lake Powell during water year 2002.

Due to less than full storage conditions in Lake Powell, resulting from two consecutive years of below normal runoff, releases above powerplant capacity are not likely in 2002. In the unlikely event that releases above powerplant capacity are required in 2002, such releases would be made consistent with the 1956 Colorado River Storage Project Act, 1968 Colorado River Basin Project Act, and 1992 GCPA. Reservoir releases in excess of powerplant capacity, required for dam safety purposes during high reservoir conditions, may be used to accomplish objectives of a beach/habitat-building flow according to stipulations cited in the ROD and the Operating Criteria for Glen Canyon Dam (62 Fed. Reg. 9447, March 3, 1997).

Releases from Lake Powell in water year 2002 will continue to reflect consideration of the uses and purposes identified in the authorizing legislation for Glen Canyon Dam. Powerplant releases and beach/habitat-building flows will reflect criteria based on the findings, conclusions, and recommendations made in the ROD for the Glen Canyon Dam EIS pursuant to the GCPA of 1992. As required by the Interim Surplus Guidelines ROD, an experimental flow program is being considered by the Glen Canyon Dam AMP. In 2002, the AMWG may forward recommendations on this matter for the Secretary's consideration.

Daily and hourly releases will continue to be made within the parameters of the ROD for the Glen Canyon Dam EIS and the Operating Criteria for Glen Canyon Dam (62 Fed. Reg. 9447, March 3, 1997). Exceptions to these parameters may be made during power system emergencies or for purposes of humanitarian search and rescue. Monitoring and research activities will be conducted through the Glen Canyon Dam AMP on the effects of Glen Canyon Dam operations.

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM ADMINISTRATIVE ACTIVITIES

Adaptive Management Work Group Recommendations to the Secretary of the Interior in Fiscal Year 2001

In January 2001, the AMWG met to discuss ongoing scientific monitoring and research activities and potential impacts of the operation of the dam. Under the program charter, the AMWG may make recommendations to the Secretary on these issues. During January 2001, the following formal recommendations to the Secretary were passed by motion and vote:

- Recommend that the Secretary adopt the fiscal year 2002 AMP Work Plan and budget request ($6.576 million power revenues for U.S. Geological Survey scientific work; $1.399 million power revenues for Reclamation administration, tribal consultation, and cultural compliance work; and $1.01 million U.S. Geological Survey appropriations request for scientific work) for a total of $8.985 million.

- Recommend support for the U.S. Geological Survey seeking appropriations for the AMP.

- Recommend that the Secretary seek funding for AMWG federal agencies to support tribal participation.

- Recommend that the TWG Budget Process Ad Hoc Group be charged to develop and ensure implementation of the prioritization process.

- Recommend that the Secretary seek funding for AMWG federal agencies to support scientific activities related to experimental flows in fiscal year 2002.

These formal recommendations were the result of extensive discussion among AMWG members. For additional background information on the recommendations, see Appendix D.

Tribal Consultations for the Adaptive Management Program

The meetings of the various work groups within the AMP are designed to provide opportunity for the five tribes (Hopi, Hualapai, Navajo Nation, Pueblo of Zuni, and Southern Paiute Consortium) to express their viewpoints on all issues related to Glen Canyon Dam operations and downstream issues that are of concern to the tribes. These meetings are viewed as one aspect of ongoing government-to-government consultation over the AMP and geographically related issues.

With respect to tribal involvement in the AMP, the major change in 2001 was that instead of continuing to fund tribal participation through the exclusive use of power revenues, each of the five Department of the Interior agencies participating in the AMP (Reclamation, U.S. Fish and Wildlife Service, Bureau of Indian Affairs, National Park Service, and U.S. Geological Survey) contributed funds to the tribal cooperative agreements. This shift recognizes that each agency,

with their differing missions, has a responsibility to consult with the tribes on issues relating to Colorado River ecosystem resources and AMP actions.

Programmatic Agreement for Cultural Resources

Completion of a National Register of Historic Places determination of eligibility for the Grand Canyon and Glen Canyon below Glen Canyon Dam, as a place of traditional cultural importance to the tribes, was the major issue worked on in 2001 under the Programmatic Agreement for Cultural Resources. The determinations are not yet complete; however, major progress was made by having the AMP agencies recognize the significance and value of the Grand Canyon to each of the participating tribes.

Budget for the Glen Canyon Dam Adaptive Management Program

Funding needs for the Glen Canyon Dam AMP for fiscal year 2003 are described in Appendix E. The total budget, which includes costs for the support of the AMWG, TWG, Reclamation's Programmatic Agreement Program, and GCMRC, is $9,904,000.

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM SCIENTIFIC ACTIVITIES

Protocol Evaluation Panel Reviews

The Protocol Evaluation Panels (PEP) were initiated to provide independent external review of all GCMRC monitoring and research programs and provide recommendations to the GCMRC and the AMP regarding the specific monitoring protocols that will be used. The PEP process for evaluating current and new alternative protocols in all program resource areas is scheduled for completion by the end of fiscal year 2002.

The final PEP reviews and accompanying reports have been reviewed by the TWG and are in the process of being forwarded to the AMWG for each of the resource areas listed below. A list of the findings and recommendations of each independent review panel is included.

Aquatic Resources

- Water Quality: A water quality program that monitors physical and biological parameters of the Colorado River in Grand Canyon should be established.
- Food Base: The food base program needs to be critically reviewed because the current level of understanding about the linkages between lower trophic levels and food availability of native fishes is not adequate to interpret food base data in relation to the management goal. Lower trophic levels can also be used to monitor ecosystem changes.
- Humpback Chub: The panel recommends that further work be conducted to develop a conceptual model of the metapopulation biology of chub in the Grand Canyon ecosystem to provide a context for a long-term monitoring program. Consideration should be given to the inclusion of genetic concerns in the monitoring program.

- Other Native Fish: The panel was concerned that there was no plan for monitoring the status of the three other extant native fish of the Grand Canyon ecosystem.
- Exotic Fish: For the Grand Canyon ecosystem below Lee's Ferry, the management goals for non-native fish are related to their impacts on native species. The panel was impressed by the efforts to develop a program to estimate the abundance of salmonids in the Colorado River, but felt some effort should be reallocated to the other components of risk to native species, especially with respect to predation. There is no explicit program for warm-water exotic fish species. The panel suggests that the species should be ranked for their potential for impacting native species, and that monitoring metrics be developed for the important species that address potential risk to native fish.
- Management Issues: The panel observed considerable variation in the analytical effort expended, the timeliness of reporting, and the availability of standardized data bases among programs for aquatic resources. A standardized annual reporting cycle is a key component of any monitoring program.

Cultural Resources

- Refine the definition of the Area of Potential Effect for the program.
- A Historic Preservation Plan must be completed and adopted as a top program priority.
- Expand Native American involvement at multiple levels.
- Prepare an archaeological research design as soon as possible.
- Redefine the roles of archaeological monitoring and monitoring of other cultural resources.
- Develop an archaeological treatment plan.
- Improve coordination and integration of a complex program.
- Improve cultural resource contracting procedures.

Integrated Water Quality Program

- Shift emphasis from Lake Powell to downstream.
- Employ water quality-ecosystem models in Lake Powell and the Colorado River to link Glen Canyon Dam operations and physical/chemical/ecosystem responses in a timely manner using the best information available.
- Work with other programs in the GCMRC Biological Resources Program in the integration of results to allow decision making by the TWG and AMWG by linking operations of Glen Canyon Dam and various ecosystem responses.
- Develop a "proactive" long-range water quality monitoring strategy to prepare for a wide range of possible management actions.
- The GCMRC should work with the TWG to improve the management objectives/information needs process.
- The Lake Powell forebay station should be changed to the White Category.
- It is imperative that the GCMRC provide critical information in a timely manner to allow cost-effective and environmentally effective decisions for the AMP.
- Provide other specific technical findings and recommendations pertaining to data collection, water sample preservation and analytical procedures, data management, water quality-ecosystem monitoring, priorities for sampling, etc.

Kanab Ambersnail

- Additional analyses of shell morphology, anatomy, and molecular genetics (i.e., mitochondrial DNA), using state-of-the-art methods, are urgently needed to resolve taxonomic, phylogenetic, and, in part, distributional questions.
- Also urgently needed are additional field surveys of potential succineid habitats both upstream of Glen Canyon Dam and downstream within the Colorado River drainage, as well as in regions outside the Colorado River Basin that provide potential habitat.
- In contrast, additional efforts at translocation and establishment of captive populations are not warranted.
- Population viability analysis of the Vaseys Paradise population, and probably other *Oxyloma* populations, is not likely to be informative or helpful for conservation of these populations; preferable alternatives to population viability analysis exist.
- Flooding from dam releases within the historic (pre-dam) seasons and levels is justified ecologically and is unlikely to pose a significant threat to the Vaseys Paradise snail population, which appears to have evolved under an intense flooding regime.
- No scientific basis exists for heroic efforts to maintain or create artificially large or multiple populations of the Vaseys Paradise snail; instead, available information on historical ecology supports a minimally invasive approach to management of Vaseys Paradise and other populations of *Oxyloma*.
- The Recovery Plan for the *Oxyloma* populations in this region should be re-written as soon as the major taxonomic issues are resolved. The Vaseys Paradise population may warrant listing and conservation as a distinct, imperiled taxon, perhaps a single-site endemic.
- The administrative and management implications of new taxonomic findings should be discussed and disseminated widely and promptly to all parties. Any subsequent management or recovery plan should be subjected to a review process similar to that of this panel prior to implementation.
- Our conclusions suggest a reconsideration of current management direction for these snails and their ecosystems.

Lee's Ferry Trout

- The GCMRC should develop an explicit set of study objectives, based on desires of stakeholders, that will drive all activities.
- Leadership by the Arizona Game and Fish Department is needed to suggest to stakeholders what management options are available and which are optimal.
- The GCMRC should provide leadership and promote collaborative research that leads to integrative understanding of the Colorado River from Glen Canyon through the Grand Canyon.
- Collaborative work and integrated understanding will improve research and management effectiveness.
- The GCMRC and the new senior scientist should ensure that the research and monitoring it supports leads to an integrative understanding of the entire ecosystem.
- The GCMRC should promote outreach involving Grand Canyon researchers and other members of the scientific community.
- Monitoring and research should be directed toward ecosystem understanding and should directly support adaptive management decisions.
- Linkages between upstream and downstream areas and between aquatic and terrestrial habitats must be explicitly acknowledged.
- Monitoring protocols should be optimized to maximize statistical power while minimizing collection

of unnecessary information.
- Recommend analyzing existing data.
- Creel sampling of the Lee's Ferry fishery should be continued.
- Monitoring for whirling disease should be added to the monitoring protocol.

Sediment

- Emphasized the importance of developing a conceptual framework that would encompass all GCMRC science programs. The panel believes that the ecosystem model being developed is probably the best way to do that.
- Saw a need for clarifying the way the information needs are stated – it is part of the two-step process where the AMWG and TWG prepare the broader goals and then the scientists from each program determine precise information needs.
- Emphasized the importance of using a synoptic or snapshot picture of the riverbed as a basemap for identifying how to focus in on the detail study reaches.
- Emphasized that the 1-D and 2-D sediment modeling is critical to the sediment budget and should continue. The collection of daily sediment samples along the main channel is also critical to the sediment budget and the panel believes sampling could be expanded to include some of the other tributary channels that provide significant amounts of sediment to the main channel.
- The panel was satisfied with the way the physical resources program is being managed.

Terrestrial Aspects of the Biological Resources Program

- Recommend developing a comprehensive monitoring strategy for addressing the terrestrial monitoring program's diverse mission, rather than the current approach which treats these needs in a piecemeal fashion.
- There appears to be little scientific direction to the monitoring program. Recommend appointing the Scientific Advisory Board as described in the Long-Range Strategic Plan. The GCMRC also should employ a chief scientist.
- Ensure integration across disciplines. Recommend encouraging cooperation, including shared sampling sites and joint river trips, among investigations of hydrology, sediment transport, fisheries, vegetation, and terrestrial animals.
- There appears to be no mechanism to ensure long-term comparability of monitoring data across contractors and GCMRC personnel. Recommend developing protocols for evaluating responses and selecting study sites before any further proposals for terrestrial studies are requested, and ensure that new contractors are properly trained in these protocols.
- The GCMRC has focused on short-term events rather than long-term responses. Recommend that the AMWG and TWG incorporate a long-term perspective into their information needs. This perspective should also be incorporated into monitoring plans and methodologies.
- Insufficient emphasis has been placed on developing models that will predict the effect of dam operations on terrestrial ecosystems. Recommend developing a terrestrial ecosystem model with the same level of detail as the current aquatic model. Such a model, linked with field work on specific ecological relationships and ecosystem responses, is probably the only way to address "what if" management questions regarding dam operations.

- The effort dedicated to the Kanab ambersnail is out of proportion compared with work on other field

components. Recommend confirming whether or not the snail population at Vaseys Paradise is actually the Kanab ambersnail. Reduce the scale and frequency of the current monitoring effort and use minimally invasive methods. Minimize disruption of other endemic snail species caused by translocation of the Vaseys Paradise population.

- The GCMRC has several immediate needs before a monitoring program can be implemented. The Biological Resources Program, in collaboration with other programs of the GCMRC, should place high priority on developing and/or completing a number of products needed for development of a comprehensive monitoring program; i.e., a Geographic Information System (GIS) coverage and current land cover map of the entire river corridor, a random sample of spatially distributed study sites, cost- effective response indicators and protocols, and protocols to ensure interdisciplinary cooperation.

Experimental Flow Testing – Water Year 2000

One element of the 1994 Biological Opinion on the Operation of Glen Canyon Dam calls for development of a program of experimental flows intended to benefit native fish in the Colorado River below the dam. In September 1999, a hydrograph and study approach for experimental native fish flows was presented to the Glen Canyon Dam TWG. Soon thereafter it became apparent that the hydrologic conditions for conducting the first experimental flow, being a release year of approximately 8.23 maf, were becoming increasingly likely. During February 2000, meetings were held with researchers and managers to develop a science plan for a "test of concept" flow in water year 2000.

A letter seeking concurrence with the proposed flow regime was sent by Reclamation to the U.S. Fish and Wildlife Service on March 30, 2000, and a positive response was received on April 5, 2000. The science plan was finalized in April and studies began that month.

The experimental flow regime, shown in Fig. 3, contained features identified in the 1994 Biological Opinion, including high steady flows in spring and low steady flows during summer and autumn. Habitat maintenance flows consisting of short-term spikes to powerplant capacity were released in May and September 2000. One power emergency (PE) in mid-September (see PE, Fig. 3) created a short-term deviation from planned steady flows.

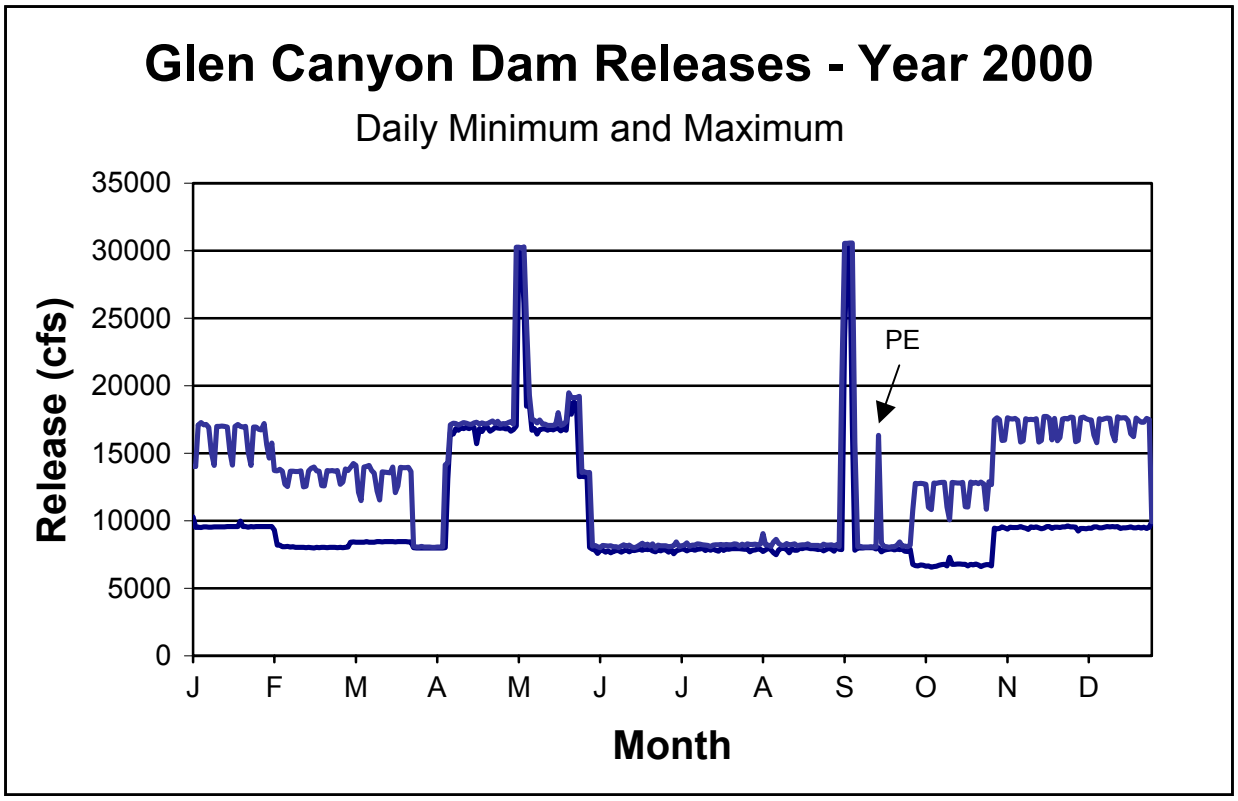

Figure 3.—Daily Minimum and Maximum Releases from Glen Canyon Dam During Water Year 2000.

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM STATUS AND TRENDS OF DOWNSTREAM RESOURCES

Preliminary conclusions indicate that after implementation of ROD dam operations there is greater aquatic productivity, many more non-native trout, a declining endangered humpback chub population, and ongoing erosion of sediment and cultural resource sites. The specific cause and effect relationship of some of these trends is still unclear. Since the humpback chub and sediment are such key resources, the AMP is placing greater focus and effort on activities that can counter these trends.

Evaluation by Resource Category

Aquatic Resources

The aquatic foodbase refers to the phyto-benthic community (algae, macrophytes, and invertebrates) that is utilized by consumers such as fish and 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 and water quality of discharge), colonizing substrate (sand or cobble), and top down effects (overpopulation and 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. 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 operation of 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 are a management concern.

Research findings have revealed a longitudinal decrease in standing biomass of algae, epiphytes (other plants growing on algae), and invertebrates as a function of increasing distance downstream from Glen Canyon Dam. The significant decrease has far-reaching trophic consequences. Similar patterns exist for fish distribution, composition, and relative abundance. Many of the native fishes of the Colorado River are presently listed as threatened or endangered. And changes to some of the abiotic (i.e., temperature and sediment flux) and biotic (i.e., food availability and predation pressures) factors are implicated in their decline and/or extirpation. In addition to this, a non-native rainbow trout fishery was established within the tailwater section of the dam and is considered an important recreational resource. The invertebrate assemblage supports a trout fishery in the Glen Canyon reach and a fish community downstream of Lee's Ferry that includes both native and non-native warm-water fish as well as rainbow and brown trout. In recent years, rainbow and brown trout populations have increased in abundance reaching levels of 750,000 and 75,000 fish, respectively (Arizona Game and Fish Department, 2001).

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 operation of Glen Canyon Dam.

The native fish community in the Colorado River in Grand Canyon was once one of the most unique in the world, supporting eight species that occurred nowhere else. Of the eight native fish species, three (Colorado pikeminnow, roundtail chub, and bonytail chub) have been extirpated from Glen and Grand Canyons; one – listed as endangered (razorback sucker) – has not been observed in the system since 1991; one (humpback chub) is listed as endangered; one (flannelmouth sucker) is a candidate for listing; and the remaining two (bluehead sucker and speckled dace) appear to be doing reasonably well in the Grand Canyon although much remains to be learned about their ecology and population dynamics.

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 effort 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. The 1996 beach/habitat-building test flow 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 in arroyo mouths. The overall findings of this high flow on cultural resources suggest that the deposit of sediments in erosion prone areas can slow the rate of erosion in archaeological locations. Recent research in the physical resources area at the GCMRC indicates that the timing of beach/habitat-building flows relative to tributary inputs with heavy sediment loads is the most beneficial in providing materials for margin deposition.

Current resource monitoring of archaeological and traditional resources suggests that archaeological resources continue to be impacted by physical impacts such as surface erosion and gullying 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. Visitor impacts such as trailing and collection of artifacts have also been noted at archaeological sites and locations of traditional importance.

Monitoring of traditional plant resources continues by tribal groups. Graffiti at two rock art sites was observed by the Southern Paiute Consortium and visitor impacts were observed at two important Navajo sites. Monitoring by the Southern Paiute Consortium indicated that plant resources at 75 percent (nine 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. 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. 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.

Endangered Fish (Humpback Chub) and Non-Native Fish Control

The humpback chub was listed as endangered under the Endangered Species Act in 1973. Subsequently, for humpback chub in the Grand Canyon, the U.S. Fish and Wildlife Service issued its first jeopardy biological opinion to Reclamation in 1978. The consultation process was reinitiated by Reclamation on the preferred alternative of the Glen Canyon Dam EIS, yet resulted in the receipt of a second jeopardy biological opinion in 1995. Activities in response to the biological opinions for humpback chub have been incorporated into the Glen Canyon Dam AMP.

In addition, the Upper Colorado River Endangered Fish Recovery Program calls for the establishment of three core populations at levels sufficient to ensure viability of the population. The population of humpback chub in the Grand Canyon is thought to be the largest of the five remaining humpback chub populations, and is the only significant population of the species found in the Lower Colorado River Basin. It is plausible that the Grand Canyon population will be one of the three core populations required to meet the recovery goals and achieve down listing and eventual de-listing of the species.

There are a number of challenges to sustaining native fish in the Colorado River ecosystem below Glen Canyon Dam. These include: (1) providing the physical characteristics (habitat) that allow fish to reproduce and survive (recruit), (2) providing a food supply adequate for fish growth, (3) minimizing predation and competition from other species that could limit or threaten a population of native fish, and (4) limiting the impact of disease and parasites. In addition, various combinations of the above factors need to be considered and addressed.

The first population estimate of humpback chub in the Grand Canyon suggests that in 1982 there were 7,000 to 8,000 humpback chub larger than 200 millimeters. Approximately ten years later, in 1992, it was estimated that there were approximately 4,000 to 5,000 humpback chub larger than 150 millimeters. In 2001, there were approximately 2,000 to 3,000 humpback chub larger than 150 millimeters. While there is some question over the accuracy of the absolute numbers, there is little question that the population of humpback chub in the Grand Canyon has declined over time. The decline in the abundance of fish larger than 150 millimeters appears to be the result of a sustained decline in recruitment beginning in 1992.

Information on the status and trends of humpback chub was presented to the TWG at its November 2001 meeting and to the AMWG at its January 2002 meeting. Along with information on the decline in population of the humpback chub, a number of possible factors that might explain the decline were also presented. Unfortunately, at this point in time there is little data that can provide a direct cause and affect explanation for the downward trend.

Factors that need to considered include:

- Predation or Competition – Has predation on, or competition between humpback chub and non-native fish in the mainstem of the Colorado River as well as the Little Colorado River, led to the population decline?

- Hydrology – Have flows from Glen Canyon Dam, beginning in 1991 with interim flows and continuing with ROD flows to the present, affected the population? Has the natural hydrology of the Little Colorado River resulted in a poor year class (i.e., 1992)?

- Parasitism – Is the decline in population the result of an apparent increase of Asian tapeworm and the variables that might affect its abundance and distribution?

- Natural Variability – Is this just a cycle of natural recruitment variability or are we seeing the beginning of a sustained downturn in recruitment success?

- Food – Has there been a change in the quantity and quality of food resources and is this having an affect on the population?

- Water temperature and clarity. Does water temperature and clarity play a role in humpback chub recruitment and survival?

- Interactions of the above factors and other explanations not yet considered.

While we continue to collect additional data on some of these factors, there is a suggestion that we begin examining non-native fish control. This would focus on brown trout whose population abundance is centered on the mouth of Bright Angel Creek, carp and catfish found in the mouth of the Little Colorado River, and rainbow trout found below the Paria River. Fish biologists and TWG members are considering a proposal to implement non-native fish control. The ideas being considered are:

- Control of brown trout in Bright Angel Creek through installation of a weir for counting fish, examining how much of the population spawns in Bright Angel Creek as compared to the mainstem, and then removal of brown trout as a second phase.

- Examination of methods for capturing carp and catfish in the Little Colorado River to better estimate their numbers, examine their stomachs to determine the amount of predation, and then initiate removal of these non-native fish.

- Continue to capture rainbow trout in the mainstem of the Colorado River ecosystem below the Paria River to evaluate predation, and then examine methods of removal, including the possibility of using flows from the dam as a means of disrupting the spawning success of rainbow trout below the Paria River.

There are many factors that potentially affect the humpback chub. Therefore, the ability to detect changes in the population dynamics of humpback chub resulting from predator control activities will be challenging. It will require robust scientific planning, aggressive

implementation, and cooperation from management entities in order to separate the effects of the control efforts from the effects of dam operations and other variables.

All of the stakeholders in the AMP support taking necessary actions to benefit the endangered humpback chub. The National Park Service has indicated a willingness to move forward with implementing the brown trout activity discussed above. The Arizona Game and Fish Department and Trout Unlimited have raised concerns about prematurely targeting rainbow trout as the cause of the decline of humpback chub.

Reclamation believes that the AMWG will propose a set of non-native fish control actions that should be implemented as soon as possible. These actions must be implemented in a way that does not detract from ongoing monitoring activities. Adequate funding to support these actions will be required.

Information Technology Program

The Information Technologies Program is comprised of several key areas which together help achieve the GCMRC mission goals of providing reliable, credible, and objective scientific information for the Glen Canyon Dam AMP and the public.

Systems Administration and Data Base Management System – These areas encompass a major Oracle data base development project, Internet map server, and World Wide Web server. Currently in the pilot stage, the goal is to achieve a functional Oracle/GIS data base and Web-based query application structured on key data sets. Oracle's data base management software is being combined with GCMRC's ARC/INFO GIS to enable data sets to be viewed and queried in a spatial context. Because the GCMRC is structured as and has proven to be an independent objective science center, other agencies and organizations tend to recognize the GCMRC as responsible data stewards. This enables integration of other disciplines' data into a common framework. Work is continuing on electronically archiving all data sets and final reports of investigation. Refinement of computer applications will further enable researchers to electronically record data collected during monitoring and research trips while they are still in the field, saving valuable data processing time back in the office. The resulting multidisciplinary, relational data base will assist with analyses of long-term changes and trends in the Colorado River ecosystem. To date, significant progress has been made in these areas and will result in a user-friendly computing environment accessible to researchers, the Glen Canyon Dam AMP, other adaptive management programs, and the public. The GCMRC is utilizing Oracle data base specialists to achieve this goal by the end of December 2002.

Geographic Information System and the GCMRC Library – The GCMRC's GIS department is primarily dedicated to evaluation, archiving, and distribution of data sets collected during any given period of research. Currently, significant accomplishments of the GIS department include the evaluation, archiving, and distribution of data sets collected during the 2000 flow experiments, including the LSSF and the fall spike flow. It also completed quality assurance checks on all remotely sensed data sets collected in 2000, including the spring and fall LIDAR

and orthophotography and the summer color infrared digital photography. The GIS department checked over 20,000 files, filling over 2000 gigabytes of hard drive space for readability, meta-data content, and adherence to contract specifications and data standards. It helped develop an archive structure to store all GIS layers, imagery, data base tables, and library reports. The data will be made available on the GCMRC website. The GIS department is actively involved in development of the integrated data base management system.

The GCMRC's Library is a valuable resource and accessed regularly by researchers and the public. Its responsibilities include managing information requests, checking and archiving data collected, management of independent peer review of incoming reports and contract deliverables, and conversion of historic research information into electronic format.

Remote Sensing and Survey – The GCMRC remote sensing department primarily collects remotely sensed data via contracted annual aerial overflights that record data in black-and-white and color photography. Natural-color photography is critical to vegetation studies. Black-and-white stereo photography is collected of the entire Colorado River ecosystem. Acquisition and archiving of this annual aerial photography is vital for current and historical references of the canyon and its ecosystem. The remote sensing department also evaluates ground-based and airborne remote sensing technologies to ensure that the technology used will provide a reliable, scientifically beneficial result in an overall cost-effective manner. Current accomplishments include evaluation of various remote sensing technologies to enable recommendations that will fulfill the monitoring requirements of GCMRC program elements. These elements include mapping riparian vegetation and warm-water fish habitats, detecting and monitoring cultural resources, and monitoring terrestrial sandbar deposits. The collected and processed data provides information in response to stakeholders' management objectives. The remote sensing recommendations and report will be completed in fiscal year 2002.

The survey department's main focus is maintaining a network of survey "control" points throughout the Colorado River ecosystem, and hydrographic topographic data collection. Periodic mapping of these points using a common, repeatable geographic coordinate system is critical to detect changes in resources and enable water, ground, or aerial spatial measurements to be recorded at a given point in time. The survey department provides terrestrial contour and hydrographic base maps. These mapping activities and archives provide valuable information on status and changes in physical, biological, and cultural resources including sediment movement and storage, test flood analyses, and threatened and endangered species habitat. It provides support to GCMRC contracted scientists and investigators for spatially referencing data collected in the field.

In coordination with the National Geodetic Survey, the survey department has established extremely accurate, monumented rim control points as a framework for all mapping and survey operations within the canyon. This supports spatial measurement of scientific data for monitoring and research activities. The department has also developed and implemented multi-beam hydrographic technology for collecting very high-resolution sub-aqueous channel topography (underwater mapping). This can be used for sediment modeling, channel topography base maps, biological habitat research, etc. The department is also utilizing static differential global positioning in the canyon. This is important for extending an accurate survey control framework within the river corridor.

Kanab Ambersnail

The Kanab ambersnail is a federally endangered landsnail that was listed in 1992. Living Kanab ambersnail were first collected by J.H. Ferriss in 1909 near Kanab, Utah, in seep vegetation. The genus has a broad distribution (North America, Europe, and South Africa), but the taxonomy has been based on internal and shell morphology, and is being revisited through molecular genetic techniques. Extant populations of Kanab ambersnail are described from: (1) Three Lakes, near Kanab, Utah; (2) in seeps and springs along Kanab Creek, near Kanab, Utah; (3) Vaseys Paradise, a spring at Colorado River mile 31.5R in Grand Canyon, Arizona; and (4) populations on the east slope of the Canadian Rocky Mountains in Alberta. Vaseys Paradise is a fast flowing, cool, dolomitic-type spring, with abundant wetland and phreatophyte vegetation, especially native crimson monkeyflower, sedge, smartweed, and poison ivy, and non-native watercress.

Within Grand Canyon, the Kanab ambersnail is apparently restricted to Vaseys Paradise: no Kanab ambersnail has been detected at more than 150 other Grand Canyon springs surveyed from 1991 through 1998. This suggests that the Vaseys Paradise Kanab ambersnail population, like many southwestern spring species, is a Pleistocene relict which became restricted in distribution as the Holocene climate dried out. Genetic dissimilarity with other ambersnail populations in the Colorado River drainage further supports this contention.

Kanab ambersnail monitoring at Vaseys Paradise has continued to follow the protocols begun in 1997. Population estimates for the snail indicate that 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. There is also a large segment of potentially suitable habitat for this species above 100,000 cfs which is not being surveyed under current protocols because the work requires special climbing skills. There is no currently available population dynamics model for Kanab ambersnail which would allow a framework for considering both variability and habitat relationships.

Genetic analysis of the snail at Vaseys Paradise and other snails assumed to be related to the Kanab ambersnail suggest that the Vaseys 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 ambersnail species from Canada and the Great Plains. While the genetic distance between the Three Lakes and Vaseys populations are greater than expected, these taxa are more similar morphologically than between Three Lakes and other snails sampled from the Kanab Creek drainage. Indications persist that the Vaseys population is a distinct species, however its exact taxonomic status remains unresolved. More genetic and morphologic analysis of the ambersnail complex resulting in taxonomic revision is needed to resolve management questions around the Vaseys Paradise taxon.

Recreational Resources

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

Beaches and sandbars 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. 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. The effects of the 1996 beach/habitat-building test flow 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.

Recent GCMRC studies have assessed camping beaches, trout fishing activities, and recreational river running and the related experiences and safety issues. An ongoing effort is studying campsite assessment and monitoring protocols that are used for quantitative beach and sandbar measurements and the detection of area and volume change. In addition, annual monitoring of 34 campsite areas is ongoing. Interim results from this monitoring indicate that camping areas continue to slowly erode. However, the erosion can be offset by flows greater than powerplant capacity combined with adequate sediment supply. Studies are ongoing regarding the magnitude and frequency of such flows.

Sediment

The Grand Canyon is one of the most spectacular erosional features in the world. While much of the sediment from the Grand Canyon was eliminated with the construction of Glen Canyon Dam, natural erosional processes, such as gullying, continue. The following is a summary of recent findings:

Fine-Sediment Overview – Monitoring and research of sedimentology, hydrology, geomorphology, and sediment transport from 1990 through 2001 indicates that sandbars in the Colorado River ecosystem below Glen Canyon Dam continue to erode, despite attempts to restore and maintain fine-sediment resources in this reach of river. The current strategy for conserving sandbar resources under Glen Canyon Dam operations is based on two final Glen Canyon Dam EIS assumptions: (1) that sand supplied by tributaries downstream from the dam would accumulate throughout the river's channel during normal dam operations under the current Glen Canyon Dam ROD, and (2) that occasional beach/habitat-building flows could effectively re-deposit channel-accumulated sand along shoreline habitats. While the 1996 beach/habitat-building flow test demonstrated that this second assumption could be achieved, the first assumption has proven to be false.

Sand Mass Balance – During mostly normal operations associated with modified low fluctuating flows, intensive monitoring of suspended-sediment transport over the past three years has shown that a significant portion of new tributary sand inputs is exported downstream to Lake Mead rapidly; often in only a few months. As a result, sediment scientists have concluded that the Glen Canyon Dam EIS prediction for multi-year accumulation of sand in the river channel is false for most ROD operations. Between 1999 and 2001, one experimental period of constant dam releases (8,000 cfs during summer 2000) did result in surplus sand storage in the river channel. However, the return to higher flows in fall 2000 resulted in continued export of sand to Lake Mead. A major reason for the rapid downstream transport of new tributary sand is related to the fine grain size of the remaining sand supply and its effect on main-channel transport rates. Grain size of the remaining sediment supply was one element of sediment transport that was not fully evaluated during EIS studies from 1990 through 1995. Cooperating scientists now predict on the basis of historical and recent data that dam operations need to be constrained to about 10,000 to 12,000 cfs (or less) in order for new sand inputs to accumulate in the river channel over multi-year periods; a restriction that may not be possible within legal dam release requirements.

Sandbar Monitoring – Annual sandbar monitoring data collected from 1990 through 2001 show that erosion of sediment resources below Glen Canyon Dam has continued despite the addition of several significant sand inputs from major tributaries below the dam during the period 1997 through 2000. While most high-elevation sandbars (above 25,000 cfs) increased in sand volume during the 1996 controlled flood test, these gains came at the cost of sand volume losses within lower elevation sand deposits (from the active fluctuating zone defined by flows of 8,000 to 25,000 cfs). Because beach/habitat-building flows have not been implemented since the spring of 1996, dam operations have exported new sand inputs and caused continued erosion of existing

sandbars, and have not deposited new sand supplied along shorelines above the actively fluctuating zone. Current trends in sediment resources warrant a re-evaluation of ROD dam operations with respect to the strategy for achieving sediment conservation, as well as restoration and maintenance of sandbars and related habitats.

Large tributary floods that enrich the river's upstream sand supply typically occur during late summer and early fall. Under the 1996 Glen Canyon Dam ROD, however, floods can only be implemented from January through July when specific hydrologic triggering criteria related to storage in Lake Powell and forecasted April through July runoffs are met. The current decision process for releasing controlled floods presumes that substantial sand accumulation on the channel bed occurs under normal dam operations, an assumption that is now known to be false on the basis of several monitoring data sets.

Sediment researchers have now proposed three alternatives to solve this problem:

- Release a beach/habitat-building flow in the fall immediately after a sediment input from one of the tributaries;

- Keep releases low (less than 10,000 cfs) between fall tributary events and the January through July hydrologic triggering criteria period; or

- Pursue sediment augmentation, perhaps through a sediment pipeline from the upper end of Lake Powell to below Glen Canyon Dam.

The first of the three options is not consistent with the current understanding of the Law of the River, the second option might be viable during a low steady flow test such as the water year 2000 test, and the third option might be viable, but may be expensive and require accompanying changes in hydrology.

Currently, ad hoc groups of the TWG are developing a program of experimental flows in response to both the sediment deposition issue and the requirements of the 1994 Biological Opinion on the Operation of Glen Canyon Dam. The Biological Opinion requires testing low steady flows to benefit the endangered humpback chub. This test flow program will directly address the two most pressing resource concerns in the Grand Canyon: sediment and the humpback chub.

With respect to the sediment issue, the TWG ad hoc groups have proposed that Reclamation conduct experimental flow tests that are less controversial and less expensive than the three recommendations of the sediment researchers. These flow scenarios would have the same goal of restoring sandbar deposits, but would remain within the time period of the hydrologic triggering criteria and attempt to minimize the economic impact of such tests to power users. The flow scenarios would accomplish this by:

- Conducting a beach/habitat-building test flow during the January through July period. This would

comply with the Law of the River and the agreement between the Department of the Interior and the Colorado River Basin states (Utah, Wyoming, Colorado, New Mexico, Arizona, California, and Nevada).

- Ensuring that sediment is available for the beach/habitat-building flow to suspend. This would be accomplished by releasing either a powerplant capacity habitat-maintenance flow or high powerplant fluctuations immediately after a fall tributary input. These options would both be consistent with the Law of the River. The tributary sediment input would thus be moved from the main channel to low velocity eddies where it should remain until a beach/habitat-building flow could occur during the January through July time period. An alternative approach would be to conduct a beach/habitat-building flow after the conclusion of a low release period in which fall releases would be lower than normal and there was a greater probability of main channel accumulation of sediment. Such low releases could occur either during a test required by the 1994 Biological Opinion or during normal operations during an 8.23 maf release year.

- Increasing the magnitude and reducing the duration of the beach/habitat-building flow, thus attempting to limit the amount of bypassed water. The 1996 beach/habitat-building test flow proved that the high flow concept does work, but most researchers believe that the benefit from such a flow would persist longer if the flow were of greater magnitude and of shorter duration. A key goal would be to minimize the economic impact to the power users from bypassed water.

Stakeholders have strong feelings regarding beach/habitat-building flows and diverse viewpoints exist on this issue. The National Park Service, recreation groups, and environmental interests are pressing for beach/habitat building flow and habitat maintenance flow tests which they perceive may counteract sand bar degradation and help restore native species to the Colorado River ecosystem. Water and power interests resist any circumventing of the Law of the River and unacceptable reductions in power production and related revenues. Trout interests are leery of another beach/habitat building flow due to the negative effects on fishing and the temporary reductions to the aquatic foodbase.

The AMP is in the process of formulating an experimental flow program within the collaborative framework of the AMP that adheres to the Department of the Interior's commitments and protects the resources of the Grand Canyon. Such an experimental flow program is expected to receive approval by the TWG and a formal Federal Advisory Committee Act recommendation by the AMWG in 2002.

Coarse-Sediment Tributary Inputs – Hundreds of tributaries add gravel to boulder-sized sediment to the main channel of the Colorado River ecosystem below Glen Canyon Dam. Coarse-grained sediment transport to the river occurs during tributary debris flows that have the ability to move boulders up to several meters in diameter as well as finer gravels related to aquatic habitats. The direct impact of such sediment inputs is to: (1) increase navigational hazards within whitewater rapids, (2) bury existing sandbars, (3) alter depositional patterns related to sand storage within eddy complexes, (4) alter habitats related to the food base, and (5) influence spawning nursery habitat conditions. Results of the 1996 controlled flood experiment showed that dam operations do have the potential for redistributing new coarse sediments after they are deposited within rapids and that these changes can improve navigational conditions. However, in 1996, coarse-sediment reworking was

shown to occur mostly when dam releases exceeded the hydropower plant capacity (about 33,000 cfs).

Monitoring of coarse-sediment inputs from 1998 through 2001 documented many new geomorphic changes to river shorelines owing to recent debris flows. In fact, recent observations indicate that the 2001 summer monsoon season produced the highest number of debris flows ever recorded in the Grand Canyon. At this point, it is not clear whether the high number of debris flows is completely attributable to an unusually active monsoon, to unusually large individual storms, or (at least in part) to improved in-situ observational techniques. Past work has shown that debris flows are relatively infrequent in Grand Canyon tributaries and that no more than eight debris flows were recorded in any given year since the advent of environmental monitoring in 1984. In 2001, 20 new debris flows were documented, and since the last monitoring trip in 1999, a total of 25 debris flows have occurred below Glen Canyon Dam, underscoring tributary debris flows as a major geomorphic agent of change through delivery of coarse sediment to the Colorado River corridor. Relevant linkages to coarse-sediment include: (1) dynamics of coarse substrates related to benthic productivity, (2) linkages with spawning success and early life history of endangered native fishes, and (3) navigational conditions of rapids and sand storage within the main channel.

Southwestern Willow Flycatcher

The southwestern willow flycatcher is a Neotropical migrant. Overall, the willow flycatcher species has a broad breeding range, extending from Nova Scotia to British Columbia and south to Baja California. The southwestern willow flycatcher feeds on insects associated with riparian habitats along rivers and streams. The historic breeding range includes Arizona, New Mexico, southern California, and southern portions of Nevada, Utah, and perhaps southwestern Colorado, and extends east into western Texas. It probably winters from Mexico to Panama, with historical accounts from Colombia. The regional southwestern willow flycatcher population has declined over the past 50 years, corresponding with loss and modification of riparian habitats. Population reduction since 1950 was so dramatic that it was proposed and listed, with designated critical habitat (including the Grand Canyon), under the Endangered Species Act in 1993. An estimated 300-500 breeding pairs remain in the United States.

From 1974 through 1996, the Grand Canyon population was detected between Colorado River miles 47 and 71. Since 1982, the number of breeding pairs of southwestern willow flycatchers observed in the Grand Canyon above Diamond Creek has varied between one and 11. One breeding pair has been observed in the Grand Canyon (above Diamond Creek) each of the past five years. It is unknown whether fluctuations in the number of breeding pairs are related to Glen Canyon Dam operations.

The Hualapai Tribe, who monitors the southwestern willow flycatcher below Diamond Creek, observed no individuals in 2001. However, the San Bernadino County Museum, which performs independent monitoring of the species, did locate an abandoned nest and observed individuals up the creek at Spencer Canyon in late July 2001. There was no confirmation of any active nesting activity below Diamond Creek in 2001.

Terrestrial Resources

The Colorado River ecosystem in the Grand Canyon supports a diverse set of resources in the area adjacent to the river. This type of interface between a river and its adjoining land is typically called a riparian zone – that portion of the land resource directly influenced by the river.

The riparian area in the Grand Canyon is divided into two distinct zones due to historic flooding and the more recent operation of Glen Canyon Dam. The Old High Water Zone (OHWZ) is the level of historic flood flows prior to Glen Canyon Dam. This area corresponds to the high flows that occurred prior to the dam and has a vegetation community distinctly different from surrounding areas due to the influence of historic flooding. It is comprised of woody plants such as native mesquite, catclaw acacia, apache plume, and hackberry, and is generally in decline likely due to dewatering and a lack of nutrient-laden sediment inputs. The OHWZ is an artifact of pre-dam conditions, is not influenced directly by operations of Glen Canyon Dam, and may migrate downslope over time. However, most of the plants in this zone are long lived and thus the OHWZ still forms a distinct band of vegetation in the Grand Canyon.

The area directly influenced by previous and current operations of Glen Canyon Dam is referred to as the New High Water Zone (NHWZ). This zone extends from the waters' edge to a flow level equivalent to the highest releases from Glen Canyon Dam. The NHWZ is composed mostly of exotic saltcedar (also called tamarisk) with associated native species such as willow, arrowweed, and baccharis or seep willow, and is subject to dynamic changes based on dam operations for hydropower or management objectives.

The impacts of these changes are not well understood at present, but an integrated community level monitoring program implemented by the GCMRC will very likely reveal changes in both the NHWZ and historic OHWZ communities. The addition of highly productive wetland and riparian vegetation to areas formerly scoured by spring high flows creates habitat patches and is likely to have impacts on birds, reptiles, insects, and small mammals. The notion of community level monitoring means that all of these kinds of organisms will be monitored in addition to changes in the vegetation upon which they are wholly or partially dependent. This monitoring program is being conducted by studies in the Grand Canyon itself and by developing vegetation classification systems using color infrared imagery from overflights of the canyon. The latter data are intended to allow extrapolation of specific site based observations in the canyon to the entire Colorado River ecosystem in Grand Canyon. At this juncture, there are no data suggesting dramatic changes in riparian vegetation, bird, reptile, insect, or small mammal species. One bird species, the southwestern willow flycatcher, is a federally listed endangered species and is discussed separately in this report (see previous page).

APPENDIX A

OPERATING CRITERIA FOR GLEN CANYON DAM IN ACCORDANCE WITH THE GRAND CANYON PROTECTION ACT OF 1992

These Operating Criteria are promulgated in compliance with section 1804 of Public Law 102-575, the Grand Canyon Protection Act of 1992. They are to control the operation of Glen Canyon Dam, constructed under the authority of the Colorado River Storage Project Act. These Operating Criteria are separate and apart from the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs prepared in compliance with the Colorado River Basin Project Act of 1968.

1. Annual Report

As required in the Grand Canyon Protection Act, a report shall be prepared and submitted to Congress annually that describes the operation of Glen Canyon Dam for the preceding water year and the expected operation for the upcoming water year. The annual plan of operations shall include such detailed rules and quantities as are required by the Operating Criteria contained herein. It shall provide a detailed explanation of the expected hydrologic conditions for the Colorado River immediately below Glen Canyon Dam.

2. Review of Criteria

The Secretary shall review these Operating Criteria as the result of actual operating experiences to determine if the Operating Criteria should be modified to better accomplish the purposes of the Grand Canyon Protection Act. Such a review shall be made at least every five years in consultation with the appropriate federal agencies, Governors of the Colorado River Basin States, Native American tribes, representatives of academic and scientific communities, environmental organizations, the recreation industry, and contractors for the purchase of federal power produced at Glen Canyon Dam.

3. Specific Operational Constraints

The plan of operations will follow the description of the preferred alternative (Modified Low Fluctuating Flow) in the GCDEIS and the ROD. The specific criteria are as follows:

Minimum Releases – 8,000 cfs between 7:00 a.m. and 7:00 p.m. and 5,000 cfs at night.

Maximum Releases – 25,000 cfs. Several circumstances warrant exception to this restriction. These are the beach/habitat-building flows and the habitat maintenance flows (both described below) and the release of large volumes of water to avoid spills or flood flow releases from Glen Canyon Dam. These latter releases would most likely result from high snowmelt runoff into Lake Powell; if such high releases above 25,000 cfs are required, they shall be made at constant daily flow rates.

Allowable Daily Flow Fluctuations – 5,000 cfs/24 hours for monthly release volumes less than

600,000 acre-feet, 6,000 cfs/24 hours for monthly release volumes of 600,000 to 800,000 acre-feet, and 8,000 cfs/24 hours for monthly release volumes over 800,000 acre-feet.

Maximum Ramp Rates – 4,000 cfs/hr when increasing, and 1,500 cfs/hr when decreasing.

Emergency Exception Criteria – Normal powerplant operations will be altered temporarily to respond to emergencies. These changes in operations typically would be of short duration (usually less than 4 hours) and would be the result of emergencies at the dam or within the interconnected electrical system. Examples of system emergencies include:

1. Insufficient generating capacity
2. Transmission system: overload, voltage control, and frequency
3. System restoration
4. Humanitarian situations (search and rescue)

Flood Frequency Reduction Measures – The frequency of unanticipated flood flows in excess of 45,000 cfs will be reduced to no more than 1 year in 100 years as a long-term average. This will be accomplished initially through the Annual Operating Plan process and eventually by raising the height of the spillway gates at Glen Canyon Dam 4.5 feet.

Habitat Maintenance Flows – Habitat maintenance flows are high steady releases within powerplant capacity (33,200 cfs) not to exceed 14 days in March, although other months will be considered under the AMP. Actual powerplant release capacity may be less than 33,200 cfs under low reservoir conditions. These flows will not be scheduled when projected storage in Lake Powell on January 1 is greater than 19,000,000 acre-feet, and typically would occur when annual releases are at or near the minimum objective release of 8,230,000 acre-feet. Habitat maintenance flows differ from beach/habitat-building flows because they will be within powerplant capacity, and will occur nearly every year when the reservoir is low.

Beach/Habitat-Building Flows – These controlled floods will occur as described in the EIS (steady flows not to exceed 45,000 cfs, duration not to exceed 14 days, up-ramp rates not to exceed 4,000 cfs/hr, and down-ramp rates not to exceed 1,500 cfs/hr) except instead of conducting them in years in which Lake Powell storage is low on January 1, they will be accomplished by utilizing reservoir releases in excess of powerplant capacity required for dam safety purposes. Such releases are consistent with the 1956 Colorado River Storage Project Act, the 1968 Colorado River Basin Project Act, and the 1992 Grand Canyon Protection Act.

/s/ Bruce Babbitt
Secretary of the Interior

February 24, 1997
Date

APPENDIX B

GLEN CANYON DAM ADAPTIVE MANAGEMENT WORK GROUP
FEDERAL ADVISORY COMMITTEE

CHARTER

Official Designation: Glen Canyon Dam Adaptive Management Work Group.

Scope and Objectives: The Committee will provide advice and recommendations to the Secretary of the Interior relative to the operation of Glen Canyon Dam in accordance with the additional criteria and operating plans specified in Section 1804 of the Act and to the exercise of authorities under existing laws in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and the Glen Canyon National Recreation Area were established, including but not limited to the natural and cultural resources and visitor use.

The Secretary of the Interior is implementing the Grand Canyon Protection Act (Act) of October 30, 1992, embodied in Public Law 102-575. The Act calls for implementation of long-term monitoring, research, and experimental programs and activities. As part of long-term monitoring, the Secretary's Record of Decision (ROD) mandated development of an Adaptive Management Program (AMP). The AMP provides for monitoring the results of the operating criteria and plans adopted by the Secretary and research and experimentation to suggest appropriate changes to those operating criteria and plans.

The AMP includes an Adaptive Management Work Group (AMWG). The AMWG will facilitate the AMP, recommend suitable monitoring and research programs, and make recommendations to the Secretary as required to meet the requirements of the Act. The AMWG may recommend research and monitoring proposals outside the Act which complement the AMP process, but such proposals will be funded separately, and do not deter from the focus of the Act.

Duration: It is the intent that the AMWG shall continue indefinitely, unless otherwise terminated by the Secretary.

Agency or Official to Whom the Committee Reports: The AMWG reports to the Secretary through the Secretary's designee who shall serve as the chairperson and Designated Federal Official of the AMWG. In the absence of the Chairperson, a senior level Interior representative will act as Chairperson for the AMWG.

The Secretary's designee shall be responsible for preparation of meeting agendas and scheduling meetings of the AMWG. The Secretary's designee shall attend and chair all meetings of the AMWG. The Secretary's designee will also be responsible for sending a formal summary report after each Advisory Committee meeting directly to the Secretary of the Interior with copies of subject summary report to be provided to all AMWG members.

Bureau Responsible for Providing Necessary Support: The logistical and support services for the meetings of the AMWG shall be provided by the Bureau of Reclamation (Reclamation).

Estimated Annual Operating Costs: The operating costs are estimated at $200,000 annually for the establishment and support of the AMWG. This includes costs for required staff support, Reclamation staff and AMWG members, and expenses incurred in the recording and reproduction of meeting minutes, reports, notices, etc.

Description of Duties: The duties or roles and functions of the AMWG are in an advisory capacity only. They are to:

a. Establish AMWG operating procedures.

b. Advise the Secretary in meeting environmental and cultural commitments of the Record of Decision.

c. Recommend the framework for the AMP policy, goals, and direction.

d. Define and recommend resource management objectives for development and implementation of a long-term monitoring plan, and any necessary research and studies required to determine the effect of the operation of Glen Canyon Dam on the values for which the Grand Canyon National Park and Glen Canyon National Recreation Area were established, including but not limited to natural and cultural resources, and visitor use.

e. Review and provide input on the report required in Section 1804 (c)(2) of the Act to the Secretary, the Congress, and the Governors of the Colorado River Basin States. The report will include discussion of dam operations, the operation of the AMP, status of resources, and measures taken to protect, mitigate, and improve the resources defined in the Act.

f. Annually review long-term monitoring data to determine the status of resources and whether the AMP Strategic Plan goals and objectives are being met. If necessary, develop recommendations for modifying the GCDEIS ROD, associated operating criteria, and other resource management actions pursuant to the Grand Canyon Protection Act.

g. Facilitate input and coordination of information from stakeholders to the Secretary to assist in meeting consultation requirements under Sections 1804 (c)(3) and 1805 (c) of the Act.

h. Monitor and report on compliance of all program activities with applicable laws, permitting requirements, and the Act.

Allowances for Committee Members (compensation, travel, per diem, etc.) While engaged in the performance of official business at AMWG and AMWG sub-group meetings (regular, ad hoc, and Protocol Evaluation Panel meetings) away from home or their regular places of

business, all AMWG members or AMWG sub-group members shall, upon request, be reimbursed for travel expenses in accordance with current Federal travel regulations.

Estimated Number and Frequency of Meetings: The AMWG is expected to meet biannually. The Secretary's designee, who will serve as the Designated Federal Official, may call additional meetings as deemed appropriate. Fifteen members must be present at any meeting of the AMWG to constitute a quorum.

In accordance with FACA, a notice of each meeting of the AMWG shall be published in the Federal Register at least 15 days prior to the meeting advising the date, time, place, and purpose of the meeting. If it becomes necessary to postpone or cancel an announced meeting, a subsequent notice shall be published in the Federal Register as early as possible and shall explain the reasons for the postponement or cancellation. A news release for each meeting, postponement, or cancellation shall also be provided to selected major newspapers in Arizona, California, Colorado, Nevada, New Mexico, Wyoming, and Utah. News releases shall also be provided to agencies and organizations expressing interest in publishing meeting announcements in newsletters.

In accordance with FACA, all meetings of the AMWG shall be open to the general public. Any organization, association, or individual may file a written statement or, at the discretion of the AMWG, provide verbal input regarding topics on a meeting agenda in accordance with FACA.

The minutes of each AMWG meeting; reports; related documents; and copies of all documents received, issued, or approved by the AMWG shall be available for public inspection and duplication during regular business hours within 30 working days after the meeting at the:

Upper Colorado Regional Office
Bureau of Reclamation
125 South State Street, Room 6107
Salt Lake City, Utah 84138-1102
(801) 524-3880

Termination Date: It is the intent that the AMWG shall continue indefinitely, unless otherwise terminated by the Secretary. The committee is subject to the provisions of the Federal Advisory Committee Act (FACA), 5.U.S.C. Appendix 2, and will take no action unless the charter filing requirements of section 9 of FACA have been complied with. The Committee is subject to biennial review and will terminate 2 years from the date the charter is filed, unless, prior to that time, the charter is renewed in accordance with Section 14 of the FACA.

Committee Membership: Members of the AMWG to be appointed by the Secretary shall be comprised of:

a. Secretary's Designee, who shall serve as chairperson for the AMWG.

b. One representative each from the 12 cooperating agencies associated with the EIS:

(1) Bureau of Reclamation
(2) Bureau of Indian Affairs
(3) U.S. Fish and Wildlife Service
(4) National Park Service
(5) Western Area Power Administration
(6) Arizona Game and Fish Department
(7) Hopi Tribe
(8) Hualapai Tribe
(9) Navajo Nation
(10) San Juan Southern Paiute Tribe
(11) Southern Paiute Consortium
(12) Pueblo of Zuni

c. One representative each from the seven basin states:

(1) Arizona
(2) California
(3) Colorado
(4) Nevada
(5) New Mexico
(6) Wyoming
(7) Utah

d. Two representatives each from:

(1) Environmental groups
(2) Recreation interests
(3) Contractors who purchase Federal power from Glen Canyon Powerplant

Members will be appointed to the AMWG by the Secretary, with input and recommendations from the cooperating agencies, States, tribes, contractors for Federal power from Glen Canyon Dam, environmental representatives, and other stakeholders. To be eligible for appointment to the AMWG, a person must (a) be qualified through education, knowledge, or experience to give informed advice on water supply, diversion and delivery facilities, and their operation and management, or the environmental aspects of such operation; and (b) have the capability to constructively work in a group setting toward a common objective of structuring a mechanism for program implementation.

Members of the AMWG will be appointed for a 4-year term. At the discretion of the Secretary, members may be reappointed to additional terms. Vacancies occurring by reason of resignation, death, or failure to regularly attend meetings will be filled by the Secretary for the balance of the vacating member's term using the same method by which the original appointment was made.

Failure of an organization to be represented at two consecutive meetings will substantiate grounds for dismissal. The Chairperson will make the final determination in dismissing a member.

To avoid conflict of interest issues arising from entities, including Federal agencies, having representatives on the AMWG and also submitting responses to request for proposals to perform work, the Federal procurement process shall be strictly adhered to. While members of the AMWG may give advice to the Secretarial Designee, all decisions in the procurement process shall be made by Federal procurement officials free of influence from AMWG members.

Subgroups: The committee may establish such workgroups or subcommittees as it deems necessary for the purposes of compiling information, discussing issues, and reporting back to the AMWG.

Authority: The Grand Canyon Protection Act (Act) of October 30, 1992, embodied in Public Law 102-575, directs the Secretary of the Interior (Secretary), among others, to operate Glen Canyon Dam in accordance with the additional criteria and operating plans specified in section 1804 of the Act and to exercise other authorities under existing law in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and the Glen Canyon National Recreation Area were established, including but not limited to the natural and cultural resources and visitor use. The Secretary shall implement this section in a manner fully consistent with and subject to Section 1802 of the Act. Section 1805 of the Act calls for implementation of long-term monitoring programs and activities that will ensure that Glen Canyon Dam is operated in a manner consistent with that of Section 1802.

Bruce Babbitt
Secretary of the Interior

January 10, 2001
Date signed

January 10, 2001
Date Filed

APPENDIX C

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM

VISION AND MISSION

The combined Vision and Mission statement reads as follows:

> 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.

PRINCIPLES

The nine principles of the Glen Canyon Dam Adaptive Management Program 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 Adaptive Management Program, 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 the Adaptive Management Program 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 Adaptive Management Program goals, through experimentation and monitoring, to meet the intent of the Grand Canyon Protection Act, Glen Canyon Dam 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 Glen Canyon Dam Environmental Impact Statement and the Record of Decision.
8. If the target of a management objective proves to be inappropriate, unrealistic, or unattainable, the Adaptive Management Program will reevaluate that target and the methods used to attain it.
9. Recognizing the diverse perspectives and spiritual values of the stakeholders, the unique aesthetic value of the Grand Canyon will be respected and enhanced.

GOALS

The 12 goals of the Adaptive Management Program are:

1. Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels.
2. Maintain or attain viable populations of existing native fish, remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.
3. Restore populations of extirpated species, as feasible and advisable.
4. Maintain a naturally reproducing population of rainbow trout above the Paria River, to the extent practicable and consistent with the maintenance of viable populations of native fish.
5. Maintain or attain viable populations of Kanab ambersnail.
6. Protect or improve the biotic riparian and spring communities, including threatened and endangered species and their critical habitat.
7. Establish water temperature, quality, and flow dynamics to achieve the Adaptive Management Program ecosystem goals.
8. Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve the Adaptive Management Program ecosystem goals.
9. Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of the Adaptive Management Program ecosystem goals.
10. Maintain power production capacity and energy generation, and increase where feasible and advisable, within the framework of the Adaptive Management ecosystem goals.
11. Preserve, protect, manage, and treat cultural resources for the inspiration and benefit of past, present, and future generations.
12. Maintain a high quality monitoring, research, and adaptive management program.

APPENDIX D

ADDITIONAL BACKGROUND INFORMATION ON THE ADAPTIVE MANAGEMENT WORK GROUP'S RECOMMENDATIONS TO THE SECRETARY OF THE INTERIOR IN FISCAL YEAR 2001

MOTION: Recommend that the Secretary adopt the fiscal year 2002 AMP Work Plan and budget request ($6.576 million power revenues for United States Geological Survey [USGS] scientific work; $1.399 million power revenues for Reclamation administration, tribal consultation, and cultural compliance work; and $1.01 million USGS appropriations request for scientific work) for a total of $8.985 million.

Under the Energy and Water Development Appropriation of fiscal year 2001, the funding from Colorado River Storage Project Act power revenues has been capped at the fiscal year 2001 level of $7.85 million, adjusted in subsequent years for inflation. This amount covers both the administrative, tribal consultation, and cultural compliance work of the programs and the scientific monitoring and research work administered by the USGS. Because the financial needs of the AMP exceed this amount, the USGS is also requesting about $1 million in appropriations for supplemental scientific work.

The AMP stakeholders are concerned that insufficient funds are being directed toward the monitoring of Grand Canyon resources in compliance with the Grand Canyon Protection Act; thus, Department of the Interior agencies are seeking to apply appropriated funds to the issues of tribal consultation and monitoring and research.

MOTION: Recommend support for the USGS seeking appropriations for the AMP.

Since the Grand Canyon Monitoring and Research Center is institutionally located within the USGS, stakeholders agree that the USGS should be the focus of additional appropriations requests to augment the monitoring and research activities of the AMP.

MOTION: Recommend that the Secretary seek funding for AMWG federal agencies to support tribal participation.

Federally recognized Indian tribes are domestic dependent nations, and the legal relationship between the Federal Government and tribes is one as set forth in the Constitution of the United States, treaties, statutes, Executive orders, and court decisions. Indian tribes have a guaranteed right to self-govern and to exercise inherent sovereign powers over their members and reservations. The United States government works with Indian tribes on a government-to-government basis to address issues concerning Indian tribal self-government, trust resources, and Indian tribal treaty and other rights. Tribal trust resources include land and natural resources

either on or off Indian reservations, and other assets retained by or reserved by or for Indian

tribes held by the Federal Government in trust, and are protected by a fiduciary obligation on the part of the United States.

To ensure the fulfillment of the federal Indian trust responsibility, the Department of the Interior has established policies and procedures for government-to-government consultation with federally recognized Indian tribes and tribal members for the identification, conservation, and protection of American Indian trust resources, trust assets, or tribal health and safety. Indian trust assets are values derived from land resources including surface water and groundwater, natural vegetation and wildlife, and air quality. Any potential impacts from federal actions or activities to tribal trust assets must be properly addressed between the affected tribe and the appropriate federal agency prior to any disturbance to such resources. In the case of the AMP, this consultation is unusually extensive and complex, requiring significant tribal resources. This recommendation by the AMWG addresses the need for federal agencies to finance this consultation through appropriations.

MOTION: Recommend that the Technical Work Group Budget Process Ad Hoc Group be charged to develop and ensure implementation of the prioritization process.

With the limitation placed on the amount of power revenues available for the AMP, it will be crucial that the most important scientific needs are being addressed through the monitoring and research program. Due to the uncertain status of annual appropriations, it would be impossible to specifically allocate all program costs in advance, but this recommendation directs the TWG to consider the priorities of various proposals in accomplishing the intent of the Grand Canyon Protection Act.

MOTION: Recommend that the Secretary seek funding for AMWG federal agencies to support scientific activities related to experimental flows in fiscal year 2002.

In the context of an adaptive management program, the conducting of experimentation is viewed as essential to increasing the scientific understanding of the ecosystem. Such experimental flows from Glen Canyon Dam carry both the economic impact to power generation, but also the need to fund additional scientific research to understand the impacts of such experiments. In the past, the cost of monitoring such experiments has ranged from $1 million to $3 million. The AMP has an experimental flow account to fund such monitoring from power revenues, but is here recommending that the Department of the Interior allocate additional appropriations to the AMP to allow additional experimentation to continue.

APPENDIX E

Glen Canyon Dam Adaptive Management Program
Funding Needs – Fiscal Year 2003

I. PROGRAM ADMINISTRATION

A. ADAPTIVE MANAGEMENT WORK GROUP[1]

1. Personnel Costs 173,000
2. AMWG Member Travel Reimbursement 10,000
3. Reclamation Travel 17,000
4. Facilitation Contract 25,000
5. Other 11,000

Subtotal 236,000

B. TECHNICAL WORK GROUP[2]

1. Personnel Costs 81,000
2. TWG Member Travel Reimbursement 10,000
3. Reclamation Travel 18,000
4. TWG Chair Reimbursement 25,000
5. Other 2,000

Subtotal 136,000

C. SCIENCE ADVISORS

Program Manager 0

Subtotal 0

D. COMPLIANCE DOCUMENTS[3]

1. Biologist (0.25 fte) 26,000

Subtotal 26,000

E. TEMPERATURE CONTROL DEVICE

F. CONTRACT ADMINISTRATION[4]

1. Contract Specialist (0.25 fte) 25,000

Subtotal 25,000

II. TRIBAL CONSULTATION

A. Cooperative Agreements with Tribes[5]

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

Subtotal 400,000

B. River Trip Logistical Costs to GCMRC[6]

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

Subtotal 75,000

Glen Canyon Dam Adaptive Management Program
Funding Needs (continued) – Fiscal Year 2003

III. PROGRAMMATIC AGREEMENT FOR CULTURAL RESOURCES

A. WORK PLAN ACTIVITIES

1. Reclamation Administrative Costs[7] 50,000
2. Geomorphological Effect Study with GCRMC[8] 200,000
3. NPS Monitoring Costs[9] 228,500
4. Contract for Treatment Plan & Monitoring Plan[10] 200,000

Subtotal 678,500

IV. EXPERIMENTAL FLOW FUND[11] 450,500

V. GCMRC SCIENTIFIC ACTIVITIES[12, 13]

A. TERRESTRIAL ECOSYSTEM ACTIVITIES

1. Monitoring & Inventory of Terrestrial Resources[14] 445,000
   a. Tribal Participation 125,000
2. Monitoring Kanab Ambersnail[15] 81,000
3. Kanab Ambersnail Taxonomy (Year 1)[16] 100,000
4. New Research in Terrestrial Ecosystems[17] 7,000
5. Mapping Holocene Deposits[18] 112,000
6. Implementation of GCMRC HPP & PEP Activities[19] 0
7. Terrestrial Habitat Mapping and Inventory 251,000
8. Cultural Resource Monitoring & Mitigation 22,000

Subtotal 1,143,000

B. AQUATIC ECOSYSTEM ACTIVITIES

1. Phyto-benthic Monitoring[20] 256,000
2. Monitoring Downstream Fish[21] 929,000
3. Monitoring Lee's Ferry Trout[22] 155,000
4. Native and Non-native Fish Interactions Research[23] 91,000
5. Ongoing Population Genetics of Humpback Chub[24] 7,000
6. IWQP Downstream Activities[25] 150,000
7. IWQP Lake Powell (O&M Funding)[26] 300,000

Subtotal 1,888,000

C. INTEGRATED TERRESTRIAL & AQUATIC ECOSYSTEM ACTIVITIES

1. Monitoring Fine-grained Sediment Storage[27] 366,000
   a. Beach Monitoring (continuation of NAU work) 75,000
2. Monitoring Streamflow & Fine Sediment Transport[28] 575,000
   a. One-year Evaluation of In-Situ Continuous Monitoring of Suspended-Sediment Transport[29] 80,000
   b. Installation of Automated Pump Samplers[30] 50,000
   c. Advance Warning for Paria River Sediment Inputs[31] . 30,000
3. Monitoring of Coarse-grained Sediment[32] 138,000
4. One-dimensional Fine Sediment Routing Model[33] 231,000
5. Conceptual Modeling of Coarse-grained Sediment[34] 100,000
6. Control Network[35] 86,000
7. Channel Mapping[36] 118,000
8. Recreational Effects to Cultural & Biological Resources[37] ... 47,000

Subtotal 1,896,000

Glen Canyon Dam Adaptive Management Program
Funding Needs (continued) – Fiscal Year 2003

D. REMOTE SENSING ACTIVITIES
1. Digital Imagery and LIDAR 523,000

E. OTHER SCIENCE ACTIVITIES
1. Unsolicited Proposals 53,000
   i. Adopt-a-Beach with Integration Report 10,000
2. AMWG/TWG Requests 76,000
3. In-house Research..... 26,000
4. Tribal Training, Science/Tribal Perspectives Integration/ Tribal Interns[38]..... 44,000
5. PEP/PA stipulated public outreach/involvement plan[39]..... 35,000
6. Cultural Resources Synthesis and Status Report[40]..... 15,000

Subtotal 259,000

VI. GCMRC ADMINISTRATIVE & TECHNICAL SUPPORT

A. ADMINISTRATIVE & MANAGEMENT[41]
1. Administrative Operations..... 755,000
2. Program Planning & Management 302,000
3. AMWG/TWG Participation..... 52,000
4. Independent Review Panels..... 212,000

Subtotal 1,321,000

B. TECHNICAL SUPPORT SERVICES[42]
1. Geographic Information Systems..... 150,000
2. Data Base Management 113,000
3. Library Operations..... 62,000
4. Survey Operations 122,000
5. Decision Support System[43] 150,000
6. Systems Administration..... 250,000
7. Aerial Photography (see budget under V.B.1.)
8. Logistics (costs distributed to projects)

Subtotal 847,000

TOTAL FY 2003 BUDGET---------- 9,904,000

FY 2003 FUNDING REQUESTS

AVAILABLE FUNDS	AMOUNT
CRSP Power Revenues	$ 8,325,000
DOI Tribal Funding Appropriations	$ 475,000
O&M – IWQP Lake Powell Studies	$ 300,000
USGS Appropriations	$ 774,000
Other Funding Sources	$ 30,000
TOTAL	$ 9,904,000

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM
Project Descriptions for Fiscal Year 2003

[1] 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.

[2] 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.

[3] Compliance Documents. This covers funding for preparation of compliance documents for AMP-proposed actions in order to comply with ESA, NEPA, and NHPA.

[4] Contract Administration. These are Reclamation personnel costs needed to administer the AMWG facilitation, TWG Chairperson, and Programmatic Agreement contracts.

[5] Cooperative Agreements with Tribes. Each of the five tribes with demonstrated interests in the effects of Glen Canyon Dam operations on resources of tribal concern will continue to be funded through cooperative agreements. These agreements are for $80,000 per tribe (or consortium of tribes) annually. Funds are designed to cover salary, benefits, travel, and indirect costs to enable an 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.

[6] River Trip Logistical Costs to GCMRC. Each of the five tribes is allocated $15,000 to monitor resources of tribal concern and to report back to the AMP and the Secretary regarding the observed effects of dam operations or other management actions. The funds are transferred from the federal agencies within the AMP to Reclamation to the GCMRC to pay for river guides, boats, fuel, food, etc.

[8] Reclamation Administrative Costs. A total of $50,000 has been projected to cover salary, benefits, travel, and indirect costs of administering the PA program.

[8] Geomorphological Effect Study with GCMRC. Depending upon the results of the geomorphology workshop (FY02), it may be reasonable and feasible to conduct geomorphological investigations into mapping or modeling exactly where and how dam operations affect historic properties. This project is contingent upon the workshop,. Costs are estimates based on some preliminary input from geomorphologists.

[9] NPS Monitoring Costs. Existing monitoring programs of the NPS will remain unchanged until the new plan is implemented in FY04 (contract for treatment and monitoring plan is FY02).

[10] Contract for Treatment and Monitoring Plan. When the research design is complete and there is an evaluation of the relative values of the historic properties, and once the direct and indirect effects of dam operations are more precisely mapped or identified, it is necessary to resolve adverse effects of dam operations on properties eligible to the National Register. This resolution and the proposed mitigation measures will be described in a treatment and monitoring plan that will be contracted.

[11] Experimental Flow Fund. Experimental Flows are a key part of the Adaptive Management Program. These funds cover monitoring and research activities required for doing experimental flows in an effort to improve our understanding of ecosystem processes. It's anticipated these funds could be carried over from year-to-year and accumulate to such a level that an experimental test flow could occur.

[12] 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 2003 given existing information.

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

[14] Monitoring & Inventory of Terrestrial Resources & Tribal Participation: Integrated biological monitoring linking birds, foodbase and vegetative structure on reach and river-wide scale, using bird patch as minimum unit. Also linking hydrology to vegetation composition change and developing minimum sampling scheme for long-term monitoring.

-- Tribal Participation: One year continuation of work begun in FY 2001 and continued in FY 2002. All five participating tribes to work with biologists on terrestrial monitoring to incorporate tribal perspectives within biological monitoring project.

[15] Monitoring Kanab Ambersnail: Measuring and estimating population status of snails at Vaseys Paradise. Includes measurement of habitat. Logistics support for supplemental population surveys included.

[16] Kanab Ambersnail Taxonomy (Year 1): First year of multi-year project to resolve taxonomic issues associated with *Oxyloma* complex.

[17] Terrestrial Interactions Research: Unidentified research depending on information needs and strategic planning.

[18] Holocene Mapping: Continuation of approved work for FY 2002 to document Holocene deposits within the Canyon. Project purpose is to define the area potentially affected by dam operations relative to sediment deposits, cultural and recreational resources. Implements a

cultural PEP recommendation. Scale of project defined by existing information and feasibility based on scoping meeting held early in FY 2002.

[19] Cultural Resource Monitoring Plan: Implementation of GCMRC portion of HPP and PEP specified integrated Monitoring Plan that was developed during FY 2002 by BOR and GCMRC. Monitoring Plan specifies articulation between AMP cultural programs.

[20] Phyto-benthic Fast-response Monitoring: Data collection and analysis of algae, benthos and drift to measure response to operations. Emphasis may be in Glen Canyon and in association with gauging stations in Grand Canyon. Program is under review and development.

[21] Monitoring Downstream Fish: Data collection and analysis of fish populations in the mainstem and Little Colorado River. Request is for 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.

[22] Monitoring Lee's Ferry Trout: Population estimates for Lee's Ferry trout fishery including proportion stock density and condition factor of fish.

[23] Native and Non-native Fish Interactions Research: Projects are not currently defined, but may include predator – prey interactions, competition, and bioenergetics model development. Dependent on information needs.

[24] Ongoing Population Genetics of Humpback chub: The third year of project to examine the relationships of mainstem and LCR humpback chub. Results will be incorporated into monitoring efforts and compliance issues associated with HBC.

[25] IWQP Downstream Activities: Water quality monitoring downstream within the intention of expansion of parameters measured as per PEP recommendations. Monitoring plan is under development.

[26] IWQP Lake Powell: Water quality monitoring of reservoir, includes monthly and quarterly sampling and incorporation of modeling effort into monitoring program. Monitoring plan is under development consistent with PEP recommendations as indicated in "Response to Comments" document.

[27] 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.

[28] 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.

[29] One-year Evaluation of In-Situ Continuous Monitoring Of Suspended-Sediment Transport: 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. (Includes purchase of customized LISST-25 instrumentation).

[30] Installation of Automated Pump Samplers: Installation of Automated Pump Samplers at Moenkopi Wash, Lower Marble Canyon, Grand Canyon and Diamond Creek Stream gages intended to obtain additional needed suspended-sediment data at key main channel sites for use in tracking monthly fine-sediment mass balance by geomorphic reach. This strategy also requires additional funding needed to support stage/discharge monitoring at the Lower Marble Canyon stream gage. These samplers are needed owing to the very remote nature of main channel locations where insufficient sediment samples are currently obtained to track monthly sediment export. These devices could eventually be used to verify additional LISST instruments if that technology proves to be successful.

[31] 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.

[32] 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.

[33] One-dimensional Fine Sediment Routing Model: 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.

[34] Conceptual Modeling of Coarse-Grained Sediment Inputs: This project relates ongoing impacts of coarse-sediment inputs to the evolution of the geomorphic framework of the Colorado River ecosystem, under current dam operations, over periods ranging from decadal to centennial time scales. The project specifically examines simulation related to local and system-wide changes to the main channel thought to influence fine-sediment storage, related physical habitats and food base dynamics.

[35] 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.

[36] 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.

[37] Recreational Effects to Cultural and Biological Resources (New Work): New project that identifies and assesses recreational impacts to significant cultural and biological resources in Glen and Grand Canyons. Responds to concerns about commercial boats in Glen Canyon and tribal concerns within Grand Canyon.
Estimated Cost: $ 20,000.

[38] 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.

[39] PEP/PA stipulated public outreach/involvement plan: Development of public outreach and involvement plan as stipulated in the PA agreement and recommended by the cultural PEP. New work that will be jointly funded by the BOR and GCMRC.

[40] 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.

[41] Includes salaries for GCMRC staff not otherwise assigned to project costs.

[42] Includes contract costs, salaries for GCMRC staff, logistics support, and other operational costs not otherwise assigned to project costs or administrative operations and support.

[43] Decision Support System Development: GCMRC provides objective, scientific information to the AMWG for use in making recommendations to the Secretary of the Interior regarding the effects of dam operations on the Colorado River ecosystem (CRE). In support of this effort, GCMRC is developing: (1) a conceptual (i.e., computer) model of the CRE, (2) a detailed map of the CRE, (3) GIS overlays for the CRE, and (3) an integrated Oracle database of research on the CRE. Missing from this equation is the decision-support system (DSS) overlay that can act to integrate these various efforts and support the AMWG in examining various management actions/policy changes that they may wish to recommend to the Secretary.

THE SECRETARY OF THE INTERIOR

WASHINGTON

COPY

FEB 2 1 2003

Honorable Jeff Bingaman
Ranking Member
Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510

Dear Senator Bingaman:

The Department of the Interior is pleased to transmit to the Congress the enclosed Report to the Congress: Operations of Glen Canyon Dam Pursuant to the Grand Canyon Protection Act of 1992 (Water Years 1999-2001). This report was prepared pursuant to the provisions of Title XVIII of the Grand Canyon Protection Act (Public Law 102-575) that states:

> Each year after the date of the adoption of criteria and operating plans pursuant to paragraph (1), the Secretary shall transmit to the Congress and to the Governors of the Colorado River Basin States a report, separate from and in addition to the report specified in section 602(b) of the Colorado River Basin Project Act of 1968, on the preceding year and the projected year operations undertaken pursuant to this Act.

The Report was collaboratively prepared by the Bureau of Reclamation and Grand Canyon Monitoring and Research Center. The report contains historical information on Glen Canyon Dam, a description of the Glen Canyon Dam Adaptive Management Program, descriptions of dam operations, information on Adaptive Management Program activities, and a section on the status and trends of downstream resources.

If you have questions or need additional information, please contact Mr. Randall V. Peterson, Bureau of Reclamation, 125 South State Street, Suite 6107, Salt Lake City, Utah 84138-1147, telephone (801) 524-3758, or visit the Bureau of Reclamation's and Grand Canyon Monitoring and Research Center's WEB pages at http://www.uc.usbr.gov and http://www.gcmrc.gov/, respectively.

Sincerely,

Gale A. Norton

Gale A. Norton

Enclosure

bc: Secretary's Surname
Secretary's Reading File (2)
AS/WS (3)

W-1530, W-2000, W6000, W-6330

WBR: CKaras:ac:5/16/2002:202-513-0667:#2000895
J:CKaras2000895Bingamanfinal.wpd PRJ-13.00
Revised CKaras:ac:8/07/2002:202-513-0667:#2000895
Revised: CKaras:ac:2/04/2003:202-513-0667:2000895
Revised: CKaras:ac:2/13/2003:202-513-0667:2000895

Identical letters sent to:

Honorable Richard Pombo
Chairman
Committee on Resources
House of Representatives
Washington, DC 20515

Honorable Nick J. Rahall
Ranking Member
Committee on Resources
House of Representatives
Washington, DC 20515

Honorable Ken Calvert
Chairman
Subcommittee on Water and Power
Committee on Resources
House of Representatives
Washington, DC 20515

Honorable Grace Napolitano
Ranking Member
Subcommittee on Water and Power
House of Representatives
Washington, DC 20515

Honorable Pete V. Domenici
Chairman
Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510

Honorable Lisa Murkowski
Chairwoman
Subcommittee on Water and Power
Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510

Honorable Byron L. Dorgan
Ranking Member
Subcommittee on Water and Power
Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510

Honorable Richard B. Cheney
President of the Senate
Washington, DC 20510

Honorable J. Dennis Hastert
Speaker of the House
of Representatives
Washington, DC 20515