RECLAMATION
Managing Water in the West

Report to Congress
Operations of Glen Canyon Dam
Pursuant to the Grand Canyon Protection Act of 1992

Water Years 2016-2017

U.S. Department of the Interior
Bureau of Reclamation

September 2017

EXECUTIVE SUMMARY

This report by the Department of the Interior (Interior) is submitted pursuant to section 1804 of the Grand Canyon Protection Act (GCPA) of 1992, which provides

> 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.

This report provides an update from the last report, which was submitted on November 18, 2016, by Interior for years 2015 (observed) and 2016 (projected). The current report covers dam operations and other activities undertaken pursuant to the GCPA for 2016 (observed) and 2017 (projected). In this report, the timeframe for water and fiscal years is identical, October 1 through September 30.

INTRODUCTION

Glen Canyon Dam was authorized for construction by the Colorado River Storage Project Act of 1956. 43 U.S.C. § 620. The dam was completed in 1963 and is operated by the Bureau of Reclamation (Reclamation). In 1992, Congress enacted the GCPA, which requires the Secretary of the Interior (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.

Congress also directed that such operations be undertaken

> in a manner fully consistent with and subject to the Colorado River Compact, the Upper Colorado River Basin Compact, the Water Treaty of 1944 with Mexico, the decree of the Supreme Court in Arizona v. California, and the provisions of the Colorado River Storage Project Act of 1956 and the Colorado River Basin Project Act of 1968 that govern allocation, appropriation, development, and exportation of the waters of the Colorado River basin.

In 1997, the Secretary established the Glen Canyon Dam Adaptive Management Program (GCDAMP) to carry out the requirements of the GCPA. As part of the GCDAMP, the Secretary also established the Adaptive Management Work Group (AMWG), a 25-member federal advisory committee that operates pursuant to the provisions of the Federal Advisory Committee Act, 5 U.S.C. § App. 2. The Secretary's Designee is the Assistant Secretary for Water and Science who serves as the Chair of the AMWG.

STATUS REPORT

Five agencies within Interior have responsibilities under the GCPA and undertake operations pursuant to the GCPA; the: (1) Bureau of Indian Affairs (BIA); (2) Reclamation; (3) National Park Service (NPS); (4) United States Fish and Wildlife Service (FWS); and (5) United States Geological Survey (USGS). Collectively these five agencies fund five American Indian Tribes (Hopi, Hualapai, Pueblo of Zuni, Kaibab Paiute, and the Navajo Nation) to participate in the GCDAMP and two Tribal Liaison positions within Interior that assist in coordination between Interior and the tribes. The Western Area Power Administration (WAPA) also has statutory responsibilities pursuant to the Department of Energy Organization Act, Flood Control Act, Reclamation Project Act, Colorado River Storage Project Act, and the GCPA. The role of each responsible Interior agency under the GCPA is briefly addressed below.

Bureau of Indian Affairs

The BIA's mission, among other objectives, includes enhancing quality of life, promoting economic opportunity, and protecting and improving trust assets of Indian Tribes and individual American Indians. This is accomplished within the framework of a government-to-government relationship in which the spirit of Indian self-determination is paramount. As part of the AMWG, the BIA works hand-in-hand with interested tribes and other participating agencies to ensure that this fragile, unique, and traditionally important landscape is preserved and protected.

Bureau of Reclamation

Reclamation operates Glen Canyon Dam in accordance with and subject to interstate compacts, an international treaty, federal laws, court decisions and decrees, contracts, and regulatory guidelines collectively known as the "Law of the River," additional criteria and operating plans specified in section 1804 of the GCPA, and approved experimental plans. Reclamation also provides support to the Secretary's Designee in administering the GCDAMP, including coordinating logistics for the AMWG and the Technical Work Group (TWG).

National Park Service

The NPS manages units of the national park system and administers resource-related programs under the authority of various federal statutes, regulations, and executive orders, and in accordance with written policies set forth by the Secretary and the Director of the NPS, including the NPS Management Policies 2006 and the NPS Director's Orders. The NPS manages Grand Canyon National Park and Glen Canyon National Recreation Area under the NPS Organic Act, 16 U.S.C. §§ 1 and 2-4, as amended; other acts of Congress applicable generally to units of the national park system; and the legislation specifically establishing those park units. 16 U.S.C. §§ 221-228j and 16 U.S.C. §§ 460dd through 460dd-9 (2006). The NPS Organic Act directs the NPS to "promote and regulate the use of . . . national parks . . . in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." The NPS helps the Secretary achieve the goals outlined in the GCPA through its resource management and resource monitoring activities.

U.S. Fish and Wildlife Service

The FWS provides Endangered Species Act (ESA) conservation and associated consultation and recovery leadership with various stakeholders primarily to benefit five listed species: the

humpback chub (*Gila cypha*), razorback sucker (*Xyrauchen texanus*), southwestern willow flycatcher (*Empidonax trailii extimus*), yellow-billed cuckoo (*Coccyzus americanus*), and Kanab ambersnail (*Oxyloma haydeni kanabensi*).

U.S. Geological Survey

The Grand Canyon Monitoring and Research Center (GCMRC) of the USGS was created to fulfill the mandate in the GCPA for the establishment and implementation of a long-term monitoring and research program for natural, cultural, and recreational resources of Grand Canyon National Park and Glen Canyon National Recreation Area. GCMRC provides independent, policy-neutral scientific information to the GCDAMP on (a) the effects of the operation of Glen Canyon Dam and other related factors on resources of the Colorado River ecosystem using an ecosystem approach, and (b) the flow and non-flow measures to mitigate adverse effects. The GCMRC's activities are focused on (a) monitoring the status and trends in natural, cultural, and recreational resources that are affected by dam operations, and (b) working with land and resource management agencies in an adaptive management framework to carry out and evaluate the effectiveness of alternative dam operations and other resource conservation actions described in this report.

2016 OPERATIONS

Bureau of Indian Affairs

In 2016, the BIA participated in consultation meetings with the tribes regarding the Tribal Consultation Plan, conducted pre-meetings with tribal representatives prior to the AMWG meetings, met with the Interior Tribal Liaison to discuss tribal concerns, participated in meetings regarding cultural and natural resources issues and concerns, and participated in the GCDAMP assessment interview. Principal among tribal concerns for 2016 remains the importance of traditional cultural values and the fact that overall the tribes do not feel they are being consulted with to the level they believe they should be. The tribes are especially concerned with the mechanical removal of non-native fish in the Colorado River. The BIA commented on the final Long-Term Experimental and Management Plan (LTEMP) Environmental Impact Statement (EIS) and Record of Decision (ROD). The BIA continued to provide its portion of funding to tribes for their participation in the GCDAMP. Other activities included continued coordination of efforts for tribal participation in the GCDAMP, coordinating with other agencies on approval of the fall high-flow event (HFE), reviewing annual tribal monitoring reports, commenting on the Programmatic Agreement (PA), and continuing to work with the Interior Tribal Liaison to maximize tribal consultation and involvement.

Bureau of Reclamation

Water Operations

As in 2010 through 2015, a water year 2016 hydrograph was jointly developed by the Interior AMWG agencies and WAPA. The recommended hydrograph was consistent with the "Law of the River" (including the GCPA) and was designed to enhance protection of downstream

resources. This approach to operations is consistent with the Interim Guidelines, operating criteria, and 2007 ROD, and falls within the parameters of the modified low fluctuating flow (MLFF) alternative adopted in the 1996 ROD. The recommended hydrograph received consensus support from members of the AMWG and was approved by the Secretary on November 19, 2015.

Releases from Lake Powell in water year 2016 continued to reflect consideration of the uses and purposes identified in the authorizing legislation for Glen Canyon Dam and were consistent with the 1996 ROD; the 2012 Environmental Assessment/Finding of No Significant Impact (EA/FONSI) for Development and Implementation of a Protocol for High-Flow Experimental Releases from Glen Canyon Dam, Arizona, 2011-2020; and the 2016 hydrograph. The monthly release volumes for water year 2016 are displayed in Table 1. The end of water year 2016 elevation for Lake Powell was 3,611 feet.

Table 1. Lake Powell Monthly Release Volumes
Water Year 2016

Month	Monthly Release Volumes (maf*)
October 2015	0.600
November 2015	0.577
December 2015	0.857
January 2016	0.857
February 2016	0.700
March 2016	0.694
April 2016	0.666
May 2016	0.700
June 2016	0.800
July 2016	0.950
August 2016	0.900
September 2016	0.699
Total Releases	9.000

*maf = million acre-feet

On October 16, 2015, the Glen Canyon Technical Team (Technical Team) recommended against conducting a high-flow experimental release from Glen Canyon Dam for water year 2016 (calendar year 2015). As described in the Technical Team recommendation, concerns for biological resources warranted a cautious approach of not conducting an HFE, even though the sediment trigger had been met. Specifically, the presence of green sunfish, an invasive and predaceous non-native fish in Glen Canyon, indicated that a fall 2015 HFE could have the negative effect of dispersing these non-native fish into new habitats downstream. Dispersal of green sunfish could have a negative effect on downstream populations of native, endangered fish species including the humpback chub and razorback sucker. As a result, an HFE was not conducted in water year 2016.

LTEMP EIS

The Department of the Interior, through the Bureau of Reclamation and National Park Service, jointly published the final LTEMP EIS on October 7, 2016, and a Record of Decision was signed December 15, 2016. The purpose of the LTEMP is to increase scientific understanding of the ecosystem downstream from Glen Canyon Dam and to improve and protect important downstream resources, while maintaining compliance with relevant laws including the GCPA, "Law of the River," and Endangered Species Act. The EIS had 15 cooperating agencies (including six tribes). A primary function of the LTEMP EIS is to continue the successful experiments completed under the Glen Canyon Dam Adaptive Management Program.

Conservation Measures for Humpback Chub and Razorback Sucker

From fiscal years 2009 through 2016, Reclamation has funded the NPS to remove non-native brown and rainbow trout and translocate humpback chub into three tributaries: Shinumo Creek, Havasu Creek, and if non-native removal is successful, Bright Angel Creek. These actions are implemented to fulfill: (1) conservation measures from two biological opinions on the operations of Glen Canyon Dam and (2) recovery goals as defined by the FWS for humpback chub that require the establishment of additional reproducing populations of humpback chub. These efforts are to provide additional refuge populations that minimize the effects of predation and competition from non-native fish, contribute to mainstem populations of humpback chub, and may eventually establish new spawning populations.

Although the LTEMP Biological Opinion replaces the 2011 Biological Opinion, ongoing conservation measures will continue with adjustments based on emerging science. New actions are mostly in anticipation of potential hydrological conditions that could result in non-native fish establishment. Further planning and compliance may be needed to implement components of the new measures.

Translocations into Shinumo Creek that occurred from 2009 to 2013 have been discontinued. In May 2014, a lightning-caused fire burned 6,100 acres in the drainage followed by monsoon flood events in July and August. These events flushed and scoured the aquatic fauna from the creek and greatly altered habitat conditions making it unsuitable for fish. Monitoring of Shinumo Creek continues in order to evaluate the recovery and suitability of the habitat for future translocations. Some humpback chub previously translocated into Shinumo have been located each year in the mainstem aggregation near the Shinumo confluence, and two Shinumo chubs were re-located almost 40 miles upstream at the mouth of the Little Colorado River where they were spawned.

Juvenile humpback chub have been translocated to Havasu Creek since 2011. Two monitoring trips per year are conducted to determine abundance, annual survival, and growth estimates for the translocated humpback chub. These data indicate that the objectives of the translocations are being met and in addition, non-tagged or non-translocated humpback chub and chub less than 150 millimeters have also been captured. Their occurrence indicates that there is naturally occurring humpback chub in Havasu that are reproducing. Evidence of reproduction has been

consistently demonstrated since 2012. Consequently, a spawning population may be present and translocations will likely occur in the future only to assure the genetic diversity of the population.

Fiscal year 2016 will see the completion of a five-year adaptive management action to remove trout from Bright Angel Creek in order to make the creek suitable for humpback chub translocations and benefit other native species. The removal effort consisted of blocking both brown and rainbow trout from entering the creek to spawn with a fish weir, electrofishing the entire creek multiple times a year, and boat electroshocking the mainstem Colorado at the confluence area of Bright Angel Creek in the fall. Reduction efforts have removed thousands of brown and rainbow trout and as a result, the population structure has changed and there are 80 percent fewer trout. Scientists will now review the five years of data to determine whether the creek is suitable for translocations and at what level mechanical removal should continue to occur.

Monitoring has shown that abundance of adult chub in the mainstem has increased or remained stable at all aggregations since sampling began in the 1990s. Humpback chub adults are currently abundant (12,000 adults plus) and expanding in range. Humpback chub translocated to Shinumo Creek and Havasu Creek from 2009-2016 have contributed to the mainstem aggregations that are located at the tributary mouths. Mainstem aggregation sampling indicates that humpback chub translocated into Shinumo and Havasu tributaries are approximately 70 percent and 35 percent of the total aggregation, respectively. Other areas not associated with known aggregations were sampled for the last four years and results indicate that chub are more widely distributed in the mainstem than had been detected previously. There has also been an expansion of chub below Havasu Creek in the mainstem, which is likely a result of emerging habitat below Diamond Creek and chub leaving tributaries where they were translocated and joining mainstem aggregations.

The razorback sucker was thought to be extirpated from the Grand Canyon reach of the Colorado River. However, in 2013, two razorbacks were captured downstream of Diamond Creek (RM 225), more than 50 miles upstream from Pearce Ferry near the inflow of the Colorado River to Lake Mead and the termination of Grand Canyon. Consequently, Reclamation continued financial and staff support of a monitoring project for razorback sucker aimed at better understanding the use and life history needs of the species in Lake Mead and western Grand Canyon.

While researchers have known that razorback sucker occupy and are able to reproduce and recruit in Lake Mead since the 1990s, this project found that the species also uses the Colorado River in western Grand Canyon much farther upstream. Other findings include the presence of juvenile fish in the Lake Mead inflow area indicating recruitment, larval fish above Lava Falls indicating spawning and possible recruitment in the river reach, and long-distance movement of adult razorback suckers throughout Lake Mead and western Grand Canyon.

Because the capture of larval fishes helps to identify where spawning takes place, the duration of spawning activities, habitat use, and availability and fish community dynamics, Reclamation funded additional research for larval fish surveys in the lower reaches of Grand Canyon. For the last three years, biologists have sonic-tagged adult razorback suckers to track movements and

possibly locate spawning aggregations. Evidence indicates razorback sucker had migrated upstream from Lake Mead and had spawned in Grand Canyon during February and March of each year. Larvae were found above Lava Falls, which suggests that spawning is occurring somewhere above that point in the river. This is encouraging news for native fish restoration because the detection of these larvae fish indicates that razorback suckers may be naturally reproducing in an area where the species has not been seen in more than 20 years.

Tribal Activities

Reclamation continued to fund five American Indian Tribes (Hopi, Hualapai, Pueblo of Zuni, Kaibab Paiute, and the Navajo Nation) to participate and provide their perspectives to the GCDAMP. They identify and monitor traditional cultural properties and provide annual reports detailing their activities, findings, and monitoring of data.

Several government-to-government consultations with interested tribes were conducted throughout the year, and additional staff level meetings and conference calls with interested tribes were also held.

In addition to the high-flow experimental release and consultations for the LTEMP EIS, Reclamation continues to conduct government-to-government consultations with American Indian Tribes as part of the GCDAMP on operations of Glen Canyon Dam and activities of the GCDAMP in services of its responsibilities, including those under section 106 of the National Historic Preservation Act, Executive Order 13175, Secretarial Order 3206, and the November 5, 2009, Presidential Memorandum on Tribal Consultation.

Reclamation continued implementation of two memoranda of agreement (MOA) to mitigate for adverse effects under section 106 of the National Historic Preservation Act for the High-Flow Experimental Protocol and non-native fish management described above. The consultation process leading to execution of these two MOAs included consensus determination of eligibility of the Grand Canyon as a traditional cultural property for several tribes, at their request. Reclamation also continued its efforts with the signatories to develop a new Programmatic Agreement for operation of Glen Canyon Dam pursuant to the GCPA that is consistent with the LTEMP, and anticipates completing the new PA in conjunction with the LTEMP ROD.

Other Activities

Grand Canyon National Park employs a permitting specialist and staff who review all proposals for projects to be completed in the park. Reclamation funds these positions to offset the park's administrative burden from GCDAMP activities. In 2016, Grand Canyon National Park's Research Office issued 18 river trip permits, which fulfilled obligations under the GCDAMP. This was a reduction of four applications from the 22 filed in 2015. The GCMRC was issued nine research and collection permits and 18 river launch permits, totaling 4,858 river user days. In addition to science trips, the GCMRC permits included logistics for five tribal monitoring trips. Due to the sensitivity of the Little Colorado River area to tribes and others, efforts have been made to reduce, combine, and eliminate river trips and helicopter flights into the area wherever possible.

National Park Service

Three units of the NPS (Glen Canyon National Recreation Area, Grand Canyon National Park, and Lake Mead National Recreation Area) provide support for various operations. In 2016, staff from the Intermountain Regional Office, along with staff from both Grand Canyon National Park and Glen Canyon National Recreation Area, were instrumental in working with Reclamation and the other agencies on review of a potential November HFE. Staff from NPS and GCMRC were able to successfully treat a small backwater slough area experiencing a second invasion by non-native green sunfish located within the Colorado River of Glen Canyon National Recreation Area. Because of the successful treatment of all known green sunfish, the agencies recommended implementing an HFE, which was successfully accomplished in November 2016 (water year 2017). This recommendation was made after thorough review of the resource information and in consultation with Interior agencies, Arizona Game and Fish Department (AGFD), tribal governments, and stakeholders.

LTEMP EIS

In 2016, Reclamation and the NPS completed five years of coordination with federal and state agencies and recreation and power stakeholders who are part of the GCDAMP. The final LTEMP EIS was published in October 2016, the Biological Opinion in November 2016, and the LTEMP ROD in December of 2016. Reclamation has continued follow-up meetings with the NPS, tribes, the Arizona State Historic Preservation Office, and the Advisory Council on Historic Preservation as well as other stakeholders to finalize agreements.

Archaeological/Cultural Resources

Grand Canyon National Park: Field work in 2016 consisted of condition assessments at 81 river corridor archaeological sites as part of ongoing Colorado River Management Plan implementation. The NPS participated on one tribal monitoring river trip visiting ethnographic resources to determine condition and threats from a tribal perspective. Grand Canyon staff, working with colleagues from the Intermountain Regional Office and Glen Canyon National Recreation Area, continued work on the LTEMP and collaboratively drafted the associated Programmatic Agreement.

The Zuni Cultural Resource Advisors and NPS archaeologists continue to document tribal values related to appropriate stabilization techniques. The tribe and the NPS will continue to monitor the success of stabilization at one specific river corridor location.

Glen Canyon National Recreation Area: Staff from Glen Canyon National Recreation Area continued to contribute to the development of the LTEMP EIS. These efforts included clarifying the nature of potential effects from dam operations through field investigations on additional cultural sites, analyzing a series of photos from automatic cameras, and continuing to prepare a long-term monitoring protocol for known sites that could potentially be impacted by dam operations and HFEs. Glen Canyon National Recreation Area staff also continued to support the GCMRC's monitoring of dam related topographic changes at select cultural sites.

Tribal Consultation

In 2016, the NPS continued to participate in consultation meetings with the various tribes who are directly involved in the GCDAMP and other Colorado River related programs. The NPS's Grand Canyon National Park and Glen Canyon National Recreation Area continued discussions with tribes and incorporated tribal perspectives into implementation of the NPS's Comprehensive Fisheries Management Plan. Tribal advisors were consulted on specific monitoring and mitigation protocols relative to Grand Canyon National Park's Colorado River Management Plan implementation. The NPS participated in on-river monitoring with two tribes and continued to work closely with tribal staff on monitoring and mitigation protocols and implementation.

The NPS worked with Reclamation to consult with interested tribes involved in the LTEMP. Consultation is government-to-government and includes all tribes who are interested in the planning effort regardless of their role as a cooperating agency for the EIS. They also worked extensively together on the draft Programmatic Agreement associated with the final EIS and ROD.

Again in the fall of 2016, Grand Canyon National Park and Glen Canyon National Recreation Area engaged in consultations with the Hopi Tribe, Hualapai Tribe, Kaibab Paiute Tribe, Navajo Nation, and the Pueblo of Zuni regarding the second green sunfish invasion in the Upper Slough of Glen Canyon National Recreation Area. Tribes suggested several actions that were implemented and that facilitated resolution of the problem.

Glen Canyon National Recreation Area engaged in consultation with the Hopi Tribe, Hualapai Tribe, Kaibab Paiute, Navajo Nation, and Pueblo of Zuni to discuss next steps in addressing the mitigation needs of Nine Mile Terrace, a large alluvial terrace more than 15-feet deep with numerous, buried archeological deposits that are at least 3,000 years old. Nine Mile Terrace is adversely affected by fluctuating and high flows related to the operation of the Glen Canyon Dam. A number of ethnographic field trips are planned with tribal representatives to visit this terrace and other Glen Canyon Reach sites in 2017 to allow for informed decisions to be made on how best to monitor and protect this specific terrace impacted by dam operations. Funding for that work is being provided by Reclamation as part of their section 106 responsibilities associated with the operation of Glen Canyon Dam, and one of the purposes is to help inform the mitigation of archeological sites that are affected by dam operations within Glen Canyon.

Further, Glen Canyon National Recreation Area discussed with each of those tribes the possibility of ethnographic work to understand the contemporary and cultural significance of archeological sites within the Glen Canyon reach. Funding for that work is being provided by Reclamation as part of their section 106 responsibilities associated with the operation of Glen Canyon Dam, and one of the purposes is to help inform the mitigation of archeological sites that are affected by dam operations within Glen Canyon.

Humpback Chub Translocation and Fisheries Management

In 2016, the Grand Canyon National Park continued implementation of the Comprehensive Fisheries Management Plan for native fish within the Grand Canyon National Park and sport fish

in the Lees Ferry area of the Glen Canyon National Recreation Area. These efforts included an evaluation of the status and habitat use of endangered razorback sucker (thought to have been extirpated until 2014), translocations and/or monitoring of endangered humpback chub to Havasu and Shinumo creeks and the nearby mainstem Colorado River, and the removal of non-native fishes threatening endangered and native fish in Bright Angel Creek and the Bright Angel Creek inflow area of the Colorado River. The recovery of habitat in Shinumo Creek following a fire and flood was also monitored.

Monitoring of humpback chub translocation efforts in 2016 allowed the NPS to document the successful establishment of a reproducing population of the endangered species. Humpback chub that were produced as a result of spawning in Havasu Creek were found to have grown to maturity. The population of humpback chub was estimated to be approximately 300 fish.

Invasive species monitoring continued in 2016 in Glen Canyon with emphasis on invasive fish and quagga mussels. Quagga mussel colonization at depth in the river within Glen Canyon is increasing, but remains very patchy. The brown trout population in Glen Canyon continued to increase; brown trout are a high-risk non-native predator for targeted mechanical removal in the Comprehensive Fisheries Management Plan that may threaten the rainbow trout fishery in Glen Canyon and native fish in Grand Canyon.

As in 2015, green sunfish were also detected in a backwater in the Colorado River, approximately three miles below Glen Canyon Dam, by the NPS and USGS. This invasive species reproduced rapidly, and was eradicated from the area after an interagency group of scientists from the AGFD, NPS, USGS, and Reclamation, in consultation with the Arizona Department of Environmental Quality, developed an experimental chemical removal plan after mechanical removal failed. Mechanic removal via boat and backpack electrofishing, seining, and minnow trapping was conducted on multiple trips prior to the chemical treatment.

During removal treatments, green sunfish were collected and put to beneficial use after consultation with Traditionally Associated Tribes. This rapid response effort would not have been possible without the collaboration, dedication, and shared vision held by many agencies.

For the river within Glen Canyon, the angler catch rate of rainbow trout has declined, and in some areas (the "walk-in"), the stocking of sterile rainbow trout, in coordination with the AGFD and FWS, may be considered. Any stocking would be consistent with the NPS Comprehensive Fisheries Management Plan, including the development of an implementation plan for stocking that would minimize risk to endangered species in Grand Canyon.

Wildlife Surveys and Monitoring

Grand Canyon National Park: In 2016, Grand Canyon National Park activities included assisting researchers with a desert bighorn sheep study to inform connectivity models, determine genetic diversity of herds, and gain insights on desert bighorn sheep ecology and disease impacts. Park biologists continued monitoring California condors and Mexican spotted owls. In addition, park staff continued collaborative work with the AGFD intended to collect baseline data for bats before the expected arrival of white-nose syndrome. Park staff also did southwestern willow

flycatcher surveys for vegetation project compliance, and camera trapping for presence of the hognosed skunk.

Glen Canyon National Recreation Area: In 2016, Glen Canyon National Recreation Area staff and partners worked on great blue heron, waterfowl, and raptor surveys along the 16-mile reach below the dam. Work continued on monitoring aquatic/riparian invertebrates and terrestrial vertebrate populations creating open water habitat at Leopard Frog Marsh.

Bald eagle surveys were conducted in January 2016 on the Colorado River and Lake Powell. New bat monitoring efforts were also implemented both above and below the dam in order to identify the bat species using the Colorado River corridor.

Monitoring for impacts from quagga mussels both above and below the dam and for invasive fish (including brown trout which also recently began spawning in the Glen Canyon Reach in addition to green sunfish) and other invasive species is ongoing.

Vegetation Management/Exotic Species Removal

Grand Canyon National Park: In 2016, the NPS continued to implement exotic plant species removal at priority sites, expand plant collection and propagation efforts in preparation for future watershed restoration projects, and provide hands-on stewardship opportunities. The NPS also maintained native plants and removed exotic species at Granite Camp as part of a pilot riparian restoration project. Specific accomplishments along the river corridor in Grand Canyon National Park were:

- Continued the Adopt-a-Camp program by working with individuals, Grand Canyon Youth, and commercial companies to remove priority exotic plant species from the camps and attraction sites.
- Continued the first riparian restoration project in the river corridor at Granite Camp (RM 94) through site maintenance and outreach to project partners.
- Continued propagation of riparian plant species for supplemental planting at Granite Camp and other future riparian restoration projects.
- Removed tamarisk (685) and camelthorn (288) from the Granite Camp restoration site.

Glen Canyon National Recreation Area: In 2016, the NPS, partners, and volunteers implemented invasive plant management efforts, native plant restoration activities, and vegetation monitoring efforts along the Colorado and Paria rivers below Glen Canyon Dam. Specific accomplishments in Glen Canyon National Recreation Area were:

- Restored native upland plants at a number of sites along the roadways into Lees Ferry.
- Grand Canyon Wildlands Council (under cooperative agreement with the NPS) continued monitoring native plant restoration success at Hidden Slough.
- Grand Canyon Wildlands Council and the NPS continued work on re-establishing open water habitat at Leopard Frog Marsh and Hidden Slough.
- Continued native seed collection and plant propagation efforts for restoration activities at Hidden Slough, Leopard Frog Marsh, and Paria River Bridge.

- Conducted initial plantings of native species associated with the Lees Ferry Road and Paria River Bridge projects.
- Controlled, mapped, and/or monitored the following invasive non-native species infestations:

    - ✓ Russian olive – No recent plants seen between the dam and Glen Canyon/Grand Canyon boundary.
    - ✓ Tamarisk – Continued monitoring of tamarisk leaf beetle impacts at Hidden Slough, Leopard Frog Marsh, and Lees Ferry.
    - ✓ Ravenna grass – Some remain near the base of the dam in inaccessible areas.
    - ✓ Surveys and some control work on Sahara mustard in Lees Ferry District.

Research Review and Permitting

The Grand Canyon's Research Office continues to have one of the largest research and collection permitting programs within the NPS. There are more than 200 researchers that are listed as either principal or co-principal investigators presiding over current studies. In 2016, the Grand Canyon's Research Office received 23 river trip applications to fulfill obligations under the GCDAMP. The GCMRC was issued 9 research and collection permits and 18 stand-alone river permits, totaling 4,858 user days. Five tribal research permits with corresponding river trips were permitted for the Hopi, Hualapai, Navajo, Paiute, and Zuni tribes, totaling 783 user days. Overall, 5,641 user days were spent on the river conducting GCDAMP-related research.

For each GCMRC and tribal permit, an interdisciplinary team of technical experts reviewed and provided comments on the research proposal or logistics and assistance was given to the principal investigator in completing the minimum requirement analysis and related compliance documents.

Additionally in 2016, Grand Canyon Science and Resource Management staff participated in GCDAMP-related meetings and river trips; attended and participated in GCMRC's annual reporting meeting; and attended Glen Canyon Dam Technical Work Group meetings, knowledge assessment workshops, and other meetings with the GCMRC and TWG. These discussions are integral to future collaborations and allow for shared input and an increase in NPS involvement in the GCDAMP.

Outside of the GCDAMP, the research office continued to review proposals, coordinate efforts, and provide permitting guidance as needed for all GCPA projects in 2016. An additional 44 research permits were issued to independent or university researchers and logistical planning was provided to various disciplines including vegetation baseline monitoring, geomorphology, terrestrial remote sensing, and soundscape monitoring. Grand Canyon National Park anticipates continuation of research and permitting activities in 2017 at similar levels as 2016.

The Glen Canyon National Recreation Area continued administration of 11 research permits associated with the GCDAMP between Glen Canyon Dam and the Paria River. The NPS anticipates continuation of research and permitting activities in 2016 at similar levels as 2015. For each of the research projects in support of the GCPA, evaluation of the need for National

Environmental Policy Act (NEPA) compliance and completion of minimum requirement analysis will be completed. Updating of annual investigator reports will be done for each research permit and coordination with Reclamation will continue.

Resource Monitoring and Mitigation

In 2016, the Grand Canyon National Park began the process of integrating monitoring of Colorado River campsites with all backcountry campsite monitoring. The opportunity presented itself when the strategic pause in Grand Canyon NPS river operations allowed staff to review and revise Colorado River Management Plan (CRMP) methods and create a final, written protocols document. At the same time, a plan for adaptive management of day and overnight use in the Grand Canyon backcountry, tied to drafts of the Backcountry Management Plan, was in development. Methods for monitoring backcountry campsites were aligned with CRMP campsite monitoring in ways that allowed integration of the two into a single database with shared fields.

The Glen Canyon National Recreation Area continued multi-faceted efforts to prevent aquatic invasive species transport to and from Lake Powell and Lees Ferry. Aquatic invasive species (including New Zealand mudsnails, didymo, and quagga mussels) present extreme potential impacts to a wide range of GCPA associated resources.

The Glen Canyon National Recreation Area also employed the use of cameras at several localities to monitor terrace erosion and changes related to dam operations and HFEs. This work will continue in 2017.

Greater Grand Canyon Landscape Assessment

Grand Canyon National Park staff completed the Greater Grand Canyon Landscape Assessment in October 2016. An interdisciplinary team of NPS experts, agency partners, scientists, and other groups and individuals completed the assessment and identification of resource conditions and trends and prioritization of conservation needs facilitating ecosystem-based stewardship. The collaborative efforts of the previous four years by NPS, Northern Arizona University, and numerous other partners (including federal and state agencies, tribes, universities, non-profit organizations, and special interest groups) came to fruition and the data for many of the focal resources has been synthesized and is being used to develop spatial layers to assist in subsequent analyses. The document is in the final editing phase and publication is expected to occur in spring 2018. This report will serve as a baseline for current resource conditions and help guide park planning and decision making for the future

U.S. Fish and Wildlife Service

The FWS has been participating in the LTEMP as a cooperating agency and has been active in the development of alternatives and modeling for biological resources through attendance at webinars and providing comments to the joint lead agencies. The FWS led agency cooperators in evaluation and modification of trout removal triggers for inclusion into the LTEMP process.

The new triggers are sensitive to tribal concerns with trout removal and provide a more direct conservation benefit to humpback chub.

The FWS continued to consult with the NPS regarding the Comprehensive Fisheries Management Plan, which guides NPS activities for native and non-native fish in Grand Canyon National Park and Glen Canyon National Recreation Area. The FWS will continue to participate in the AMWG, TWG, and various ad hoc groups and other related assignments. The FWS is also engaged with Grand Canyon National Park in the development of resource conditions for the Greater Grand Canyon Landscape Assessment process.

In 2016, the FWS conducted four monitoring trips on the Little Colorado River to generate population estimates for humpback chub and to monitor trends of other native fishes. Since 2006, the Little Colorado River population of humpback chub in Grand Canyon has significantly increased in size. Population estimates in 2016 remained near 2015 levels representing a decline in humpback chub in the Little Colorado River and is likely a result of reduced numbers of chub moving into the system from the Colorado River. The FWS conducted one trip on the Little Colorado River to monitor the success of upstream translocations of humpback chub within the Little Colorado River. These translocation efforts have been successful, with humpback chub experiencing high growth rates, and high survival in this upper portion of the river. In 2016, the FWS continued this translocation effort, moving an additional 303 humpback chub upstream of Chute Falls.

The FWS has continued to work collaboratively with the GCMRC and Grand Canyon National Park in the collection and transport of young humpback chub for translocation into Havasu Creek. No larval humpback chub were collected in 2016 for grow-out and translocations.

The FWS, in collaboration with GCMRC and NPS, continues to develop and refine a monitoring program to effectively sample mainstem aggregations of humpback chub in the Colorado River in Grand Canyon. In 2016, the FWS and the GCMRC conducted one sampling trip to estimate the population size of humpback chub in these aggregations. Large numbers of juvenile and adult humpback chub were collected in western Grand Canyon and appear to represent downstream population expansion. It is encouraging that the effect of translocating humpback chub into Shinumo and Havasu creeks has resulted in a measurable augmentation of these two mainstem aggregations.

U.S. Geological Survey

In 2016, the GCMRC continued to serve in its role as the primary science provider to the GCDAMP. The GCMRC's primary activities during 2016 were: (1) conducting an annual reporting meeting that summarized findings from the previous year's research and monitoring activities and summarized knowledge-to-date concerning the Colorado River ecosystem, (2) implementing the second year of a three-year Budget and Work Plan encompassing fiscal years 2015-2017, (3) maintaining a stream flow and sediment transport measurement and internet-based real-time reporting program that was the foundation for planning a November 2016 HFE, (4) analysis of those data so as to inform dam and river management activities in the months immediately before the HFE, (5) collection and reporting of data describing resource conditions

immediately following the November 2016 HFE, (6) collection and reporting of native and non-native fish population data in support of management decisions regarding non-native fish control, and (7) monitoring key cultural resources and physical processes that may affect them. Additionally, the GCMRC conducted numerous field and laboratory studies and provided logistics support for river trips and other field activities and provided scientific support for completion of the LTEMP EIS.

Knowledge Synthesis

In January 2016, the GCMRC conducted an annual reporting meeting with GCDAMP stakeholders during which results from research and monitoring in key resource areas in Glen and Grand canyons from the previous year were presented by scientists from the GCMRC and cooperating agencies as well as tribal representatives. The foci of the January meeting were biology, ecology, hydrology, sediment transport, geomorphology, cultural resources, and recreation resources. All materials presented at the workshops were made available in electronic postings at the GCMRC and Reclamation websites.

Implementation of a Three-Year Budget and Work Plan for Fiscal Years 2015-2017

In close cooperation with the GCDAMP stakeholders, the GCMRC implemented the second year of a three-year Budget and Work Plan for fiscal years 2015-2017. The plan is organized into a relatively small number of focused projects. Key topics of study include hydrology, sediment transport, geomorphology, fisheries, aquatic ecology, riparian vegetation, cultural resources, and socioeconomics.

Implementation of Stream Flow and Sediment Measurement Program in Support of the High-Flow Experimental Protocol

The periods from December 1 to June 30 and July 1 to November 30, 2016, mark the "sediment accumulation periods" for spring and fall high-flow experiments, respectively, as defined under the High-Flow Experimental Protocol that was adopted by the Secretary in 2012. The HFE Protocol necessitates the estimation in real time of sand delivery from the Paria River and sand retention in Marble Canyon in the months immediately prior to the HFE. The GCMRC worked in collaboration with the Arizona and Utah Water Science Centers of the USGS to measure suspended-sediment transport and to process field samples in the GCMRC sediment lab. Telemetered data from remotely deployed instruments were shared in real time on the GCMRC website while data from physical samples were shared with Reclamation via the GCMRC website on a bi-weekly basis in an unmatched effort to provide sediment data in a near real-time format for HFE planning purposes.

The GCMRC estimated that between 44,000 and 54,000 metric tons of sand was delivered from the Paria River to the Colorado River during the period between December 1, 2015, and June 30, 2016, and between 770,000 and 942,000 metric tons between July 1 and November 30, 2016. The amount of sand delivered during the spring sediment accumulation period was inadequate to trigger a HFE, but sand inputs during the fall sediment accumulation period exceeded the quantity needed to conduct a 96-hour HFE in November 2016 (water year 2017).

The GCMRC evaluated sediment transport and sediment mass balance data and made recommendations to Reclamation concerning the design of the HFE hydrograph so as to provide the most effective benefit-to-resource condition and scientific learning, consistent with the protocol defined in the 2012 published environmental assessment.

Implementation of a Plan to Evaluate HFE Effects

The GCMRC utilizes a network of field time-lapse cameras to evaluate the effects of HFEs and other flows on sandbars throughout the Colorado River ecosystem. Scientists were sent into the field in February 2016 to collect photographic data and recover gaging station data. Preliminary results indicate that there was favorable bar building in Marble and Grand canyons caused by each of the fall HFEs conducted in November 2012, November 2013, and November 2014 (water years 2013, 2014, and 2015). Sandbar size at a majority of sites (> 88%) either increased or was maintained in response to each HFE. No HFE occurred in fall 2015 (water year 2016) and preliminary results indicate erosion occurred at most monitored sandbars as a result of normal dam operations (e.g., daily variation due to hydropower load-following flows) in water year 2016. The most recent topographic surveys of long-term monitoring sites from fall 2016 (water year 2017) indicate sandbars increased in size during the first four years of implementation of the HFE Protocol.

In addition, rainbow trout populations and the aquatic food base in Glen Canyon were sampled before and after each of the November 2012, November 2013, and November 2014 HFEs to evaluate any effects on the aquatic ecosystem. Results indicate that fall HFEs do not trigger downstream movement of rainbow trout or affect rainbow trout growth rates. Rainbow trout abundance in Glen Canyon did decline substantially over the period that included the November 2012, November 2013, and November 2014 HFEs and also through water year 2015. These changes appear to be related to an overabundance of young trout produced in water year 2011 and a limited aquatic food base rather than any effect of fall HFEs. The abundance of young rainbow trout increased dramatically in water year 2016 suggesting a recovery of the Glen Canyon rainbow trout population is underway. Catches of non-native brown trout have been increasing in Glen Canyon coincident with the implantation of the HFE Protocol with evidence of spawning in water years 2015 and 2016. The influence of fall HFEs on increases in this fish-eating predator are unknown, but is a topic of ongoing discussion among scientists and managers.

Results from monitoring also suggest that the aquatic food base only responds weakly to fall HFEs. This was shown by slight increases in abundance of some aquatic insects and New Zealand mudsnail, an invasive species, and slight decreases in abundance of other non-insect invertebrates (tubificid worms and amphipods) within weeks to months of these events. These observations stand in stark contrast to the dramatic change in the aquatic food base observed following the March 2008 HFE when tubificid worms and New Zealand mudsnails declined sharply and aquatic insects increased dramatically. No HFE occurred in November 2015 (water year 2016), but only modest changes were observed in the aquatic food base in water year 2016. Amphipod and New Zealand mudsnail abundance did increase, but the abundance of insects and tubificid worms were unchanged again suggesting any fall HFE effect on the aquatic food base is weak.

Presentations concerning the effects of the November 2012, November 2013, and November 2014 HFEs were given at the January 2016 annual reporting meeting. Additional information about the effects of these HFEs was presented at a GCDAMP meeting in February 2016. Preliminary information on the effects of the fall 2016 HFE was presented to the Upper Colorado River Commission at its Las Vegas meeting in mid-December 2016.

Fisheries Information in Support of Non-Native Fish Control EA

The GCMRC conducted monitoring of native and non-native fish populations in support of Reclamation's non-native fish control EA and its associated biological opinion for endangered humpback chub. This biological opinion identifies several triggers which, if met, require management actions to be taken to reduce non-native fish populations in an effort to protect humpback chub. Information provided by the GCMRC for specific triggers included the abundance of non-native rainbow trout and brown trout in the Colorado River near the Little Colorado River confluence.

The GCMRC and its cooperators also generated estimates of the abundance of several life stages of humpback chub in the Little Colorado River itself and near its confluence with the Colorado River, as well as survival rates of juvenile humpback chub in this latter area. Only one of four triggering criteria for humpback chub or trout were reached in 2016, sub-adult humpback chub abundance in the Little Colorado River was below the trigger level identified in the 2011 Biological Opinion. Adult humpback chub abundance and juvenile humpback chub survival rates were above trigger levels and non-native trout abundance remained below trigger levels, so no non-native fish control actions were required or implemented.

As in fall 2015, green sunfish were detected in Glen Canyon below Glen Canyon Dam in August of 2016. Distribution was more limited, however, with these fish found only in a small pond. Green sunfish have rapid invasion and expansion potential and prey upon and compete with native fishes. Given these concerns and that the pond would be inundated by HFE flows, multiple mechanical removal efforts were conducted in and attempt to eradicate green sunfish from the area. Although numbers were reduced considerably, eradication by mechanical means was deemed unlikely. In October 2016, in cooperation with the NPS and AGFD, the backwater was successfully treated with ammonia as an experimental piscicide to remove green sunfish. With the successful eradication of green sunfish from this area, the HFE was allowed to proceed as planned in fall 2016 (water year 2017).

Cultural Resource Monitoring in Support of the High-Flow Experimental Protocol and GCDAMP

The plan for monitoring geomorphic change at archaeological sites prepared in 2015 in consultation with Reclamation, the NPS, and Native American Tribes affiliated with the GCDAMP was implemented in fiscal year 2016. In February 2016, GCMRC scientists worked with Glen Canyon National Recreation Area staff to classify all archaeological sites in the Glen Canyon reach of the Colorado River to create a baseline record of the sites' erosion status and susceptibility to future dam-related effects. In May 2016, GCMRC scientists worked with NPS staff from both Grand Canyon National Park and Glen Canyon National Recreation Area to map

and monitor seven archaeological sites in Grand Canyon using terrestrial lidar and other methods. The GCRMC also conducted a geographic information system analysis to investigate how landscape characteristics of terrain located between minimum and maximums river flow elevations that occur during HFEs influence the distribution and area of wind-transported river sand above the maximum flow elevation. In addition, GCMRC continued to assess changes in the distribution and abundance of riparian plant species that were traditionally valued and utilized by Native American Tribes affiliated with the GCDAMP.

Other Science Activities and Findings

In the course of its regular and mandated science monitoring and research activities, the GCMRC and its cooperators provided stakeholders and the GCDAMP with other information including: (1) critical data concerning the status and trends of endangered humpback chub populations in the Colorado River downstream of Glen Canyon Dam as well as key tributaries; (2) status and trends of rainbow trout in Glen Canyon, Marble Canyon, and near the Little Colorado River confluence; (3) distribution and relative abundance of potentially harmful non-native fish species between Glen Canyon Dam and Lake Mead reservoir; (4) status and trends of the aquatic food base in the Colorado River ecosystem; and (5) status and trends of riparian vegetation.
The GCMRC was permitted for and provided logistics support for 22 mainstem river trips in 2016. Trips in 2016 included 15 GCDAMP approved research and monitoring trips led by GCMRC or cooperating agency scientists that launched from Lees Ferry; one fisheries monitoring trip that launched from Diamond Creek; five tribal-led monitoring trips; and two youth "Partners-in Science" trips that included participation of Sally Jewel, Secretary of the Interior, on one of the trips. Logistics support, including helicopter transport, was also provided for GCDAMP-funded projects in the Little Colorado River conducted by the FWS, AGFD, and GCRMC. Five Little Colorado River trips were conducted in 2016 (same as in 2015) with each trip requiring two flight days, one to take crews into field camps along the river and one to retrieve them.

Many GCMRC scientists also provided support to help complete the LTEMP EIS process. Support included data analysis, document review, peer review coordination, development of a science plan, and other activities to help ensure a sound scientific foundation for the final EIS.

Tribal Activities

GCMRC staff met with tribal representatives to the GCDAMP on several occasions in 2016 to consult about ongoing science projects and solicit input on ideas and opportunities for future collaboration. The GCMRC Chief and staff met with the director of the Hopi Cultural Preservation Office and his staff at Kykotsmovi, Arizona, in February. The GCMRC Chief and GCMRC economist met with the Zuni Tribal Council in March to discuss a planned socioeconomic study that is being developed with tribal involvement. In April, the GCMRC Chief and staff met with the heads of the Navajo Nation Department of Fish and Wildlife and Navajo Nation Historic Preservation Department and their staff. In May, the GCMRC Chief accompanied staff from the Department of the Interior and FWS on a tour of a proposed fish rearing facility located on the Hualapai Reservation. In addition, tribal representatives were

invited to make presentations and participate in the Fisheries Protocol Evaluation Panel review that was organized and hosted by GCMRC in August.

2017 OPERATIONS

Bureau of Indian Affairs

In 2017, the BIA will continue to take an active role in supporting stakeholder tribes related to the GCDAMP. The BIA will participate in meetings concerning the Tribal Consultation Plan, the PA, pre-meetings with tribal representatives prior to AMWG meetings, and continue to participate in various ad hoc groups regarding tribal, cultural, and natural resource issues and concerns. The BIA will continue to be involved with any future HFE releases from Glen Canyon Dam as staffing permits. The BIA will coordinate with, and if necessary meet with, Interior's Tribal Liaisons to facilitate stakeholder tribe participation in various aspects of the GCDAMP.

Bureau of Reclamation

Water Operations

As in 2010 through 2016, an initial water year 2017 hydrograph was jointly developed by the Interior AMWG agencies and WAPA. The recommended hydrograph was consistent with the "Law of the River" (including the GCPA) and was designed to enhance the protection of downstream resources. This approach to operations is consistent with the Interim Guidelines, operating criteria, and 2007 ROD, and falls within the parameters of the MLFF alternative adopted in the 1996 ROD. The recommended hydrograph received broad support from members of the AMWG during the meeting of August 24-25, 2016, and was sent for approval by the Secretary.

On December 15, 2016, the Record of Decision for the Glen Canyon Dam Long-Term Experimental and Management Plan was signed by the Secretary. The LTEMP replaces the 2017 recommended hydrograph with alternative operating hydrographs developed for different hydrological year classes. These monthly release volumes are found in Attachment B to the ROD (Table 3, page B-4). The LTEMP monthly release volumes were phased in through interim operations between January 1, 2017, and September 30, 2017.

Releases from Lake Powell in water year 2017 reflect consideration of the uses and purposes identified in the authorizing legislation for Glen Canyon Dam and were consistent with the 1996 ROD; the 2012 EA/FONSI for Development and Implementation of a Protocol for High-Flow Experimental Releases from Glen Canyon Dam, Arizona, 2011-2020; and the 2016 LTEMP ROD. As of September 14, 2017, the observed and projected monthly release volumes for water year 2017 are displayed in Table 2. The end of water year 2017 elevation for Lake Powell is projected to be 3,629 feet.

Table 2. Lake Powell Monthly Release Volumes
Water Year 2017

Month	Monthly Release Volumes (maf*)
October 2016	0.601
November 2016	0.750
December 2016	0.898
January 2017	0.880
February 2017	0.711
March 2017	0.722
April 2017	0.623
May 2017	0.652
June 2017	0.749
July 2017	0.850
August 2017	0.900
September 2017**	0.663
Total Releases**	9.000

*maf = million acre-feet
** = projected release

The fourth experimental release under the High-Flow Experimental Protocol was successfully conducted during November 2016 (water year 2017). Reclamation released the maximum available capacity (38,000 cubic feet per second) during the experiment, which began on November 7 and ended on November 12, 2016. Preliminary findings suggest that the first four high-flow experimental releases have been very successful in transporting sediment accumulated near the confluence of the Colorado and Paria rivers to beaches and sandbars where sediment replenishment was needed. Reports from the Grand Canyon white water rafting community have been positive on the improvement of beaches in Grand Canyon over this five-year period. Fisheries researchers have also indicated that these releases have temporarily rebuilt important backwater habitats where sandbars are adequately enhanced throughout Grand Canyon.

Reclamation will continue planning for high-flow experimental releases from Glen Canyon Dam in accordance with the LTEMP High-Flow Experimental Protocol. Under the LTEMP HFE Protocol, high-flow experimental releases from Glen Canyon Dam are timed to occur following sediment inputs to the Colorado River from downstream tributaries to maintain and improve beaches and sandbars and associated habitat. HFEs may be conducted in the fall or the spring[1] when conditions warrant.

LTEMP EIS

The LTEMP EIS and ROD provide a comprehensive framework for adaptively managing Glen Canyon Dam over the next 20 years consistent with the GCPA and other provisions of applicable

[1] Under the LTEMP High-Flow Experimental Protocol, spring HFEs will be considered after September 30, 2019. No spring HFEs will occur prior to water year 2020.

federal law. The LTEMP includes a communication and consultation process that ensures input and consultation with stakeholders throughout the 20-year implementation. In 2017, Reclamation will continued a phased implementation of LTEMP. Ongoing communication and coordination with stakeholders will continue.

Conservation Measures for Humpback Chub and Razorback Sucker

In 2017, ongoing conservation measures will continue as described above for 2016. Reclamation will continue to provide funding to the GCMRC for aquatic and sediment research.

Tribal Activities

In 2017, Reclamation will continue to provide funding to the GCMRC and NPS for cultural research and will also continue to fund the five American Indian Tribes in the GCDAMP (as described above for 2016). Reclamation also completed efforts to finalize a new Programmatic Agreement for the operation of Glen Canyon Dam consistent with the action identified in the LTEMP EIS. The PA was finalized on September 6, 2017. Under the new PA, tribal and NPS monitoring activities will continue. In addition, a Historic Preservation Plan will be developed and implemented. This plan will, among other activities, continue consultation with interested parties, identify mitigation measures to address any adverse effects to historic properties, and develop a cultural sensitivity training for all researchers.

Other Activities

In 2017, Reclamation will continue to fund Grand Canyon National Park for a permitting specialist and staff to review all proposals for projects to be completed in the park. Reclamation funds these positions to offset the park's administrative burden from GCDAMP activities. Reclamation will also continue to fund Grand Canyon National Park to conduct management actions that fulfill Endangered Species Act compliance for the LTEMP EIS.

National Park Service

LTEMP EIS

Following the LTEMP Record of Decision in 2016, LTEMP implementation was initiated in phases beginning on January 1, 2017. Budgeting, coordination, and experimental planning are underway.

NPS staff will continue to work on implementation of the National Historic Preservation Act section 106 compliance program, working with all interested parties on updating plans and developing field review strategies.

Archaeological/Cultural Resources

Grand Canyon National Park: In 2017, work will include participating in tribal monitoring field sessions along the river. One assessment river trip with GCMRC and USGS scientists will be

conducted to reassess drainages documented in 2000 to determine if dam operations have resulted in any landscape changes. NPS Archaeological Sites Management Information System (ASMIS) condition assessments will be conducted at 30-40 sites. The NPS is proposing to conduct ASMIS assessments at upwards of 100 additional sites as part of the GRCA Colorado River Management Plan monitoring in September 2017.

Glen Canyon National Recreation Area: In 2017, work will include progress in the development and evaluation of monitoring protocols for terrestrial and non-native fish resources to evaluate potential effects resulting from dam operations. Glen Canyon will continue to support the GCMRC's monitoring of dam related topographic changes at select cultural sites and classification of all sites for aeolian transport, drainage type, and erosion ranking. Staff will continue opportunistic monitoring around planned HFEs.

Tribal Consultation

In 2017, the NPS anticipates continued participation in consultation meetings with the various tribes who are directly involved in the GCDAMP and other Colorado River related programs. The Grand Canyon National Park and Glen Canyon National Recreation Area will continue discussions with tribes to incorporate tribal perspectives into implementation of the NPS's Comprehensive Fisheries Management Plan and a potential follow-up plan specific to potentially harmful non-native fish species. Tribal advisors will continue to be consulted on specific monitoring and mitigation protocols relative to the Colorado River Management Plan implementation. The Grand Canyon National Park anticipates working with the Pueblo of Zuni and external partners on projects to better protect important resources along the Colorado River. Specific efforts will be made with the Pueblo of Zuni relative to creating a "buffer" zone near the confluence of Bright Angel Creek and Ribbon Falls Creek. This zone will incorporate specific removal techniques including use of nets and elimination of electrofishing in that area. Additional crew training will occur with representatives from Zuni to discuss specific concerns. Park staff anticipates working with representatives from Traditionally Associated Tribes to gather information on the salt mines located along the river downstream of the Little Colorado River confluence. The NPS will continue to work with Reclamation to consult with interested tribes involved in the LTEMP.

In continuance of the 2016 consultations with the Hopi Tribe, Hualapai Tribe, Kaibab Paiute, Navajo Nation, and the Pueblo of Zuni, Glen Canyon National Recreation Area anticipates letting sole source contracts with each of those tribes to produce ethnographies that will facilitate contextualization of the archeological sites in the Glen Canyon Reach. As stated above, the purpose of that work will be to help inform mitigation of sites adversely affected by dam operations and to provide the federal land manager with an understanding of tribal histories in that stretch of the river to facilitate informed and culturally sensitive land management.

Further, Glen Canyon National Recreation Area, in partnership with Grand Canyon National Park, will conduct a debriefing with the same tribes to inform them of the outcome of the effort to control the green sunfish invasion and to seek their input on next short-term and long-term plans to minimize further invasions.

Humpback Chub Translocation and Fisheries Management

In Grand Canyon, implementation of the Comprehensive Fisheries Management Plan will continue into 2017. These efforts will include an expert panel evaluation of the results of the status and habitat use monitoring of endangered razorback sucker, monitoring of translocated endangered humpback chub in and around Havasu and Shinumo creeks, and the removal of non-native fishes threatening endangered and native fish in Bright Angel Creek and the Bright Angel Creek inflow area of the Colorado River (year five). An assessment of the first five years of the Bright Angel Creek project will be completed and future efforts may be adapted to achieve objectives. The recovery of Shinumo Creek will continue to be monitored for the suitability of humpback chub translocation in the future. Collaboration with Reclamation, FWS, GCMRC, and others will continue on all fisheries projects leading to well integrated projects.

In Glen Canyon, monitoring for invasive species, especially invasive fish, will continue with partners in 2017. At the request of the GCDAMP, along with partner agencies, the NPS will plan and coordinate a workshop to assess the risks the expanding brown trout population poses to native fish and the rainbow trout fishery, and to develop solutions for the brown trout increase. Quagga mussel colonization monitoring will continue.

Green sunfish populations, especially in the backwater area, will be monitored carefully with partners in 2017 while long-term solutions are sought and investigated. A series of metal fish screens and buoyed nets will be installed in the spring of 2017 to prevent sunfish from accessing, and thereby reproducing in the Upper Slough backwater area. Monthly monitoring will also occur. These solutions are sought as an alternative to regular chemical treatments, which only treat the symptom and are offensive to tribes and others.

Wildlife Surveys and Monitoring

Grand Canyon National Park: In 2017, the Grand Canyon National Park will continue work on bighorn sheep issues, monitor California condors and Mexican spotted owls, and expand work with the AGFD collecting baseline data on bats. We also propose to begin regular ESA avifauna surveys for the southwestern willow flycatcher and clapper rails as identified in the LTEMP ROD.

Glen Canyon National Recreation Area: In 2017, Glen Canyon National Recreation Area plans to continue programs related to aquatic/riparian invertebrates, bats, other terrestrial vertebrate populations, and northern leopard frog and ambersnail habitat enhancements.

Vegetation Management/Exotic Species Removal

In 2017, NPS staff will continue site maintenance and monitoring at Granite Camp. Two additional riparian restoration sites will be initiated, one at Cardenas Camp and another in the lower gorge at mile 274L. Initial site preparation including creating a detailed species list and planting plans, plant material collection, monitoring transect establishment, ground water monitoring well installation, and site mapping will be conducted at both sites in 2017. NPS staff also plan to implement the Colorado River Monitoring Program campsite monitoring and

mitigation river trip in 2017. Work on this trip will include campsite monitoring using the CRMP rapid assessment tool, tamarisk beetle monitoring, exotic species removal, and vegetation pruning.

In 2017, the NPS (both Grand Canyon National Park and Glen Canyon National Recreation Area), partners, and volunteers will continue invasive plant management, native plant restoration, and vegetation monitoring activities along the Colorado and Paria rivers below Glen Canyon Dam.

Research Review and Permitting

The NPS (both Grand Canyon National Park and Glen Canyon National Recreation Area) anticipates continuation of research and permitting activities in 2017 at similar levels as 2016. For each of the research projects in support of the GCPA, peer review of the proposals, evaluation of need for NEPA compliance, and completion of minimum requirement analysis will be completed. Updating of annual investigator reports will be done for each research permit and coordination with Reclamation will continue.

Resource Monitoring and Mitigation

In 2017, fieldwork will resume with the resumption of NPS and contracted river operations. A springtime monitoring trip is planned, with required stops at 48 core monitoring campsites and as many additional campsites as time allows. A fall mitigation trip is planned to address issues identified from monitoring data and information gained from other sources. In addition, a cooperative monitoring and mitigation program is in development which will use monitoring done by the USGS (Grand Canyon Monitoring and Research Center) to inform NPS mitigation work where flow-related changes in vegetation and geomorphology degrade campsite conditions. Discussions were also begun with the Northern Arizona University Environmental Genetics and Genomics lab to determine the feasibility of combining future mitigation projects with field tests to address questions related to conservation genetics and community genetics.

Greater Grand Canyon Landscape Assessment

Grand Canyon National Park staff and partners completed the Greater Grand Canyon Landscape Assessment in 2016 and will work with partners on accessing the information contained in the report. An interdisciplinary team of NPS experts, agency partners, scientists, and other groups and individuals completed the assessment and identification of resource conditions and trends and prioritization of conservation needs facilitating ecosystem-based stewardship. The NPS will continue to work on the riparian rehabilitation project at Granite Camp, removing non-native tamarisk and revegetation with native plants, as well as identify new riparian rehabilitation sites along the Colorado River corridor in western Grand Canyon.

U.S. Fish and Wildlife Service

In 2017, the FWS will conduct four monitoring trips on the Little Colorado River to generate population estimates for humpback chub and other native fishes, and to also monitor the success

of upstream translocations. The FWS will continue to work cooperatively with the NPS and Havasupai Tribe on monitoring Havasu Creek and collecting larval fish for additional translocations of humpback chub in the summer of 2018. Fish will be collected for translocations from the Little Colorado River and held at the Southwest Native Aquatic Resources and Recovery Center until they are large enough to be marked with a small tag. The FWS will continue to take the lead on developing a monitoring protocol for effectively sampling the mainstem aggregations of humpback chub and will conduct one sampling trip in 2017.

U.S. Geological Survey

The major focus of the GCMRC's activities in 2017 is to continue to serve in its role as the primary science provider to the GCDAMP by conducting the field and laboratory studies described in the fiscal years 2015-2017 Budget and Work Plan. Additionally, the GCMRC plans to continue providing real-time scientific data needed to implement the LTEMP. Specifically, the GCMRC will maintain its internet-based real-time reporting of stream flow and sediment storage and transport in Marble and Grand canyons as well as continue providing estimates of the mass of sand, silt, and clay supplied to the Colorado River by the Paria and Little Colorado rivers and the mass of fine sediment stored in various parts of Marble and Grand canyons. The GCMRC will continue monitoring and reporting on resource conditions following HFEs and working with Reclamation in refining HFE planning protocols. Native and non-native fish population data will continue to be collected and reported on in support of management decisions regarding non-native fish control. The GCMRC will also work with the Department of the Interior, Reclamation, and other Interior partners, cooperators, and stakeholders to develop a Budget and Work Plan for research and monitoring to be conducted in fiscal years 2018-2020. The emphasis of this Work Plan will be to provide information in support of implementation of the LTEMP Record of Decision.