BUREAU OF RECLAMATION

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

Water Years 2020 (Observed) to 2021 (Projected)

Colorado River Storage Project, Glen Canyon Unit
Interior Region 7 – Upper Colorado Basin

U.S. Department of Interior May 2021

Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Acronyms and Abbreviations

AGFD	Arizona Game and Fish Department
AMP	Adaptive Management Program
AMWG	Adaptive Management Work Group
BIA	Bureau of Indian Affairs
BO	Biological Opinion
CRSP	Colorado River Storage Project
EA	Environmental Assessment
FEIS	Final Environmental Impact Statement
ESA	Endangered Species Act
FONSI	Finding of No Significant Impact
FWS	U.S. Fish and Wildlife Service
GCD	Glen Canyon Dam
GCMRC	Grand Canyon Monitoring and Research Center
GCPA	Grand Canyon Protection Act
GLCA	Glen Canyon National Recreational Area
GRCA	Grand Canyon National Park
HFE	High Flow Experiment
Interior	Department of the Interior
LiDAR	Light Detection and Ranging
LTEMP	Long-Term Experimental and Management Plan
MAF	million acre-feet
MOA	memorandum of agreement
NPS	National Park Service
Reclamation	Bureau of Reclamation
ROD	Record of Decision
Secretary	Secretary of the Department of the Interior
TWG	Technical Work Group
USGS	United States Geological Survey
WAPA	Western Area Power Administration

Contents

Introduction

Statutory Reporting Requirements

This report by the Department of the Interior (Interior) is submitted pursuant to the Grand Canyon Protection Act (GCPA) of 1992. Pub. L. No. 102-575, 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.

GCPA § 1804(c)(2). This report provides an update from the last report for years 2019 (observed) and 2020 (projected). The current report covers dam operations and other activities undertaken pursuant to the GCPA for 2020 (observed) and 2021 (projected). In this report, the timeframe for water and fiscal years is identical, October 1 through September 30.[1]

Statutory Guidance Regarding Glen Canyon Dam Operations

Glen Canyon Dam was authorized for construction by the Colorado River Storage Project Act of 1956. See 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 Department 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.

See GCPA § 1802(a). 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

[1] This report was finalized during water year 2021. Notwithstanding the timing of finalization of this report, the format follows the direction of GCPA Section 1804(c)(2) and describes the 2021 operations as "projected."

> 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.

GCPA § 1802(b). In 1997, the Secretary established the Glen Canyon Dam Adaptive Management Program (AMP) to carry out the requirements of the GCPA. As part of the AMP, 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.

Roles of Department of the Interior Bureaus

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 Tribe, Hualapai Tribe, Pueblo of Zuni, Southern Paiute Consortium, and the Navajo Nation) to participate in the AMP and two Joint 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 together 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 AMP, 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 (GRCA) and Glen Canyon National Recreation Area (GLCA) 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. See 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.

United States Fish and Wildlife Service

FWS provides Endangered Species Act (ESA) conservation and associated consultation and recovery leadership with various stakeholders primarily to benefit five listed species located in the Colorado River: the humpback chub (*Gila cypha*), razorback sucker (*Xyrauchen texanus*), southwestern willow flycatcher (*Empidonax trailii extimus*), Yuma Ridgway's rail (*Rallus obsoletus yumanensis*), and Kanab ambersnail (*Oxyloma haydeni kanabensi*), as well as other relevant resource issues.

United States 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 GRCA and GLCA. GCMRC provides independent, policy-neutral scientific information to the AMP on (1) 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 (2) the flow and non-flow measures to mitigate adverse effects. The GCMRC's activities are focused on (1) monitoring the status and trends in natural, cultural, and recreational resources that are affected by dam operations, and (2) 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.

2020 Dam Operations (Observed) and Adaptive Management

Bureau of Indian Affairs

In water year 2020, the BIA met with the Interior Tribal Liaison via monthly telephone calls to discuss tribal concerns and participated in meetings regarding cultural and natural resources issues and concerns. One of the principal concerns for Tribes in 2020 was difficulty in commenting or participating in routine AMP activities and the proposed down-listing of the humpback chub due to widespread tribal government shutdowns attributed to COVID-19. The BIA continued to provide funding to tribes for their participation in the AMP. Other activities included continued coordination of efforts for tribal participation in the AMP, coordinating with other agencies on whether or not to conduct a fall high-flow experiment (HFE) and a spring Macroinvertebrate Production Flows ("Bug Flows") experiment, and continuing to work with the Interior Tribal Liaison to maximize tribal consultation and involvement. BIA also continued to work closely with Reclamation on whether to fill the vacant Joint Tribal Liaison position.

Bureau of Reclamation

Water Operations

The August 2019 24-Month Study projected the January 1, 2020, elevations of Lake Powell and Lake Mead to determine the water year 2020 operating tier for Lake Powell. Using the most probable inflow scenario, and with an 8.23 million acre-feet (MAF) annual release pattern for Lake Powell, the January 1, 2020, reservoir elevations of Lake Powell and Lake Mead were projected to be 3,618.56 feet and 1,089.40 feet, respectively. Given these projections, the annual release volume from Lake Powell during water year 2020 was consistent with the Upper Elevation Balancing Tier (section 6.B of the 2007 Interim Guidelines) and under section 6.B.1, the annual release would be 8.23 MAF.

The Upper Elevation Balancing Tier provides for the possibility of adjustments to the operation of Lake Powell based on the projected end of water year condition of Lake Powell and Lake Mead from the April 2020 24-Month Study. The April 2020 24-Month Study was run with an 8.23 MAF annual release volume to project the September 30, 2020, elevations of Lake Powell and Lake Mead. Under the most probable inflow scenario, and with an 8.23 MAF annual release volume, the projected end of water year elevation at Lake Powell was 3,614.87 feet and Lake Mead was 1,084.17 feet. Since the projected end of water year elevation at Lake Powell was below the 2020 Equalization elevation of 3,657 feet and above 3,575 feet, and the projected Lake Mead elevation was above 1,075 feet, section 6.B.1 of the 2007 Interim Guidelines governed for the remainder of water year 2020. Under section 6.B.1, the Secretary shall release 8.23 MAF from Lake Powell. The annual release volume during water year 2020 was 8.23 MAF.

Under the Long-Term Experimental and Management Plan (LTEMP), the third Bug Flows experiment was designed and conducted during May-August 2020. Information on the background and benefits of the experiment can be found on page 15. Bug Flows are intended to increase the diversity and abundance of aquatic insects by improving egg laying conditions for these aquatic insects. Releases were held steady during weekends to attempt to increase production of aquatic insects.

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 and, beginning in WY 2020, in the spring, when conditions warrant. The periods from July 1 to November 30 and December 1 to June 30 mark the "sediment accumulation periods" for fall and spring HFEs, respectively. Based on sediment data from these periods, it was determined that there was insufficient sediment to support implementing an HFE at Glen Canyon Dam in WY 2020. The monthly release volumes for water year 2020 are displayed in Table 1. The end of water year 2020 elevation for Lake Powell was 3,595.98 feet.

Table 1. Lake Powell Monthly Release Volumes for Water Year 2020

Month	Monthly Release Volumes (MAF)	Monthly Release Volumes as listed in LTEMP ROD Table 1
October 2019	0.625	0.643
November 2019	0.626	0.642
December 2019	0.750	0.715
January 2020	0.760	0.763
February 2020	0.675	0.675
March 2020	0.700	0.713
April 2020	0.630	0.635
May 2020	0.629	0.632
June 2020	0.650	0.663
July 2020	0.750	0.749
August 2020	0.833	0.800
September 2020	0.602	0.600
Total Releases	8.230	8.230

The ten-year total flow of the Colorado River at Lees Ferry[2] for water years 2011 through 2020 was 92.51 MAF (USGS stream flows, Lees Ferry plus Paria River gage data). This total is computed as the sum of the flow of the Colorado River at Lees Ferry, Arizona, and the Paria River at Lees Ferry, Arizona, surface water discharge stations which are operated and maintained by the USGS.

Environmental Program Funding and AMP Budget

Several programs necessary to achieve environmental and ESA compliance for the continued operation of the Colorado River Storage Project (CRSP) have historically been funded with hydropower revenues generated by CRSP facilities. However, in fiscal year 2019, the Office of Management and Budget directed Western Area Power Administration to transfer $21.4 million to the U.S. Treasury for repayment of original project construction costs and replacements, rather than following the historic practice explicitly authorized in Section 3 of PL 106-392, whereby CRSP power revenues were used for partially funding the environmental programs. Impacted programs included the Glen Canyon Dam Adaptive Management Program, Upper Colorado River Endangered Fish Recovery Program, San Juan River Basin Recovery Implementation Program, Consumptive Use Studies, and Quality of Water Program. As a result of stakeholder outreach, then-Senator Hatch (Utah) sponsored an amendment to the Energy & Water Development Appropriations bill that addressed the issue for FY 2019 (P.L. 115-244, section 505); the programs were fully funded via additional appropriations rather than hydropower revenues. However, the resolution did not address future years.

The FY 2020 Energy and Water Development appropriations bill (P.L. 116-94, Division C, Title III, Section 307) directed the transfer of $21.4 million in power revenues to Reclamation to carry out environmental stewardship and endangered species recovery efforts. Nevertheless, the Western Area Power Administration has determined that support from hydropower revenues cannot be sustained at current levels. Significant reductions in hydropower funding are anticipated beginning in FY 2023. It is unclear whether the CRSP environmental programs will continue to be funded by power revenues or by Water and Related Resources appropriations in FY 2021 and beyond.

In FY 2020, the Adaptive Management Work Group, recommended a budget and work plan for fiscal years 2021-2023 to support AMP activities. The 2021-2023 Triennial Budget and Work Plan was approved for implementation by the Secretary of the Interior on December 22, 2020.

Long-Term Experimental and Management Plan (LTEMP) Final Environmental Impact Statement (FEIS) and Record of Decision (ROD)

Interior, through Reclamation and the NPS, jointly published the final LTEMP FEIS on October 7, 2016, and a Record of Decision (ROD) was signed on 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 "Law of the River," GCPA, and ESA. The FEIS had 15 cooperating agencies, including six tribes. A primary function of the implementation of the LTEMP

[2] A point in the mainstem of the Colorado River one mile below the mouth of the Paria River.

FEIS and ROD is to continue the successful experiments completed under the AMP. To date, one fall high flow experiment (November 2018) and three Bug Flows experiments (2018, 2019, and 2020) have been implemented under the LTEMP.

Conservation Measures for Humpback Chub and Razorback Sucker

From fiscal years 2009 through 2020, Reclamation has funded the NPS to remove non-native trout and intermittently translocate humpback chub into two tributaries: Shinumo Creek and Havasu Creek. In 2018, scientists determined that a five-year adaptive management action to remove non-native trout from Bright Angel Creek was adequately successful, and thus, humpback chub were translocated there as well. In 2020, 415 humpback chub were again translocated to Bright Angel Creek. These actions were implemented to fulfill: (1) conservation measures from the 2016 LTEMP Biological Opinion (BO), and (2) recovery goals as defined by FWS for establishing additional reproducing populations of humpback chub. These efforts are meant to provide population redundancy 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.

Translocations to Shinumo Creek occurred from 2009 to 2013 but were suspended following a lightning-caused fire that burned 6,100 acres in the drainage and led to a series of ash-laden floods. These events flushed and scoured the aquatic fauna from the creek and greatly altered habitat conditions making the lower portion temporarily unsuitable for fish. Monitoring of Shinumo Creek has continued since the flood to determine the recovery and suitability of the habitat. Surveys indicate that the habitat has improved, and humpback chub translocations may resume in the future.

Juvenile humpback chub were translocated to Havasu Creek annually from 2011-2016, and evidence of reproduction has been observed since 2012. Typically, two monitoring trips per year are conducted to estimate abundance, annual survival, reproductive rates, and growth of the translocated humpback chub population. However, in 2020 only a single monitoring trip was conducted due to COVID-19 restrictions with the objective of better understanding the population dynamics. Data indicates that the population has been maintained through ongoing reproduction and the objectives of the translocations are being met. Though translocations of humpback chub to Havasu Creek were not planned for 2020, preliminary survival estimates suggest that humpback chub translocated to Havasu Creek are contributing to the overall population in Grand Canyon.

The number of adult humpback chub has remained above the threshold identified in the LTEMP BO that would trigger additional management action. However, preliminary estimates of sub-adult humpback chub in the mainstem from river mile 63.45-65.2 (referred to as Juvenile Chub Monitoring reach) are below the trigger level and, if confirmed, will require consideration of additional conservation actions in 2021.

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 the termination of Grand Canyon at Pearce Ferry. 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.

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 continues to fund additional research for larval fish surveys in the lower reaches of Grand Canyon. Since 2014, 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 spawned in the Grand Canyon during February and March of each year. However, the number of larval razorback suckers collected has dropped significantly since the first collections of larvae in 2014 which coincides with the changing of Pearce Ferry Rapid to a barrier. No larval razorback suckers were detected in 2020 upstream of Pearce Ferry Rapid, though this may have been in large part due to the suspension of monitoring trips in April and May due to COVID-19. April and May are the months when razorback sucker larvae are typically identified.

Due to decreasing water levels in Lake Mead, habitat conditions have changed at Pearce Ferry Rapid making it a barrier to navigation and possibly to upstream fish passage. Reclamation is supporting a project with AGFD and Biowest to examine the fish composition above and below the rapid to determine the extent it is serving as a barrier. Initial results show a much higher composition of native fish above the rapid and non-natives below the rapid, suggesting that the rapid prevents fish movements upstream. This work is scheduled to continue into 2022.

In 2018, the FWS completed rigorous species status assessments that recommended downlisting the razorback sucker and the humpback chub from endangered to threatened. Both species are found in multiple population centers throughout the Upper and Lower Colorado River basins. Downlisting a species requires formal notification via the Federal Register and a public review process. A proposed rule for humpback chub was published in the Federal Register on January 22, 2020; a final rule has not yet been issued. A proposed rule for razorback sucker is also pending.

Tribal Activities

Reclamation continued to fund five American Indian Tribes (Hopi, Hualapai, Pueblo of Zuni, Kaibab Paiute, and the Navajo Nation) to participate in and provide their perspectives to the AMP. The tribes identify and monitor traditional cultural properties and provide annual reports detailing their activities, findings, and monitoring of data. Interactions between the AMP and the American Indian Tribes have been facilitated in recent years by two Joint Tribal Liaisons. However, one of the liaisons resigned near the end of fiscal year 2019. In 2020, Reclamation worked with Interior to evaluate the success of the liaison program and explore opportunities for improvement. After soliciting feedback from Interior bureaus and AMP stakeholders, it was determined that, beginning in 2021, the Tribal Liaison Program would be restructured to consist of one full time liaison rather than two part-time joint liaisons.

In addition to consultations per the LTEMP Programmatic Agreement, Reclamation continues to conduct government-to-government consultations with American Indian Tribes on operations of Glen Canyon Dam and on activities of the AMP in support of its responsibilities 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 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, in collaboration with other stakeholders, completed a new Programmatic Agreement (May 9, 2017) for the operation of Glen Canyon Dam pursuant to the GCPA that is consistent with the LTEMP. Reclamation also completed a Historic Preservation Plan (November 5, 2018) as required by the LTEMP Programmatic Agreement in fiscal year 2018. Reclamation has plans to begin consultation to replace the two existing MOAs.

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 AMP activities. Permitting activities completed in 2020 are described by the NPS in the following section of this report.

National Park Service

Three units of the NPS (Glen Canyon National Recreation Area [GCLA], Grand Canyon National Park [GCRA], and Lake Mead National Recreation Area) provide support for various AMP operations and activities. In 2020, staff from the NPS Regional Office Serving Interior Regions 6, 7 & 8 along with staff from both GLCA and GCRA continued to work with Reclamation on implementation of the LTEMP ROD, including processing interagency agreements and addressing environmental commitments for cultural resources, endangered species, avifauna, and vegetation management.

LTEMP FEIS and ROD

Since completion of the LTEMP FEIS and ROD in late 2016, the NPS, working with Reclamation and other Interior partners, has continued to work on implementation of the action and specific resource management recommendations. NPS conducts fisheries management, archaeological monitoring and mitigation, vegetation monitoring and mitigation, and avifauna monitoring through interagency agreements with Reclamation to support 2020 priorities listed in the GCDAMP Triennial Budget and Work Plan.

Expanded Non-Native Aquatic Species Management Plan

In 2019, NPS completed an EA related to non-native fish and other aquatic species below Glen Canyon Dam entitled the Expanded Non-Native Aquatic Species Management Plan. The NPS held public scoping meetings, solicited input from cooperators and AMP stakeholders on the development of alternatives, consulted with tribes, and then released a public EA in September 2019. The work with partners provided NPS with the opportunity to develop an adaptive, tiered

approach to non-native aquatic species management that allows for the use of many tools but addresses concerns by using less management intensive approaches first. The selected alternative allows for a proactive approach to non-native removal that allows anglers and tribal youth and elders to get involved with removing non-native fish through an incentivized harvest program.

Archaeological/Cultural Resources

Grand Canyon National Park: In 2020, GRCA conducted an archaeological site monitoring river trip from March 16 – April 1. The primary objective of the river trip was to conduct assessments at archaeological sites documenting current conditions, impacts, and treatment recommendations. In total, 39 archaeological sites were assessed for disturbances and current condition. Staff also visited location where previous LTEMP-associated vegetation management occurred. A majority (33 of 39) were classified as "good" condition, with the remaining six sites categorized as "fair" condition. Water erosion continues to be the most documented impact to LTEMP archaeological sites. Natural disturbances, in contrast to visitor-caused disturbances, remain more frequently documented.

Glen Canyon National Recreation Area: Staff monitored 5 river corridor sites in the Glen Canyon Reach, monitored the submerged Spencer Steamboat, and finished compiling a synthesis of the Ethnographic Reports from 5 participating tribes. GLCA continued to add to and improve park photogrammetry capabilities as part of the monitoring plan.

Tribal Consultation

In 2020, the NPS continued to participate in consultation meetings with the various tribes who are directly involved in the AMP and other Colorado River related programs. GRCA and GLCA continued discussions with tribes and incorporated tribal perspectives into implementation of the NPS Comprehensive Fisheries Management Plan and the LTEMP, and the initiation of the Expanded Non-Native Aquatic Species Management Plan.

GLCA and GRCA finalized the Programmatic Agreement for addressing Section 106 concerns in the Fall of 2019 for the Expanded Non-Native Aquatic Species Management Plan. This Programmatic Agreement incorporated the MOA from the Comprehensive Fish Management Plan at the request of the tribes so that one agreement was in place for all NPS fisheries work in Glen, Marble, and Grand Canyons. Notifications occurred primarily through updates at Technical Work Group Meetings regarding a fourth green sunfish treatment in the Upper Slough at GLCA. In May 2019, 691 green sunfish were removed and in September 2019, 11,299 were removed through the ongoing pump down removal program. All fish were collected, frozen, and provided for beneficial use to the tribal aviaries.

GLCA staff discussed options for an ethnographic study with the Pueblo of Zuni representatives at two AMWG meetings in late 2019 and early 2020. The purpose of the study is to document Pueblo of Zuni tribal concerns with potential impacts to the Traditional Cultural Properties of Glen, Marble, and Grand Canyons. The hope was to include this study in the 2021-2023 Triennial Budget and Work Plan. However, the pandemic made it very difficult to complete the planning for this project so it has not yet been drafted.

Humpback Chub Translocation and Fisheries Management

In 2020, NPS continued translocation and monitoring of endangered humpback chub. Translocation of humpback chub to Bright Angel Creek followed suppression of invasive brown and rainbow trout. Monitoring was conducted in 2020 to better understand the population dynamics prior to additional translocations. Preliminary survival estimates that are comparable to the source population suggest that humpback chub that were translocated to Havasu Creek in previous years are contributing to the population in Grand Canyon. Activities related to humpback chub were limited in spring and summer 2020 due to the COVID-19 pandemic. However, trips to monitor humpback chub translocation and population dynamics were conducted to Havasu and Shinumo Creeks. Shinumo Creek continues to be monitored as a potential location for future translocations since the habitat was destroyed by a fire and subsequent flood a few years ago.

Invasive species monitoring continued in 2020 in Glen Canyon with an emphasis on invasive fish and quagga mussels. Quagga mussel colonization in the river within Glen Canyon is increasing but remains primarily below the 8,000 cfs flow level on the riverbanks and boulders. The non-native brown trout population in Glen Canyon continued to increase. Due to numerous public comments from angling groups and guides, AGFD, and the tribes expressing concerns about large scale and extensive mechanical harvest efforts to remove brown trout from the Glen Canyon reach, NPS researched and implemented an Incentivized Harvest Program. The program rewards anglers for helping to control brown trout numbers thru angling in the Glen Canyon Reach and was initiated on November 11, 2020. NPS will implement various additional incentives and programs during 2021 to attempt to increase participation. GLCA pumped water from the backwater slough at river mile -12 in October 2019 and removed > 3,000 nonnative green sunfish. A reproducing population of green sunfish was also detected in Kanab Creek, which is well below the dam. NPS biologists are evaluating options to remove the population.

In 2020, angler catch rate of rainbow trout within Glen Canyon declined for both boat anglers and walk-in anglers. Prior to 2020, a slow increase in boat angler catch of rainbow trout was observed from 2016-2019. Catch for walk-in anglers that accessed approximately 2.5 miles of the Colorado River near the boat ramp and Paria Riffle was higher in 2019 which may have been due to stocking by AGFD of sterile triploid rainbow trout during this time.

Wildlife Surveys and Monitoring

Grand Canyon National Park: In 2020, through collaborative efforts between GRCA and AGFD, baseline data continued to be collected on bat diversity, seasonal activity patterns, cave hibernacula, and surveillance for white-nose syndrome (which has not been detected in Grand Canyon) was conducted. However, during 2020 no bat capture and handling was allowed after March due to COVID-19 transmission concerns, only acoustic data on bats was collected.

Glen Canyon National Recreation Area: In 2020, GLCA staff and partners conducted surveys for great blue heron, waterfowl, and raptor along the 16-mile reach below Glen Canyon Dam. Monitoring of aquatic/riparian invertebrates and terrestrial vertebrate populations utilizing the open water habitat at Leopard Frog Marsh also continued.

Bat monitoring was conducted both above and below the dam to identify the bat species using the Colorado River corridor and as a surveillance effort for white-nose syndrome.

Experimental Vegetation Treatment and Mitigation

Grand Canyon National Park: In September 2020, GRCA and partners continued implementation of non-flow experimental vegetation treatment to mitigate Glen Canyon Dam operation impacts on riparian vegetation along the Colorado River. Vegetation treatments in support of the LTEMP FEIS included: control of non-native plants, collection of seed and cuttings to develop native plant materials for replanting, control/removal of vegetation encroaching on campsites, and vegetation management for cultural site protection. GRCA monitored the success of vegetation removals to increase campable areas, and continued site maintenance and monitoring of previous native plant restoration efforts conducted at Granite and Cardenas camps.

Glen Canyon National Recreation Area: In 2020, the NPS, partners, and volunteers continued 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 GLCA were:

- Continued native seed collection and plant propagation planning efforts for riparian plant restoration in important habitat areas in the Glen Canyon Reach.
- Tribal youth and other crews began to remove tamarisk at river mile -12 in preparation for riparian restoration plantings in 2021 and 2022. Monitoring occurred at river mile -7, but COVID-19 restrictions prevented planting of native plants from occurring.

Research Review and Permitting

GRCA's Research Office continues to have one of the largest research and collection permitting programs within the NPS. There are more than 150 researchers that are listed as either principal or co-principal investigators presiding over current studies. In 2020, GRCA's Research Office received 9 Scientific Research and Collection Permit applications from GCMRC and issued 8 permits. One permit was not issued due to access restrictions related to COVID-19. Additionally, 13 administrative river launch permits were issued, totaling 2,535 river user days for the 2020 calendar year for GCMRC to fulfill the mission of these research projects and obligations under the AMP. Each project requiring administrative river access must go through requisite compliance prior to NPS approval. The permits correlate with the projects outlined in the FY2018-2020 GCDAMP Triennial Budget and Work Plan. Additionally, in response to the COVID-19 pandemic, all five GCDAMP partner tribes (Hopi Tribe, Hualapai Tribe, Navajo Nation, Pueblo of Zuni, and Southern Paiute Consortium) cancelled their annual river trips. Overall, there was a net decrease of 3,480 user days (down from 2019's efforts) for a total of 2,939 user days spent on the river conducting AMP-related research in 2020.

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

Additionally, in 2020, several GRCA Science and Resource Management staff members participated in virtual GCDAMP meetings, river trips, the GCMRC Annual Reporting Meeting, and workshops.

Due to concerns for visitor and employee safety due to the COVID-19 pandemic, the acting superintendent made the decision to close the park on April 1, 2020. This decision affected all park operations, including administrative river access. In May 2020, the new superintendent worked with GRCA staff to develop a phased reopening of the park, which included administrative river and backcountry access. To ensure visitor and employee safety at Lees Ferry and at campsites along the river corridor, a limit of two administrative launches per week was set by park management, beginning on June 15, 2020. Prior to the pandemic, the maximum number of allowable administrative launches was two per day. This substantial decrease in access created new challenges for completing work obligations on the river corridor for both park employees and partner agencies.

GLCA continued administration of 5 research permits associated with the AMP between Glen Canyon Dam and the Paria River. The NPS anticipates that 2021 research and permitting activities will be at levels similar to 2020.

United States Fish and Wildlife Service

FWS continued to cooperate with the NPS regarding the Comprehensive Fisheries Management Plan, Expanded Non-native Aquatic Species Management Plan, and other plans that guide NPS activities for native and non-native fish in GCRA and GLCA. FWS also cooperates with AGFD regarding recreational angling in the same area, and with USGS and Reclamation on other plans and activities within Grand Canyon reach of the Colorado River. FWS will continue to participate in the AMWG, TWG, and various ad hoc groups and other related assignments.

In 2020, FWS conducted two fall monitoring trips on the Little Colorado River to generate population estimates for humpback chub and to monitor trends of other native fishes. The spring 2020 population estimates were canceled due to access restrictions related to the COVID-19 pandemic. Since 2006, the Little Colorado River population of humpback chub has significantly increased in size. Adult population estimates in fall of 2019 were similar to fall 2018 and continue a reversal of declines seen in 2014 and 2015. FWS did not conduct a trip on the Little Colorado River to monitor the success of upstream translocations of humpback chub within the Little Colorado River in 2020 due to COVID-19 access restrictions. In 2020, FWS translocated 306 humpback chub to the Little Colorado River upstream of Chute Falls. Translocation efforts have been successful with humpback chub experiencing high growth rates and high survival in this upper portion of the river.

In addition, FWS worked collaboratively with GRCA to translocate humpback chub into Bright Angel Creek. The fish were removed from the Little Colorado River as larvae and grown to adult size at the Southwest Native Aquatic Research and Recovery Center. In 2020, 415 humpback chub were translocated to Bright Angel Creek.

FWS has continued to lead work in collaboration with the GCMRC and GRCA in the collection and transport of young humpback chub for translocation into tributaries within Grand Canyon. Due to COVID-19 related access restrictions, no larval humpback chub were collected in 2020 for grow-out and translocations.

In collaboration with the GCMRC and NPS, FWS continues to develop and refine a monitoring program to effectively sample mainstem aggregations of humpback chub in the Colorado River in Grand Canyon. In 2020, FWS and GCMRC conducted two sampling trips to assess population size of humpback chub in and outside these aggregations. Since 2014, humpback chub populations in western Grand Canyon have increased in size. Large numbers of juvenile and adult humpback chub provide evidence of an expanding population comprised largely of in-situ spawning and recruitment in western Grand Canyon.

United States Geological Survey

In 2020, the GCMRC continued to serve in its role as the primary science provider to the AMP. The GCMRC's primary activities during 2020 were: (1) collaborating with Reclamation and WAPA to develop the experimental Bug Flows hydrograph and then monitoring the ecosystem response to this flow experiment during its implementation; (2) 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; (3) implementing the third year of a three-year Budget and Work Plan encompassing fiscal years 2018-2020; (4) completing a three-year Budget and Work Plan for fiscal years 2021-2023 that was signed by the Secretary of the Interior; (5) maintaining a stream flow and sediment transport measurement and internet-based real-time reporting program that is the foundation for planning and implementing HFEs; (6) analysis of these data to inform dam and river management activities on the possibility of an HFE; (7) collection and reporting of data describing resource conditions following HFEs; (8) collection and reporting of native and non-native fish population data in support of management decisions regarding recovery of humpback chub, maintaining the Lees Ferry sport fishery, and non-native fish control; (9) monitoring key cultural resources and geomorphic processes that may affect them; and (10) providing science support for experimental riparian vegetation management. Additionally, the GCMRC conducted numerous field and laboratory studies, published the results of numerous scientific investigations, provided logistical support for river trips and other field activities, and provided scientific support for implementation of the LTEMP FEIS and ROD.

Bug Flows Experiment Implementation and Monitoring

In 2020, GCMRC monitored ecosystem response to the third consecutive year of experimental Bug Flow releases from Glen Canyon Dam. Aquatic insects are an important prey item that fuels growth of fish, birds, bats, and countless other wildlife living in and along the Colorado River. However, prior studies by GCMRC demonstrated that the low diversity and abundance of aquatic insects in the Colorado River was limiting the growth and condition of native fish and non-native sport fish populations. A 2016 paper by GCMRC scientists demonstrated that the hourly variation in flows arising from hydropower production was limiting aquatic insect abundance and diversity by causing desiccation and mortality of insect eggs laid along unstable river shorelines. Bug Flows are intended

to increase the diversity and abundance of aquatic insects by improving egg laying conditions. These experimental releases involve low, steady flows on weekends from May through August to enhance egg laying conditions for aquatic insects while maintaining fluctuating flows for hydropower production, which occur during weekdays and include slightly higher peaks to compensate for the lower weekend flows. This design minimizes impacts of the experiment on hydropower production. Bug Flows have occurred each year from 2018-2020.

GCMRC monitored ecosystem response to the 2020 Bug Flow experiment through continuation of long-term citizen science insect monitoring in Grand Canyon and through continuation of insect drift and emergence monitoring in Glen Canyon. Monitoring by citizen scientists did not start until mid-June due to the closure of the Colorado River in GRCA in response to COVID-19. The loss of early season monitoring data in 2020 limits detection of fine-scale patterns of aquatic insect emergence relative to prior years, but hundreds of monitoring samples were collected which allows interpretation of broad-scale trends. Principal among these, GCMRC scientists observed high abundances of caddisflies (*Trichoptera*), a type of aquatic insect that is sensitive to environmental perturbation and represent higher quality prey for fishes. In 2020, caddisfly abundance exceeded levels observed in 2019 and was similar to the 400 percent increase observed in 2018. Collectively, the past three years of Bug Flows represent the three highest abundance years of these caddisflies in the nine-year citizen science sampling record. Thus, Bug Flows appears to be enhancing the diversity and production of aquatic insects as intended.

GCMRC scientists have also documented additional, unanticipated benefits of the Bug Flows experiment to the Colorado River ecosystem. Algae and other types of aquatic primary producers fuel growth of aquatic insects and fish in the Colorado River. Detailed dissolved oxygen budgeting has been used during the 2018 and 2019 Bug Flows to estimate daily rates of aquatic primary production in 11 discrete reaches spanning the 400-kilometer Grand Canyon segment. These data demonstrate that spring (May and June) rates of gross primary production were an average of 40% higher during weekend Bug Flow releases compared to weekdays with fluctuating flows. This weekend increase in primary production arises because water clarity is higher during low steady flows, and hence sunlight penetrates to a greater area of the river bottom on weekends. Using a longer-term dataset from four of the river reaches examined above, weekly gross primary production was increased during Bug Flows, such that the effect is not limited to weekend days alone. Thus, Bug Flows also enhance rates of algae production across hundreds of kilometers of river, which may in turn be fueling growth of caddisflies and fish.

Annual Reporting Meeting

In January 2020, the GCMRC conducted an annual reporting meeting with AMP 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 meeting were made available in electronic postings at Reclamation's GCDAMP website (https://www.usbr.gov/uc/progact/amp/amwg.html).

Implementation of Stream Flow and Sediment Measurement Program in Support of the LTEMP ROD

The periods from July 1 to November 30 and December 1 to June 30 mark the "sediment accumulation periods" for fall and spring HFEs, respectively, as defined under the High-Flow Experimental Protocol that was initially adopted by the Secretary in 2012 and carried forward into the 2016 LTEMP ROD. 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. 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 (https://www.gcmrc.gov/discharge_qw_sediment/index.jsp). Data from physical samples were shared with Reclamation via the GCMRC website on a bi-weekly basis to provide sediment data in a near real-time format for HFE planning purposes.

Analyses of Sediment Transport Data to Inform HFE Planning and Design

Based on GCMRC measurements, 47,000–58,000 metric tons of sand were supplied to the Colorado River by the Paria River between July 1, 2019 and November 30, 2019, and at least 330,000 metric tons of sand were exported from Marble Canyon during this same period. The GCMRC continuous mass-balance sand budgets for this period indicate that 140,000–180,000 metric tons of sand were eroded from Upper Marble Canyon (river miles 0 to 30) and 92,000–150,000 metric tons of sand were eroded from Lower Marble Canyon (river miles 30 to 61) between July 1, 2019, and November 30, 2019. Thus, substantial net erosion of sand from Marble Canyon occurred during the summer–fall accumulation period from July 1, 2019, through November 30, 2019. Because no net accumulation of sand in Marble Canyon occurred, an HFE was not triggered.

Based on GCMRC measurements, 46,000 - 56,000 metric tons of sand were supplied to the Colorado River by the Paria River between December 1, 2019, and June 30, 2020, and at least 110,000 metric tons of sand were exported from Marble Canyon during this same period. The GCMRC continuous mass-balance sand budgets for this period indicate that net erosion of 71,000 - 130,000 metric tons of sand occurred in Upper Marble Canyon (river miles 0 to 30) whereas net deposition of between 26,000 and 53,000 metric tons of sand occurred in Lower Marble Canyon (river miles 30 to 61) between December 1, 2019, and June 30, 2020. Thus, during the spring accumulation period from December 1, 2019, through June 30, 2020, net accumulation of sand in Marble Canyon did not occur and was insufficient to trigger an HFE.

Implementation of a Plan to Evaluate HFE Effects

The GCMRC utilizes annual topographic surveys and a network of field time-lapse cameras to evaluate the effects of HFEs and other flows on sandbars throughout the Colorado River ecosystem. Scientists collected photographic data and recovered gaging station data in February 2020. Preliminary results indicate that there was sandbar building in Marble and Grand canyons caused by each of the fall HFEs conducted in November of 2012, 2013, 2014, 2016, and 2018,

(water years 2013, 2014, 2015, 2017, and 2019). Sandbar size at a majority of sites (> 88%) either increased or was maintained in response to each HFE. No HFE occurred in fall 2015, 2017, 2019, or 2020 (water years 2016, 2018, 2020, and 2021) and preliminary results indicate erosion occurred at most monitored sandbars as a result of normal dam operations (e.g., daily variation in flows due to hydropower load-following) in water years 2016, 2018, and 2020.

During 2020, GCMRC continued to monitor effects of the HFE Protocol (which began in 2012) on source-bordering aeolian dune fields that contain archaeological sites within GRCA. There are 57 large, source-bordering aeolian dune fields along the Colorado River in Grand Canyon and another 60 similarly large areas of unvegetated sand located at high elevations outside of the active river channel. Many of those dune fields and high elevation sand areas contain archaeological sites. While HFEs do not directly inundate most of these areas, they do resupply them with river sand by rebuilding upwind sandbars.

The LTEMP FEIS predicted that conditions for achieving the goal of preservation of cultural resources, termed "preservation in place," will be enhanced as a result of implementing the selected alternative. HFEs are one component of the selected alternative that will be used to resupply sediment to sandbars in Marble and Grand Canyons which, in conjunction with targeted vegetation removal (described above as *Vegetation Management/Exotic Species Removal* conducted by NPS in GRCA), is expected to resupply more sediment via wind transport from HFE-deposited sandbars to dune fields and archaeological sites. While HFEs have been shown to directly erode terraces that contain archaeological sites in GLCA, HFEs have also been shown to rebuild or maintain sandbars that provide sand to resupply aeolian dune fields containing archaeological sites throughout Marble and Grand Canyons.

GCMRC infers that the relative success of HFEs as a regulated-river management tool for resupplying sediment to dune fields that contain archaeological sites is analogous to the frequency of resupply observed for river sandbars. GCMRC determined that dune field sediment storage increased cumulatively when HFEs were conducted consistently on an annual basis from 2012 to 2014. However, sediment storage more commonly decreased during one-year hiatuses from HFEs such as occurred in 2015, 2017, 2019 and 2020. GCMRC used these research and monitoring results to help design and participate in experimental vegetation removal treatments that were implemented by the NPS in 2019 and again in 2020. In GRCA, these treatments are intended to help to increase aeolian sediment supply from HFE sandbars to dune fields that host archaeological sites and help preserve archaeological sites in-situ.

Rainbow trout populations in Glen Canyon were sampled before and after each of the November 2012, 2013, 2014, 2016, and 2018 HFEs to evaluate any effects on the aquatic ecosystem. Results indicate that fall HFEs do not trigger downstream movement of rainbow trout but they may have a weak effect on trout growth and condition. Rainbow trout abundance in Glen Canyon declined substantially over the period that included the November 2012, 2013, and 2014 HFEs and also through 2015. However, rather than an effect of fall HFEs, the rainbow trout population crash in 2014-2015 appears to be related to an overabundance of young trout produced in water year 2011 following an equalization event combined with a limited aquatic food base stemming from a reduction in soluble reactive phosphorus from the reservoir. The abundance of young rainbow trout

increased dramatically in 2016 and 2017, with the latter year representing the largest recruitment event since 2011. Rainbow trout abundance of catchable sized fish remained stable from 2017-2019 and trout relative condition has remained above 1.0, suggesting a recovery of the rainbow trout population is underway.

Catches of non-native brown trout have been increasing in Glen Canyon coincident with the implementation of the HFE Protocol. Since 2015, annual brown trout recruitment events have been relatively large with the exception of 2017, which is the last year rainbow trout had a moderately large recruitment event. Adult brown trout condition remains higher than rainbow trout and relative abundance has progressively increased since 2015. An incentivized harvest program was developed by NPS and may be implemented early in WY2021, with the goal of decreasing the population size of predatory brown trout to reduce risk to downstream humpback chub populations. The influence of fall HFEs on this species is unknown but is a topic of ongoing discussion among scientists and managers.

Fisheries Information in Support of the LTEMP ROD

In 2020, GCMRC conducted monitoring of native and non-native fish populations in support of the LTEMP ROD and its associated BO for endangered species. The BO identifies several triggers which, if met, require management actions to be taken to protect humpback chub. The BO includes two tiers of possible actions to protect humpback chub. The first specifies actions to benefit humpback chub directly and the second looks to reduce non-native fish populations. Information provided by the GCMRC for specific triggers included the abundance of juvenile, sub-adult, and adult humpback chub and the abundance of non-native rainbow trout and brown trout in the Colorado River near the Little Colorado River confluence.

In 2020, humpback chub research included sampling trips to the lower Little Colorado River, the neighboring reaches of the Colorado River, and in the Colorado River near Fall Canyon. To complement these more spatially intensive sampling efforts, 2020 sampling also included more widespread sampling of the Colorado River via humpback chub aggregations and backwater seining trips. The GCMRC and its cooperators will generate estimates of the abundance of several life stages of humpback chub in the Little Colorado River and near its confluence with the Colorado River, as well as survival rates of juvenile humpback chub in this latter area. If BO triggers are met management actions may be required to protect humpback chub.

Green sunfish were detected in 2015-2019 in the Colorado River downstream from Glen Canyon Dam. Similar to 2018, distribution in Glen Canyon in 2019 was limited with these fish found primarily in a small pond off the main channel of the Colorado River called the 'slough', although 104 green sunfish were caught by USGS and cooperators while doing fish work in the main channel in 2020. It appears that the incidence of green sunfish in the main channel of the Colorado River is increasing and is likely the result of warmer water temperatures.

Cultural Resource Monitoring in Support of the LTEMP ROD and AMP

In 2020, GCMRC scientists continued to implement the plan for monitoring effects of dam operations, as well as non-flow actions of the LTEMP, on the geomorphic condition of archaeological sites. The monitoring plan was prepared in 2015 in consultation with Reclamation,

the NPS, and American Indian Tribes affiliated with the AMP and initially implemented in fiscal year 2016. In June 2020, GCMRC scientists continued to map and monitor archaeological sites in Grand Canyon using methods as described in the monitoring plan. In addition, GCMRC scientists continued to compile repeat photographs of historical images from the river corridor to assess changes in the open sand areas that resupply sediment to archaeological sites and also to assess changes in the distribution, diversity and abundance of riparian plant species, particularly those species that were traditionally valued and utilized by American Indian Tribes affiliated with the AMP.

Science Support for Experimental Riparian Vegetation Management

In 2020, GCMRC worked with NPS staff and tribal partners to design and implement experimental vegetation removal at several locations along the river. Project participants included NPS, GCMRC, Hopi Tribe, Hualapai Tribe, Navajo Nation, Southern Paiute Consortium, and Pueblo of Zuni. The purpose of the experimental vegetation removal effort is to create more camping space for recreational visitors and to improve transport of river sand between near shore sandbars and aeolian dune fields and associated archaeological sites that are located farther from the river. As a project partner, GCMRC's roles and responsibilities are to: (1) provide input to NPS and tribal partners on project design, site selection, and methods for implementation and monitoring, (2) provide scientific support via monitoring and research to evaluate vegetation management treatment outcomes, effectiveness, and success, (3) provide objective advice on project efficiency and adaptive management, and (4) help manage project data while respecting tribal data sensitivity. GCMRC conducted a river trip in June 2020 to monitor vegetation regrowth and sediment dynamics at sites treated by NPS in 2019.

Other Science Activities and Findings

In the course of regular and mandated science monitoring and research activities, the GCMRC and its cooperators provided stakeholders and the AMP 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 aquatic 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. In addition, GCMRC was permitted and provided logistics support for 11 mainstem river trips downstream of Lees Ferry during 2020. The GCMRC was also permitted and provided logistics support for 8 trips upstream of Lees Ferry in Glen Canyon to conduct AMP-funded projects during 2020. Due to COVID-19 there were multiple trip cancellations in 2020 including 4 tribal, 2 Partners in Science, 3 Little Colorado River helicopter, 3 fish study, and 2 aquatic food base trips. Upstream in Glen Canyon, 1 aquatic plant study trip was also cancelled. GCMRC is working to reschedule all trips in 2021 that

were postponed in 2020 and that are mission critical but are not dependent on sampling during specific months.

Tribal Activities

In 2020, GCMRC organized two meetings with representatives from the Hopi, Hualapai, Navajo, Southern Paiute consortium, and Zuni Tribes to discuss development of the AMP FY2021-23 Triennial Budget and Work Plan and to seek tribal input on research and monitoring priorities and get feedback on areas of concern to the Tribes. In 2020, USGS continued to provide appropriate funding for tribal participation in the AMP.

2021 Dam Operations (Projected) and Adaptive Management

Bureau of Indian Affairs

In water year 2021, the BIA will continue to take an active role in supporting stakeholder tribes related to the AMP. The BIA will participate in meetings concerning the LTEMP Programmatic Agreement, in pre-meetings with tribal representatives prior to AMWG meetings, and 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 or experimental releases from Glen Canyon Dam as staffing permits. The BIA will coordinate with, and, if necessary, meet with Interior's Tribal Liaison to facilitate stakeholder tribe participation in various aspects of the AMP.

Bureau of Reclamation

Water Operations

The operation of Glen Canyon Dam is described in a set of documents relating to the use of the waters of the Colorado River, which are commonly and collectively known as the "Law of the River." The 2007 Interim Guidelines (Guidelines) are part of this collection and set the annual operations of Lake Powell and Lake Mead according to the strategy set forth in Section 6 of the Guidelines. On December 15, 2016, the ROD for the Glen Canyon Dam LTEMP was signed by the Secretary. The LTEMP provides monthly operating hydrographs for different hydrological year classes. These monthly release volumes are found in *Table 1 – Monthly Release Volumes of the Selected Alternative* in the 2016 LTEMP ROD. The LTEMP monthly release volumes will be used in conjunction with Guidelines operations between October 1, 2020 and September 30, 2021 (water year 2021).

The August 2020 24-Month Study projected the January 1, 2021, elevations of Lake Powell and Lake Mead to determine the water year 2021 operating tier for Lake Powell. Using the most probable inflow scenario, and with an 8.23 million acre-feet (MAF) annual release pattern for Lake Powell, the January 1, 2021 reservoir elevations of Lake Powell and Lake Mead were projected to be 3,591.60 feet and 1,085.28 feet, respectively. Given these projections, the annual release volume from Lake Powell during water year 2021 will be determined by the Upper Elevation Balancing Tier (section 6.B of the 2007 Interim Guidelines). The Upper Elevation Balancing Tier provides for the possibility of adjustments to the operation of Lake Powell based on the projected end of water year condition of Lake Powell and Lake Mead from the April 2021 24-Month Study. The August 24-Month Study suggests an April adjustment to Balancing, and under section 6.B.4 of the Guidelines the annual release from Lake Powell would be 9.0 MAF.

Projected releases from Lake Powell in water year 2021 reflect consideration of the uses and purposes identified in the authorizing legislation for Glen Canyon Dam and will be consistent with the 2016 LTEMP ROD. As of the August 2020 24-Month Study, the projected monthly release volumes for water year 2021 are displayed in Table 2, and the end of water year 2021 elevation for Lake Powell is projected to be 3,587.57 feet.

Table 2. Projected Lake Powell Monthly Release Volumes for Water Year 2021

Month	Monthly Release Volumes (MAF)
October 2020	0.640
November 2020	0.640
December 2020	0.720
January 2021	0.860
February 2021	0.750
March 2021	0.800
April 2021	0.710
May 2021	0.710
June 2021	0.750
July 2021	0.850
August 2021	0.900
September 2021	0.670
Total Releases	9.000

Source: August 2020 24-Month Study

LTEMP FEIS and ROD

The LTEMP FEIS 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 federal law. The LTEMP includes a communication and consultation process that ensures input and consultation with stakeholders throughout the 20-year implementation. In 2021, Reclamation will continue a phased implementation of the LTEMP. Ongoing communication and coordination with stakeholders will continue.

Conservation Measures for Humpback Chub and Razorback Sucker

In 2021, ongoing conservation measures will continue as described above for 2020, consistent with the prescriptions set forth under the Biological Opinion for the LTEMP. Reclamation will work closely with the FWS to determine any implications due to the potential downlisting of both humpback chub and razorback sucker from endangered to threatened.

Tribal Activities

In 2021, Reclamation plans to continue to provide funding to the GCMRC and NPS for cultural resources research and monitoring, and will also continue to fund participation and monitoring by the five American Indian Tribes associated with the AMP (as described above for 2020). In accordance with the National Historic Preservation Act, Reclamation will continue to support activities described in the LTEMP Programmatic Agreement and the Historic Preservation Plan. This plan will ensure continued consultation with interested parties including tribes, identify mitigation measures to address any adverse effects to historic properties, and develop a cultural sensitivity training for all researchers conducting work in the canyons below the dam.

Other Activities

In 2021, Reclamation plans to continue to provide funding to GRCA 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 AMP activities. Reclamation also plans to continue to provide funding to GRCA to conduct management actions that fulfill ESA compliance for the LTEMP BO.

National Park Service

LTEMP FEIS and ROD

LTEMP implementation of various components will continue in 2021. Budgeting, coordination, and experimental planning will continue in collaboration with Reclamation, GCMRC, tribes, and other stakeholders and partners.

Archaeological/Cultural Resources

NPS staff will continue to work on implementation of National Historic Preservation Act Section 106 compliance activities, working with all interested parties on updating plans and developing field review strategies. This work will be guided by the 2018 Historic Preservation Plan.

Grand Canyon National Park: In 2021, NPS Archaeological Sites Management Information System condition assessments will be conducted at 50 sites as part of the monitoring for the Grand Canyon Colorado River Management Plan. The NPS is proposing to conduct assessments to a selection of 50 high priority locations identified in previous Reclamation treatment documents as recommended for mitigations. The assessments will be conducted jointly with Reclamation as part of the planning process outlined in the Historic Preservation Plan.

Glen Canyon National Recreation Area: Glen Canyon will continue research into photogrammetry monitoring at select cultural sites. Staff will also continue opportunistic cultural and natural resource monitoring around planned HFEs.

Tribal Consultation

In 2021, the NPS anticipates continued participation in consultation meetings with the various tribes who are directly involved in the AMP and other Colorado River related programs. GRCA and GLCA will continue discussions with tribes to incorporate tribal perspectives into implementation of the NPS Comprehensive Fisheries Management Plan, the Expanded Non-Native Aquatic Species Management Plan, as well as the Programmatic Agreement for both plans. Tribal advisors will continue to be consulted on specific monitoring and mitigation protocols.

GRCA 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 to create 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.

GRCA 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 2016-2019 efforts with the Hopi Tribe, Hualapai Tribe, Kaibab Paiute, Navajo Nation, and the Pueblo of Zuni, GLCA anticipates compiling the tribal ethnographic reports for the Glen Canyon reach into one final report that will facilitate contextualization of the archaeological 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, GLCA, in partnership with GRCA and the NPS Regional Office Serving Regions 6, 7 & 8,

will conduct ongoing consultations relative to the Programmatic Agreement meeting National Historic Preservation Act Section 106 requirements for implementing the Expanded Non-Native Aquatic Species Management Plan.

Humpback Chub Translocation and Fisheries Management

In 2021, GRCA efforts will include monitoring of translocated endangered humpback chub in and around Havasu, Bright Angel, and Shinumo creeks, and the continued removal of non-native fishes in Bright Angel Creek and the Bright Angel Creek inflow area of the Colorado River. The recovery of Shinumo Creek will continue to be monitored for the suitability of humpback chub translocations in the future. Collaboration with Reclamation, FWS, GCMRC, and others will continue on all fisheries projects.

In 2021, GLCA work will include additional development and evaluation of monitoring protocols for terrestrial and non-native fish resources to evaluate potential effects resulting from dam operations. The Expanded Non-Native Aquatic Species Management Plan and EA were completed in 2019 and an incentivized harvest program for brown trout control will be initiated in WY2021. Staff will also continue to monitor and manage any new populations of green sunfish in the backwater sloughs.

Wildlife Surveys and Monitoring

Grand Canyon National Park: In 2021, GRCA surveys and monitoring for ESA listed Ridgway's clapper rails and Southwestern willow flycatchers, as identified in the LTEMP ROD. The long-term bat study will continue in 2021, focusing on captures (acoustically and mist netting) and white-nose syndrome surveillance in new areas of the park, including the addition of doing bat work on a river mission.

Glen Canyon National Recreation Area: In 2021, GLCA plans to continue programs related to aquatic/riparian invertebrates, bats, other terrestrial vertebrate populations, and northern leopard frog habitat enhancements.

Experimental Vegetation Treatment and Mitigation

In 2021, GRCA and partners will continue implementation of non-flow experimental vegetation treatment to mitigate Glen Canyon Dam operation impacts on riparian vegetation along the Colorado River. GRCA staff and partners will continue implementing Colorado River Monitoring Program campsite monitoring and mitigation actions. Restoration site maintenance and monitoring will continue at Granite and Cardenas camps. Working with the GCMRC, GRCA staff will continue integrating long-term monitoring data into future mitigation efforts. In 2021, GRCA, GLCA, 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. Both parks will also initiate riparian habitat restoration projects associated with the LTEMP FEIS. Discussions were initiated 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.

Expanded Non-Native Aquatic Species Management Plan

In Glen Canyon, monitoring for invasive species, especially non-native fish, will continue with partners in 2021. Quagga mussel colonization monitoring above and below Glen Canyon Dam will continue. Green sunfish populations, especially in the backwater areas, will be monitored while annual pump out and fish removal actions are implemented. NPS will initiate an incentivized harvest program for brown trout in GLCA.

Research Review and Permitting

GRCA and GLCA anticipates continuation of research and permitting activities in 2021 at similar levels as 2020. For each of the research projects in support of the GCPA, peer review of the proposals, evaluation of the need for National Environmental Policy Act 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 2021, NPS field work will resume with the resumption of NPS and contracted river operations. One springtime monitoring to remove vegetation encroaching on campsites is planned. In addition, a cooperative monitoring and mitigation program is in development which will use monitoring done by the GCMRC to inform NPS mitigation work where flow-related changes in vegetation and geomorphology degrade campsite conditions.

United States Fish and Wildlife Service

In 2021, 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. 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 spring of 2021. 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. FWS will continue to take the lead on refining and implementing a monitoring protocol for effectively sampling the mainstem aggregations of humpback chub and will conduct one sampling trip in 2021. FWS will continue translocation of humpback chub from the lower Little Colorado River upstream to above Chute Falls in 2021.

United States Geological Survey

The major focus of the GCMRC's activities in 2021 is to continue to serve in its role as the primary science provider to the AMP by conducting the field and laboratory studies described in the FY2021-2023 Triennial 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, water quality, 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. Native and non-native fish population data will continue to be collected and reported on in support of management decisions regarding recovery of humpback chub, maintaining the Lees Ferry sport fishery, and control of non-native fish and aquatic invasive species. The GCMRC will continue monitoring and reporting on the condition of resources identified in the LTEMP before and after HFEs as well as in response to bug flows and any other flow and non-flow experiments including vegetation management. The GCMRC will also work with Reclamation in refining experimental planning protocols and will continue to work with tribal representatives to disseminate preliminary findings to tribal members, tribal governments, and the AMP.