Citizens' Environmental Assessment (CEA) on the Decommissioning of Glen Canyon Dam

Report on Initial Studies
December 2000

Produced by
Glen Canyon Institute
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Glen Canyon Institute

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Thank you for your interest in Glen Canyon Institute's report on our Citizens' Environmental Assessment (cea), on the effects of Glen Canyon Dam and potential effects of decommissioning the dam. The cea is a project of Glen Canyon Institute, a non-profit 501(c)3 organization. It is funded by foundation grants and contributions from our membership, which currently approaches 1400.

We are conducting the cea to examine and document the impacts of Glen Canyon Dam and Powell reservoir* on the environment, and to examine the implications of decommissioning the dam. When Glen Canyon Dam was built, there were few environmental or cultural preservation laws. Laws in place today would prevent the construction of a similar dam due to the environmental consequences.

The proposal to decommission Glen Canyon Dam will require intensive study and public review that is far more rigorous than the resources of Glen Canyon Institute will support. The cea is not intended to take the place of a comprehensive environmental review; rather, it is merely the first step in the process. The purpose of the cea is to demonstrate sufficient public support to justify a full Environmental Impact Study (EIS) on the operations of Glen Canyon Dam that includes decommissioning the dam and draining Powell reservoir within the range of alternatives.

Although in 1996 the Bureau of Reclamation (BOR) completed an EIS on operations of the dam, decommissioning the dam was not offered as an alternative to the public. Public comments which suggested decommissioning of the dam were simply rejected as falling outside the scope of that process. Glen Canyon Institute believes that the American public should decide whether or not the long term environmental costs of maintaining Glen Canyon Dam outweigh the short-term benefits provided by Powell reservoir.

This report contains highlights from studies commissioned by Glen Canyon Institute regarding effects of dam operations, and potential impacts of decommissioning Glen Canyon Dam and draining Powell reservoir. Complete copies of each study are available for the cost of photocopying and postage from Glen Canyon Institute. A list of these studies may be found on the back cover of this document.

This document is being provided to the public in preparation for public scoping meetings scheduled to begin in 2001. These meetings are intended to gather public comment and input in order to identify relevant resources and issues for inclusion in the draft and final cea documents. If you would like to be notified of these meeting dates, contact Glen Canyon Institute.

We invite your input on this report. Please take the time to review this document and send comments to:

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We appreciate and value your participation in this unprecedented citizen-sponsored initiative. Public involvement is vital to the process.

* As the term "lake" describes natural bodies of water, and "reservoir" is used to describe man-made bodies formed by dams, Lake Powell is referred to as Powell reservoir throughout this document.

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Purpose of and Need for Action

Glen canyon dam was built as the centerpiece of the Colorado River Storage Act. Its main purpose was to store water in the upper basin for delivery to the lower basin in accordance with the Colorado River Compact. The reservoir was to provide an adequate supply of water during drought years. Additional objectives were flow regulation, reclamation of arid land, and power generation. Today we must ask ourselves if the dam is effectively meeting its original purposes, and if these original goals are consistent with what we now know about the environmental consequences of dams.

Large dams along the Colorado River have compromised the ecological integrity of the Colorado River system. Sediment and water previously supplied to the Grand Canyon from Glen Canyon have been altered or cut off as a result of the dam. Without these critical supplies, the historical sustainability of Grand Canyon will continue to be compromised. In addition to impacts in Grand Canyon, the health of the Colorado River Delta is dependent upon management of the river upstream. Current management practices have desiccated and compromised the Delta and upper Sea of Cortez.

The flooding of Glen Canyon is considered by many to be a tragic environmental loss. Yet during the late 1950s, when construction of Glen Canyon Dam began, there were few environmental laws. Nor was there an opportunity for public debate regarding dam construction and water management.

Today we have the Endangered Species Act of 1973, which was designed to restore and protect endangered species, such as those which struggle for survival in the radically altered, post dam environment. The Clean Water Act of 1972 mandates that actions be taken to mitigate or eliminate impacts to water quality. Cultural preservation laws, such as the Archaeological and Historic Preservation Act, are in place to protect archaeological and cultural resources like those which were inundated by Powell reservoir.

Most would agree that, with these laws in place and with the current level of environmental awareness and involvement of the public, Glen Canyon Dam could certainly not be built today.

Following its completion in 1963, Glen Canyon Dam was operated to maximize power generation and flatwater recreational activities upstream, with little thought given to downstream impacts on the Colorado River through Grand Canyon National Park. These impacts were profound. Water released through the turbines fluctuated wildly in order to meet peak power demand, and could vary between 1,000 and 31,500 cubic feet per second (cfs) within a matter of hours. The clear, sediment-hungry water released by the dam eroded beaches throughout Grand Canyon.

By the 1980s, public outcry over the devastating impacts to the riparian habitat within Grand Canyon National Park reached a peak. Responding to public demand, the Secretary of the Interior directed the bor to conduct an eis on operations of Glen Canyon Dam. This eis included a thorough and rigorous examination of the impacts of the dam. It was limited in scope, however, as the bor refused to consider dam decommissioning within the range of alternatives. The public was deprived of taking part in the decision as to whether or not the environmental consequences of maintaining Glen Canyon Dam outweighed the benefits provided by the reservoir.

Periodic flow management measures, resulting from the 1996 eis, are not a long term solution to the problems resulting from the dam. In order to restore the ecological integrity of the river, we need to manage the entire system.

The focus of this cea is to reassess decisions previously made about the dam and water management through scientific examination of the impacts of Glen Canyon Dam, and the potential impacts of decommissioning. The concept of water management in the west is changing as society and demographics of this region change. We need to examine how best to manage our water resources in light of our current knowledge, and the needs of humans and the environment.

Environmental Issues

WATER LOSS

Glen Canyon Dam was built, in part, to ensure adequate water supply to the lower basin states. However, evaporation and bank seepage result in a substantial loss of water to the system. An amount of water greater than the entire volume of the reservoir has been lost since 1963 due to evaporation and seepage. Without the reservoir, water would be made available to protect resources of Grand Canyon, for consumptive use, and for restoration of the Colorado River Delta ecosystem.

- The total storage capacity of Powell reservoir was originally 27,000,000 acre-feet (af).
- Powell reservoir loses 570,000 af of water per year due to evaporation, compared to 102,000 af along this section of the Colorado River prior to dam construction.[1]
- This difference is enough water to supply Salt Lake City each year.
- This amount of water is worth $150 million at Salt Lake City water prices.
- It is estimated that if 10% of the 570,000 af flowed across the border to Mexico, a substantial portion of the Colorado River Delta could be restored.[8]
- The cumulative loss due to evaporation since 1963 is 21,410,000 af.[1]
- Water in the reservoir seeps into the surrounding porous sandstone. The total cumulative water loss due to bank seepage since construction of Glen Canyon Dam has been 10,000,000 af.[1]
- The total cumulative loss due to evaporation and seepage, since the creation of Powell reservoir, is greater than 30,000,000 af, or 2.25 years worth of river flow.[1]

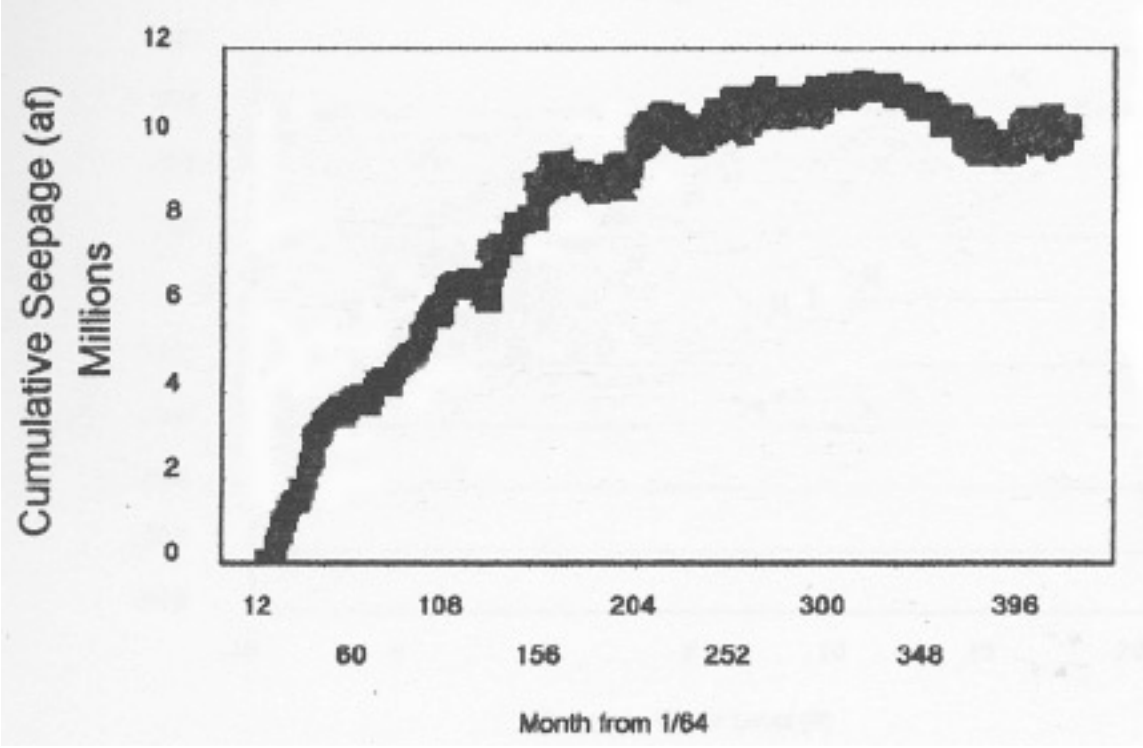


Figure 1
Cumulative seepage into surrounding sandstone as a result of the reservoir since January 1964. When reservoir level drops, some water is recovered. (adapted from Myers, 1999).

SEDIMENTS

"Too thick to drink, too thin to plow" is an old expression referring to the amount of sediment in the Colorado River. In fact, the Colorado River was named by a Spanish explorer for the reddish color of its waters, which comes from the sediments contributed by the colorful sandstones and other rocks along its course. Sediments moved downstream to form marginal sandbars and terraces and a vast delta at the river's mouth at the Sea of Cortez. In Grand Canyon, these sediments provided substrate for riparian vegetation and habitat for wildlife. Additionally, sediments protected cultural resources along the river corridor and in the side canyons.

Today, dams trap much of the vast quantity of sediment and nutrients that once flowed through the river.[29] Sediment accumulation above the dam alters river flow in tributaries through the process of aggradation. Sedimentation will eventually render the dam useless for power generation, flood control or recreation.

- Prior to dam construction, the Colorado River carried 60 to 180 million tons of sediment each year through Grand Canyon.[2, 23]
- Glen Canyon Dam traps 85% of the sediments which previously flowed through the Grand Canyon, thereby depriving the canyon of much of the sediments and nutrients necessary to maintain beaches and natural habitats.[2, 8]
- Controlled floods, of flows amounting to half the pre-dam spring runoff, were released through Glen Canyon Dam in 1996 in an attempt to mitigate the sediment-related environmental problems in Grand Canyon. The experimental floods did not bring new sediment in, but redistributed that which was already within the channel. Although the experiment was somewhat successful, it was not a long-term solution. Most of the short term benefits were lost within a year.[2]
- The reservoir has already lost 932,000 AF of storage capacity due to sedimentation.[2]
- The reservoir will totally fill with sediment in 200-800 years, depending on future sediment inflow rates.[2] The power plant intakes will be clogged sooner and will require expensive modifications to keep the dam operating.
- The process of aggradation deposits sediment upstream above the level of the reservoir. The backing up of sediments negatively impacts tributaries, such as the San Juan River and Cataract Canyon.
- Without the reservoir, built up sediments in the main channel upstream of the dam would be flushed out in 2 to 6 years.[2] Upon exposure to the elements, many of the sediments in the side canyons have been shown to migrate quickly downstream.

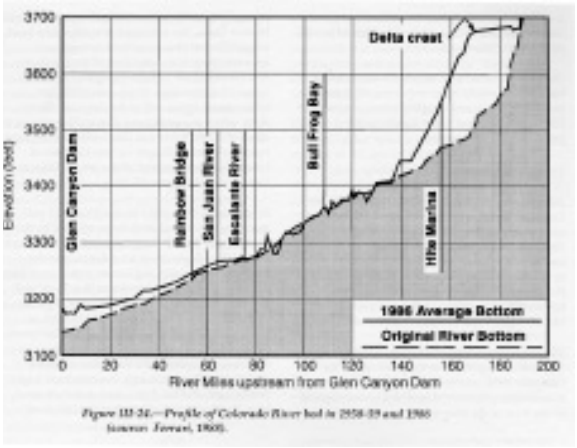


Figure 2
Sediment accumulation in main channel beneath Powell reservoir in 1986 versus prior to dam construction (BOR 1996 EIS).

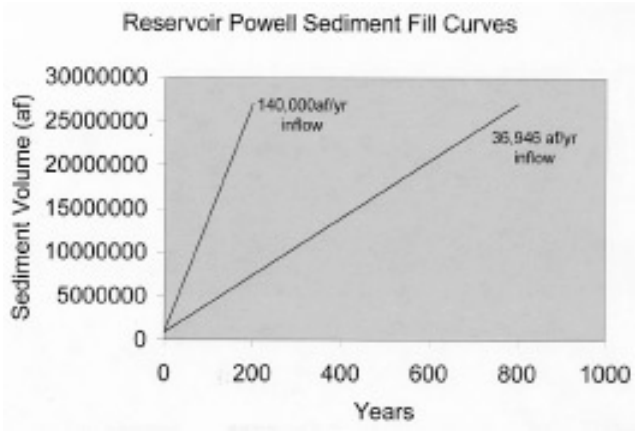


Figure 3
Predicted sediment volume with time based on two sediment inflow rates. At the faster rate (typical of the years prior to 1941) the reservoir would be totally full in 200 years. At the slower rate (typical of more recent years), the reservoir would be totally full in 800 years (Myers, 1998).

SALINITY

The Colorado River is naturally more saline than most rivers in the United States due to the geologic history of the region. Many of the sedimentary formations in the area were created when inland seas flooded the region, leaving salt deposits behind as the plateau uplifted and the seas regressed and evaporated. As rainwater and snowmelt run over these sedimentary rocks, salts are dissolved out and transported to the river. The EPA estimates that the natural salinity level in the lower basin was 334 parts per million (PPM).

Development of the river as a water resource has dramatically increased salinity levels. Evaporation from the surface of the many reservoirs along the Colorado River contributes about 12% of the salinity level. High salinity levels have important legal, economic and ecological ramifications.

- Evaporation from the surface of reservoirs increases the salinity of the water because when the water evaporates, the salts are left behind.
- Irrigation for agriculture increases salinity because diverted water leaches salt out of saline soils and then delivers it to the river through groundwater flow.
- High salinity levels have an economic impact on water users due to damage to household appliances and automobile cooling systems, decreased cleaning efficiency, reduced crop yields, and increased need for desalinization to meet US water obligations to Mexico.
- The increase in salinity, due to Powell reservoir alone, costs water users over $25 million annually.[3, 5]
- Evaporation from Powell reservoir increases salinity by 26.5 PPM each year.[4, 5]
- Although there have been no studies documenting environmental impacts of salinity upon species in the Colorado River, increasing salinity levels will eventually cause environmental degradation.

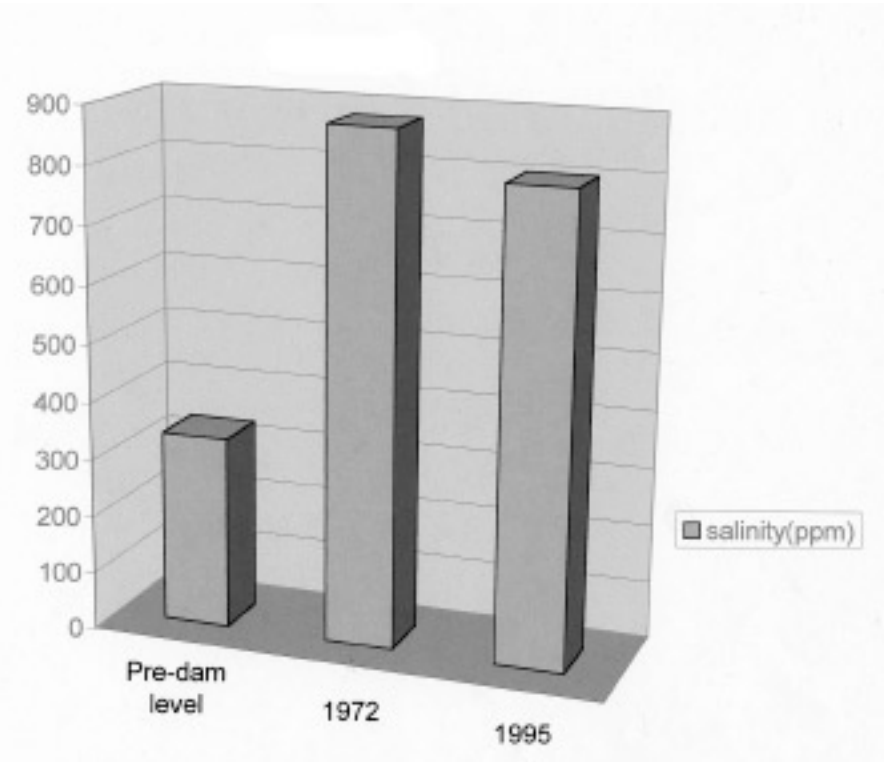


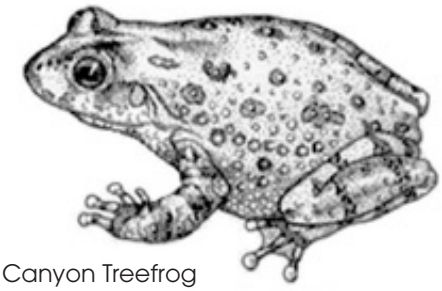
Figure 4
Salinity levels at Imperial Dam. Pre-dam salinity as estimated by the EPA.

ECOLOGY

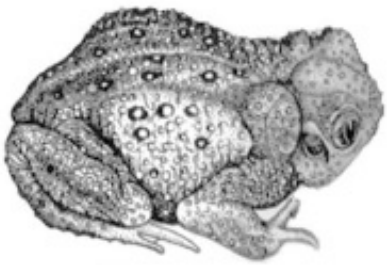
Most of the ecological impacts downstream from Glen Canyon Dam stem from the loss of sediment and nutrients in the river, loss of natural seasonal fluctuations in the flow of water, change in the temperature of the water released downstream of the dam and introduction of non-native species.

The Colorado River is home to one of the most interesting assemblages of fish fauna in North America, due to relative isolation and unique river conditions historically found in the river. Some species have been around for more than 20 million years. Adaptations of the fish to extreme and severe river conditions include large streamlined bodies, large fins, and acute sensory abilities.[30] Current river conditions, as a result of dams, have contributed to the endangerment of several native Colorado River fish species.

In addition to freshwater fish, birds and other fauna in the lower Colorado River and upper portion of the Sea of Cortez are threatened or endangered, in part, due to the reduced water, sediment and nutrient volume as a result of dams.



Canyon Treefrog



Red Spotted Toad

General Environment

- Flooding has inundated the natural riverine and riparian habitats of Glen Canyon, thereby destroying habitat for hundreds of native species.
- The Grand Canyon ecosystem originally formed in a sediment-laden, seasonally fluctuating environment. Construction of Glen Canyon Dam altered this environment and the long-term health of the Grand Canyon ecosystem. Interactions among water volume, temperature, sediment transport and downstream resources support a system quite different from pre-dam conditions.[7]
- Prior to construction of the dam, the Colorado River's temperature varied seasonally from 40 to 80 degrees F. Water released from the dam is now a steady 46 degrees F. because water releases come from the cold depths of the reservoir.
- Prior to construction of the dam, annual spring floods transported sediments that provided habitat for many native species of fish, amphibians and insects. Now water released from the dam is clear, as sediments are trapped in the reservoir.
- The dam has reduced the amount of coarse organic matter reaching Grand Canyon, depleting the level of nutrients necessary for the survival of native species.[6]
- Loss of bank-scouring spring floods has allowed non-native riparian plant species to flourish and crowd out native species.[6]

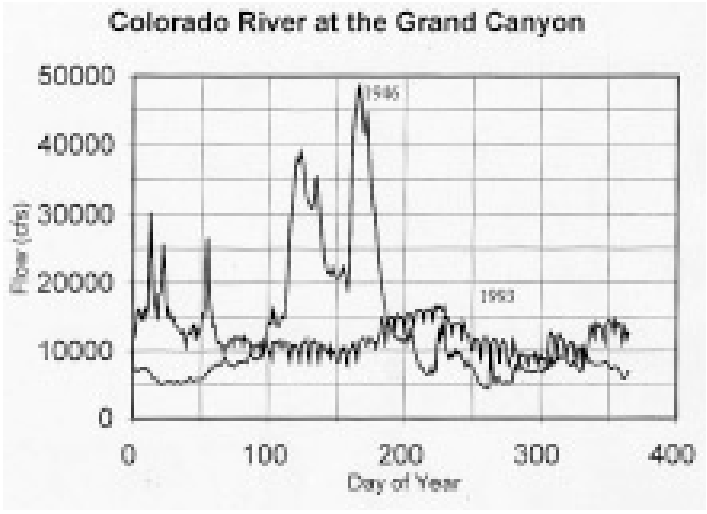


Figure 5
Flow of the Colorado River through Grand Canyon in 1946 (prior to dam construction) and in 1993 showing how dam operations have altered the annual flow cycle (Myers, 1998).

Impact on Fish and Wildlife

Fragmentation of the Colorado River and Glen Canyon ecosystems by Glen Canyon Dam has separated species, reduced the abilities for natural distribution corridors, and corrupted the ecological processes that historically defined the Colorado River system. Today the remaining species are isolated from their historic genetic distribution patterns with the result eventually leading to species loss.[35]

- Prior to the reservoir, 79 species of plants, 155 species of birds and 12 species of mammals lived along the streamsides of Glen Canyon. Flooding of the canyon drowned species not able to relocate and destroyed the natural habitats of others.[36]
- The river terraces in Glen Canyon were home to 164 species of plants, 38 species of birds and 22 species of mammals. Like the streamside organisms, the terrace organisms drowned or had their habitats destroyed during the flooding of Glen Canyon.[36]
- Habitat destruction is a major threat to native species. As the dam prevents natural flooding, native vegetation such as cottonwood and willow cannot regenerate. Many species rely on this indigenous habitat for their survival and once this becomes altered or destroyed, populations are affected. Once habitats are altered, food sources can be altered.[35]
- Glen Canyon provided a nursery area for native fish and bird life, much more so than Grand Canyon.
- Several factors have contributed to the decline of amphibian and reptile species diversity and population size. Glen Canyon Dam has created a large impact on the habitat and species that historically utilized the Glen Canyon area.[35]
- The increased tourism at Powell reservoir has created impacts from motorboats, jet skis, and garbage. This environmental and noise pollution has the potential to greatly affect the species number and diversity in Glen Canyon.

Endangered and Threatened Species

- Four native species of fish—the pike minnow (formerly the Colorado squawfish), the bonytail chub, the humpback chub, and the razorback sucker—are endangered. The pike minnow and the bonytail chub are no longer found in the Grand Canyon. The decline of these species is largely attributed to the impacts of Glen Canyon Dam.
- In 1994 the U.S. Fish and Wildlife Service designated 3168 kilometers of the Colorado River and its tributaries as critical habitat for the survival of these species.[6]
- Introduced species, thriving in the cold, clear post-dam waters have increased predation of and competition with native species.[6]
- The Endangered Species Act requires all federal agencies to use their authorities to help preserve a listed species.
- Lack of adequate water, nutrients, and sediment reaching the Colorado River Delta and Sea of Cortez has reduced critical habitat, desiccated the delta, and shrunk the wetlands. This was especially severe during the twenty years required to fill Powell reservoir, during which time the delta was essentially destroyed. The green sea turtle, Yuma clapper rail, desert pupfish, vaquita, and totoaba are currently threatened. Their decline is due, in part, to habitat degradation.[6]
- The Reservoir would have to be drained over a long time period—perhaps 15–20 years—to avoid detrimental ecological effects to endangered and threatened species.

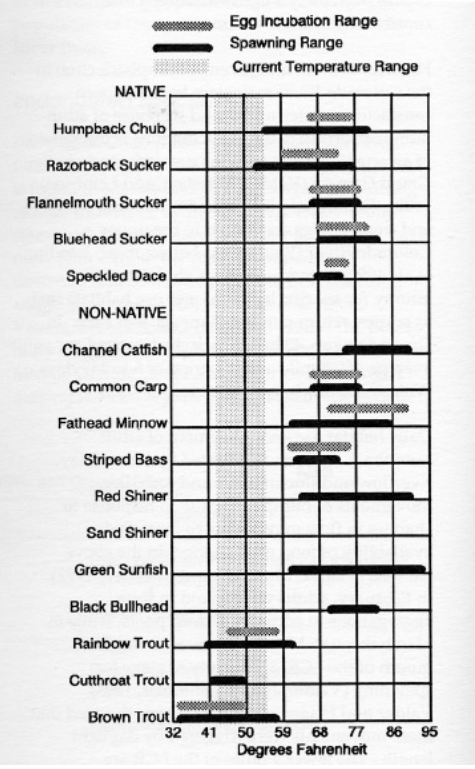
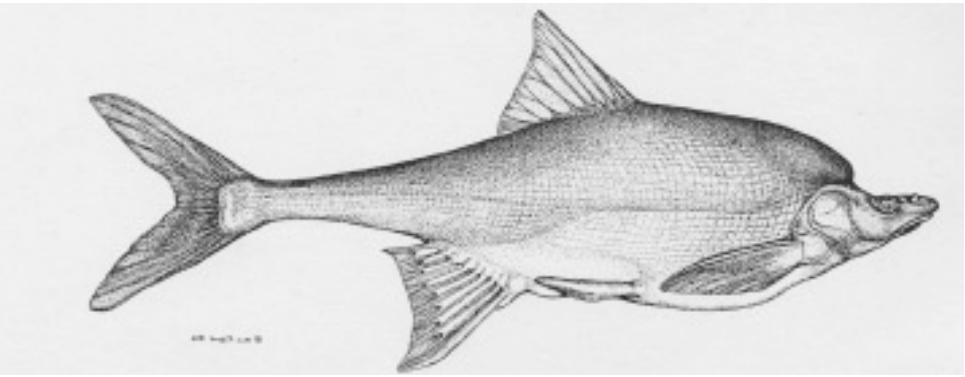


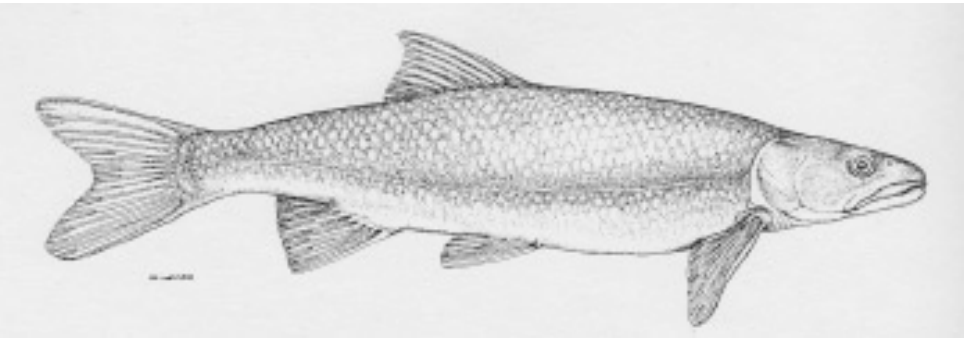
Figure 6
Spawning and egg incubation temperatures for fish species in Grand Canyon. Shaded region indicates current temperature range. Note current temperature range is too cold for successful spawning and incubation of most native fish species. (BOR 1996 EIS)

Some Native Fishes of Grand Canyon



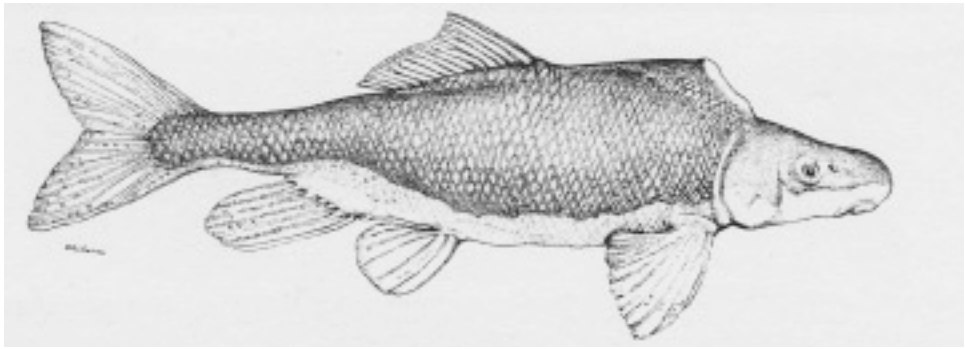
HUMPBACK CHUB
(Gila cypha)

Endangered species, found as one population in Grand Canyon.



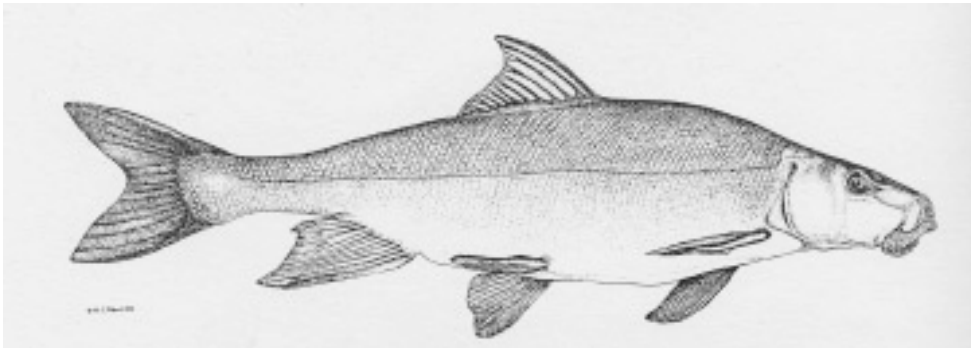
COLORADO SQUAWFISH
(Ptychocheilus lucius)

Endangered species, no longer found in Grand Canyon.



RAZORBACK SUCKER
(Xyrauchen texanus)

Endangered species, extremely rare in Grand Canyon.



FLANNELMOUTH SUCKER
(Catostomus latipinnis)

"Candidate species", protected by states of Colorado, Utah, New Mexico, Arizona, and California, found in small numbers in Grand Canyon.

Figure 7
Richard A. Valdez, Ph.D., Illustrations by M.C. Filbert.

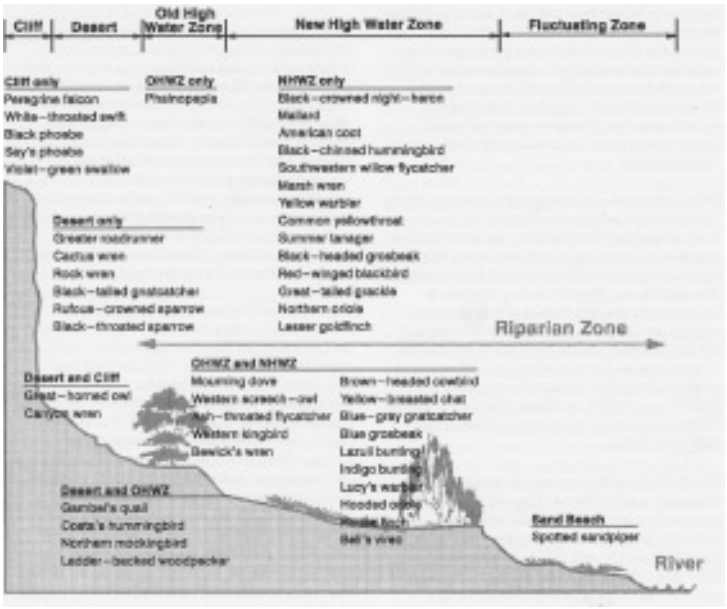


Figure 8
Riparian vegetation zones and associated nesting birds. Riparian vegetation provides important habitat for wildlife (BOR 1996 EIS).

Perceived Benefits of Glen Canyon Dam

The cold, clear, regulated flows from the dam create habitat for some species. For the most part, the benefiting species are non-native, and compete with or prey upon native species. The assemblage of native aquatic and terrestrial organisms is necessary for a sustainable, functioning ecosystem.

- Cold, clear waters released by Glen Canyon Dam allow algae to thrive, thus altering the riparian food chain to support non-native species.
- Control of natural spring flooding has stabilized riparian environment allowing non-native plants such as tamarisk to take hold and expand habitat.[6, 10]
- Prior to construction of the dam, 180 species of birds were known to exist in Grand Canyon. In 1987, 303 different species were sighted.[6]
- As a result of the 1996 Glen Canyon Dam EIS, the Adaptive Management Work Group and the Grand Canyon Monitoring and Research Center have been established to enact polices which attempt to mitigate impacts of Glen Canyon Dam on the Grand Canyon.

Health Issues

Several natural and introduced sources of pollution have contaminated the waters of Powell reservoir. These include radioactivity and heavy metals from abandoned uranium mining operations, petroleum pollution from recreational watercraft, and bacteria from human use of the reservoir.

- Naturally occurring selenium and mercury from upstream sources are trapped in the sediments in Powell reservoir rather than flowing harmlessly to the sea, as they did prior to the construction of Glen Canyon Dam.[2, 15]
- Changes in the reservoir are leading to anaerobic conditions near the sediment layer. This results in changes to the chemistry of heavy metals, causing them to migrate up into the water column and into the food chain.
- The flooding of Glen Canyon near Hite, Utah covered piles of toxic uranium mill tailings.
- Water percolating through tailings also becomes contaminated with radioactivity from Thorium-230, Radium-226 and Radon-222 left behind in the milling process.[14]
- Uranium mill tailings contain high concentrations of heavy metals including arsenic, barium, cadmium, lead, selenium and vanadium. These metals pose a significant health risk. [11, 12]
- Water percolating through these sediments extract the toxic heavy metals, which become incorporated into fish flesh.[13]
- Flushing of sediments will cause the release of heavy metals downstream. Therefore, water and sediment quality should be monitored during draining.[2]
- Draining the reservoir will expose tailings piles, which will need to be capped or removed.
- Recreational use of the reservoir has added lead and other toxic pollutants to the water and underlying sediment.
- Introduction of human waste into the reservoir increases bacteria levels, thereby requiring occasional closure of some swimming areas.

Dam Safety

Studies commissioned by the Bureau of Reclamation indicate that the probable maximum flood would result in a maximum water surface elevation 5 feet below the crest of the dam.[32] This outcome, however, relies on careful management of reservoir levels during the snowmelt and storm seasons. While it appears that catastrophic dam failure is highly unlikely, unexpected floods can cause severe damage at enormous expense. Catastrophic spillway failure is significantly more likely, and almost occurred in 1983 during a relatively low flood.

- The reservoir must remain nearly full to operate the hydropower plant economically. However, a full reservoir does not allow room for floodwaters.
- Flooding during the 1983 spring snowmelt season severely damaged the spillways of Glen Canyon Dam. Repairs cost $130 million. This flood had maximum inflows to Powell reservoir of only 120,000 cfs. A slightly larger flood, or one of longer duration, could have resulted in catastrophic failure of the spillways.
- July of 1884 delivered an estimated flood of 300,000 cfs past the mouth of the Paria River, 15 miles downstream of Glen Canyon Dam. Geological evidence indicates floods of much greater magnitude.[38]
- The probable maximum flood, based on meteorological models, would result in inflows to Powell reservoir of nearly 700,000 cfs.[32]

Figure 9
Photographs showing damage to spillway after 1983 flood (BOR).

Water Supply

One of the primary purposes of building Glen Canyon Dam was to store water for delivery to downstream users, and to protect the upper basin's water interests. Virtually all lower basin water users, however, take water from downstream sources, thereby making Powell reservoir unnecessary for water storage. Water for the town of Page and the coal-burning Navajo Generating Station, the only direct users of water from Powell reservoir, could be piped directly from the river or from a small, off-channel reservoir without the need to store 27 million acre-feet (maf) of water.

- If Powell reservoir were drained, annual delivery of water to the lower basin would fall short of 7.5 million af 27% of the time, versus 20% of the time under current operating conditions.[17] However, there is only a 1.3 in one million chance that water delivery would fall short of the requirements specified in the Colorado River Compact (75 million af over 10 years) if Powell reservoir were drained.[33]
- Water shortfalls can be compensated for through conservation and better management of resources.[6]
- Without Powell reservoir, water delivery to the upper basin states would not change from current levels.[17]
- Without Powell reservoir, average annual flows into the Colorado River Delta would increase by 444,000 af per year due to reduced evaporative loss.[6]
- Without Powell reservoir, average water delivery to the lower basin states would be reduced by 91,000 af per year.[17] This is due to inter-annual variability of river flow. In high-flow years, excess water runs to the Sea of Cortez, rather than being stored for consumptive use. In low-flow years, there is a shortfall (less than 7.5 million af) to the lower basin. This variability averages out to a 91,000 af per year shortfall.

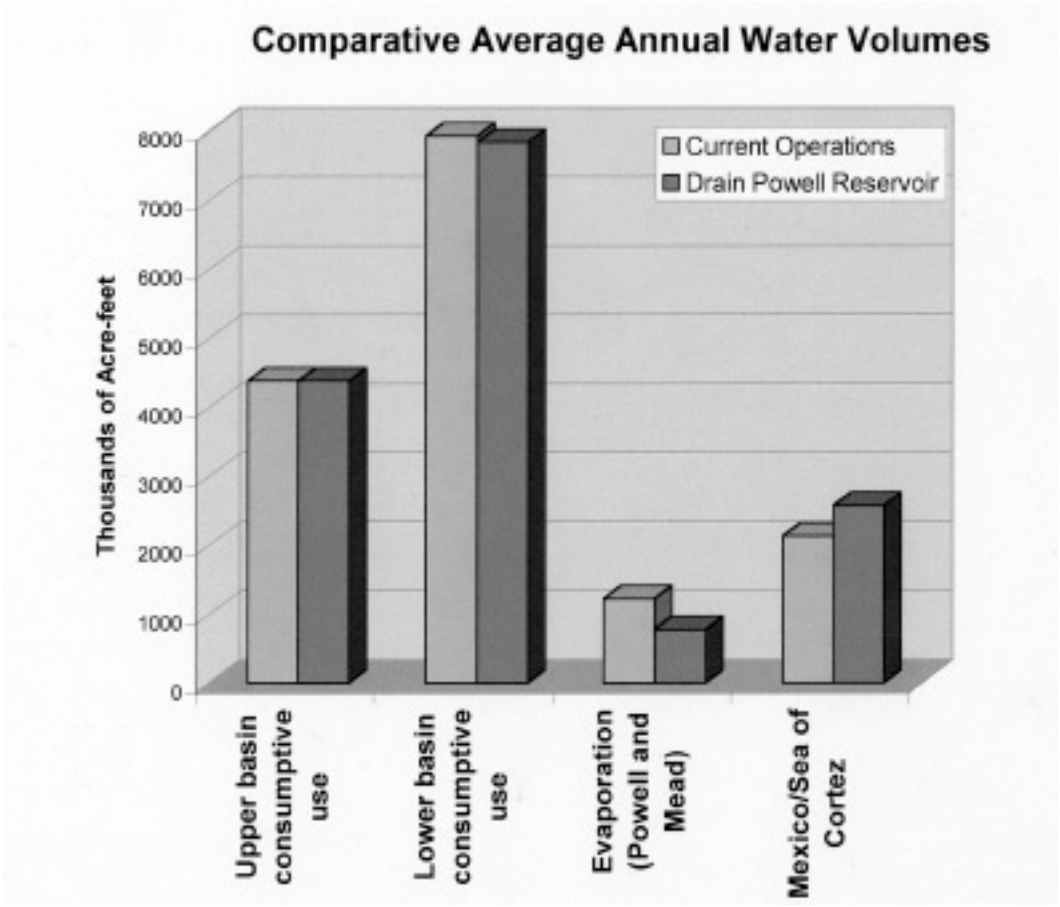


Figure 10
Predicted annual average water volumes with and without Powell reservoir. Much of the evaporative losses saved by draining the reservoir end up in Mexico and are available for replenishment of the Colorado River Delta (after Rosekrans, 1997).

Electricity Supply

In 1968, the Colorado River Basin Act mandated the priorities of Glen Canyon Dam. Power generation was listed as the last priority and only as incidental to the other objectives of the dam.[9] Nevertheless, Glen Canyon Dam does provide over forty billion kilowatt hours of electricity per year at low cost to 174 preferred customers. Day to day releases of water through the power plant are made at times of peak electricity use in order to maximize revenue, while wildlife and recreational needs are subordinated.[9, 28]

- The sediments trapped behind Glen Canyon Dam will fill Powell reservoir. Sediment will eventually clog the power plant's water intake structures, located 245 feet below the crest of the dam. Depending on sedimentation rates, this could occur in 100 to 400 years. [2]
- The Glen Canyon Dam hydroelectric plant could continue to operate and produce power for 10–15 years after decommissioning of the dam. This would allow significant time to find alternate sources of power.
- Currently Glen Canyon Dam generates 4,500–5,500 gigawatt hours per year, which is about 3% of the power currently generated in the four-state area (Colorado, Utah, Arizona and New Mexico).[17]
- Loss of this power source could increase rates for preferred customers who currently receive this heavily subsidized power.[20]
- All of the customers who receive power from Glen Canyon Dam receive power from other sources as well.[17]
- The Navajo Generating Station, a coal-fired power plant near Page, Arizona, uses water from Powell reservoir for cooling. The generating station could continue to operate indefinitely by obtaining water directly from the river.
- The Navajo Generating Station produces almost twice as much power as Glen Canyon Dam.[18]
- Loss of peaking power provided by Glen Canyon Dam could be replaced with a gas or oil-fired power plant. This type of plant is more expensive to run than a hydropower plant.[19]
- Power conservation, development of new power technologies such as fuel cells, and alternative energy sources such as solar, wind, and co-generation, may make the power generated by Glen Canyon Dam unnecessary.

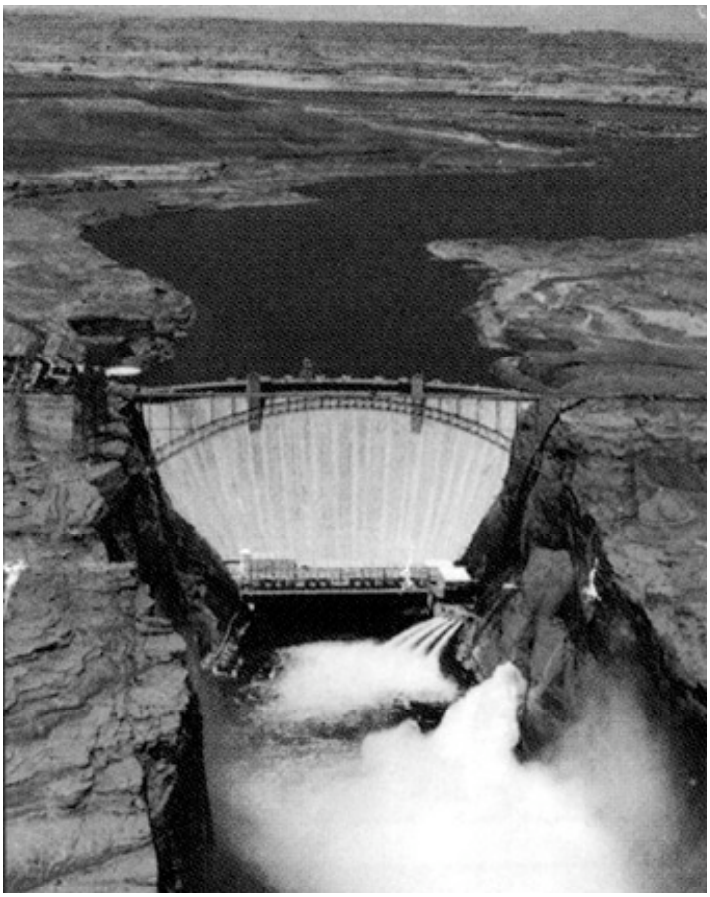


Figure 11
Glen Canyon Dam in 1984
(Bud Rusho, BOR).

Recreation

Recreational and environmental needs were listed in the Colorado Basin Act as the fourth priority for the operations of Glen Canyon Dam. Realistically, these two priorities often require substantially different management approaches. While Powell reservoir offers many recreational opportunities unique to the region, it does so at great ecological expense.

- Glen Canyon National Recreation Area (GCNRA) is the third most popular recreational attraction in Arizona, providing 250 square miles of flatwater recreation and attracting approximately 2.5 million annual visitors. Total visitor days in 1998 was 4.3 million.[21]
- Two stroke engines operate on a mixture of gasoline and oil, discharging 25-30% of this mixture unburned into the water. Approximately one million gallons of hydrocarbon pollution is disbursed into Powell reservoir each year; about 2% of this—20,000 gallons, is raw, unburned oil. This is the equivalent of an Exxon Valdez oil spill into Powell reservoir every 10 years.[34]
- Recreational opportunities offered by the GCNRA are unique in this region.
- Most visitors participate in sightseeing, boating, general Powell reservoir activities and visiting the dam.[21, 24]
- 58% of visitors participate in off-water, off-beach activities such as hiking and exploring ruins. These activities would be available without the reservoir.[21]
- Some of the most popular activities offered by the reservoir are very expensive, and limited to relatively few, affluent visitors.
- Most visitors to Powell reservoir have household incomes in excess of $70,000 per year. Mean household income of 1,278 survey respondents was $90,400.[24]
- Several national parks and monuments, including Grand Canyon, Bryce Canyon and Zion National Parks surround Page. For most visitors, Powell reservoir is one stop on an extended vacation through the region.[21, 24]
- Glen Canyon Dam has contributed to the growth of recreation in both GCNRA and Grand Canyon. Over 20,000 anglers visit Lees Ferry, and 33,000 visitors ride on motor boat tours from Glen Canyon Dam to Lees Ferry annually. The Colorado River through Grand Canyon supports 15,000 to 20,000 whitewater boaters each year.[19]
- Restoration of the 186 miles of Colorado River through Glen Canyon will expand opportunities for rafting, which is growing in demand and therefore strictly limited elsewhere by permits.[20]
- Decommissioning Glen Canyon Dam will adversely affect the trout fishery below the dam which currently provides $1.8 million to the region.[7]

Figure 12
Pollution caused by motorized watercraft is a growing concern as visitation to Powell reservoir increases. (Bluewater Network).

Native American Issues

Glen Canyon Dam and Powell reservoir have had mixed impacts on the Navajo and other Native American tribes in the region. Native Americans have inhabited this land over many millennia and their way of life is deeply rooted in their relationship with the land. The Hopi, Pai, Paiute, Navajo, Yavapai, Hualapai and Havasupai all have current and historical ties to the region.[38] While tourist dollars and inexpensive electricity have benefited otherwise isolated reservation towns, this has come at great expense in terms of culture and religion.[28]

CULTURE

- The Glen Canyon area was inhabited by Native American cultures long before invasion of white settlers. Vast archaeological resources were destroyed by the flooding of Glen Canyon.
- Over 2000 archaeological sites were documented by the University of Utah and Northern Arizona University prior to inundation that included dwellings, pottery, petroglyphs, baskets, etc.[37]
- Powell reservoir flooded the area under Rainbow Bridge, which has long been a spiritual symbol to the Navajo and Hopi. Many Native Americans are uncomfortable with increasing recreational visitation to this and other sacred sites.[26]
- Twenty-five feet of sediment has already filled in the canyon beneath Rainbow Bridge.[2]
- The Navajo Nation has argued that the flooding desecrated the area around Rainbow Bridge. They claimed the BOR, NPS, the states of Colorado and Utah, and the Southwestern and Colorado Water Conservation Districts violated their religious rights under the First Amendment (*Badoni vs. Higginson*).

ECONOMIC ISSUES

- The unemployment rate on the Navajo Reservation is between 27% and 42%.[21, 25]
- The Navajo Generating Station near Page, Arizona and the associated Kayenta Coal Mine employ 1456 Native Americans.[21]
- The Navajo Nation is currently developing marina and resort facilities at Antelope Point, on the southern shoreline of Powell reservoir.[21]
- It is anticipated that Antelope Point Marina will employ about 300 people, many of whom will be Navajo. However profits from this enterprise will go to a private corporation rather than the Navajo people.[21]
- Land inundated by Powell reservoir formerly belonged to the Navajo Nation, which retains mineral rights to the land.
- Navajo communities in the area surrounding Glen Canyon National Recreation Area are partially dependent on tourist dollars. However many tourists pass through the area to visit other destinations such as Grand Canyon.[21]

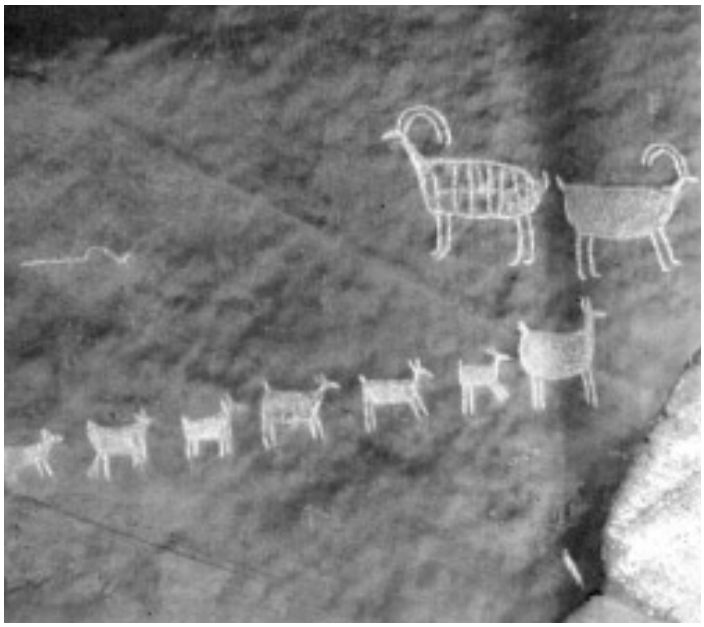


Figure 13
One of hundreds of petroglyphs now covered by the waters of Powell reservoir (Jean Bennett, June 1962).

Economics

There are many economic costs and benefits associated with Glen Canyon Dam and Powell reservoir—both in terms of traditional economics and ecological economics. Traditional economic measures (dollars and cents) are much easier to quantify and compare in terms of costs and benefits but these methods do not consider the long-term costs to future generations. Traditional accounting measures do not include the value of environmental and natural resources. In addition to examination based on traditional economics, we must ask—what are the true "costs" of the dam, and what are the benefits of a restored, sustainable environment and ecosystem?

COSTS OF GLEN CANYON DAM

- The total cost of building Glen Canyon Dam and the surrounding infrastructure was $272 million in 1963 dollars.
- Legislation which authorized Glen Canyon Dam required that initial construction costs owed to the US Treasury should be paid off within 50 years (by 2013).
- Total operating and maintenance costs are $11-29 million per year.
- The Final Record of Decision of the 1996 EIS established a federal advisory committee—the Glen Canyon Adaptive Management Work Group. This work group makes recommendations to the BOR regarding dam operations, at a cost of $8 million per year.
- Modified dam operation procedures, which resulted from the 1996 Environmental Impact Statement on the operations of Glen Canyon Dam, have limited the powerplant's ability to generate revenues.
- Flooding during the 1983 spring snowmelt season severely damaged the spillways of Glen Canyon Dam. Repairs cost $130 million.

IMPACTS OF DRAINING RESERVOIR

- Current recreational options on Powell reservoir will decline during the 15-20 year time span it would take to drain the reservoir.
- While lake-related activities will eventually cease, the restored river through Glen Canyon will provide many more sustainable activities such as hiking, rafting and sightseeing.
- The citizens of the surrounding towns, who currently depend upon income generated from the reservoir, will transition into other enterprises.
- Other towns in the region, such as Escalante and Moab, have successfully refocused their economies and adapted to new recreational opportunities.
- Economic implications of the proposal to decommission Glen Canyon Dam are complex, and should be carefully studied as part of an EIS conducted by the BOR.

Figure 14
Glen Canyon Dam Under Constriction (BOR).

CURRENT ECONOMICS OF REGION

- Powell reservoir spans four counties (Kane, Garfield and San Juan Counties in Utah and Coconino County in Arizona), all of which are sparsely populated and dependent upon tourist dollars.[21]
- The largest employer in each of these counties is the government.
- Page, Arizona is the largest town within 50 miles of the reservoir, with a population of approximately 9,250.[21]
- The major contributors to Page's economy are the reservoir, the Navajo Generating Station and tourism.[31]
- The two largest employers in Page are Aramark (which owns a number of the marinas), and the Navajo Generating Station.
- The average unemployment rate in Page is 5.8%.
- Approximately 65% of the business in Page is generated from tourism.[27]
- Visitation to Glen Canyon National Recreation Area generated about $380 million in 1998.[21] Little of that income remains in the region. Approximately $40 million remains with the citizens of Page and surrounding small towns.

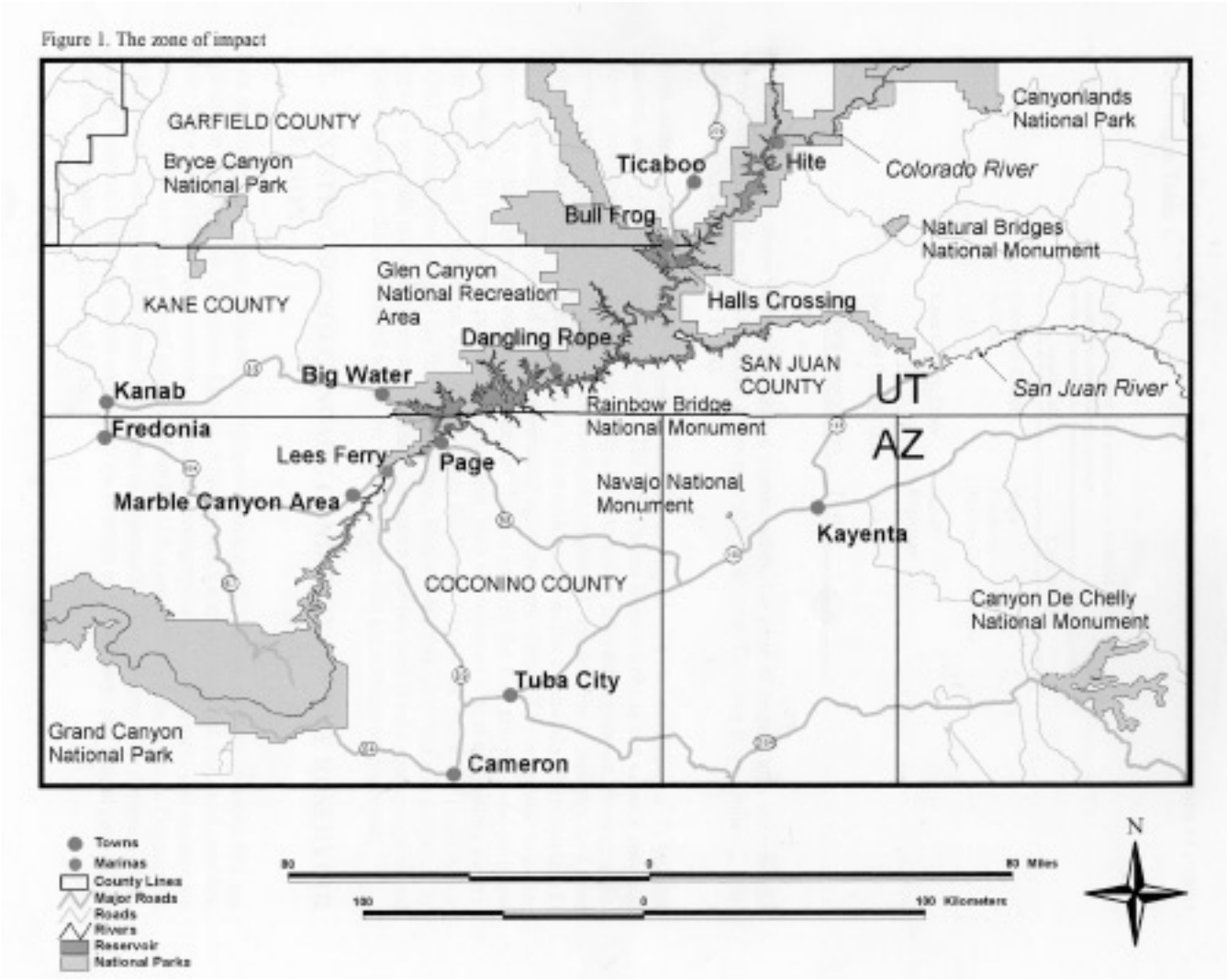


Figure 15
Map showing predicted zone of economic impact of Powell reservoir (Jonas and Moore, 1999).

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