If It Will Just Happen Naturally Anyway… A Case Study of Glen Canyon Dam and the Proposals to Decommission the Dam and Drain Lake Powell

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Introduction:

It is no exaggeration to say that much of the Southwestern United States is dry, including the area encompassing the border between Utah and Arizona. Lake Powell, formed as a result of the construction of Glen Canyon Dam, sits in a region that receives less than 6 inches of rain annually.[1] Without adequate provisions for water security, mass settlement of this area is nearly impossible. When it was built, the primary rationale for the Glen Canyon Dam (GCD) was that it would create a major reservoir (Lake Powell), storing Colorado River water for a non-rainy day.[2] Today, however, the most significant function of GCD today is power generation, providing electricity to "public utilities, agricultural irrigation districts, and rural electrical cooperatives."[3] The costs of producing this electricity are great, not only in terms of the initial and recurring costs of building and maintaining a gigantic concrete dam, but in terms of the environmental effects to the surrounding areas. Upstream from GCD lies Glen Canyon, now partially submerged under Lake Powell, while the Grand Canyon lies downstream. This paper will examine the effects that the GCD has had on its environment; the study will begin in Section I with an introduction to dam building on the Colorado River, and the legislation that surrounded the division of the water of the Colorado River – the largest and most important river in the Southwestern United States. Section II will look at what environmental, recreational and economic effects can be illustrated today; whether the GCD lived up to its stated purposes; and finally, if current uses of the water are efficient. Section III will discuss recent proposals to decommission the dam, and the effects (environmental/economic) that would result if the dam

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[1] *City of Page, Arizona: City Profile*, at http://www.cityofpage.org/profile.htm ("Average yearly total precipitation is 4.78 inches.").

[2] Clayton L. Riddle, *Protecting the Grand Canyon National Park From Glen Canyon Dam: Environmental Law at Its Worst*, 77 Marq. L. Rev. 115, 123 (1993).

[3] *Id.;* this does not mean that power generation creates the most revenue; the most significant (positive) economic result of the dam is tourism.

were taken off line. Included in this section is a discussion of the potential for natural decommission – the presumed result of prolonged drought, sediment buildup, or a combination of both. Finally, Section IV will provide any conclusions and recommendations that can be reached from the prior sections of analysis.

Section I: Taming the Colorado

The first Anglo-American expedition via the Colorado River took place in 1869, famously led by John Wesley Powell.[4] Powell recognized the harshness of the Southwestern climate, and the fact that settlement would never be possible without irrigation.[5] Irrigation, however, requires a steady supply of water, and this is not to be found in much of the Colorado River basin.[6] One way to solve this problem, to ensure a constant supply of water, is to build dams; behind the dams, reservoirs will fill, and the water can be stored for periods where rainfall is inadequate to nurture agricultural crops. Dams of the magnitude necessary to build reservoirs on the Colorado River are inherently large and expensive to build; given the costs and political ramifications of such mega-structures, it fell to the United States government to take a lead role in dam building. This section will detail the legal division of the water rights of the Colorado River – a set of laws known collectively as "The Law of the River" – and the dam building that followed.

The basic doctrine of water rights in the United States is one of reasonable use. "Eastern states, where water is abundant, use one or another variant of riparian rights, the thrust of which is that each owner of land along a water source (riparian land) has a right to use the water,

[4] Marc Reisner, *Cadillac Desert: The American West and Its Disappearing Water* 26 (Penguin Books 1993).
[5] *Id.* at 45.
[6] *See Id*. at 46.

subject to the rights of other riparians."[7] In areas where water is scarce, however, there was a need for more definitive allocation rights. As a result, the law of prior appropriations took hold, adopting a first in time, first in right approach. "The basic principle is that the person who first appropriates (captures) the water and puts it to reasonable and beneficial use has a right superior to later appropriators."[8] This doctrine took hold in essentially every western state by the turn of the 20th century.[9]

Though not changing any rights of appropriation, the first legislation to affect the Colorado River was the Reclamation Act of 1902, creating the Bureau of Reclamation "to build projects to draw water from the rivers and settlers to the West."[10] It was the Bureau of Reclamation that would eventually build many of the nation's largest dams, including the Hoover, the Grand Coulee, and the GCD.[11] Though not among the most well-known of federal agencies, it is no stretch to say that the Bureau of Reclamation has changed the physical landscape of America more than any other government entity. Whether this is a good thing or bad thing is left to the reader to determine.

By 1920, it was becoming apparent that something needed to be done to modify the rules of prior appropriation regarding the water rights to the Colorado River. Seven states form the Colorado River basin: Wyoming, Utah, Colorado, New Mexico, Arizona, Nevada and California.[12] Of these states, only California was heavily populated at the time – and it was growing rapidly.[13] If California were to divert the majority of the flow of the Colorado River for irrigation in the Imperial Valley, or for its rapidly growing southern city – Los Angeles – there

[7] Jesse Dukeminier and James E. Krier, *Property* 40 (5th Ed. 2002).
[8] *Id*.
[9] *See* Scott K. Miller, *Undamming Glen Canyon: Lunacy, Rationality, or Prophecy?*, 19 Stan. Envtl. L.J. 121, 133 (2000).
[10] *Id.* at 134.
[11] *Id*. at 140.
[12] Reisner, *supra* note 4, at 124.
[13] *Id.*

would be nothing the other states could legally do in the future to share the Colorado's water, so long as California was able to continue beneficial use of the water. This prospect raised the concerns of the other states in the basin, and was potentially the source of a great injustice, given that California provides none of the flow of the Colorado, which is supplied in great part by Wyoming and Colorado.[14] In order to find a workable solution, representatives of the seven states gathered at a resort outside of Santa Fe, New Mexico, under the guidance of then Commerce Secretary Herbert Hoover.[15] Negotiations took eleven months, and resulted in a division of the basin into upper (Wyoming, Colorado, Utah, New Mexico) and lower states (California, Arizona, Nevada), with the dividing line being Lee's Ferry, Arizona, which is just south of the Utah border.[16] "Using the Reclamation Service's estimated average flow of 17.5 million annual acre-feet . . . . [e]ach basin was allotted 7.5 million acre-feet. How they were to divide that among themselves was their problem. Of the remainder, 1.5 million acre-feet were reserved for Mexico" and the remainder was given as a concession to the lower basin.[17] The signing of the agreement was hardly the end of the disputes however; though the details are beyond the scope of this paper, it is important to note that the agreement did not become law until Congress acted in 1928, "authoriz[ing] Boulder Dam and the All-American Canal on the condition that at least six of the seven states ratify the compact, and that California limit its annual diversion to 4.4 million acre-feet [maf] per year."[18] Arizona refused to ratify the

[14] *Id.*
[15] *Id.*
[16] *Id*. at 124-5.
[17] *Id*. at 124-5.
[18] Id. at 125; the All-American Canal was to replace a canal originally built in 1901 to deliver Colorado River water to California's Imperial Valley, but went through a portion of Mexican territory. The new canal would be entirely within America, hence the name. Miller, *supra* note 9, at 134.

agreement, unhappy with its allocation in relation to California; this dispute would eventually end up in the Supreme Court for over a decade.[19]

Once Congress enacted the Boulder Canyon Project Act in 1928,[20] the era of dam building had begun. The Hoover Dam, situated on the Arizona/Nevada border, was completed in 1935, at the height of the Great Depression.[21]

> At the time, it was the largest structure ever built. Hoover's 4.4 million cubic yards of concrete – more than all fifty of the Bureau's previous dams combined – stood 726.4 feet high, arched 1244 feet, and spread 660 feet thick at its base. It generated more hydroelectric power than any installation on Earth and stored 28.5 [million acre-feet] of Colorado River water – more than two years worth of flow.[22]

Most of the water and electricity from the Hoover Dam served ever-growing California. "By 1952, California was consuming 5.3 maf of Colorado River water each year – nearly 1 maf more than it was allocated by the Boulder Canyon Project Act."[23] But that was not the only problem with the allocation scheme. "The annual flow of the Colorado was nowhere near the 17.4 maf that the parties assumed was available when the negotiated the Compact. Since 1930, an annual average of only 11.7 maf had flowed past the gages at Lee's Ferry."[24] Because of the structure of the agreements, the shortfall fell entirely on the upper basin, which was required to deliver a minimum of 75 maf to the lower basin over a ten year period.[25]

The solution to the upper basin's problem was all too evident to the Bureau of Reclamation: build more dams to store more water. In 1949, the Bureau proposed the Colorado River Storage Project (CRSP); the original plan called for the construction of four major dams in

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[19] Arizona v. California, 373 U.S. 546 (1963) (one of the main issues was whether the flow of tributary rivers in Arizona would count against its quota; the court decided that these waters were separate).
[20] Codified at 43 U.S.C. § 617.
[21] Miller, *supra* note 9, at 139.
[22] *Id*.
[23] *Id.* at 142.
[24] *Id*.
[25] *Id*. at 142-3.

the upper basin, including two dams that would essentially book-end Grand Canyon National Park, flooding a portion of the National Monument.[26] The plan also called for a dam in Echo Park, part of Dinosaur National Monument.[27] Its purpose was to serve as a "cash register dam" – a giant hydroelectric power plant whose revenue would subsidize agriculture and future Bureau of Reclamation water projects in the region.[28] Opposition to the Echo Park Dam was strong; among other reasons, it would set the precedent of building dams in national parks, leaving a great number of national treasures in peril. The specifics of the battle to stop the Echo Park Dam are beyond the scope of this paper,[29] but the end result is that a trade was made: "for the sake of victory at Echo Park, [opponents] had agreed to leave Glen Canyon Dam alone."[30] The fate of Glen Canyon was sealed, and on April 11, 1956, Congress passed the Colorado River Storage Project Act into law.[31] Construction of the Glen Canyon Dam began on October 15 of the same year, "at the signal of President Eisenhower."[32] GCD stands today 710 feet above bedrock; construction required more than three years, 5.3 million cubic yards of concrete, and $314 million in total.[33]

Section II: Effects of the Glen Canyon Dam

The construction of the Glen Canyon Dam left a remarkable legacy: in addition to a massive concrete structure, the effort significantly changed the geography of the area. The purpose of this section is to understand exactly how GCD has affected the region in which it was built, for better and for worse. These effects can be grouped into three major categories:

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[26] *Id*. at 145; Reisner, *supra* note 4, at 287.
[27] Reisner, *supra* note 4, at 284.
[28] *Id*.
[29] *See generally Id*. at 284-5; *see also* Miller, *supra* note 9, at 145-51.
[30] Reisner, *supra* note 4, at 284.
[31] 43 U.S.C. § 620 et seq.; Miller, *supra* note 9, at 148.
[32] *Id.* at 151.
[33] *Glen Canyon Fact Sheet – Upper Colorado Region Office*, at http://www.usbr.gov/uc/news/gcdfacts.html.

environmental, recreational, and generative. This section of the paper will deal with each of the three categories in separate parts. The final part of this section will discuss whether the dam has lived up to its stated purpose, and whether the current uses of the Colorado River are efficient.

Part A: Environmental Effects

Any time that a river is dammed, there are bound to be significant environmental effects. At the very least, the area upstream from the dam will see significant flooding, while the downstream portion of the river will have a lower flow rate than normal, at least until the reservoir fills to capacity. Given the size and importance of the Colorado River and its watershed - in an otherwise dry region - the effects of a major dam to the surrounding ecosystem must be analyzed carefully. These effects can be broken down into four main types: water storage and flow, flora and fauna, pollution, and effects to the Colorado River Delta.

(i) Water Storage System and Water Flows

Lake Powell, the reservoir that was formed by the GCD, is over 180 miles long with a surface area of over 260 square miles.[34] It is so massive that it took 17 years for the reservoir to fill to its capacity of 27 maf.[35] One of the main hazards of placing a reservoir in a desert is the threat of evaporation: the average high temperatures for Page, Arizona during June, July and August all exceed 90 degrees Fahrenheit.[36] According to the calculations of one commentator, "annual evaporation levels from the reservoir range from 570,000 af to 1 million af per year.

[34] *Wikipedia: Lake Powell* (Mar. 25, 2006), at http://en.wikipedia.org/wiki/Lake_Powell.
[35] David L. Wegner, *Looking Toward the Future: The Time Has Come to Restore Glen Canyon*, 42 Ariz. L. Rev. 239, 244 (2000).
[36] *Weather and Water Temperatures for Lake Powell and Page, Arizona*, at http://www.canyon-country.com/lakepowell/weather.htm.

Pre-reservoir evaporation is estimated to have been 102,000 af per year."[37] But that is not the only water loss suffered by the reservoir; Glen Canyon was formed by the Colorado River cutting its way over millions of years through Navajo sandstone, an extremely porous material. It is believed that substantial amounts of water seep into the sandstone walls every year, with a cumulative volume of about 11 maf by 1983.[38] Put together, it means that the reservoir has a net water loss of at least half a million acre-feet per year – "enough water to have supported over 2.2 million people each year."[39]

While a serious problem, water loss is not the only environmental effect related to the dam's water storage system. Because of the design of large dams, the water that gets released into the river comes from near the bottom of the reservoir. As a result, this water is nearly uniform in temperature year-round; releases "from Glen Canyon Dam have ranged from 43 to 54 F and average about 46 F."[40] Prior to the construction of the dam, temperatures varied by season, following a natural cycle; the warmest temperatures exceeded 80 degrees while the coldest were below 40 degrees.[41] The nearly uniform temperatures that are seen now have significant effects on the animal and plant life in and around the Colorado River; these effects will be discussed in detail in the next part.

In addition to regulation of the water temperature, the Glen Canyon Dam also regulates the flow rate of the water. Before the Dam was built, at its peak (during flood periods), the river could carry as much as 400,000 cubic feet per second of water; during drought periods, that

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[37] Wegner, *supra* note 35, at 248.
[38] *Id*.
[39] *Id.*; *Glen Canyon Fact Sheet – Upper Colorado Region Office*, at http://www.usbr.gov/uc/news/gcdfacts.html ("An acre-foot of water = 325,851 gallons (1,233,350 liters); enough to supply an average family of four for one year")
[40] *Operation of Glen Canyon Dam: Final Environmental Statement* 88 (1995), at http://www.usbr.gov/uc/envdocs/eis/gc/pdfs/Ch3/chap3-1.pdf
[41] Bob Ribokas, *Grand Canyon Explorer, The Colorado River*, at http://www.kaibab.org/misc/gc_coriv.htm.

might be reduced to 1,000 cubic feet per second (cfs).[42] "The flow could change from a few thousand cfs to a couple of hundred thousand cfs in just a few days. The total flow was also highly variable, ranging from 4.4 million acre-feet to more than 22 maf per year."[43] After the dam was constructed the daily flow was initially determined by the needs of the hydroelectric plant. Prior to the 1980s the releases were not regulated and could increase, decrease, or both by as much as 30,000 cfs in a matter of hours, depending on power needs.[44] "The tidal-like waves produced by the daily increase and subsequent decrease in the amount of water released threatened both recreationists and the ecosystem in the Grand Canyon."[45] Today, however, "daily releases from Lake Powell are not permitted to vary more than 5000 cfs in months of low flows and 8000 cfs in months of high flows, with strict limitations on rates of increase and decrease."[46]

In its natural state, Colorado River water has a remarkably high sediment content; much of this is caused by the Navajo sandstone, which is cut into and carried downstream, giving the river its famous red color. "Historic measurements reveal that between 85.9 and 195 million tons of silt, clay, and sand flowed through the [river] each year."[47] Because the water now pools in the reservoir before it is released downstream of the dam, the sediment settles on the bottom, and the water that gets released is essentially free of sediment.[48] "This water can no longer replenish the Grand Canyon's beaches and river corridor because it is 'hungry,' or clear water,

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[42] Reisner, *supra* note 4, at 130; Miller, *supra* note 9, at 125.
[43] Miller, *supra* note 9, at 125.
[44] *Id.* at 160; "During periods of peak demand the 'ramping rate,' or rate of change, in the release of water causes the river to have high and low water lines that have been measured at thirteen feet in a single day. *No natural conditions could ever duplicate this tremendous fluctuation in daily water levels*." Riddle, *supra* note 2, at 124 (emphasis added)
[45] Miller, *supra* note 9, at 125.
[46] *Id.* at 162; *see also* David A. Harpman, *The Short-Run Economic Cost of Environmental Constraints on Hydropower Operation*s 15 (Jun. 1997), at http://www.usbr.gov/pmts/economics/reports/HOPT_REP003.pdf (page number reflects PDF file, not the report pagination).
[47] Wegner, *supra* note 35, at 241.
[48] *Riddle*, supra note 2, at 124.

and quickly erodes the loose soil and sandstone it contacts below the dam."[49] In recognition of the problem, the Bureau of Reclamation conducted an experiment in 1996, simulating a flood through the canyon by releasing 45,000 cfs of water for a week; in the immediate aftermath, several beaches and sandbars were fortified.[50] Unfortunately, within a year, the sand that had been deposited by the simulated flood had once again been removed by the clean water of the dam-era Colorado River, leaving the experiment a failure in the long-term.[51]

It should be clear to the reader now that the environmental effects of the Glen Canyon Dam have been enormous and varied. Glen Canyon and hundreds of small side canyons have been flooded, destroying substantial amounts of riparian land and submerging thousands of archaeological sites. Massive amounts of water are lost to evaporation and absorption. The nature and character of the water that flows below the dam has been altered, and with it the ecosystem that depends on the river.

(ii) Flora and Fauna

The Colorado River basin is home to an ecosystem unique in the world. Over 5,000 species of plants and aquatic animals have made their home in the Grand Canyon area for millennia.[52] Only eight species of fish, however, are native to the region of the basin that encompasses Glen Canyon and the Grand Canyon.[53] Five of these eight are endangered or already extinct, and perhaps only one still has a naturally reproducing population.[54] The changes in water temperature are believed to be the most significant cause of the rapid decline in native

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[49] *Id.*
[50] Miller, *supra* note 9, at 162.
[51] Peter M. Lavigne, *Dam(n) How Times Have Changed…*, 29 Wm. & Mary Envtl. L. & Pol'y Rev. 451, 476 (2005).
[52] Riddle, *supra* note 2, at 122.
[53] Miller, *supra* note 9, at 196.
[54] *Id.*; *see also Nature and Science: Fish*, National Park Service, at http://www.nps.gov/grca/pphtml/subanimals4.html.

fish populations in the area.[55] Other causes include "the introduction of exotic species, the physical obstruction of spawning migrations by Glen Canyon and Hoover Dams, [and] the destruction of habitat[.]"[56] The native species had adapted to the harsh natural climate of the Grand Canyon ecosystem, and find themselves unable to adapt to the cold, clean water of the dam-era Colorado. The native fish also find themselves in competition with twenty species of invasive fish, like rainbow trout, that are better suited to the new Colorado River.[57]

Fish are not the only living species to be harmed by the Glen Canyon Dam. In total, "there are presently seventy-four species of fish, birds, mammals, and plants listed on the endangered species list and another twenty-five on the threatened list"[58] that live in the Colorado River basin. The habitats of many species of birds and amphibians that rely on riparian conditions were destroyed by the flooding of Glen Canyon; it was not just the flood that caused problems, but the change from a river ecosystem to a reservoir.[59] This same phenomenon holds true for plants: many species rely on the replenishment of nutrient-rich soils in annual flooding of the river's banks, but the dam has eliminated both the flooding and the soil replenishment, as described in the prior subpart. Invasive species of plants have taken hold in areas where they were not found naturally, which causes further reductions in the native plant populations through competition for resources.[60]

In terms of species diversity, it actually appears as though the cold, clean waters and reduced flooding have help promote a richer ecosystem in the Grand Canyon and downstream

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[55] Miller, *supra* note 9, at 196.
[56] *Id.*
[57] *See Id.*
[58] Wegner, *supra* note 35, at 252.
[59] *See Id.* at 253.
[60] *See* Larry E. Stevens, *Exotic Tamarisk on the Colorado Plateau*, at http://www.cpluhna.nau.edu/Biota/tamarisk.htm.

than previously existed.[61] Ironically, this phenomenon has helped some endangered species. "For example, bald eagles, which were virtually absent from the Grand Canyon before the installation of Glen Canyon dam, largely prey on cold-water trout that are dependent on the insects that thrive in the unnaturally cold water."[62] In addition, "peregrine falcons . . . which likely existed in substantially reduced numbers historically, prey on the unnaturally abundant smaller birds that prey on [the same] insects."[63] If operations of the Glen Canyon Dam were modified to favor native animal and plant species, or if the dam was decommissioned entirely, it could have the unintended effect of harming these endangered species that have taken up residence in the new ecosystem, and reducing the overall specifies diversity in the area.

(iii) Pollution

Most of the pollution in this area is a result of human activities on Lake Powell. A major tourist destination, boating is one of the most popular activities on the lake.[64] Nearly all recreational craft and houseboats run on petroleum fuels, and pollution is inevitable. "Motor oil and gasoline spilled on the surface of the reservoir are . . . major sources of pollution."[65] In

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[61] Carl Walters, Josh Korman, Lawrence E. Stevens, and Barry Gold, *Ecosystem modeling for evaluation of adaptive management policies in the Grand Canyon*, 4 Conservation Ecology No. 2, at http://www.consecol.org/vol4/iss2/art1/ ("Natural flows (prior to 1963) were violently seasonal, extremely turbid, and highly variable in temperature. Regulated flows have permitted the development of a productive aquatic community in the upper canyon[.]"); *see also* Robert H. Webb, Grand Canyon - a Century of Change Rephotography of the 1889-1890 Stanton Expedition, (quoted in 25 Reasons to Keep Lake Powell, at http://www.lakepowell.org/page_two/information/25_reasons/25_reasons.html) ("Clover and Jotter (1938)...were the first scientists to systematically record observations on the flora of the river corridor. The photographs of Franklin Nims and Robert Brewster Stanton well document the conditions seen by Clover and Jotter; showing a stark river corridor largely devoid of trees and riparian plants . . . most of this zone was devoid of plants because they could not survive the scouring and inundations by periodic floods.").

[62] Miller, *supra* note 9, at 198.

[63] *Id*.

[64] See *infra*, Part C of this section.

[65] Wegner, *supra* note 35, at 254; the gas and oil pollution is "the equivalent of an Exxon Valdez oil spill dumped into the lake every 4.4 years by recreational boating." Jeremiah Centrella, *Charting the Colorado Plateau Revisited, Regional Management Issues* (Jun. 2002), at http://www.coloradocollege.edu/Dept/EC/Faculty/Hecox/CPwebpage/issuespagerestoreGlC.htm.

addition, "due to the large amount of human waste dumped into the reservoir, isolated beaches now must be periodically closed to protect human health."[66] Other sources of pollution include heavy metal accumulation, particularly selenium and mercury; uranium tailings, a form of waste from uranium mining, are also prevalent in the ecosystem.[67] Not all of the pollution is human caused: a significant amount of heavy metals flow through the river naturally, and would be flushed into the seas if not for the dam, which causes them to accumulate on the bottom of Lake Powell instead.[68]

What to do about this pollution is a serious concern. Most of it is currently accumulating at the bottom of the reservoir, along with all of the sand and silt that gets trapped by the dam. In terms of getting a response from the government, the problem is not urgent at this point, since the reservoir has not approached its sediment capacity yet.[69] The problem is most noticeable to recreational users today: several boat launches are no longer accessible because the sediment level has risen and the water level dropped to the point that the area is nothing but (contaminated) mud flats.[70] At some point, attention is going to need to be paid to all of this contaminated sediment, but in the meantime, the land and water will continue to get more polluted, particularly from boaters.

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66 *Id*.

67 *Id*.; *Frequently Asked Questions About Restoring Glen Canyon*, at http://www.glencanyon.org/aboutgci/faq.php ("Sediment, which historically traveled harmlessly to sea are now trapped behind the dam. Naturally occurring heavy metals such as selenium, mercury, boron, lead, and arsenic from upstream sources are contained in these sediments. Additionally, the flooding of Glen Canyon also covered toxic uranium mill tailings near Hite.").

68 *Id*. (Obviously, if GDC were removed, the metals would accumulate instead behind the Hoover Dam; the Colorado would need to be free flowing in order to have these pollutants flush naturally to the sea.).

69 *Frequently Asked Questions About Restoring Glen Canyon*, at http://www.glencanyon.org/aboutgci/faq.php ("Scientific studies predict the reservoir will fill completely with sediment within 300-700 years. However, within 100 years, sediment will reach the River Outlet Works 237 feet above river level, rendering it unsafe in the occurrence of an earthquake or flood."). *Id*.

70 *Lake Powell Information* (Mar. 23, 2006), at http://www.wayneswords.com/primative.htm (this leads to expensive projects to extend road and boat ramps or build new ones in locations less affected by sediment).

(iv) Colorado River Delta

At the end of its run, the Colorado River – in its native state – lets out into the Sea of Cortez. The delta was "one of the world's great estuaries, its vast wetlands supporting an estimated 200 to 400 species of vascular plants and legendary swarms of waterfowl and fish."[71] It was fed by "an average of 13.5 maf of water – about half of the freshwater input"[72] of the Colorado River. During the period of the filling of Lake Powell – 1963 to 1980, the delta was entirely dry: "nothing but mud flats."[73] Today, the delta is roughly five percent of its historic size, and supports but a fraction of the animal and plant life that it once nurtured.[74] The reduction in water to the delta has had significant consequences: "less silt, fewer nutrients, higher salinity, and higher concentrations of pollutants. Erosion – rather than accretion – is now the dominant physical process in the delta, a highly unusual condition for a river delta."[75]

The destruction of the Colorado River Delta poses unique geopolitical problems for anyone who attempts to restore this critical habitat. Although the majority of the Colorado River is in the United States, the delta is located in Mexico, beyond the reach of American laws. As part of a 1944 treaty between the United States and Mexico,[76] the US is obligated to deliver 1.5 maf annually to Mexico from the Colorado River. There is, however, "no provision for allocating water to support the ecological health of the Colorado's riparian zone or the delta and upper Gulf."[77] Even if the Glen Canyon Dam were to be decommissioned, or the flow rates adjusted to require the delivery of more water to Mexico, that would not guarantee any

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[71] Miller, *supra* note 9, at 128.
[72] *Id*. at 127.
[73] *Id*. at 199.
[74] *Id*.
[75] Daniel F. Luecke, Jennifer Pitt, et al*, A Delta Once More: Restoring Riparian and Wetland Habitat in the Colorado River Delta* 4 (Jun. 1999), at http://www.environmentaldefense.org/documents/425_Delta.pdf.
[76] Treaty with Mexico Respecting Utilization of the Waters of the Colorado and Tijuana Rivers and of the Rio Grande, February 3, 1944, 59 Stat. 1219.
[77] Luecke, *supra* note 80, at 11.

revitalization of the delta. Mexico would have the option of using the additional water for irrigation or other consumptive uses, unless another agreement was worked out to guarantee a minimum flow to the delta for preservation of the wetlands ecosystem.

Part B: Power Generation

When the Glen Canyon Dam was proposed and constructed, its primary purpose was to provide "water storage and control of seasonal flood and run-off waters."[78] Power generation was merely "incident" to the storage and flood control aspects;[79] at the time of construction, and even today, the border area between Arizona and Utah is sparsely populated (and lacking industry), having little need for large amounts of power. This potential lack of demand was not problematic for the Bureau of Reclamation, which built the dam with a generating capacity of 1300 megawatts.[80] The 5000 gigawatt hours of marketable energy account for roughly three percent of the electrical capacity in the region.[81] Most of the power is sold – at highly subsidized rates – to local rural power co-ops, Native American nations, and government facilities.[82] Revenue from the dam goes to pay the treasury back for its initial construction costs, as well as to fund other water projects in area.[83]

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[78] Riddle, *supra* note 2, at 123.
[79] 43 U.S.C. § 620.
[80] Miller, *supra* note 9, at 185.
[81] *Id.* at 188; Wegner, *supra* note 35, at 250 (this amount can serve the needs of approximately 210,000 customers per year); however, this 3% comprises a great percentage of the excess capacity in the region: "[d]uring peak load conditions [during the summer], Glen Canyon Dam capability represents 25% of the capacity margin for the Rocky Mountain States, and the South West (excluding California). Without Glen Canyon dam the margin would drop to 12%, or the level where system reliability is in question." *Power Generation,* Friends of Lake Powell, Inc., (1999), at http://www.lakepowell.org/powergen.htm.
[82] *Power Generation*, Friends of Lake Powell, Inc., (1999), at http://www.lakepowell.org/powergen.htm.
[83] *Frequently Asked Questions About Restoring Glen Canyon*, at http://www.glencanyon.org/aboutgci/faq.php.

Prior to 1991, the dam's hydroelectric plant was operated in ways to maximize power production.[84] The main value of the plant was not for its raw power but "for its 'peaking' or 'load-following' – its capacity to respond to fluctuations in power demand. Glen Canyon Dam, like other hydroelectric dams, is optimal for load-following because water can be spilled through its generators almost instantaneously"[85] to provide additional power, whereas coal-fired plants cannot respond so quickly. In 1991, the Department of the Interior issued new guidelines for operating the power plant, as a result of the environmental damage that was being wrecked upon the Grand Canyon by the river's fluctuations – caused by the dam's use for peaking.[86] The result today is less damage to the canyon, but less power available to the grid. One government economist calculated that the current scheme for managing the power plant to minimize environmental impacts "results in a 21 percent loss in generation capacity and a $5 million (6.4 percent) decrease in the short-run economic value of the energy produced."[87] Although the total water released by the dam on a monthly basis has not changed since the implementation of the new guidelines, "less energy is generated during the onpeak hours [7pm-11pm, Monday thru Friday] and more energy is generated during the offpeak hours when it is less valuable."[88] This management scheme – the result of conscious choices to benefit ecological interests – clearly diminishes the dam's primary electrical purpose of load-following, making it less efficient and less economically productive.[89]

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[84] Miller, *supra* note 9, at 186.
[85] *Id*.
[86] *See supra*, note 44, and accompanying text.
[87] David A. Harpman, *The Short-Run Economic Cost of Environmental Constraints on Hydropower Operations* 7-8 (Jun. 1997), at http://www.usbr.gov/pmts/economics/reports/HOPT_REP003.pdf (page numbers given are of the PDF file, not as numbered in report).
[88] *Id.* at 18.
[89] *See* Walters et al, *supra* note 61 ("Water and power interests believe that a significant transfer of benefits has already occurred through reduced daily flow fluctuations beginning in 1990 (currently about U.S.$6 million/yr in lost power revenues . . .), the 1996 BHBF ($2.5 million in lost power revenues plus $1.5 million in research costs), and through support of current research and monitoring activities . . . (>$9.6 million in fiscal year 2000).

Part C: Recreation

The creation of Lake Powell initiated an era of increased recreation through Glen Canyon and the Grand Canyon. In 1963, roughly 44,000 people visited Glen Canyon to take a "last look" before the land was inundated with water.[90] Today, there are more than four million visitor-days a year to Lake Powell; much of this is for water-sports, including owners of houseboats, ski boats and jet skis, who make up over 1.5 million boater nights a year.[91] These tourists bring in over $400 million to the local economy.[92] "The busiest gas station in Utah floats on the reservoir at Dangling Rope Marina, and the estimated value of the boats themselves at lake Powell is $191 million."[93]

Significant tourist industries were also created downstream from the dam, complementing the lake-enabled recreation. By controlling the flow rates, dam engineers working the hydroelectric plant inadvertently extended the rafting season to encompass more months every year.[94] Prior to the dam's construction, no more than 200 people per year rafted through the Grand Canyon.[95] Today, more than 50,000 rafters and boaters travel the Colorado River through the Grand Canyon each year, and they provide more in revenue to the region than the hydroelectric power plant at Glen Canyon Dam.[96] The fact that the water is now cold and clear as it leaves the dam has nurtured another tourist industry, as 20,000 come to the Colorado every year to fish its waters for rainbow trout, an invasive species that thrives due to the changes

Stakeholders representing ecological and recreational values believe that the rate of transfer of benefits has not been fast enough. From their perspective, the Grand Canyon ecosystem has been subsidizing an annual benefit of about U.S. $70 million worth of power from Glen Canyon Dam, in addition to the benefits from supplying water for irrigation and urban development since 1963. Undoubtedly, the desired rate of transfer of benefits for different stakeholders depends on their individual value systems.") (internal citations omitted).

[90] *Miller, supra note 9,* at 190.

[91] Wegner, *supra* note 35, at 254-5.

[92] *Id* at 255.

[93] *Id.*

[94] Miller, *supra* note 9, at 190.

[95] *Id*. at 191.

[96] *Id*. at 190-1.

in the water brought about by the dam.[97] Overall, though the dam was not originally constructed with recreation as a priority, it has created a financial boon for an otherwise sparsely populated corner of America, as marinas, convenience stores, motels and gas stations have sprouted up to support the tourist economy. Management issues of the dam, then, are clearly complicated by the fact that tourism and recreation have the largest economic impact of any activity associated with the dam.

As remarkable as the increase in tourism at Glen Canyon has been since the erection of the dam, when viewed in isolation, the numbers do not tell the whole story. By analyzing data from the National Park Service Visitation Database for other parks and recreation areas in the region, a more accurate view of the impact of the dam – regarding recreation – can be determined.

Recreation Visits by Year:[98]

Year	Glen Canyon	Bryce Canyon	Grand Canyon	Zion
1950	N/A	219,976	665,039	323,402
1955	N/A	254,200	892,400	406,800
1960	196,400 (1964)	272,000	1,187,700	575,800
1965	303,500	366,800	1,689,200	763,600
1970	907,500	345,900	2,258,200	903,600
1975	1,108,800	579,200	2,625,100	1,055,200

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[97] *Id.* at 190.

[98] *National Park Service Visitation Database*, at http://www2.nature.nps.gov/NPstats/select_report.cfm?by=year. Individual Park information is generated dynamically (no static URL) – One the site options i to extract the data as an Excel file; information was copied directly from the Excel file for each park. Note that methodologies for each park may differ, so attempts to compare between parks (e.g., Grand Canyon was more than twice as popular as Zion in 1975) may be misleading. Also, while these numbers do not account for all visits to the parks, this is the best the author could find as far as comparative figures, and should represent an adequate proxy for total visits.

Taking the number of visitors from 1963 (44,000) quoted above, as accurate,[99] that means there was a 346% increase in tourism at Glen Canyon in one year alone, followed by a 54% increase the next year. Between 1965 and 1970, there was an additional 199% increase. No other park in the region saw increases anywhere this large over the same time period.[100] At Bryce, there was only a 23.6% increase between 1950 and 1960; between 1960 and 1965, 34.8% increase in recreation days, and between 1965 and 1970, there was a decrease of about 5.7% - which appears to be an anomaly given the large increase by 1975. At the Grand Canyon, the decade 1950 to 1960 saw a 78.6 percent increase in use; from 1960 to 1965 there was an additional 42.2% increase, and from 1965 to 1970, recreation days increased another 33.7%. Finally, Zion saw visits increase 78% from 1950 to 1960; 32.6% from 1960 to 1965; and 18.3% from 1965 to 1970. There is clearly a positive trend in visitation and use of all the parks in the region; this could be due to a number of factors, including the construction of the federal interstate highway system[101] and increasing automobile ownership among the general public,[102] both of which would make accessing remote national parks considerably easier for the average American (or foreign tourist). Regardless of the general trends, it is clear that the increase in recreation days at Glen Canyon exceeds that of other parks, and a large part of that must be due solely to the dam and its effects. In other words, if the dam had not been built, Glen Canyon probably would have seen a large increase in visits over the last 45 years proportional to the

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[99] 1964 is the first year of data available from the NPS.
[100] Unfortunately, it is not possible to determine the exact nature of the recreation uses, and the author was unable to find any more detailed use figures from the National Park Service. It would be helpful to perform additional analyses on what types of recreation saw the greatest increases at each park, but the necessary data does not appear to exist, at least in an easily publicly accessible form.
[101] Federal-Aid Highway Act of 1956, 23 U.S.C. § 139.
[102] *Automobile Registrations for Selected Countries, 1950-2002*, Transportation Energy Data Book, at http://www-cta.ornl.gov/data/tedb24/Spreadsheets/Table3_01.xls (roughly 50% increase in car registrations in US during 1950s – an increase that has not even come close to being matched since).

increases at nearby parks, but the number of visitors – and the revenue they bring the area – would be a fraction of the figures today.

Part D: For What Purpose? And is it efficient?

As discussed above, the primary rationale for the dam was to increase water storage capabilities. If this is the measure by which the dam is to be judged, then one may conclude that it has been less than successful. Even before the dam was constructed, scientists knew that the net storage effects of the reservoir were potentially insignificant, due to diminishing returns from increased evaporation as reservoir size is increased.[103]

> A recent computer simulation of the effects of draining Lake Powell on water administration of the river confirms these results. The simulation showed that in average years, decommissioning Glen Canyon Dam would have no impact on water deliveries in the Upper Basin, would decrease the delivery of water to the Lower Basin by one percent . . . and would *increase* the total availability of water by approximately 500,000 acre-feet per year.[104]

Inefficient storage is not the only problem with the reservoir. Because of its placement at the very bottom of the upper basin, it does not provide any protection from droughts to the upper basin states. If Colorado or Wyoming needed to draw upon the stored reserves of Colorado River water to irrigate crops or provide water to homes during a drought, the water stored at Lake Powell could not help them because it is south – downstream – of those locations.[105] The only benefit that Lake Powell provides to the upper basin is the assurance that it will be able to

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[103] Miller, *supra* note 9, at 174 ("In 1959, Walter Langbein calculated that '[w]ater control by storage follows a law of diminishing returns . . . . The gain in regulation to be achieved by increasing the . . . capacity appears to be largely offset by a corresponding increase in evaporation.'" (alteration and first ellipses in original)); evaporation imposes other costs on the system due to increased salinity of the already-salty Colorado River – as more water evaporates from the reservoir, the remaining water retains an increased proportion of salt.

[104] *Id*. (emphasis added) (though it is important to note that drought conditions were not studied in the simulation; in drought situations, when flows of the river are less than the Upper Basin's use plus the Lower Basin's allocation, the storage is needed to make up the difference).

[105] Unless, of course, and entirely new pumping system were installed to bring the water back to these states from the reservoir, but that would certainly be cost prohibitive, not to mention illogical.

meet its quota under the compact to deliver 7.5 maf to the lower basin each year.[106] Given that Lake Mead, a reservoir larger than Lake Powell, is in the lower basin, "[s]ome analysts theorize that there would have been no need for the Glen Canyon Dam if they had merely changed the upper basin's delivery point from Lee's Ferry to the foot of the Hoover Dam[.]"[107] That would have shifted Lake Mead to the upper basin, and provided the same delivery assurances that Lake Powell does today.[108] In the end, it may be too early to pass final judgment on the storage capabilities of Glen Canyon Dam. There have been minor droughts since its construction, but nothing truly severe or prolonged. We may not know until such a drought occurs whether the storage capacity was actually needed to avoid delivery shortfalls to downstream users.

The second primary reason to build the dam was flood control. Lake Powell was designed to take pressure off of Lake Mead, to prevent flooding downstream from the Hoover Dam.[109] "However, during its more than twenty years of operation at capacity before Glen Canyon Dam was constructed, Hoover Dam only spilled once, and the spill was a purposeful test."[110] This does not, of course, mean that a natural flood would never occur, as precipitation variability occurs on cycles far longer than twenty years. But it does point to the fact that Hoover Dam is well-enough equipped to handle natural flooding without catastrophic failure.

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[106] *Id*. at 178; this is not an insignificant benefit, despite the fact that the environmental lobby tries to minimize it – in a prolonged drought, if the upper basin could not meet its quota (and Lake Powell were drained), it was be disastrous for the lower basin water users who rely on their allocation – this includes users like the Metropolitan Water District of Southern California. *See Coping with Severe and Sustained Drought in the Southwest* (May 18, 2004), at http://geochange.er.usgs.gov/sw/changes/natural/codrought/impacts.html ("In some months, some stretches of river would be completely dry in order to maintain reservoir storage elsewhere in the system. Water levels in Upper Basin reservoirs (like Powell Dam) would decline to "dead storage" levels [at which point releases of water are mechanically infeasible] during the worst years of the drought. Reservoirs in the Lower Basin (like Hoover Dam) would still have water in active storage during the worst years.") (internal references omitted).

[107] Bruce Clotworthy, *Parched: The Future of the Glen Canyon Dam in a Drier West*, 17 Utah Bar J. 8, 8 (2004).

[108] There is considerable debate among the two sides as to whether the storage purposes of Lake Powell are important. Lake proponents point to the 1950s and 1960s droughts, when the level of Lake Mead dropped precipitously; now, with Lake Powell, there is added insurance in the system to ensure that the power works in Hoover Dam are not threatened by low water levels. *See, E.g.*, *25 Good Reasons Not to Drain Lake Powell*, Friends of Lake Powell, at http://www.lakepowell.org/page_two/information/25_reasons/25_reasons.html.

[109] *Miller*, supra note 9, at 177.

[110] *Id.* at 177-8.

Further reducing the need for Lake Powell, 9 maf of storage has been added since 1960 between the two major reservoirs.[111] Once again, Lake Powell may appear difficult to defends based on its initial rationales. This does not, of course, mean that the dam is worthless. It just seems to prove that as time has gone by the unintended, or incidental, consequences of building the dam have proven to be as important, if not more important than the stated purposes at the time of proposal and construction.

While one could conceivably conclude, based on the evidence provided above, that the promised storage and flood control benefits have not fully materialized with the construction of the Glen Canyon Dam,[112] the question of whether the current uses of the Colorado River water are efficient is yet more complicated. Currently, upper basin states do not even use their entire 7.5 maf quota; only about 4 maf is actually used by these states.[113] "With development, use in the Upper Basin is projected to reach approximately 5 million af by the year 2030."[114] Combined with the fact that over 80 percent of Colorado River water is used for agricultural purposes,[115] it would appear easy to conclude that the current allocations and uses are inefficient. After all, the southwest has the fastest growing population in the country, which cannot be sustained without adequate supplies of water. This precious resource should not be wasted on cotton and citrus farms, but should be used to support the burgeoning populations of metropolitan cities like Las Vegas and Phoenix. Of course, nothing in life is really as easy as a declaration that Colorado River water should be used to sustain human populations instead of crops.

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[111] *Id.* at 178.
[112] This author would prefer to equivocate on that point, deferring until we have seen a more prolonged drought to know how the storage capacity performs under severe stresses (though, of course, hopefully that will not happen in our lifetimes).
[113] Wegner, *supra* note 35, at 249.
[114] *Id.*
[115] *Colorado River Water Users Association: Agriculture Uses*, at http://www.crwua.org/colorado_river/agriculture.htm.

Though not as populous at Phoenix, Tucson is nonetheless a major metropolitan area, situated in the Sonoran Desert roughly 100 miles south of Phoenix. By the late 1980's, the city realized that it faced a major problem: the aquifers that were supplying Tucson residents with fresh water were being depleted at an alarming rate.[116] Tucson looked to the Colorado River to supply additional water, in order to prevent further depletion of its groundwater source, which has been causing significant subsidence problems throughout the city.[117] The Central Arizona Project (CAP)[118] brings Colorado River water over 330 miles from Lake Havasu, Arizona to Phoenix, and then down to Tucson via open-air canals.[119]

> Starting in November 1992, CAP water was delivered to approximately 84,000 customers . . . . Problems were soon reported by some customers. Many people complained of red, brown or yellow-colored water coming from their taps. Some reported broken pipes, damage to water-using appliances such as water heaters or evaporative coolers, skin rashes, and even dead fish in aquariums and damage to pools.[120]

By November 1994, deliveries of CAP were stopped in order to make repairs to the system, and the Tucson City Council voted to discontinue direct delivery to households because of the poor water quality and resultant problems.[121] As this example illustrates, delivering water to people

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[116] Joe Gelt et. al, *Water in the Tucson Area: Seeking Sustainability*, at http://ag.arizona.edu/AZWATER/publications/sustainability/report_html/chap3_01.html ("Since 1940, approximately 6 to 8 million acre-feet, or 9 to 11 percent of the total has been withdrawn" from Tucson's aquifers.).

[117] *Id*. at http://ag.arizona.edu/AZWATER/publications/sustainability/report_html/chap3_02.html#impacts ("The U.S. Geological Survey (USGS) reports that since 1940 groundwater levels in Central Arizona have dropped over 220 feet, with Central Tucson subsiding at least one foot since 1950."); on a personal note, the house owned by the parents of the author, located in central Tucson, has been damaged by subsidence – large cracks are evident throughout the walls and ceilings.

[118] The Central Arizona Project was authorized as part of the Colorado River Basin Project Act in 1986; see Earl Zarbin*, Central Arizona Water Conservation District A Miracle of Unity*, at http://www.cap-az.com/about/index.cfm?action=founding&subSection=5 for a detailed history.

[119] Gelt, *supra* note 115, at http://ag.arizona.edu/AZWATER/publications/sustainability/report_html/chap2_04.html.

[120] *Id*. at http://ag.arizona.edu/AZWATER/publications/sustainability/report_html/chap2_04.html; on a personal note, the author visited friends in December 1992 (or so) who had been switched to CAP water, and became ill within an hour of drinking CAP water for the first time.

[121] *Id*. at http://ag.arizona.edu/AZWATER/publications/sustainability/report_html/chap2_05.html; today, CAP water is blended with groundwater before it is delivered to Tucson customers. Maureen O'Connell, *Flow begins across Tucson Thursday, with Little River Water in the Mixture* (Apr. 29, 2001), at http://www.azstarnet.com/cap01/sunday.html.

who need it is not necessarily as easy as it appears at first glance. The millions of dollars that were spent to treat and deliver CAP water to Tucson residents, along with the water that was used during the first experiment, ended up being essentially wasted.

Such experiences may lead one to argue that the current uses of the Colorado River water are generally efficient, since some agricultural crops (cotton, barley) are more resistant to high salinity than people. This is not to say, however, that water with high salt content is compatible with sustainable agriculture. Due to a number of factors, including evaporation and agricultural effluent, Colorado River water becomes increasingly saline as it travels downstream. Large areas of once-irrigated land in California and Arizona are unsuitable for agriculture because the soil quality has been so heavily degraded as a result of the high salt content.[122] South of the border, the small amount of water that actually makes it to Mexico had originally been unusable for agriculture due to the salinity.[123] While Mexico was guaranteed 1.5 maf annually, there was no guarantee as to the quality of the water; in 1974, President Nixon signed an agreement assuring that Mexico would not received poisoned water, which was vitally important because the Colorado River watershed contains some of the most agriculturally important land in all of Mexico.[124] "The simplest and cheapest way to solve Mexico's salinity crisis would have been for the U.S. government to buy out the . . . farmers [whose irrigation contributes significantly to the problem] and retire their lands."[125] Instead, the world's largest reverse-osmosis desalinization plant was constructed near Yuma, Arizona, at a reported (but widely thought understated) cost of $293 million.[126] "In its brief eight-month life, it never operated at more than one-third of capacity and processed a grand total of 23,000 acre-feet of water - about the same

[122] Reisner, *supra* note 4, at 461.
[123] *Id*. at 463.
[124] *Id.* at 463-4.
[125] *Id*. at 464.
[126] *Id*. at 464.

amount that would be used in a year on just six average-sized cotton farms."[127] Annual operating costs were estimated at between $25.8 million (Bureau of Reclamation) and $33.7 million (inspector general).[128] To put those expenses into perspective, assuming that the desalinization plant remains idled,[129] the total costs have been at least $310.2 million.[130] One acre-foot of water contains 325,851 gallons;[131] multiply that by the 23,000 acre-feet that were processed, and we find that 7,494,573,000 gallons of water were treated during the plant's operating lifetime. The per gallon cost of that desalinization was a staggering $0.041 – or roughly one-twentieth the cost of buying one gallon of bottled drinking water at the local supermarket. The corporate farms that purchase subsidized water from the Colorado River (upstream from the Yuma plant) pay about $3.50 per acre-foot,[132] or roughly $0.000011 per gallon. That means the government paid over 3,700 times more to treat the water than it was charging the very users who caused much of the need for the desalinization treatment in the first place by their irrigation practices.[133]

The above examples illustrate a significant problem: the water in its current form is unsuitable for human consumption, and ill-suited to sustainable agriculture. These are two of the main ways in which water can be used beneficially, particularly in an arid climate like the desert Southwest. Do the problems with the water quality, resulting in large part from irrigation practices, necessarily mean that the current uses are inefficient? It is difficult to determine how

[127] Martin Van Der Werf, *Draining the budget to desalt the Colorado* (Feb. 21, 1994), at http://www.hcn.org/servlets/hcn.Article?article_id=97.
[128] *Id*.
[129] *Plans Announced to Restart Desalinization Plant Near Yuma*, U.S. Water News Online (May 2005), at http://www.uswaternews.com/archives/arcsupply/5plananno5.html (to date, nothing has happened toward getting it operating again).
[130] $293 million sunk cost plus 8 months at $25.8 million per year ($17.2 million.)
[131] *Supra,* note 39.
[132] Reisner, *supra* note 4, at 464.
[133] *Id.* at 462-5 (large amounts of water are recycled by the farms, increasing the salt content with each iteration; once the water is too salty to use on their plants, they dump it back into the river).

the practices can be modified in such a way as to make them more economically efficient, given the current legal regimes and political climate.[134] The corporate farmers wield considerable power, and are not likely to give up their subsidized water (and power) without a fight. Even the large cities like Tucson and Phoenix cannot complain too loudly about the water quality, as they know that they are dependent (or will soon be) on the water to maintain population growth. If the alternative is not getting any Colorado River water, cities will do what they need to on their own, at their own expense, to bring the water up to a usable quality; they know that they cannot wait for the federal government to step in and save them.

If one thing here is clear, it is that the decision-making processes regarding water allocation and use have been flawed, resulting in vast amounts of money that have been wasted on inefficient, poorly thought out projects. It leads one to question how these decision are made in the first place, and why we, as taxpayers, are forced to finance (among other boondoggles) irrigation projects to grow surplus crops on desert land that is otherwise unsuitable for such uses, using water whose price to the farmers reflects only a fraction of its total cost. Is the root of the problem that these decisions are made by unaccountable administrative agencies like the Bureau of Reclamation, or is it the machinations of influential politicians like Arizona's former Senator Carl Hayden, who made sure that water projects in the Southwest, including the Central Arizona Project, would be funded and built?[135] Might there be other factors at work that distort the democratic process, or is this the best we can hope for in today's world, particularly given the reality of the recreation dollars generated by Lake Powell, which sustain entire towns that would

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[134] This illustrates an important connection between the rationales for building the dam and the efficiency of the uses – does it make sense for the federal government to build gigantic reservoirs to store water that will then be used for agriculture, which benefits only a few large corporate owners? One could argue that such large public works projects should include a requirement that the end use of the water will not just be "beneficial" but actually benefit living people. This would not only end a considerable amount of corporate welfare, but it would solve a lot of the quality problems with the Colorado River water.

[135] George F. Will, *Carl Hayden's Water* (Apr. 23, 2006), at http://www.townhall.com/opinion/columns/georgewill/2006/04/23/194747.html.

otherwise disappear from the map? While it would be impossible here to even begin to answer these questions, it is important that they be raised, as it appears that the whole history of water rights in the Southwest has been afflicted with puzzling pattern handouts and subsidies, with the public left footing astronomical bills on every occasion.

Section III: Squeezed to the Point of Catastrophe?

In 1996, the Sierra Club adopted a position in favor of the draining of Lake Powell and the decommissioning of the Glen Canyon Dam.[136] Several law review articles have since been written about the subject, identifying the relative pros and cons of letting the Colorado River run free through Glen and Grand Canyons.[137] Congress even held oversight hearings on the subject in 1997.[138] Despite these efforts, little actual momentum has been gained in the fight to free (this portion of) the Colorado. Entrenched interests, including the energy and recreation/tourism industries, have too much to lose to see the dam decommissioned without a major fight. To counter the efforts of the Sierra Club and other environmental organizations, pro-Lake Powell forces have mobilized and formed their own organizations to lobby for the preservation of the dam and lake.[139] This section of the paper will illustrate why neither side is entirely correct, and how nature may have its own plan for the region. Part A will briefly cover the results that would be expected from draining Lake Powell, in relation to the three categories discussed in Section III (environment, recreation, power generation). Part B will discuss how two causes, sediment and drought, are independently threatening the future of the lake.

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[136] *See* Reed McManus, *The Comeback Canyon Drought is Draining Lake Powell*, at http://www.sierraclub.org/sierra/200311/canyon.asp.
[137] *See, E.g.*, Wegner, *supra* note 35; Miller, *supra* note 9; Riddle, *supra* note 2.
[138] Wegner, *supra* note 41, at 240.
[139] *See, E.g.*, *Friends of Lake Powell*, at http://www.lakepowell.org.

Part A: Draining Lake Powell

(i) Environmental Effects

{a} Water Storage

As discussed above, draining Lake Powell would have few effects on the total delivery of water to the lower basin states, except perhaps in times of extreme, prolonged drought. In nearly all other aspects of water management, however, this action would have significant consequences. The most obvious effect would be the loss of Lake Powell as a standing body of water. This has actually already begun happening in some places, as dry conditions have significantly dropped the level of the reservoir since 1999. In January 2005, the reservoir was only 37% full, and several side canyons have been exposed by the receding waters.[140] "For example, the Lower Escalante near its confluence with Coyote Gulch, which was previously under water as recently as 1999, is now lined with 20-foot tall vegetation and exhibits little evidence of its recent submersion."[141] In addition, the white ring of mineral deposits in the sandstone that appeared as the waters receded has also disappeared in many places after being exposed for a few years.[142] This evidence shows that the canyon would likely recover to a condition near that of the pre-Lake basin, though it would probably take several decades – or more – for the full restoration.

In the area below the dam, similarly drastic changes would occur. If new spillways were created and the Colorado was allowed to run completely unaltered through this portion, large amounts of sediment that are now trapped above the dam would wash through the Grand

[140] *The Restoration of Glen Canyon*, Glen Canyon Institute, at http://www.glencanyon.org/library/glenrestoration.php (page contains photographs illustrating areas where canyons have been reclaimed from the shrinking lake).
[141] *Id.*
[142] *Id.*

Canyon, as happened during the 1996 "flood."[143] Unfortunately, because of the contaminated nature of the current sediment, the Grand Canyon would probably see an increase in pollution for the first several years after the dam is decommissioned.[144] Eventually, though, the system would reach an equilibrium and the contaminated soil would be flushed through the river into the delta, and finally to the Sea of Cortez.[145] The unrestricted water that would run through the canyon would return to its original temperature variations and high sediment content, and that would cause significant effects to the animals and plants that have adapted to the dam-era river.

{b} Flora and Fauna

The greatest changes to the plants and animals in the river basin would occur below the dam. Since the dam was erected, new species of fish and invasive plants have made their homes in the cold, clear water flowing through the Grand Canyon.[146] If the river were to revert to its natural state, it could kill off many of these animals or force them to migrate to more hospitable waters. At the same time, it is unlikely that the currently endangered species would make significant recoveries. The populations have been devastated by the rapid change in the river, and unless the dam were physically removed – which is less even likely than a mere decommission – it will still provide a physical barrier between the current river and the portion of the river that would be reclaimed by draining the lake.[147] If the dam were modified to allow fish to cross easily, it "raises the concern that exotic species will move into the new habitat more successfully than would the natives, thereby aggravating threats posed by competition."[148]

[143] See *Supra*, notes 56-7, and accompanying text.
[144] This could be avoided, but it would take a massive dredging effort that would almost certainly be cost prohibitive.
[145] Or, more likely, it would just accumulate behind the Hoover Dam.
[146] See *supra*, notes 62-8, and accompanying text.
[147] Miller, *supra* note 9, at 197-8.
[148] *Id*. at 197.

Most interestingly, from a legal standpoint, is the fact that endangered species have taken up residence and rely on the cool, clear waters of the river. It raises questions under the Endangered Species Act (ESA), which are beyond the scope of this paper, but worth noting generally. Changes in the operation of the dam, even decommissioning it entirely, could be stopped by courts under the authority of the ESA, if it threatened the populations of bald eagles or peregrine falcons.[149]

Plant life in the canyon would be affected in similar ways. "Natural flows through the canyon would build sandbars and reduce riparian vegetation, thereby likely decreasing the species diversity."[150] On the other hand, "[r]estoring the natural flow dynamics to the Colorado River will provide the seasonal high flows (floods), hydrographs necessary for shallow-water habitats, and low flows necessary for exposure of sediments for plant recruitment."[151] The addition of pollution from the currently trapped sediment could have negative impacts on the plant life as well. Though the possibility also exists that the plant life could absorb some of the pollutants, cleaning the river in a process known as phytoremediation.[152] Regardless, there is no doubt that significant changes would occur to the plant life sustained by the Colorado River.

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[149] Clotworthy, *supra* note 104, at 9 ("The ESA indeed that the power to challenge the validity of a giant dam project as it did in the landmark case, *Tennessee Valley Authority v. Hill.* In that case, the presence of the endangered snaildarter was enough to half the construction of the mighty Tellico Dam."). Of course, the article is discussing using the ESA to advocate returning the river to its natural state, not to keep the status quo, but the argument can be made either way since there was a native endangered population supplanted by invasive endangered populations as a result of the ecological changes. How would a court rule on this? The author does not claim to have an answer – it is, however, an interesting question to raise.

[150] Miller, *supra* note 9, at 198 (as discussed above, it is interesting to note that species diversity has actually increased in the area since the dam was built; while native species have been decimated, they've been replaced by a greater variety of flora than previously existed).

[151] Wegner, *supra* note 35, at 253.

[152] Kelly E. Belz, *Phytoremediation* (1997), at http://ewr.cee.vt.edu/environmental/teach/gwprimer/phyto/phyto.html.

{c} Pollution

As discussed above, pollution concerns would be brought out in the contexts of river storage and the effects on plant and animal life in the river ecosystem. Heavy metals, human waste, and petroleum pollution have turned the bottom of Lake Powell into a thick muck of contamination. By letting the river run free through the canyons, much of this pollution will either have to be dredged out or it will end up somewhere downstream. It might be absorbed by plants in the Grand Canyon, or it might move to the reservoir at Lake Mead, creating more pollution there; it may even find its way all the way to the Colorado River Delta, contaminating the estuary further. In the end, some governing body needs to take a serious look at the pollution problem; there could be a serious ecological disaster if the dam were to be decommissioned without taking into account what will happen to all of the contaminated soil and sediment when the waters run free.

If nothing is done about the problem, and large amounts of the lake-bed become dry, the problem could turn out similar to the one faced at Owens Lake in California. There, a historic lake has been left empty by diversions (primarily) for agricultural uses, leaving behind a dry mass of fine silt.[153]

> The dry bed of Owens Lake has produced enormous amounts of windblown dust since the desiccation of the lake. The term "Keeler fog" (for the town on the east side of the lake) was coined locally decades ago for the pervasive, unusually fine-grained, alkaline dust that infiltrates the smallest cracks and contaminates residences. The lake bed is probably the largest single source of PM10 dust (aerosol particles smaller than 10 microns in aerodynamic diameter) in the United States; by one estimate, 900,000-8,000,000 metric tons per year.[154]

Certainly, the last thing the Southwest needs is large masses of blowing dust – and contaminated dust no less. While the accumulated silt and sand in some portions of Lake Powell would wash

[153] Marith, C. Reheis, *Owens (Dry) Lake, California: A Human-Induced Dust Problem* (Dec. 1, 2003) , at http://geochange.er.usgs.gov/sw/impacts/geology/owens/.
[154] *Id*. (Internal references removed).

downstream, in the wider areas of the lake-bed, much of the sediment would probably remain behind.

{d} Colorado River Delta

Decommissioning the Glen Canyon Dam may not have any measurable impact on the delta. Even if every acre-foot of water that is currently deposited in the reservoir were allowed to flow downstream, there is no guarantee that it will reach the delta. First, there is Lake Mead, the level of which has been dropping significantly over the last few years.[155] The water would initially just pool there, and not go any further. But even if it made it past the Hoover Dam, and all the way to the Mexico border, it would still not necessarily reach the delta. The US is obligated to deliver 1.5 maf of water to Mexico, but what Mexico then does with it is out of the control of the United States. Even if the flow rate were increased, there is nothing to stop the Mexican government from diverting the entire volume for irrigation or other productive uses. In short, it would take an international agreement to restore the delta, and removing the Glen Canyon Dam would have – at best – minimal effect in this area.

(ii) Power Generation

If the hydroelectric power plant at Glen Canyon Dam was taken off-line permanently, there would be a substantial impact to the power grid in the Southwestern United States. Though this one plant produces only a fraction of the power in the Rocky Mountain region, it is nonetheless a very important power source for system reliability.[156] If the hydroelectric plant were taken off-line, the capacity would need to be replaced somewhere else in the system; that

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[155] Jesse Allen, *Drought Lowers Lake Mead*, NASA Earth Observatory (Nov. 13, 2003), at http://earthobservatory.nasa.gov/Study/LakeMead/.
[156] See *supra*, note 86, and accompanying text.

almost certainly means building new generating stations, which will increase air pollution from carbon dioxide emissions and have increased operation costs.[157] A traditional coal power plant, for example, emits over 2,000 pounds of carbon dioxide per Megawatt Hour of power generated.[158] This is not an insignificant amount of pollution, and it needs to be accounted for in any plan to replace the power produced by the GCD.

The Glen Canyon hydroelectric plant is not the only generation station in the area that would be affected by the lake. The Navajo Generating Station is a traditional coal-fired power plant located nearby, that uses water from Lake Powell for cooling.[159] Debate exists as to whether the Navajo Generating Station would have to be shut down if the lake was drained.[160] Either way, there would be substantial costs imposed on electricity purchasers in the Southwest,[161] and create instability during summer months when peak loads tax the power grid.[162] The environmentalists who have written about this subject have not provided adequate answers for replacing the electrical capacity that would be lost. Merely stating that additional costs and pollution will result, and moving on, is not going to win arguments against energy companies and the 30 million people who receive cheap power from the Glen Canyon and Navajo Generating Stations.

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[157] Miller, *supra* note 9, at 187.

[158] *All About Geothermal Energy – Environment*, Geothermal Energy Association, at http://www.geo-energy.org/aboutGE/environment.asp.

[159] *$20 Million Plan for Generating Station in Drought-Stricken Lake* (Sep. 10, 2004), at http://www.sfgate.com/cgi-bin/article.cgi?file=/news/archive/2004/09/10/state1103EDT7124.DTL.

[160] *See, E.g., Navajo Generating Station*, at http://www.glencanyon.net/navajo.htm (claiming it would need to be shuttered if the dam were decommissioned); *but see* Wegner, supra note 35, at 250-1 ("Maintaining the generating station after the reservoir is drained would require either extending the cooling water intake to the river, developing a more efficient cooling system for the generation station, developing a closed cycle cooling system, or some combination of these methods. It would raise the short-term cost of power from the Navajo Generating Station but would not require the plant to be closed down.").

[161] *Navajo Generating Station*, at http://www.glencanyon.net/navajo.htm (Los Angeles owns 1/5 of the generating station's power, and Las Vegas owns more than 10 percent).

[162] See *supra*, note 86, and accompanying text.

(iii) Recreation

Obviously, the largest impact on recreation from the draining of Lake Powell would be the total loss of boating activity on the Lake. Boating activity represents the largest portion of the $400 million in tourist activity taking place in the region.[163] Losing this activity would be devastating for Page, Arizona, the town many boaters pass through on their way to the Lake. Tourism accounts for the majority of the economic activity in Page, a town that exists essentially because of Lake Powell.[164] Environmentalists posit that the lost boating tourism would be replaced by back-country tourism,[165] but it is implausible that the increase in use of the reclaimed Glen Canyon would make up for the economic and recreational juggernaut that is Lake Powell today.[166]

Impacts on recreation in the Grand Canyon itself would be noticeable, though not as severe as the loss of boating on the Lake. Even if the entire prized trout fishery were destroyed, that would only put out 20,000 people a year, less than 2% of the number of boater days using the surface of the lake every year. In terms of river activity, given the waiting lists to take boat and raft tours through the Grand Canyon, plus the shorter rafting season that exists naturally, there is almost no chance of an increase in activity on a free-flowing river.[167] Rather, the

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[163] See *supra*, note 93, and accompanying text.

[164] Traci Watson, *Drought shrinking jewels of the desert: Drops in Lake Powell, other lakes in West threaten tourism, entire towns*, USA Today 15A (Sep. 29, 2004), at http://www.usatoday.com/printedition/news/20040930/a_lakes30.art.htm?POE=click-refer.

[165] Wegner, *supra* note 35, at 255. ("A drained reservoir would provide areas useable by recreationists such as river runners, day hikers, and backcountry advocates, who would likely make up for the 1.5 million boater days." *Id.*; The author finds this claim pure fantasy – boating is, by its nature, expensive, and brings in far more revenue per capita than backcountry uses. Boaters require fuel, and houseboats, a common site on Lake Powell, are equipped with full kitchens, meaning that users can bring large amounts of food and drink with them when on the Lake. On the other hand, backpackers and other environmentally-conscious users take pains to only bring with them what they need, and live by rules such as "pack it in – pack it out" and "leave no trace" of having been present in a given area.).

[166] *See supra*, note 96, and accompanying text (showing that the increase in tourism at Lake Powell is due in large part to the dam, and is disproportionate to the increases at other nearby national parks).

[167] Jim Wright, *Rafting the Grand Canyon Discover the Colorado's Sacredness, Power, and Lure*, at http://gorp.away.com/gorp/location/az/pad_grandcanyon.htm. ("For private boaters, a Grand Canyon permit is the

shortened season would decrease the number of people who could traverse the river each year, leading to a loss in revenue for commercial boat operators,[168] since boat operations already run at capacity allowed by the government. Therefore, the net effects on recreation, currently the highest revenue generating activity associated with the Glen Canyon Dam, are certain to be negative if the Lake were to be drained.

Part B: Nature's Plan for Glen Canyon

Lake Powell is being attacked by two competing forces of nature: drought, and sediment. One cuts the flow of the river and increases the amount of evaporation from the reservoir, while the other slowly fills the reservoir and creeps up to the level of the hydroelectric works, threatening to shut down the power plant. This part discusses these competing forces, and concludes with a critique of both sides of the debate.

The reader may recall from Section I that the reservoir took seventeen years to fill completely. Since then, the water level has not stabilized, but has dropped precipitously. According to the Lake Powell Water Database, the reservoir sat 44.0% full as of April 2, 2006.[169] The top of the water was 112 feet below the level considered full.[170] The last time water levels were this low was during the initial filling of the reservoir, in the 1970-71 era.[171] The main cause of the reduced storage is a lack of precipitation in upstream areas, which

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most highly prized permit for any outdoor activity in the West. There is a waiting list of more than 7,000 names, so it takes a long time for your number to come up. The average wait is now about 10 years. Even commercial outfitters, who take more than 70 percent of the passengers down river at about $2,000 a person, can have waiting lists up to two years.")

[168] In reality, the tour operators would probably just raise their prices to make up for the revenue lost from being allowed fewer trips per year through the Canyon.

[169] *Water Summary For Lake Powell*, at http://lakepowell.water-data.com/WaterDB/LP_WaterDB.php (last visited Apr. 2, 2006).

[170] *Id*.

[171] *Id*. at http://lakepowell.water-data.com/WaterDB/LP_WaterDB_2.php?as_of=1996-04-02.

prevents the river from flowing at a high enough rate to replenish the outflows from the dam and make up for losses due to evaporation.

> Recent projections show that if the drought continues at rates prevalent in 2003, the reservoir level may fall below the outlet words as early as 2007. If that happens, the generators at the dam will become inoperable and water flows through the Grand Canyon will return to a run of the river situation; water will flow out of Glen Canyon through the dam's outlet works at the rate it comes in to the remaining reservoir.[172]

The "[m]inimum power operating level, where the Glen Canyon Dam loses its capacity to generate electricity, is at 3490 feet."[173] As of April 2, 2006, the water level is 3588 feet.[174] Looking at data from every January 1st, the water level has dropped from 3682 feet to 3598 between 1999 and 2006.[175] That 84 foot drop, if repeated, would place the water only 14 feet above the minimum operating level of the hydroelectric plant. The good news is that the major drought from 1999 to 2004 has subsided, at least for now.[176] On the other hand, Phoenix experienced, this past winter, 143 consecutive days without measurable precipitation, ending on March 11, 2006.[177] It is, of course, nearly impossible to predict what the long-term conditions are going to be, but evidence from global warming and the recent drought indicate that significant relief will elude Arizona and Utah for some time.[178]

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[172] Lavigne, *supra* note 57, at 477.
[173] Clotworthy, *supra* note 103, at 10.
[174] *Water Summary For Lake Powell*, at http://lakepowell.water-data.com/WaterDB/LP_WaterDB.php (last visited Apr. 2, 2006).
[175] *Id*. at http://lakepowell.water-data.com/WaterDB/LP_WaterDB_2.php?as_of=1996-01-01.
[176] *Hydrologic Conditions in Arizona During 1999–2004: A Historical Perspective*, at http://pubs.usgs.gov/fs/2005/3081/ ("Streamflow records indicate that a drought in Arizona during 1999–2004 was the worst drought since the early 1940s and possibly earlier. . . . An unusually wet December 2004 and January 2005 in Arizona has interrupted the multiyear drought.").
[177] Pat Kossan, Diana Balazs and Carl Holcombe, *Moisture finally arrives Few complain as events are disrupted* (Mar. 12, 2006), at http://www.azcentral.com/12news/news/articles/0312rain0312-CP.html.
[178] *US Seasonal Drought Outlook*, National Weather Service Climate Prediction Center (Mar. 16, 2006), at http://www.cpc.noaa.gov/products/expert_assessment/seasonal_drought.html ("Despite the short term relief, the dry season is just around the corner and the region will not receive enough rain and snow to make up for the record dryness. Therefore, temporary short term relief will be followed by drought persistence.").

In addition to the drought cycles that occur relatively often in the Southwest, another scourge is threatening the future of Lake Powell: sedimentation. "With over thirty-five years of storage behind Glen Canyon Dam, approximately one-fifth of the reservoir capacity has already been lost to sediment accumulation above Bullfrog basin."[179] Examples of how the sediment are already affecting Lake Powell abound. In an article written in 2002, reference was made to "a recent NPS-sponsored study . . . [finding that] the sediment deposit is quickly advancing toward Hite [Marina], and will make the launch ramp there inaccessible within two years whenever the reservoir surface level falls to 3,630 feet above sea level."[180] Sure enough, the Hite (among other marinas) is completely out of commission today, having been stranded by the combination of muddy sediment and low water levels.[181]

At the current rates of sediment deposit, according to one commentator, "[w]ithin as little as 125 years . . . sediment will begin affecting the hydroelectric capacity of the dam."[182] While sediment is a serious problem, one that has already hindered recreation on the Lake and contributed to further pollution, it is not nearly as urgent as the prospects of continued drought. Given that there should be at least a century before the power plant is affected, there is some time to put off planning for how to deal with the loss of the dam's power supplies. The does not mean the problem should be ignored, only that careful study is called for, and the low level of urgency means that there is no excuse for not considering all the available options.

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[179] Wegner, *supra* note 35, at 249-50 (The wording here is ambiguous – he could not have possibly meant that one fifth of the total capacity has been lost, but one fifth of the capacity above some point in the north.).

[180] *Beginning of the End for Lake Powell?*, Cyberwest Magazine (Jan, 14, 2002), at http://www.cyberwest.com/cw21/lake_powell_sediment.shtml; the problem has actually been known for some time: "Living Rivers points out that the NPS, in its 1979 General Management Plan for Glen Canyon NRA, estimated that Hite Marina would have to be abandoned "within thirty years" because of sediment accumulation. The silt arrived ahead of schedule." *Id*.

[181] *See Lake Powell Information*, at http://www.wayneswords.com/primative.htm#Hite (one user of the site reported: "looked at the last ramp area at the south end of Hite – you can see the tires stuck in the mud - it's all silted in and will not be accessible for a long time.").

[182] Wegner, *supra* note 35, at 250.

Section IV: Conclusion

Having reviewed the arguments made for and against draining Lake Powell,[183] the biggest weakness on both sides is that they ignore all evidence that is contrary to their favored viewpoint. Pro-Lake Powell forces stress the economic benefits, dismissing the very real – and urgent – environmental concerns[184] and the problems that can be created by prolonged drought. Drain-the-lake environmentalists dismiss legitimate concerns over replacing the dam's hydroelectric power and the increase in air pollution that would result;[185] they also ignore the lure, money and power of the boating and recreation industries,[186] and the tourists who make Lake Powell one of the most heavily used national recreation areas or parks in the country. As the largest economic engine within hundreds of miles on nearly all sides, the loss of Lake Powell would spell disaster for the thousands of people there who rely on tourism for their livelihood.[187]

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[183] *See, E.g., 25 Good Reasons Not to Drain Lake Powell*, Friends of Lake Powell, at http://www.lakepowell.org/page_two/information/25_reasons/25_reasons.html; *See also* Miller, *supra* note 9..

[184] *25 Good Reasons Not to Drain Lake Powell*, Friends of Lake Powell, at http://www.lakepowell.org/page_two/information/25_reasons/25_reasons.html (Neither his page, nor any other page on the Friends of Lake Powell website directly address the substance any of the salient environmental concerns expressed by critics of the Dam; instead, it only provides information about the negative effects of draining the Lake.).

[185] *Frequently Asked Questions about Restoring Glen Canyon*, Glen Canyon Institute, at http://www.glencanyon.org/aboutgci/faq.php ("Without Glen Canyon Dam's "clean" power, wouldn't the mostly coal-burning power plants have to make up for the lost power, leading to increased pollution? First of all, Glen Canyon Dam doesn't generate "clean" power. While there is no air pollution from the dam, the 186 mile long reservoir (which serves as the "fuel" for power generation) has destroyed one of the most incredible regions in the world. Add to that the batteries, feces, and gasoline dumped into the reservoir each year by the myriad speedboats and houseboats. . . . Most, if not all, of the power generated by Glen Canyon Dam could be recovered with simple conservation measures and expanded cooperation with power distributors." Clearly, this answer is misleading at best, in that the dam does not generate pollution as a result of the electrical power generation; the human created pollution is not caused by the power plant, but by surface recreation. Further, to say that the electrical capacity could be replaced with conservation is again misleading, given that the dam serves primarily for load-peaking purposes.).

[186] Id. ("Upon the restoration of Glen Canyon, Page will adapt once again to a sustainable non-motorized recreation based economy and function as the access point to one of the most-visited attractions in the West, the Glen Canyon Dam Site." This assumes that people will visit the site of the decommissioned dam in as large of numbers as people today visit the Lake for other forms of recreation. Is that realistic? This author does not think so, particularly given the fact that they will not be purchasing gasoline and other boating provisions from Page's merchants.).

[187] On a personal note, when the author was younger, he was active in his high school's nationally prominent photography program. His instructor, Jerry Halfmann, led a trip to Page, Arizona in 1993 to participate in a photography competition. The author placed third in the regional Vocational Industrial Clubs of America

The environmental effects that resulted from the construction of the Glen Canyon Dam are very real, but they cannot be reversed by simply allowing the Colorado River to run free again. New plants and animals have taken up residence in the Grand Canyon, increasing diversity of life in the park, if pushing out native species. No one knows exactly what will happen to the populations – native or exotic – if the river ecology is altered once again. It can never return exactly to the state it was in before the dam, and may even end up worse than it is now. If massive amounts of pollution are released into the canyon, it could have detrimental effects on the plants and animals living in and off the river.

In reality, there is absolutely no chance of draining Lake Powell in the near or moderate future. The proven economic impacts of keeping the dam active will always beat out the projected – but by no means assured – environmental benefits of dam decommission.[188] The governmental agencies that control the Dam, Lake, and River system need to look seriously at how to manage the dam in an era of droughts and global warming. The biggest threat to the future operation of Glen Canyon is clearly from water loss – not from environmentalists. If the water level drops to the point that the power plant is inoperable, it would be a disaster for the Southwest if the generating capacity was not immediately replaced. If the level continued to drop, and fell below 3371 feet, "the water would reach the bottom of the river outlets and the dam would not be able to release any water."[189] To put it mildly, this would be an ecological disaster, as Lake Powell would become a "dead pool" – a stagnant body of water 200+ miles

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Commercial Photography competition that week (and placed second in the statewide competition the next year), but much of the time there was spent photographing the areas around Page and on Lake Powell. The reason we went to Page specifically is that Mr. Halfmann's in-laws live there, where they run a hotel and other businesses related to the tourism industries. Families like theirs would be devastated financially by the loss of tourism to the area. Photos from the trip are online at the author's website, at http://jeremy.klezmer.org/page.

[188] One is certainly free to disagree with this ordering of priorities; is it rational to place recreation on a reservoir above environmental protection? Perhaps not, but the economic reality of the tourist dollars have placed a virtual stranglehold on the debate, as Congressmen and Senators will never stand by and watch as half a billion dollar a year industries are dismantled within their districts and states.

[189] Clotworthy, *supra* note 104, at 10.

long – and the Colorado River would be completely dry below the dam. Though the possibility of this happening is remote, it is still a risk that needs to be mitigated through smart management of the Dam and Lake.

The best course of action is to get all of the stakeholders to try to agree on the major issues. It is almost inconceivable that the environmental side will have much of an impact when their proposal will necessitate the loss of hundreds of millions of dollars a year in economic activity, increase air pollution, and signal the death of at least one town of several thousand people. This is not to say that the environmental issues are not important – they clearly are – but to be taken seriously the advocates must look to minor changes in dam operations to preserve what can be saved, rather than look to sweeping solutions that promise only possibilities while assuring significant economic hardship for entire communities. At the same time, the defenders of the status quo need to acknowledge that the environmental problems associated with the Lake and Dam are serious, and that energy and recreation interests do not always have to be in direct conflict with conservation interests. If no changes are made to the management schemes, it will not solve any problems; instead, it will only push back the time when some disaster befalls the area, and increase the costs of undoing the resultant damage to the ecosystem.