4 Ariz. J. Envtl. L. & Pol'y 160

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*160 ADAPTIVE MANAGEMENT IN GRAND CANYON: TOWARDS A MORE SUSTAINABLE APPROACH

Glen Canyon Dam has had a dramatic impact on the American West. Originally constructed to provide a steady water supply and cheap hydropower to downstream consumers, dam managers have recently been forced to balance newfound environmental, recreational, and tribal concerns alongside more traditional water delivery and power generation interests. Like all natural resource allocation questions on public lands, decision making in Grand Canyon is constrained by the public interest. In a place as sacred and iconic as Grand Canyon where interests are diverse and complex, finding the proper balance among competing interests is no easy task. To help ensure that Glen Canyon Dam is operated in a manner consistent with both federal mandates and the public interest, Glen Canyon Dam operators have increasingly relied on recommendations from an arguably unrepresentative group of interested stakeholders as a proxy for the public interest. The result has been management decisions that have historically favored hydropower and water delivery interests at the expense of important environmental, cultural, recreational, and aesthetic resources. Input from a stakeholder group can be a valuable resource, but only if the group is truly representative, in relevant proportions, to the interests at stake. As currently configured, the Glen Canyon Dam Adaptive Management Working Group fails to adequately represent all interests affected by Glen Canyon Dam operations. Through an expanded stakeholder group, however, important environmental, recreational, and cultural resources of Grand Canyon can be afforded the protection deserving of a place that is a crown jewel of our national park system, the lifeblood of millions of westerners, and the most sacred of places for many western Tribes.

TABLE OF CONTENTS

***162INTRODUCTION**

In 1857, Lieutenant Joseph C. Ives of the U.S. Army Corps of Topographical Engineers led a survey expedition to Grand Canyon. Reporting on one the transformative experiences of his life, Ives wrote of the Grand Canyon:

> It can only be approached from the south, and after entering it there is nothing to do but leave. Ours has been the first, and will doubtless be the last, party of whites to visit this profitless locality. It seems intended by nature that the Colorado River, along the greater portion of its lonely and majestic way, shall be forever unvisited and undisturbed.[1]

How wrong Ives was. Today, the Colorado River is among the most regulated river systems in the world.[2] Colorado River water serves over 30 million people in the United States and Mexico,[3] and irrigates over 3.7 million acres of land[4] across eight states.[5] The largest and most iconic of all the Colorado River dams is Glen Canyon Dam. Consisting of 4,901,000 cubic yards of cement and standing at 710 feet tall, Glen Canyon Dam can ***163** impound 27 million acre-feet of water.[6] At Full Pool, Lake Powell stretches for 186 miles and has a surface area of 161,390 acres.[7] The eight hydroelectric generation units in Glen Canyon Dam provide a combined generation capability of 1,320 megawatts,[8] providing peak electricity demands for about 240 wholesale power customers who serve approximately 1.7 million residential, commercial, industrial, and agricultural users in the seven Colorado River Basin States.[9]

At the time Glen Canyon Dam was constructed, there was little consideration of the potential downstream effects.[10] A utilitarian view of western waterways was deeply embedded in natural resource policy, and the predictable benefits of "sustainable" improvements in human welfare from big dams on the Colorado River simply outweighed the anticipated environmental consequences.[11] Scientists and river recreationists, however, soon began to observe and document the physical transformation of the Colorado River in Grand Canyon, including the loss of large beaches, narrowing of the rapids, and changes in the distribution and composition of riparian vegetation.[12] The local extirpation of native fish species was also well-documented at this time.[13] For all the benefits Glen Canyon Dam ***164** provides, the environmental consequences have been just as dramatic. This realization, coupled with a shifting public sentiment towards environmental protection,[14] has

forced managers to balance newfound environmental, recreational, and tribal concerns alongside the more traditional water delivery and power generation interests for which Glen Canyon Dam was constructed.[15]

In 1997, Secretary of the Interior Bruce Babbitt established the Glen Canyon Dam Adaptive Management Program[16] ("AMP" or "Program") to help manage contentious resource disputes between seemingly intractable interests. At the heart of the adaptive management program lays the Adaptive Management Working Group ("AMWG"), from which management recommendations to the Secretary emanate. Created under the auspices of the Federal Advisory Committee Act,[17] the AMWG consists of representatives from federal and state natural resource management agencies, as well as representatives from the Colorado River basin states, environmental groups, recreation and power interests, and several Native American Tribes.[18] Specifically, the AMWG currently consists of: six representatives from local Native American Tribes, including the Hopi Tribe, Hualapai Tribe, Kaibab Band of the Paiute Indians, Paiute Indian Tribe of Utah, Navajo Nation, and the Pueblo of Zuni; two representatives from environmental interests, including Grand Canyon Wildlands Council and the National Parks Conservation Association (which recently replaced the Grand Canyon Trust); two representatives from recreational interests, including Federation of Fly Fishers and Grand Canyon River Guides; and two representatives from federal power purchasers, Colorado River Energy Distributers Association and Utah Associated Municipal Power.[19] The seven basin states, generally motivated by economic considerations, are afforded a single AMWG representative each. Federal land management agencies also participate in the AMWG stakeholder process, albeit in a non-voting capacity. Agency representatives include the Bureau of Reclamation, U.S. Fish and Wildlife Service, ***165** Department of Energy, Bureau of Indian Affairs, and National Park Service, as well as the Arizona Game & Fish Department, a state agency.[20] Consensus among stakeholders is generally sought, but recommendations may be provided by a 60% majority vote.[21] Given the divergent and often conflicting interests at stake, consensus is difficult to achieve, and the AMWG has been characterized as a slow-moving and deliberate entity whereby meaningful changes to current operations are difficult to come by.

There is much room for improvement in the AMWG, both in form and in process. Because the AMWG is of limited membership, it has been criticized of failing to adequately represent the diversity of interests, in relevant proportions, impacted by Glen Canyon Dam operations. If the Secretary of the Interior is to rely on AMWG recommendations as a proxy for the public interest, the range of interests represented within the stakeholder group must be expanded. It is the thesis of this article that an expanded stakeholder group can help afford greater protections to environmental, cultural, and recreational resources of Grand Canyon. In support of this thesis, the article proceeds on three parts. Part I introduces general concepts of federal land management, management of Glen Canyon Dam in particular, and outlines some of the more obvious impacts Glen Canyon Dam has had on downstream resources. Part II discusses the Glen Canyon Dam Adaptive Management Program, and offers a brief critique of the Program generally, and the AMWG specifically. The justifications for an expanded stakeholder group are provided in Part III, as are other recommendations for improving the AMWG collaborative decision making process. There is no doubt that Glen Canyon Dam provides immeasurable social and economic benefits to many westerners. Social and economic benefits, however, must be balanced with the benefits intrinsic in healthy ecosystems, thriving native cultures, and scenic beauty unmatched anywhere else on the planet.

I. FEDERAL LAND MANAGEMENT

Under the Property Clause of the U.S. Constitution, management of federal property is tasked to the legislative branch.[22] Because Congress lacks both the ability and the expertise to manage all federal property, this authority has generally been delegated to the various federal land management agencies, who manage public property according to broadly-conferred management objectives. Glen Canyon Dam is owned and operated by the ***166** United States Bureau of Reclamation, a federal agency housed within the Department of the Interior. Throughout much of its history, the Bureau of Reclamation has relied on a strategy of water storage, diversion, and delivery on a massive scale to reclaim the West from the desert and "make the desert bloom."[23] Instrumental in facilitating western agriculture and supporting the western population boom since the end of the Second World War, perhaps no other land management agency has altered western landscapes more than the Bureau of Reclamation.

Unlike the Bureau of Land Management and U.S. Forest Service, which are directed to manage resources according to a Multiple-Use Sustained Yield ("MUSY") policy,[24] and in contrast to the National Park Service, which is directed to provide for visitation while preserving natural resources for future generations,[25] the Bureau of Reclamation has no general policy guiding natural resource management. This, in part, is due to the fact that the Bureau of Reclamation lacks a true organic act. Instead, Reclamation receives congressional authority for each individual project, typically as part of a recurring Reclamation

Authorizations and Adjustments bill. Thus, management objectives for Glen Canyon Dam must be inferred from the various congressional authorizations and amendments enacted throughout the 50-year history of the dam. Not surprisingly, congressional intent regarding the management of Glen Canyon Dam has evolved over time, yet in many respects remains vague and ambiguous.

A. Management of Glen Canyon Dam

Generally, a utilitarian view of natural watercourses has dominated water policy throughout much of the early history of the Bureau of Reclamation. Between authorization of Hoover Dam in 1928 and authorization of Glen Canyon Dam in April 1956,[26] Congress had voted 110 separate authorizations for the Bureau of Reclamation, some encompassing a dozen or more individual projects.[27] Because the best dam sites had been taken and the most ***167** profitable irrigation projects were already constructed, by the mid-1940s the Bureau of Reclamation was including cash-register dams--dams whose primary purpose was generation of hydropower--in project proposals to offset the costs associated with otherwise uneconomical projects.[28] Glen Canyon Dam was pitched as one such cash-register dam, and once Lake Powell was filed, the dam was operated almost exclusively to maximize revenue from power sales.

Despite a number of opportunities to adjust dam operations after 1956,[29] for over 30 years Congress remained largely content with dam operations aimed at maximizing revenue from power sales. By the late 1980s, however, the downstream impacts of wildly fluctuating flows that responded to the hourly, daily, and seasonal changes in power demands were well-documented.[30] Succumbing to pressure from environmental groups and spearheaded by Senator John McCain, the United States Congress ended the primacy of power production in 1992 with passage of the Grand Canyon Protection Act,[31] a measure designed to address the impacts of dam operations on environmental, recreational, and cultural resources in future dam management. Specifically, the 1992 Act requires the Secretary of the Interior to "operate Glen Canyon Dam ... in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established, including, but not limited to natural and cultural resources and visitor use."[32] Noting that water delivery obligations still trumped all other interests, the 1992 Act failed to provide any guidance on how newfound environmental and cultural interests were to relate to the generation of hydropower for which the dam was originally constructed.[33] By requiring the completion of an Environment Impact Statement, Congress seems to have left this important question to the Department of the Interior, the agency left in charge of the everyday management of Glen Canyon Dam.

***168** In 1995 the first Environmental Impact Statement on the operation of Glen Canyon Dam was completed.[34] To address the arguably competing mandates of hydropower production, water delivery, and environmental protection, Interior Secretary Bruce Babbitt instituted an adaptive approach to management. Within the adaptive management program, ultimate decision making authority remained vested in the Secretary of the Interior, but management recommendations were solicited from a newly formed group of interested stakeholders, the Adaptive Management Working Group ("AMWG"). What has emerged since the formation of the Glen Canyon Dam Adaptive Management Program in 1997 is perhaps best described as a balancing approach to management akin to the Multiple Use Sustained Yield approach employed by many natural resource management agencies. Nearly 25 years after the stakeholder process was initiated, however, many have commented that the Glen Canyon Dam Adaptive Management Program has failed to adequately protect the unique aesthetic, environmental, recreational, and cultural resources of Grand Canyon.[35] Under the Grand Canyon Protection Act, failure to adequately protect these and other important resources violates federal law.

B. Constraints on Glen Canyon Dam Management

Glen Canyon Dam operations are first and foremost constrained by the water delivery obligations set forth in the Colorado River Compact of 1922 and the ensuing collection of statutes, decrees, and treaties collectively known as the "Law of the River."[36] Subject to modification under the Equalization Criteria and supplemented by Upper Basin flows allocated to Mexico, a ten-year running average of at least 7.5 million acre-feet of water is required to pass through Glen Canyon Dam each year.[37] The timing of these flows, on daily, monthly, and seasonal timescales, however, is largely up to the Secretary of the Interior. So long as annual water delivery obligations are met, there is great flexibility to alter the quantity, quality, and timing of dam releases at sub-annual timescales.

In response to documented degradation of the downstream environment, the first environmentally conscious constraints on Glen Canyon Dam operations were instituted in ***169** 1991.[38] The first restraints included limits on daily flow fluctuations and ramping rates, as well as the establishment of minimum and maximum flows, many of which remain in effect.[39] However, even within the confines of the 1997 Operating Criteria and subsequent long-term management obligations, significant discretion remains with the Secretary in setting daily, monthly, and seasonal dam releases. As previously mentioned, the Secretary typically seeks recommendations from the Adaptive Management Working Group in setting these sub-annual flow regimes, which can take many different forms. In addition to the fluctuating flows already discussed, previous and current flow regimes include the use of artificial floods thought to conserve sediment and riparian vegetation,[40] steady flows hypothesized to benefit endangered fish species,[41] and flushing flows employed during certain times of the year to suppress non-native fish populations.[42] Despite continued degradation of downstream environmental, recreational, and cultural resources, fluctuating flows that respond to changing power demand have at all times remained the dominant management strategy at Glen Canyon Dam.

C. The Degraded State of the Colorado River Ecosystem in Grand Canyon

The Colorado River ecosystem in Grand Canyon has been altered by Glen Canyon Dam in dramatic and fundamental ways. Since at least the 1960s, scientists have ***170** quantitatively and qualitatively described the impacts of big dams on western rivers.[43] Although all impacts may not yet be fully realized, many of the more obvious impacts of Glen Canyon Dam stem from both the dramatic reduction in the sediment concentration of the Colorado River in Grand Canyon, and the altered flow regime of the river on annual, seasonal, and daily timescales.[44]

1. Sediment

Perhaps the biggest impact of Glen Canyon Dam has been the significant reduction in the sediment load of the downstream river. Often described as the muddiest river in the world, the unregulated Colorado River once carried 160 million tons of sediment past Yuma each year--11 tons of dirt for each acre-foot of water.[45] Although the Paria and Little Colorado Rivers still contribute fine-sediment to the Grand Canyon stretch of the Colorado River, scientists estimate the total sediment input of these two tributaries is only 14-16 percent of total sediment transported through Grand Canyon in the pre-dam era.[46] Because the sediment-deprived water released from Glen Canyon Dam retains its capacity to transport sediment, important sediment resources, relics from the pre-dam era, have been lost to erosion, resulting in smaller and fewer sandbars since Glen Canyon Dam was closed in 1963.[47] Highly fluctuating flows are thought to have exacerbated this erosion.[48]

***171** Sediment resources are an important resource in Grand Canyon for several reasons. First, above-water sandbars are an important recreational resource. They provide flat, soft camp sites for the tens of thousands of recreational and commercial river runners, hikers, and other backcountry users that enjoy Grand Canyon each year.[49] Second, these sandbars were utilized by ancient cultures and house important and sacred archeological resources;[50] with the loss of sandbars comes the potential loss of irreplaceable archeological artifacts.[51] Third, exposed sandbars provide unique terrestrial habitat for riparian vegetation and associated fauna, including endangered species such as the Southwest Willow Flycatcher.[52] Finally, sediment deposits are an integral part of the natural riverscape, and provide important backwater habitat for native fishes.[53]

2. Flow Regime

Operation of Glen Canyon Dam to maximize revenue from power generation has dramatically altered the daily, seasonal, and annual flow regimes. In the pre-dam era, median daily discharge ranged only 524 cfs.[54] After Glen Canyon Dam was constructed, the median daily range of discharge increased to 8,580 cfs.[55] With greatly fluctuating flows, areas along the channel margin are inundated and dried several times each day, wreaking havoc on fish ***172** and aquatic invertebrate species that rely on the warmer, shallow, low-velocity areas along the channel margins as essential habitat.

Seasonal changes in flow have also been altered. During the winter months in the pre-dam era, while snow accumulated high in the Rocky Mountains, the historic Colorado River in Grand Canyon was just a trickle, supplied only by the springs, seeps and groundwater inputs that constitute the base flow of the river.[56] In the spring, the snow would melt and the river would swell to a torrent, reaching a maximum discharge of 85,000 cfs every other year on average.[57] After all the snow was melted, the river would again retreat to its base flow for the duration of the hot and dry summer months, which were historically

among the lowest discharge months for the Grand Canyon section of the Colorado River.[58] The late summer and early fall monsoon season would provide pulses of water and sediment from tributary inputs as a result of largely localized thunderstorm activity.[59] Over the winter, the river would retreat to base flow as snow once again accumulated in the Rocky Mountains, the cycle ready to repeat itself.[60]

After the construction of Glen Canyon Dam, seasonal variation in flows were reversed.[61] Winter and mid-summer flows, which were historically the lowest flows of the year, are now typically the highest discharge months.[62] The spring snowmelt flood and early fall monsoon inputs are captured by Glen Canyon Dam, to be discharged at times of higher energy demands.[63] The 2-year recurrence interval flood (i.e. the flood that on average would occur every other year) has been reduced from 85,000 cfs to 31,500 cfs.[64] By eliminating ***173** both base and flood flows, Glen Canyon Dam has essentially "flattened" the annual hydrograph of the Colorado River in Grand Canyon.[65]

The impacts of an altered flow regime are numerous. The lack of a spring snow melt flood has resulted in a narrowing of the active riparian corridor, and has encouraged vegetation encroachment, mostly by nonnative species, which has resulted in systematic losses in campsites available to river runners and other backcountry users.[66] Specifically, scientists reported that between 1983 and 1994, 41% of camping sites surveyed were determined to be unusable because of vegetation overgrowth.[67] Between 1998 and 2003, campsite area above 25,000 cfs decreased 55%.[68] Altered flow regimes also have detrimental impacts to native fish species, most notably the endangered humpback chub, through increased predation by nonnative fish, confusion of spawning cues, and reduced habitat for fish species and their associated food base.[69] Reduced water temperatures caused by Glen Canyon Dam are thought to be an additional factor impacting humpback chub survival rates.[70]

***174** Through a reduction in sediment influx and alteration of the natural flow regime, Glen Canyon Dam is affecting the Colorado River ecosystem in Grand Canyon in fundamental ways. These effects are manifested in the numerous impacts to the natural, cultural, and recreational resources unique to Grand Canyon. Because of the enormous complexities of the system involved and the vast uncertainty that management decisions entail, Glen Canyon Dam managers have moved away from traditional management methods, and in the late 1990s were among the first to implement an adaptive management program, one of the longest-running and comprehensive adaptive management programs to this day. Although an adaptive management scheme may be particularly well-suited to the complexities of the Colorado River ecosystem in Grand Canyon, effective and efficient implementation has been difficult.

II. ADAPTIVE MANAGEMENT IN GRAND CANYON

First implemented in 1997, the Glen Canyon Dam Adaptive Management Program is founded on the same basic premise as all adaptive management programs in the natural resource context: complex and dynamic ecosystems are best managed when management itself is dynamic and flexible.[71] An adaptive approach to management--often described as "learning while doing"--is characterized by understanding management decisions as experiments, and utilizing continuous monitoring and assessment to inform future decisions.[72] Adaptive management proponents argue that this approach to management provides managers to the best opportunity to respond to constantly changing scientific information, altered physical conditions, and shifts in political and social climates.[73]

In addition to an adaptive approach to management, the Glen Canyon Dam AMP relies on a collaborative decision making model to gather public sentiment and broaden the diversity of interests represented in the decision making process. Largely seen as a necessary response to the increasing distrust of traditional rigid top-down, centralized regulatory decision making processes, collaborative decision making proponents allege flexible, longer lasting decisions that are generally more efficient and cost-effective.[74] Implemented in the ***175** form of the Adaptive Management Working Group, the group of 26 interested stakeholders previously identified, collaborative decision making is an important part of the Glen Canyon Dam AMP and may be particularly well-suited to the complexities of managing such a vast and diverse resource. Although not a universally accepted means of allocating natural resources,[75] the collaborative decision making approach continues to be a central component of the Glen Canyon Dam AMP, though it has been criticized on a number of different levels.

A. Critiques of the Glen Canyon Dam Adaptive Management Program

Critiques of the Glen Canyon Dam Adaptive Management Program come from two different camps with vastly different

ideologies of proper natural resource management. The first set of critiques can generally be characterized as those stemming from a broader critique of the 'Multiple-Use Sustained Yield' (MUSY) land use policy. Within the context of the management of Glen Canyon Dam, dam managers constrained by MUSY-like approaches are essentially tasked with balancing the often incompatible dominant natural resource uses, notably hydropower generation and water storage and delivery, with environmental, recreational, and cultural interests. In Grand Canyon, this balancing approach is carried out with little guiding criteria from Congress. What has resulted, much like MUSY management approaches in other contexts, is management that fully satisfies no one. In Grand Canyon, although hydropower is produced by Glen Canyon Dam, the amount produced is inadequate for power purchasers but too much for environmental groups; although some sediment is replenished during artificial floods, river runners and environmental interests demand more floods while power producers complain that precious water is 'wasted' during high-flow events; and although fish friendly flows are occasionally provided for, conservationists cite unsustainable practices.

Those who view MUSY as an inappropriate land management policy often advocate for what is commonly referred to as a dominant land use approach. Under a dominant land use approach, a particular use or set of uses are identified for a particular parcel of land, and management decisions are made to further those specific interests.[76] Here, the dominant use could be generation of cheap hydropower, or it could be preservation of the landscape for the enjoyment of future generations. Either way, advocates to this approach emphasize that dominant use decisions must be made by democratically elected and publically accountable representatives, thus ensuring that dominant land uses reflect true public sentiment. These dominant approach advocates assume that as public sentiment changes, so will dominant uses.

***176** A second critique of the Glen Canyon Dam Adaptive Management Program stems from those who approve of a MUSY approach to public land management, but have criticized the specific approach implemented by the Glen Canyon Dam AMP. Generally, these critiques view the Program as an ineffective tool for balancing competing interests. These critiques abound in the literature; commentators have critiqued the Glen Canyon Dam AMP as being a disjointed and slow-moving entity that has failed to reconcile the various use priorities of the Colorado River,[77] as failing to stabilize or otherwise improve the quality of the fragile downstream ecosystem,[78] and as falling short of ensuring effective stakeholder participation.[79] Instead of fostering effective and meaningful participation in a collaborative decision making process, critics argue, the Glen Canyon Dam AMP has forced dissatisfied parties to seek redress outside the scope of the Program.[80]

One important point made by both MUSY advocates and MUSY critics is that any federal land management program must be constrained by the public interest. Thus, any future management scheme must include an appropriate and reliable method for identifying, characterizing, and quantifying public sentiment. Since Glen Canyon Dam was authorized in 1956, environmental consciousness has increased. The Bureau of Reclamation, once a stalwart dam-building and river development agency, has been transformed to an agency that increasingly realizes the benefits of free-flowing rivers and encourages sustainable management practices.[81] These changes in public sentiment should be reflected in current ***177** dam management. It is the thesis of this paper that an underlying problem with the Glen Canyon Dam Adaptive Management Program is that the AMWG consists of an unrepresentative group of stakeholders, and their recommendations, although sometimes a product of consensus, are improperly seen as a proxy for the public interest. As a result stakeholders and outside parties view the recommendations, and decisions made in reliance of those recommendations, with skepticism. This skepticism results in ineffective AMWG participation, and can force stakeholders to pursue litigation, an often inefficient use of precious resources.[82]

In short, the problem with Glen Canyon Dam management is that there is undue reliance placed on an unrepresentative group of stakeholders. These stakeholders, dominated by local hydropower and water delivery interests, favor a status quo that has resulted in continued detrimental impacts to important environmental, cultural, and recreational resources of the Colorado River ecosystem in Grand Canyon. For these resources, current Glen Canyon Dam management is not sustainable.

III. MOVING FORWARD

A. Broadening the Scope of Stakeholders

Because any management decision must be constrained by the public interest, an important aspect of any new management regime for Glen Canyon Dam operations is that it address all relevant interests. As the Glen Canyon Dam AMP currently

operates, only a handful of largely local interests are allowed to participate in the management recommendation process. How this group was chosen has never been adequately explained, and there is little reason to believe that this group sufficiently represents the diversity of interests at stake in a place as vast, diverse, and important as the Colorado River ecosystem in Grand Canyon.[83] As currently configured, the Glen Canyon Dam AMWG consists of only 26 stakeholders.[84]

Not only is diversity of interests inadequately represented, but the relative apportionment of interests prohibits meaningful participation. Ideally, the constituents of ***178** any stakeholder group should approximate the divisiveness of the issues the group addresses. Here, there is little indication that the make-up of the AMWG stakeholder group, with its dominance of water and power interests, accurately reflects true public sentiment on the issues that the stakeholder group is tasked with resolving. Further, the group of AMWG stakeholders has not meaningfully changed since its inception over 25 years ago. Thus, the AMWG stakeholder group not only misrepresents the diversity of interests at stake in the management of Glen Canyon Dam, it also represents interests in an arguably unfair and inappropriate manner, allowing one group to dominate over the interests of all others.

In choosing whose interests are represented at the table, it is also important to consider *who* gets to represent those interests. Considering just the environmental interests first, for many years environmental interests were represented in the AMWG by two entities: Grand Canyon Trust and Grand Canyon Wildlands Council.[85] Both Grand Canyon Trust and Grand Canyon Wildlands Council are relatively small, local organizations, with limited resources, and efforts focused on a limited geographic region. Grand Canyon Trust involves itself with a broad array of environmental issues across the Colorado Plateau, including energy policy, forest restoration, and renewable energy development.[86] Grand Canyon Wildlands Council has narrowly focused their efforts on native species conservation within "the Grand Canyon ecoregion."[87] Can these two groups, with their specialized knowledge and local focus areas, adequately represent all potential environmental issues associated with Glen Canyon Dam operations? This article suggests the answer is no. As relatively small organizations with limited resources, these groups must pick and choose their battles. To properly advance certain interests, others must be sacrificed.

Further, with annual visitation at Grand Canyon National Park reported at over 4 million people,[88] most of them not from Northern Arizona or even the Colorado Plateau, why should local environmental interests be the only ones represented? Why should larger environmental groups like the National Resources Defense Council, or even international environmental organizations like the World Wildlife Fund, who might view Glen Canyon Dam operations through a different lens, be limited to resource intensive lobbying or litigation strategies outside the scope of the Glen Canyon Dam AMP? These larger organizations, who may be more efficient participants due to their prior experiences and expertise with collaborative processes, may be better able to raise funds and apply pressure to managers than smaller local interests. With greater resources, these larger organizations may also be able to advance a greater diversity of interests.

***179** The justification for allowing only two environmental interests, and these two in particular, has never been provided by the Department of the Interior. Although there is no doubt that both the Grand Canyon Trust and the Grand Canyon Wildlands Council do great work and are passionate in the stances they take, they might not adequately represent all environmental interests at stake for the Colorado River ecosystem in Grand Canyon. Outside parties, however, are not without redress. Any final agency decision is challengeable under the Administrative Procedure Act,[89] and several environmental groups, including the Sierra Club and Center for Biological Diversity have challenged agency decisions and forced litigation with varying degrees of success.[90] However, if resources spent on costly litigation could instead be redirected towards effective participation in an expanded stakeholder group or other form of participatory decision making model, this could not only increase confidence in the decisions ultimately made, but might reduce the skepticism that often results in costly litigation.

B. Beyond Environmental Interests

Although environmental interests offer a good example of a stakeholder group perhaps not adequately represented within the AMWG, the critique can be extended to justify the inclusion of other interest groups. Presently, recreational interests are represented by only two groups: Grand Canyon River Guides and the Federation of Fly Fishers.[91] Although commercial river guiding is big business in the canyon, thousands of private boaters enjoy the Grand Canyon stretch of the Colorado River each year. Because the interests of private boaters may be different than commercial boaters, there is adequate justification for including representatives from both camps. Additionally, backcountry hikers regularly hike and camp down by the river,

and also have a recreational interest potentially affected by Glen Canyon Dam operations. More general National Park visitation groups may be another candidate for inclusion in an expanded stakeholder group.

Water user groups also deserve a say in the management of Glen Canyon Dam. Since western farmers use the bulk of Colorado River water, representatives from irrigation districts are likely candidates for inclusion in any expanded stakeholder group. Municipalities that use Colorado River water may have interests affected by Glen Canyon Dam operations, and may also wish to participate in an expanded AMWG stakeholder group. Invitations should additionally be extended to governmental agencies who administer water delivery infrastructure. Although industrial uses are but a small portion of the total water use, they too might also be considered for inclusion in an expanded stakeholder group.

***180** Power users are currently represented by two federal power purchase contractor representatives: Colorado River Energy Distributors Association and Utah Associated Municipal Power.[92] These power purchasers rely on cheap hydropower to satisfy not only the hourly changes in peak energy demands, but also seasonal changes in demand.[93] By utilizing cheap hydropower, these power purchasers minimize costs and pass on lower rates to consumers. These groups, however, are one-sided, concerned primarily with maximizing their ability to purchase cheap power. If particular groups of power users would be willing to pay slightly higher rates to ensure more environmentally friendly flows from Glen Canyon Dam, this type of organization could add a different perspective to the energy users group currently focused only on securing the cheapest sources of power available.

The diversity of interests mentioned above are also represented in varying degrees within each of the seven individual basin states, who are allotted only one representative each. Thus, the State of California, with a population of over 38 million people, is given the same voting power in the AMWG as Grand Canyon River Guides, an organization that boasts of membership of just over 1,700 members. Although there is an obvious justification for soliciting state input in the management of critical water resources, the AMWG process seems an illogical scheme for addressing state interests. Thus far, the seven basin states have been principally concerned with state economic interests, primarily the receipt of allotted water as dictated by the Colorado River Compact and subsequent Law of the River.[94] Discussed in greater detail below, the states pose a unique problem to any substantive changes in dam management. AMWG representation, however, seems an odd means of addressing state concerns.

Finally, not only are the interests represented in the AMWG not sufficiently representative of all the interests within a particular group, but there may be entire groups of interests left out of the AMWG recommendation process. For instance, wilderness groups, business interests, and local counties do not participate in the AMWG. Given an opportunity to chime in on Glen Canyon Dam operations, water and energy policy in the West, and the fate of the Colorado River ecosystem in Grand Canyon, no doubt many more interests will rise to the task and advocate for particular positions.

Because there are a plethora of interests who deserve more of a say in Glen Canyon Dam management, the current make-up of the AMWG stakeholder group should be reevaluated. Special attention should be paid to the diversity of interests represented by the group, the relative proportion of the interests in relation to public sentiment, and the ***181** capacity of the individual representatives invited to the group. This reevaluation alone would address many of the most powerful critiques of the Glen Canyon Dam Adaptive Management Program and the role of the AMWG stakeholder group.

There will always be dissenters in any management decision, especially one that concerns a place as sacred and iconic as Grand Canyon. The problem with the Glen Canyon Dam AMWG process is not a problem of fringe groups or particularly outspoken minorities claiming their interests are not represented, it is that AMWG members--people with a seat at the table--are unsatisfied with the process. Within just the past year, the Grand Canyon Trust, an otherwise competent and effective environmental advocacy group, resigned from AMWG citing dissatisfaction with the process as one of the reasons for their withdrawal.[95] Previously, the Grand Canyon Trust was engaged in a 4-year litigation battle with the Bureau of Reclamation over Glen Canyon Dam management.[96] Some tribal representatives have similarly been languid in their participation due to both a lack of resources and a general dissatisfaction with how their interests are perceived and addressed by the group.[97] There will never be a way to please everyone, but as long as reasonable minds elect competent leaders to represent their interests, there is no reason an expanded stakeholder group could not be effective.

There is also a down-side to an expanded stakeholder group. Adding additional voices to an already burdensome, deliberate, and slow-moving process may serve only to introduce further delay as new members navigate the waters of a process where interpersonal relationships play such an important role. Although a steep learning curve may be mitigated by dedicated

representatives and the increased use of facilitators, care must be used to not let an expanded stakeholder group get out of hand. Lines will have to be drawn, but those lines must be drawn carefully and with forethought.

C. Barriers: The Problem of the States

The seven Colorado River Basin states, with perfected rights to Colorado River water in established allocations, pose a significant barrier to any substantive changes in the management of Glen Canyon Dam. Advocating for the diverse interests of millions of citizens, the concerns of each state over Glen Canyon Dam management are expressed through a single AMWG representative. The primary concerns of the individual states relate to economic interests, most importantly the delivery of water obligations set forth in the Law of the River. As previously discussed, water delivery obligations are of the highest use priorities, and concerns over AMWG alteration of water delivery obligations are largely unfounded. Regardless, because states are forced to take a singular position through a sole representative, states tend to align themselves with the hydropower interests, likely seen as ***182** the politically-safe option.[98] In fact, the dominance of hydropower interests within the AMWG stakeholder group is largely attributed to the ability of hydropower interests to partner with the individual states, and sometimes the Tribes.[99]

In general, the AMWG stakeholder group is an odd means of addressing state concerns. First, state positions cannot be boiled down to a singular position. Like the range of interests found within the AMWG stakeholder group itself, a similar range of interests are found within each individual state. Because each basin state is given but a single AMWG representative, a single position is advanced at the expense of other state interests. Because nearly all other AMWG representatives advocate for a clearly-defined, unanimous positions, the states are unique in their need to define a single position out of many diverging and often mutually exclusive opinions. In this respect, state representatives are out-of-place in AMWG. Moreover, there is little justification for equating the interests of the states, who represent millions of citizens, to that of special interest groups, some of whom have membership of just a few thousand individuals. Because states have legal rights that special interest groups do not, it is hard to justify the equal voting power of the states with other interests. Expanding the stakeholder group to include a broader range of interests only serves to further dilute the voting power of the states. Although there is little doubt that states should be consulted where dam operations affect important state interests, the proper role for state consultation is perhaps outside of the AMWG stakeholder group.

Because an expanded stakeholder group is likely to include all relevant interests, including any interest likely to be advanced by the individual states, including state representatives in an expanded stakeholder group is unlikely to add any new or different perspectives. If the seven basin states wish to continue to have an input in the management of Glen Canyon Dam, there are other means of doing so, including assistance to established interest groups or lobbying of the Secretary directly. The states are already heavily involved in determining the Annual Operating Plan for Glen Canyon Dam, and their efforts are perhaps best focused on that process. Regardless, at the end of the day Glen Canyon Dam is owned and operated by the federal government, and ultimate decision making authority remains vested in the Secretary of the Interior. As such, the Interior Secretary can place as much or as little weight on the interests of the states as he or she sees fit. Likewise, the Secretary can choose to ignore AMWG recommendations and instead place greater weight on advice solicited from the federal land management agencies. The federal land management agencies do not vote in the AMWG, and neither should the states. By soliciting management activities from land management agencies, interested stakeholders, and individual states separately, transparency can be increased, and better management decisions can be made.

183D. Long-Term Planning Documents*

A recent trend in Glen Canyon Dam management has been the increased use of long-term planning documents to implement particular management objectives. Subject to public commenting and scientific validation, triggering criteria are increasingly incorporated into long-term planning documents initiated by both the Department of the Interior and the AMWG. One prominent example of this management technique is the establishment of triggering criteria for implementing artificial floods.[100] Beginning in 2012, provided certain sediment and reservoir conditions are satisfied on a particular date, experimental high-flows are automatically triggered, the timing and duration of which is determined by established hydrologic models.[101] Because long-term planning documents trigger NEPA requirements, including public commenting, long-term planning documents can be a good method for addressing public sentiment. Likely implemented in response to the lack of experimentation and favoring of the status quo commonly found in AMWG critiques, triggering criteria and other

long-term planning documents must not be viewed as a cure-all for a deficient AMWG. For one, long-term planning documents are resource intensive. Environmental Assessments and Impact Statements cost hundreds of thousands of dollars, and can take years to complete. Further, these documents represent a snapshot understanding of complicated and dynamic system, and often fail to provide a mechanism to update triggers as new information becomes available, as scientific understandings become more comprehensive, and as public sentiment changes. In short, triggering criteria are static, while the systems they manage are dynamic. Over time, certain triggering criteria may become obsolete, and previously unidentified factors may become relevant. In this light, the benefits of a management scheme that can respond to new information, can modify operations at short timescales, and can adjust to changing political and social climates becomes obvious. A stakeholder group like the AMWG can fulfill these essential tasks, but the validity of the AMWG depends on the constituency of the group. If not truly representative, a stakeholder group will be no better than an uninformed and outdated triggering mechanism.

E. Sustainability Principles

With an expanded stakeholder group providing input more representative of the general public sentiment, what changes are likely to come about? In other words, towards what ends should Glen Canyon Dam operators trend? The answer obviously depends on what the public thinks. Any substantive decisions must be constrained by a public interest that is increasingly understood to include "sustainable" management practices. Although sustainability is a term that has been used so often and in so many contexts that it has ***184** become almost meaningless,[102] certain *principles* of sustainability may be helpful in organizing guiding principles for Glen Canyon Dam management. In particular, ecosystem resilience and science-based management are two praiseworthy goals for Glen Canyon Dam management.

"Sustainability" is often cited as a laudable goal of natural resource management. Arguing for "sustainable" management practices, however, adds very little to the dialogue. Because there are so many important interests at stake, nearly all interests may be able to frame their positions as "sustainable." Environmentalists, looking to the language of the Grand Canyon Protection Act and the National Park Service Organic Act, might use these statutory provisions to frame an argument for requiring environmentally sustainable management decisions. Hydropower interests, however, could similarly frame their position as environmentally sustainable in that maximizing hydropower prevents construction of more environmentally-damaging fossil fuel consuming power plants. Likewise, a cheap source of energy sustains the American economy. Irrigators, by far the biggest users of Colorado River water, might frame their argument as sustaining the economy by providing a steady food supply. Because sustainability can been used by so many different interests in so many different contexts, arguments should instead focus on *principles* of sustainability.

Within the context of sustainable natural resource management, sustainability is often defined as encompassing themes of resilience--the ability of an ecosystem to absorb shocks and remain functionally similar.[103] This is an appropriate and achievable goal for Glen Canyon Dam management. The Colorado River ecosystem in Grand Canyon has been highly disturbed by Glen Canyon Dam operations, and efforts should be taken to ensure that further degradation is minimized. Because the GCPA demands the Secretary of the Interior to "operate Glen Canyon Dam ... in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established, including ... natural ... resources,"[104] this goal is not only wise policy, it is federally mandated. Similarly, preserving ecosystem function can help ensure the system will remain largely unchanged for the use and enjoyment of future generations, a founding principle of our National Parks system.

Additionally, management decisions should increasingly be grounded in scientific findings. The Glen Canyon Dam AMP is supported by one of the best science programs in the nation. Instead of ignoring the insight that scientists provide, dam managers should embrace scientific findings. The link between science and management must be strengthened. Although uncertainty will be part of any system as complex, diverse, and intricate as Grand Canyon, in an adaptive management program uncertainty should be embraced, viewed as an opportunity to learn, and not cited as an excuse to do nothing.

***185CONCLUSION**

This paper advocates for a change in the way Glen Canyon Dam is managed and operated. As currently configured, Glen Canyon Dam managers improperly rely on management recommendations from an unrepresentative group of interested

stakeholders as a proxy for the public interest. To ensure proper protection of important natural, cultural, and recreational resources of Grand Canyon, the stakeholder group should be expanded to include a broader range of interests potentially affected by dam management. This broad engagement of public sentiment can result not only in a better realization of the range of interests affected by Glen Canyon Dam operations, but can result in management decisions more aligned with the public interest. Further, where agency decisions are supported and justified by scientific evidence, public confidence in decisions will increase. With increases in public confidence, parties are less likely to pursue costly and inefficient litigation strategies which tend to delay, politicize, and complicate natural resource decision making. For any meaningful change to occur, however, Glen Canyon Dam operations cannot be considered in a vacuum--any change must be considered in the context of changing energy and water policy in the western United States more generally.

As previously described, Colorado River water is apportioned according to the Law of the River. Any substantive changes in Colorado River management must necessarily be constrained by this set of agreements, decrees, and statutory obligations well-established in the law. Water delivery obligations are clearly the highest priority as evidenced not only in protectionist congressional statutes such as the Grand Canyon Protection Act, but realized in the contractual obligations of the federal government and the reliance placed on these vested usufructuary property rights. However, as long as the states are delivered their apportioned water in the quantity and quality they are accustomed to, they will likely have little reason to oppose substantive changes in flows through Grand Canyon. Within these confines, there exists great potential to experiment with altered flow regimes and other mechanisms by which natural, recreational, and cultural resources may be conserved and enhanced.

Further, it is important that any substantive changes in Glen Canyon Dam operations be considered in the changing light of western water policy. Although any substantive discussion of western water policy is beyond the scope of this paper, some important points can be made. First, improvements in efficiency of water use should be made in nearly every sector, including agricultural, municipal, and industrial users. To incentivize more efficient uses, government subsidies can be cut, and pricing mechanisms can be used promote conservation. Water leasing and water transfers can help defray the often substantial costs of increasing agricultural efficiency. The process of transferring water from agricultural to other uses must be eased, especially in light of the higher values placed on in-stream flows for recreational and environmental purposes. With increased reliance on surface water due to diminishing groundwater resources coupled with stricter groundwater pumping regulations, water quality will become increasing important for water users. All this must be considered in the context of a changing global climate, predictions of diminished ***186** flows in the Colorado River basin over the next several decades,[105] and already low reservoir levels throughout the Colorado River basin.

Energy policy should also be implicated in any discussion of substantive changes to Glen Canyon Dam operations. Hydropower, with its unique ability open penstocks and start generating energy in a matter of minutes, is an important resource in fulfilling temporary increases in energy demand. The resulting fluctuating flows, however, wreak havoc on downstream ecosystems. Unlike water in the West, there are realistic alternatives to hydropower generation. Although it is unlikely that any state would be willing to site a replacement coal-fired power plant in their state, there exists huge potential for other sources of renewable energy. Solar, geothermal, and wind energy sources have huge untapped potential throughout the western United States. To make these energy sources price comparable to hydropower from Glen Canyon Dam, any renewable energy development would have to be heavily subsidized. This requires a dedication by Congress, and would likely have to be part of a restructured energy policy more generally.

Subsidies for energy, water development, and water delivery also deserve reconsideration. Making consumers pay the true costs of both energy and water is one way to encourage conservation and pave a way for more environmentally friendly Glen Canyon Dam operations. Water markets can also help to encourage efficient water use and ensure that water is appropriated to the most economic use. Hydropower continues to be heavily subsidized, and the Bureau of Reclamation has been lackadaisical, at best, in recouping the cost of big dams on the Colorado River. This also deserves reevaluation. In light of current energy and water policy, any substantive changes to Glen Canyon Dam operations are unlikely to occur absent significant changes on these fronts. Glen Canyon Dam operations and the resulting effects on Grand Canyon may be a good context for talking about these issues, and may be the catalyst needed to bring these broader issues to light.

Footnotes

[a1] Third-year law student at the University of Arizona, James E. Rogers College of Law. I would like to thank the editorial board of the Arizona Journal of Environmental Law and Policy and the Arizona Law Review for their insightful comments and hard editorial work, and give a special thank you to Professor Robert Glennon for all his generous support throughout law school.

[1] JOSEPH C. IVES, ET AL., REPORT UPON THE COLORADO RIVER OF THE WEST: EXPLORED IN 1857 AND 1858 (U.S. Army Corps of Engineers, 1861), *available at* http://books.google.com/books?id=7Q0***o***AAAAYAAJ

[2] There are over 20 major dams on the Lower Colorado alone. Gordon A. Mueller & Paul C. Marsh, LOST, A DESERT RIVER AND ITS NATIVE FISHES: A HISTORICAL PERSPECTIVE ON THE LOWER COLORADO RIVER, Federal Government Series: Information and Technology Report - 2002-0010 (2002), *available at* http:// www.fort.usgs.gov/Products/Publications/10026/10026.pdf; Major dams in the upper basin include Fontenelle Dam (1964, Green River), Flaming Gorge Dam (1962, Green River), Blue Mesa Dam (1962, Gunnison River), Morrow Dam (1968, Gunnison River), Crystal Dam (1976, Gunnison River), Navajo Dam (1963, San Juan River), and Glen Canyon Dam (1963, Colorado River). Steven W. Carothers & Dorothy A. House, *Decommissioning Glen Canyon Dam: The Key to Colorado River Ecosystem Restoration and Recovery of Endangered Species?* 24 ARIZ. L. REV. 215, at n.8 (2000).

[3] John F. Hamill & Theodore S. Melis, *The Glen Canyon Adaptive Management Program: Progress and Immediate Challenges*, *in*RIVER CONSERVATION AND MANAGEMENT (Philip J. Boon & Paul J. Raven, eds., 2012); Mueller & Marsh, *supra* note 2, at 1.

[4] Mueller & Marsh, *supra* note 2, at 1.

[5] The Colorado River serves four upper basin states (Colorado, Wyoming, Utah and New Mexico), and three lower basin states (Arizona, Nevada, and California), as well as the Mexican state of Sonora. An "acre-foot" is a volumetric measurement unit described as enough water to cover an acre of land in one foot of water. It is equivalent to 325,851 gallons of water, enough water, according to Bureau of Reclamation engineers, to supply a family of five for a year. RUSSELL MARTIN, A STORY THAT STANDS LIKE A DAM 25 (1999).

[6] Glen Canyon Dam, U.S. BUREAU OF RECLAMATION, http:// www.usbr.gov/projects/Facility.jsp?fac_Name=Glen+Canyon+Dam (*last visited* March 22, 2014).

[7] *Id.*

[8] U.S. DEP'T OF THE INTERIOR, U.S. GEOLOGICAL SURVEY, USGS CIRCULAR 1282, THE STATE OF THE COLORADO RIVER ECOSYSTEM IN GRAND CANYON, 166 (Steven P. Gloss et al. eds., 2005), *available at* http://pubs.usgs.gov/circ/1282 [hereinafter SCORE Report].

[9] *Id.* at 169; U.S. DEP'T OF THE INTERIOR, U.S. GEOLOGICAL SURVEY, USGS CIRCULAR 1366, EFFECTS OF THREE HIGH-FLOW EXPERIMENTS ON THE COLORADO RIVER DOWNSTREAM FROM GLEN CANYON DAM, ARIZONA (Theodore S. Melis, ed., 2011), *available at* http://pubs.usgs.gov/circ/1366 [hereinafter 2011 Circular].

[10] Bruce Babbitt, *Introduction: Down the Imperiled Colorado*, 25 LAND & WATER L. REV. 1, 2 (1990).

[11] U.S. DEP'T OF THE INTERIOR, BUREAU OF RECLAMATION, THE COLORADO RIVER - A NATURAL MENACE BECOMES A NATIONAL RESOURCE 211 (1946) (speaking of the Colorado River, the 1946 Bureau of Reclamation report asserted that, "[i]n their present state this land, this water, and these minerals are not wealth because that are not being utilized economically.").

[12] 2011 Circular, *supra* note 9, at 5 (*citing* Robert Dolan, Alan Howard, & Arthur Gallenson, *Man's Impact on the Colorado River in the Grand Canyon*, 62 AMERICAN SCIENTIST 4, 392 (1974); Maurice E. Cooley, B.N. Aldridge & Robert C. Euler, *Effects of*

the Catastrophic Flood of December 1966, North Rim Area, Eastern Grand Canyon, U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 980 (1977) *available at* http://pubs.usgs.gov/pp/0980/report.pdf; Raymond Marriner Turner & Martin M. Karpiscak, *Vegetation Changes Along the Colorado River between Glen Canyon Dam and Lake Mead, Arizona*, U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1132 (1980) *available at* http:// pubs.usgs.gov/pp/1132/report.pdf; Alan Howard & Robert Dolan, *Geomorphology of the Colorado River in Grand Canyon*, 89 J. OF GEOLOGY 269 (1981)).

[13] "Today, three of the eight native fish species have been eliminated from the Colorado River in Glen and Grand Canyons (roundtail chub (*Gila robusta*), bonytail chub (*Gila elegans*), and Colorado pikeminnow), and two are federally listed as endangered (humpback chub and razorback sucker) under the Endangered Species Act." SCORE Report, *supra* note 8, at 35.

[14] Shifting public values are evidenced by the extensive federal environmental protection law, such as The Clean Air Act of 1970, 42 U.S.C. § 7401 (1990), National Environmental Policy Act, 42 U.S.C. § 4321 (1970), Endangered Species Act, 16 U.S.C. § 1531 (1998), Water Pollution Control Act Amendments of 1977 (Clean Water Act), 33 U.S.C. § 1251 (1987), and many others.

[15] *See* Dennis M. Kubly, *Environmental Protection: Using Adaptive Management at Glen Canyon*, HYDRO REV., (Oct. 2009), http:// www.hydroworld.com/articles/hr/print/volume-28/issue7/articles/environmental-protection.html ("And the Secretary will ... balance the priorities for which the dam was built and those that have come about through ensuing laws.").

[16] *Background*, BUREAU OF RECLAMATION, GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM, http://www.usbr.gov/uc/rm/amp/background.html (last visited March 7, 2014).

[17] Federal Advisory Committee Act, 5 U.S.C. Appendix 2 (2012).

[18] The current makeup of the Glen Canyon Dam AMP can be found at *AMWG Members*, BUREAU OF RECLAMATION, GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM, http://www.usbr.gov/uc/rm/amp/amwg/amwg_members.html (last visited March 9, 2014).

[19] *Id.*

[20] *Id.*

[21] *Operating Procedures, Glen Canyon Dam, Adaptive Management Work Group*, February 9, 2011, *available at* http:// www.usbr.gov/uc/rm/amp/amwg/pdfs/OpProced020911.pdf (stating that the AMWG "should attempt to seek consensus but, in the event that consensus is not possible, a vote should be taken. Voting shall be by verbal indication or by raised hand. Approval of a motion requires a 60 percent majority of members present and voting. The views of any dissenting member or minority group shall be briefly incorporated into the information transmitted to the Secretary along with the majority recommendation.").

[22] U.S. CONST. art. IV, § 3, cl. 2 ("The Congress shall have Power to dispose and make all needful Rules and Regulations respecting the Territory or other Property belonging to the United States ...").

[23] Although references to the Bureau of Reclamation mission to 'make the desert bloom' abound, the origins of this phrase remain unknown.

[24] *See* Multiple-Use Sustained-Yield Act of 1960, 16 U.S.C. § 529 (2014) ("The Secretary of Agriculture is authorized and directed to develop and administer the renewable surface resources of the national forests for multiple use and sustained yield of the several products and services obtained therefrom."); Federal Land Policy and Management Act of 1976, 43 U.S.C. § 1701(a)(7) (2014) (The Congress declares that it is the policy of the United States that ... goals and objectives be established by law as guidelines for public land use planning, and that management be on the basis of multiple use and sustained yield unless otherwise specified by law).

[25] National Park Service Organic Act, 16 U.S.C. § 1 (2014) ("the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.").

[26] Glen Canyon Dam was authorized by the Colorado River Storage Project Act of 1956 (CRSPA), ch. 203, 70 Stat. 105-111 (1956) (codified as amended at 43 U.S.C. §§ 620-620***o*** (2012)).

[27] Marc Reisner, CADILLAC DESERT 172 (1986).

[28] Other "cash-register" dams on the Colorado River system include Flaming Gorge Dam on the Green River, Navajo Dam on the San Juan, and the three dams of the Wayne Aspinall unit on the Gunnison. George Sibley, *Glen Canyon: Using a Dam to Heal a River*, HIGH COUNTRY NEWS, July 22, 1996, http:// www.hcn.org/issues/86/2645.

[29] Relevant federal actions affecting Colorado River development include The Colorado River Basin Project Act (Lower Colorado River Basin Project Act), 82 Stat. 885 (1968) (codified as amended at 43 U.S.C. §§ 1501-1556 (2012)) and the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act September 30, 1968 (P.L. 90-537) 35 Fed. Reg. 8951-52 (June 10, 1970).

[30] *See, supra* notes 12-13, and accompanying text.

[31] Grand Canyon Protection Act of 1992 (GCPA), Pub. L. No. 102-575 § 1802. The Act was Title XVIII of the Reclamation Projects Authorizations and Adjustments Act of 1992, Pub. L. No. 102-575 (2012).

[32] *Id.* § 1802(a) ("The Secretary shall operate Glen Canyon Dam ... in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park ... [was] established, including, but not limited to natural and cultural resources and visitor use.").

[33] *Id.* § 1804(b)(1) (authorizing an Environmental Impact Statement to "audit the costs and benefits to water and power users and to natural, recreational, and cultural resources resulting from management policies and dam operations ...").

[34] U.S. Bureau of Reclamation, U.S. Dep't of the Interior, Operation of Glen Canyon Dam: Final Environmental Impact Statement (1995), *available at* http://www.usbr.gov/uc/library/envdocs/eis/gc/gcdOpsFEIS.html [hereinafter 1995 FEIS].

[35] *See infra* Part II.1.

[36] *See generally, The Law of the River*, U.S. BUREAU OF RECLAMATION, http://www.usbr.gov/lc/region/g1000/lawofrvr.html (last visited Jan. 26, 2014).

[37] Colorado River Compact of 1922, 70 CONG. REC. 324 (1928), *available at* http://www.usbr.gov/lc/region/g1000/pdfiles/crcompct.pdf; U.S. Dep't of the Interior, Record of Decision, Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (November 2007), *available at* http:// www.usbr.gov/lc/region/programs/strategies/RecordofDecision.pdf [hereinafter 2007 Equalization Criteria].

[38] U.S. Bureau of Reclamation, U.S. Dep't of the Interior, Glen Canyon Dam Interim Operating Criteria, Draft Environmental Assessment (September 1991), *available at* https:// ia600709.us.archive.org/12/items/glencanyondamint00nati/glencanyondamint00nati.pdf [hereinafter 1991 Interim Operating Criteria].

[39] *Id.*; 1995 FEIS, *supra* note 34; Glen Canyon Dam Operating Criteria, 62 Fed. Reg. 41 (March 3, 1997) [hereinafter 1997 Operating Criteria].

[40] To date, there have been 5 artificial flood releases from Glen Canyon Dam, commonly referred to as "High-Flow Experiments." The first high-flow experiment was conducted between March 26 and April 7, 1996, and involved a 7-day release of 45,000 cubic feet per second ("cfs"). 2011 Circular, *supra* note 9, at 9. The second high-flow experiment occurred between November 6 and 8, 2004, and included a 60-hour peak release of about 41,700 cfs. *Id.* The third experiment, conducted between March 6 and 8, 2008, included another 60-hour release of approximately 42,800 cfs.*Id.* The fourth high flow experiment, a 24-hour release of approximately 42,000 cfs, began on November 18th 2012. National Park Service, Grand Canyon, November 2012 High-Flow Experiment, http://www.nps.gov/grca/naturescience/upload/2012hfe-fact-sheet.pdf (last visited March 31, 2014). The most recent experimental flood occurred between November 11 and 16, with a 4-day peak release of 34,100 cfs. U.S. Dep't of Interior, Bureau of Reclamation, Glen Canyon Dam 2013 High Flow Experimental Release, http://www.usbr.gov/uc/rm/gcdHFE/2013/ (last visited March 31, 2014). Cubic feet per second is a volumetric flow measurement unit often used to describe large volume flows in American rivers. *See infra*, note 57.

[41] The use of experimental steady flows include the 2000 low summer steady flow test, which included two 4-day 31,000 cfs releases in spring and late summer, with June through August flows held constant at 8,000 cfs. SCORE Report, *supra* note 8, at 8.

[42] Experimental fluctuating flows to suppress nonnative fish species implemented relaxed hourly ramping rates between January and March, 2003-2005, and allowed daily flows to range between 5,000 and 20,000 cfs. SCORE Report, *supra* note 8, at 8.

[43] *See generally*U.S. DEP'T OF THE INTERIOR, U.S. GEOLOGICAL SURVEY, USGS CIRCULAR 1126, DAMS AND RIVERS: A PRIMER ON THE DOWNSTREAM EFFECTS OF DAMS (2nd ed. 2000).

[44] SCORE Report, *supra* note 8, at 17 ("The closure of Glen Canyon Dam and the beginning of flow regulation of the Colorado River through Grand Canyon in 1963 all but eliminated the mainstem sand supply to Grand Canyon and substantially altered the seasonal pattern of flows in the Colorado River. Dam-induced changes in both sand supply and flow have altered the sedimentary processes that create and maintain sandbars and related habitats, resulting in smaller and coarser grained deposits throughout the ecosystem.").

[45] RUSSELL MARTIN, A STORY THAT STANDS LIKE A DAM 32 (1999).

[46] 2011 Circular, *supra* note 9, at 27. Other studies show that between 77 and 79 percent of the sand and mud transported past the Grand Canyon gage, located 88 miles downstream from Lees Ferry, was supplied by the Colorado River watershed upstream from Lees Ferry. *Id.*

[47] SCORE Report, *supra* note 8, at 17 ("Dam-induced changes in both supply and flow have altered sedimentary processes that create and maintain sandbars and related habitats, resulting in smaller and coarser grained deposits throughout the ecosystem."). In the 1995 FEIS, scientists predicted that despite the drastically reduced sediment inputs, new sediment from the Paria and the Little Colorado Rivers would accumulate in the channel of Colorado River over multiyear timescales. *Id.* at 21. The scientists hypothesized that because the annual spring snow melt flood had been eliminated, the sediment transport capacity of the river had been sufficiently reduced as to prevent long-term erosion of new sediment inputs. *Id.* They thus predicted that artificial floods conducted every several years would redeposit sediment at high elevations along the margin of the river and regrow or maintain the sandbars that play an integral role in proper functioning of the Colorado River ecosystem. This sediment, in turn, could be redistributed to even higher elevations by wind. *Id.* at 18 (citing David J. Topping, John C. Schmidt, & L.E. Verra, Jr., *Computation and Analysis of the Instantaneous-Discharge Record for the Colorado River at Lees Ferry, Arizona - May 8, 1921, through September 30, 2000*, U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1677, 54 (2003), *available at* http://pubs.usgs.gov/pp/pp1677/pdf/pp1677.pdf). Recent research, however, has shown these assumptions to be incorrect. SCORE Report, *supra* note 8, at 21-25. Scientists have now shown that new sediment is transported through the system, and net erosion occurs, when flows in the main channel of the Colorado River in Grand Canyon are in excess of approximately 9,000 cfs. *Id.* at 19. Because modern stream flows are often in excess of 9,000 cfs to satisfy water delivery obligations, old sediment deposits, relics from the pre-dam era, have eroded over time. During the 1990s, for example, discharge exceeded 9,000 cfs 82.6% of the time. *Id.*; Topping et al., *supra* note 47, at 48.

[48] SCORE Report, *supra* note 8, at 17 and 24.

[49] S*ee generally*NATIONAL PARK SERVICE, *2009 Backcountry Statistics, available at* http://www.nps.gov/grca/planyourvisit/upload/2009_Backcountry_ Statistics.pdf (general information on backcountry statistics in Grand Canyon National Park).

[50] SCORE Report, *supra* note 8, at 180 (listing 336 potentially impacted sites within an area of inundation from a 300,000 cfs flood).

[51] *Id.* at 179-180. Loss of archeological artifacts can be direct or indirect. *Id.* (listing direct impacts as "sites where inundation or bank cutting from dam-controlled river flows had occurred within the site in recent years" and indirect impacts including "bank slumpage or slope steepening from river flows immediately adjacent to the site" and "arroyo cutting or other erosional phenomena tied to the effects of dam-controlled flows ...").

[52] *Id.* at 123.

[53] *Id.* at 78 ("Substantial warming occurs in various nearshore environments, ranging from shallow, open-water areas to enclosed backwaters .... These environments may be important to the survival, growth, and eventual recruitment of the larval states of native fish."). *Id.* at 44 ("During summer, the young humpback chub that survive in the mainstem occupy low-velocity, talus, and vegetated shoreline habitats, including backwaters ...").

[54] *Id.* at 19.

[55] *Id.*

[56] *Id.* at 184 ("Flows during the winter months were typically quite low, often running at less than 3,000 cfs.").

[57] Topping, et al., *supra* note 47, at 58. "Cfs" stands for cubic feet per second, and is a volumetric flow measurement typically used to describe flow on large American rivers. One cfs is equivalent to approximately 450 gallons per minute.

[58] *See* Topping et al, *supra* note 47, at 45 ("Likewise, based on discharge alone, the pre-dam months of January through March and August through December would be characterized by the accumulation of sand ..."); *see also id.* at apps. F, G; SCORE Report, *supra* note 8, at 19.

[59] SCORE Report, *supra* note 8, at 184 (In the pre-dam era, "[s]pring flows typically peaked in June or early July, with additional spikes in late summer in response to localized monsoon storm event.").

[60] *Id.* ("The predam era was generally characterized by high seasonal variability and low daily variability. Flows during the winter months were typically quite low, often running at less than 3,000 cfs.").

[61] *Id.* at 19 ("Also, because peak energy demand varies seasonally in the West, with peak demand occurring in midsummer and winter, the month-to-month flow pattern related to dam operation is substantially different from natural, predam, seasonal patterns.").

[62] *Id.* ("Highest discharges in the river now occur during the two seasons when predam discharge had typically been the lowest, midsummer and winter.").

[63] *Id.* ("Because of energy demand and hydropower economics, monthly release volumes are highest during months with high demand, including those in late summer.").

[64] *Id.*

[65] Topping et al., *supra* note 47, at 1 ("Operation of the dam has eliminated flood flows and base flows, and thereby has effectively "flattened" the annual hydrograph.").

[66] *See generally* SCORE Report, *supra* note 8, at 103-22; *see also* SCORE Report, *supra* note 8, at 124 (citing Raymond M. Turner & Martin M. Marpiscak, *Recent Vegetation Change Along the Colorado River between Glen Canyon Dam and Lake Mead, Arizona*, U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1132 (1980), *available at* http://pubs.usgs.gov/pp/1132/report.pdf.

[67] Score Report, *supra* note 8, at 110 (citing Lisa H. Kearsley, John C. Schmidt & Katherine D. Warren, *Effects of Glen Canyon Dam on Colorado River Sand Deposits Used as Campsites in Grand Canyon National Park, USA*, 9 REGULATED RIVERS: RESEARCH & MANAGEMENT 137, 137-49 (1994)).

[68] SCORE Report, *supra* note 8, at 198. This decrease is attributable to both a reduction in sandbar size and vegetation encroachment. *Id.*

[69] The humpback chub was listed as endangered on March 11, 1967. 32 Federal Regulations 4001; U.S. FISH AND WILDLIFE SERVICE, U.S. DEP'T OF INTERIOR, AESO 22410-2011-F-0100, FINAL BIOLOGICAL OPINION ON THE OPERATION OF GLEN CANYON DAM INCLUDING HIGH FLOW EXPERIMENTS AND NON-NATIVE FISH CONTROL 59, 77-80 (2011), *available at* http:// www.fws.gov/southwest/es/arizona/Documents/Biol_Opin/110112_HFE_NNR.pdf [hereinafter 2011 Biological Opinion]. Up from a population low of about 4,500-5,700 individuals in 2001, humpback chub populations in Grand Canyon were estimated to approximate 7,650 individuals in 2008. *Id.* at 17; Matthew E. Anderson, *Status and Trends of the Grand Canyon Population of Humpback Chub*, U.S. GEOLOGICAL SURVEY FACT SHEET 2009-3035 (2009), *available at* http:// pubs.usgs.gov/fs/2009/3035. Because the Colorado River in Grand Canyon lacks significant sediment, the generally clearer waters favor predation by nonnative trout species who hunt by sight. Although a three-year mechanical removal program reduced the trout population by 90% near the area surrounding the only successfully reproducing population left in the lower basin, trout populations increased 800% following the 2008 High-Flow Experiment. SCORE Report, *supra* note 8, at 42, 46; 2011 Biological Opinion, *supra* note 69, at 50.

[70] Humpback chub require water temperatures of 61-72°F for spawning, egg incubation, and optimal survival of young. 2011 Biological Opinion, *supra* note 69, at 14. Additionally, the thermal preference for humpback chub during their first year of life is estimated to be approximately 75°F. *Id.* at 15. Because Glen Canyon Dam releases water from the below the epilimnion--the top-most layer in a thermally stratified lake--the Colorado River in Grand Canyon is relatively thermally stable, with temperatures rarely exceeding 54°F or falling below 44°F. SCORE Report, *supra* note 8, at 77. In contrast, the temperature of the unregulated Colorado would range from 32°F in the winter to over 80°F in the summer. *Id.*, at 4 (citing 1995 FEIS, *supra* note 34). For an in-depth discussion of water quality in Lake Powell and the Colorado River, *see* Chapter 4 of the SCORE Report, *supra* note 8, at 69-86.

[71] *See generally* J.B. Ruhl & Robert L. Fischman, *Adaptive Management in the Courts*, 95 MINN. L. REV. 424 (2010).

[72] *Id.* at 428.

[73] *See, e.g.*C.S. HOLLING ET. AL., ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (C.S. Holling ed., 1978); Carl J. Walters & C.S. Holling, *Large-Scale Management Experiments and Learning By Doing*, 71 ECOLOGY 2060, 2062 (1990); *see also* Part I of Ruhl & Fischman, *supra* note 71, at 427-443.

[74] JULIA M. WONDOLLECK & STEVEN L. YAFFEE, MAKING COLLABORATION WORK 11-14 (2000).

[75] George Cameron Coggins, *'%7FDevolution" in Federal and Land Law: Abdication by Any Other Name* ..., 3 HASTINGS W.-NW. J. ENVTL. L. & POL'Y 211, 218 (1996) (claiming that the assertion that resource allocation decisions are ""better" when local interests are well-represented is based on false assumptions).

[76] *See generally*, Frank A. Ward & Thomas P Lynch, *Is Dominant Use Management Compatible with Basin-Wide Economic Efficiency?* 33 WATER RESOURCES RESEARCH 1165, 1165 (1997).

[77] Alejandro E. Camacho, *Beyond Conjecture: Learning about Ecosystem Management from the Glen Canyon Dam Experiment*, 8 NEV. L.J. 942, 949 (2008).

[78] Lawrence Susskind, Alejandro E. Camacho, & Todd Schenk, *Collaborative Planning and Adaptive Management in Glen Canyon: A Cautionary Tale*, 35 COLUM. J. ENVTL. L. 1, 4 n.23 (2010).

[79] Camacho, *supra* note 77, at 951.

[80] See, e.g., *Grand Canyon Trust v. United States Bureau of Reclamation*, No. CV-07-8164-PCT-DGC, 2008 WL 4417227 (D. Ariz. Sept. 26, 2008); *Grand Canyon Trust v. United States Bureau of Reclamation*, 623 F.Supp.2d 1015 (D. Ariz. 2009); *Grand Canyon Trust v. United States Bureau of Reclamation*, No. CV-07-8164-PHX-DGC, 2010 WL 2643537 (D. Ariz. June 29, 2010); *Grand Canyon Trust v. United States Bureau of Reclamation*, No. 11 16326, 2012 WL 3264499 (9th Cir. Aug. 13, 2012); Stipulation for Dismissal with Prejudice, *Center for Biological Diversity v. U.S. Bureau of Reclamation*, *Stipulation for Dismissal with Prejudice*, No. 3:06-00494 DGC, Aug. 25, 2006 (D. Ariz.), *available at* http:// www.usbr.gov/uc/rm/gcdltep/related/SettlementAgreement-08-25-06.pdf. *See also*, Camacho, *supra* note 77, at 959 (reporting that an AMWG ad hoc committee drew the conclusion that "some stakeholders feel disenfranchised because some interests have more representation on the group; this is especially significant when consensus is not achieved and issues get resolved by a vote.") (citing ROLES AD HOC GROUP, GLEN CANYON DAM ADAPTIVE MANAGEMENT GROUP, REPORT AND RECOMMENDATIONS TO THE SECRETARY'S DESIGNEE (DRAFT) (2007), *available at* http://www.usbr.gov/uc/rm/amp/amwg/mtgs/07may22CC/Attach_03a.pdf)

[81] One example of a Bureau of Reclamation dam removal projects is the removal of the Savage Rapids Dam on the Rogue River in Oregon. *Savage Rapids Dam Removal*,BUREAU OF RECLAMATION, http://www.usbr.gov/pn/programs/lcao_ misc/savage/ (last visited April 5, 2014). The push for sustainability is highlighted in Robert Glennon & Peter Culp, Op-Ed., *West must Strive for Water Sustainability*, ARIZONA REPUBLIC, Jan. 5, 2013, http:// www.azcentral.com/arizonarepublic/opinions/articles/2013/01/02/20130102glennon-culp-west-must-strive-water-sustainability.html, and *Colorado River Basin Water Supply & Demand Study, Final Study Reports*,U.S. BUREAU OF RECLAMATION, http:// www.usbr.gov/lc/region/programs/crbstudy/finalreport/index.html (last visited May 24, 2013).

[82] As an example, the Grand Canyon Trust recently ended a 4-year litigation battle with the Bureau of Reclamation over the management of Glen Canyon Dam and endangered fish species. *See supra* note 80.

[83] *See generally* Camacho, *supra* note 77.

[84] *See AMWG Members*, *supra* note 18. In contrast, the Lower Colorado River Multi-Species Conservation Program has 57 members. ARIZONA WATER POLICY: MANAGEMENT INNOVATION IN AN URBANIZING, ARID REGION 95 (Katherine Jacobs & Bonnie Colby eds., 2007); *LCR Multi-Species Conservation Program, General Program*, http://www.lcrmscp.gov/general_program.html (last visited Jan. 22, 2014).

[85] *See AMWG Members*, *supra* note 18.

[86] *See About Us*, GRAND CANYON TRUST, http:// www.grandcanyontrust.org/about.php (last visited Jan. 25, 2014).

[87] *See* Missions, Goals, Strategies, *Inside Grand Canyon Wildlands Council*, http://www.grandcanyonwildlands.org/insidegc.html (last visited March 31, 2014).

[88] Park Statistics available at http://nature.nps.gov/stats/park.cfm (select "Grand Canyon NP" from the park list and "Annual Park Visitation (all years)" from the reports list).

[89] 5 U.S.C.A. § 704 (2012).

[90] *See, e.g., Center for Biological Diversity v. U.S. Bureau of Reclamation*, *Stipulation for Dismissal with Prejudice*, http:// www.usbr.gov/uc/rm/gcdltep/related/SettlementAgreement-08-25-06.pdf (last visited Jan. 22, 2014).

[91] *AMWG Members*, BUREAU OF RECLAMATION, GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM, http://www.usbr.gov/uc/rm/amp/amwg/amwg_members.html (last visited Jan. 9, 2012).

[92] Colorado River Storage Project Act of 1956, ch. 203, 70 stat. 105-111 (1956) (codified as amended at 43 U.S.C. §§ 620-620***o*** (2012)), *available at* http://www.usbr.gov/lc/region/g1000/pdfiles/crspuc.pdf.

[93] *See generally* SCORE Report, *supra* note 8, at 165-174.

[94] The Law of the River is the complex set of statutes, treaties, judicial decisions, compacts, agreements and regulations that govern both management and allocation of Colorado River waters. *See generally*, *The Law of the River*, U.S. BUREAU OF RECLAMATION, http:// www.usbr.gov/lc/region/g1000/lawofrvr.html (last visited Jan. 23, 2014).

[95] Interview with Grand Canyon Trust employee, August 1, 2013.

[96] *See* Grand Canyon Trust litigation, *supra* note 80, and accompanying text.

[97] Interview with former AMWG representative, May 17, 2013.

[98] Camacho, *supra* note 77, at 959 ("particularly recently the one interest that has been able to fairly and consistently put together a two-thirds majority is hydroelectric power, working with states (and sometimes tribes) who increasingly have been concerned regarding expedient availability of economical energy.").

[99] *Id.*

[100] U.S. DEP'T OF THE INTERIOR, BUREAU OF RECLAMATION, Environmental Assessment, Development and Implementation of a Protocol for High-Flow Experimental Releases from Glen Canyon Dam, Arizona, 2011 through 2020 (2011), *available at* https://www.usbr.gov/uc/envdocs/ea/gc/HFEProtocol/HFE-EA.pdf.

[101] *Id.*

[102] *See, e.g.* Daniel C. Esty, *A Term's Limits*, 126 FOREIGN POL'Y 74 (2001).

[103] *See, e.g.*, Andrew Zolli, *Learning to Bounce Back*, N.Y. TIMES, Nov. 2, 2012,

http://www.nytimes.com/2012/11/03/opinion/forget-sustainability-its-about-resilience.html.

104 Grand Canyon Protection Act of 1992 (GCPA), Pub. L. No. 102-575 § 1802 (1992).

105 *Colorado River Basin Water Supply & Demand Study*, *Final Study Reports*,U.S. BUREAU OF RECLAMATION, http://www.usbr.gov/lc/region/programs/crbstudy/finalreport/index.html (last visited May 24, 2013).