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Holding Back the Waters – Dams as Water Resource Monuments

by Joe Gelt

From Glen Canyon Dam to the above catchment under construction, dams and impoundments are links in a human engineered system to store water and control its use. (Photo: Arizona Game and Fish Department)

Those who labor in the water resources field may at times feel their efforts to be slighted. Whereas military glories are marked by public monuments – statues, plaques, a cannon in the park – milestones in water resource developments are represented by laws, public policies, and court decisions. To small boys and most adults, a cannon in the park is more intriguing.

Monuments to water resource developments, however, do exist. Consider Hoover Dam stretching across Black Canyon, its swathe of concrete blocking the flow of the mighty Colorado River, a marvel to be admired – or condemned. Hoover Dam, along with other Colorado River Dams are nature-defying spectacles of engineering wizardry, serving varied purposes from power generation to recreation. These are the high-profile or celebrity dams.

Big Dams, Little Dams

Celebrity dams, their operations often the focus of news, public interest and controversy, are not typical of most dams in Arizona. First of all, celebrity dams in Arizona are few in number, representing an insignificant percentage of the 439 total dams that are in the state according to the National Inventory of Dams.

Compared to the celebrity dams, many of these smaller dams might be viewed as work-horse dams, constructed to serve a specific purpose; e.g., stock pond, mine tailing or flood control. Some smaller dams may serve several uses, including recreation, but compared to the giant multi-use dams, they provide limited opportunities for public enjoyment and use. But these dams too are monuments to water resource development.

While the differences between celebrity dams and other dams are obvious and readily apparent, the common ground they share is less noticeable. Each dam, from the largest to the smallest, contributes to

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an overall effort to control water for perceived human advantage. Each dam is part of a strategy to develop and exploit available water resources.

Charles F. Wilkinson in his book *Crossing the Next Meridian* summarizes this situation: "Western water development has proceeded on two different levels. The first, highly visible, involved the big, mostly federally subsidized dams and transbasin diversion systems... The second, much less visible but of the same magnitude in the aggregate, has been the millions of small dams, stream diversions and groundwater pumps of individual miners, farmers, agricultural districts, corporations, town, and cities... The two strains share the same origins, complement each other, and taken together, have amounted to perhaps the most far-flung natural resource development program the nation has ever undertaken."

This is a guiding premise in understanding dams. What they have in common – their shared purpose – is of greater significance than their many differences. The following discussion is mainly about the smaller, little publicized dams.

The West, A Good Place for Dams

Conditions in the West favor the building of dams to regulate and distribute the flow of water. Since the region is generally dry, a little water had to go a long way, and when the pace of development quickened, a little water had to go even further. Dams for capturing and storing water were viewed as a partial solution to the problem. Without them the water would be wasted, flowing off and out of the reach of farmers, miners and others who could put it to good practical use.

Concern that water will be wasted by flowing its complete natural course, from headwaters to river mouth, is a frequent theme in early Arizona historical documents. The University of Arizona's General Bulletin No. 3, dated 1936 and titled *Arizona and its Heritage,* calls for the building of high dams and surface reservoirs "to arrest the floods which might otherwise be lost and wasted in the ocean."

That the flow of many western rivers is erratic also invites dam building. Much of the annual flow of these rivers – 40 percent or more – derives from spring snowmelt occurring in April, May and early June. The water, however, is most needed during the irrigation season, from roughly mid-May through mid-September. Dams help even out supply for use during times of need.

As a result, in the West, where stream flow is minimal and erratic and water needs many and expanding, most rivers were dams waiting to happen. Dams are such a common feature on Arizona rivers today that a river without a dam is renown for its absence. The San Pedro River is celebrated as the state's largest undammed river.

Potential Failure Prompts Regulations

Holding back the flow of water, a dam creates a sense of tension, almost encouraging speculation about its failure or destruction and the resulting surge of released water. The effects could be devastating, with great loss of life and massive destruction of property.

Dams on the Salt/Verde River, the Aqua Fria River, the Gila River, and the Colorado River pose the greatest threat to the largest population centers within the state. For example, failure of any Bureau of Reclamation dams on the Salt/Verde River or the Aqua Fria River would cause massive flooding in Phoenix and Maricopa County.

It is not just the large dams that pose threats to human life and property. Santa Fe Dam in the City of Williams is only 42 feet high, holding back 215 acre-feet of water. Its failure, however, could result in a great loss of human life and cause extensive property damage in Williams.

Basic to dam regulations are hazard ratings to indicate the probable loss of life, property damage and environmental destruction that might result if a dam failed. Regulatory agencies use variations of a three-tier rating system indicating high, medium or significant, and low potential hazards.

Approximately 130 of the over 400 dams in Arizona are classified as high hazard potential. This does not mean that the dams are hazardous, with a high possibility of failure, but instead that if they did fail they likely would pose a high hazard to life and property.

Both state and federal agencies are involved with dams. The Arizona Department of Water Resources is

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the state agency with regulatory power over most dams in the state. The Arizona Department of Environmental Quality and the Arizona Division of Emergency Management also have some interest in dam management and regulation.

ADWR Regulates Dams

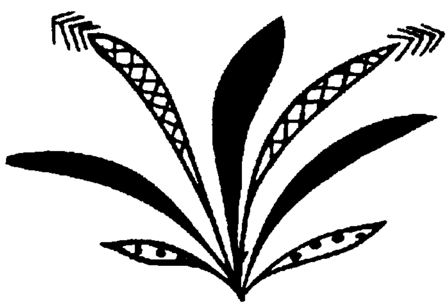
The Flood Warning and Dam Safety Section of the Arizona Department of Water Resources regulates all dams in the state except mine tailing dams and federal dams. Prior to ADWR's involvement the Arizona Highway Department regulated dams in the state.

ADWR regulates 212 dams owned by various entities. City, county and state governments own 92; private corporations and individuals own 83; water development and irrigation districts own 36; and the Boy Scouts of America has one. Dams located within Arizona not under ADWR jurisdiction include approximately 65 federal dams, 34 copper tailing dams and 110 tribal dams.

Arizona state statutes generally define a dam as an artificial barrier, either 25 feet or greater in height or capable of storing more than 50 acre-feet of water. Of the 212 state-regulated dams, 20 are concrete or masonry, and the rest, except for one inflatable dam, are constructed of earth and/or rock. The average dam is 37 feet high and stores 2,509 acre-feet of water.

(In 1993 the average ADWR-regulated dam was 38 feet high and stored 3,346 acre-feet of water, 837 acre-feet more than the current figure. The average acre-feet of water dropped because the earlier and higher figure included the 157,000 acre-feet of water stored behind Waddell Dam, by far the largest dam then under ADWR jurisdiction. Since then New Waddell Dam, located one-half mile downstream of the old dam, began operating and its storage basin encompasses the historic dam and its reservoir. BuRec, a federal agency, operates New Waddell Dam.)

The height of ADWR-regulated dams varies from 6-foot high Nutrioso Dam in Apache County, used for stock watering and irrigation, to Mineral Creek Dam, a flood control structure owned by ASARCO, which is 155 feet high. The storage capacity of state-regulated dams varies from Five Mile Wash Dam and Woodruff Dam, both with 15 acre-feet storage capacity, to Cave Buttes Dam, a flood control dam owned by Maricopa County, with a 46,000 acre-feet maximum storage.



San Ildefonso pottery plant design

The frequency of dam safety inspections is determined by the downstream hazard potential of dams, with high-hazard dams inspected annually, significant-hazard dams every three years and low-hazard dams every five years. Any problems or deficiencies are reported to the owner who then usually corrects the problem.

If the owner refuses to fix the problem, ADWR issues an order that the work must be done. If the owner still refuses to act civil penalties could be imposed. In the event of an emergency and the owner is not taking appropriate actions to mitigate the situation, ADWR has the authority to take control of the dam.

ADWR and Mine Tailing Dams

Mine tailing dams are ponds or impoundments that store tailings. Tailings are ground-up waste rock with the ore removed. Water is added to the tailings so it can be transported as slurry through pipes to a storage area or dam. The coarser materials within the slurry form the sides of the dam, with the finer materials and water settling within.

Tailing dams can be very large. The New Cornelia tailing pond on Ten Mile Wash near Ajo is listed in the 1993 Universal Almanac as the world's second largest dam, measured in terms of volume of material used in construction. Completed in 1973, this dam contains 274 million cubic yards of copper mining tailings.

Until the Arizona Legislature decided otherwise, ADWR understood state law to include mine tailing dams under its jurisdiction. The agency deemed its regulatory oversight to be appropriate since, if a mine tailing dam failed, the consequences would be the same as any dam failure. Life and property would be endangered.

The mining industry, however, questioned ADWR's oversight of tailing dams. To settle the matter ADWR asked the 1977 Arizona Legislature to change the wording of the law to clarify that ADWR did in fact regulate mine tailing dams. The Legislature took the opposite tack. It specifically excluded mine tailing dams from ADWR jurisdiction.

ADEQ'S Regulation of Dams

The Arizona Department of Environmental Quality's interest in dams has more to do with water quality, than with dam safety. Under the Aquifer Protection Program, ADEQ regulates discharging facilities including surface impoundments, solid waste disposal facilities, injection wells, recharge projects and mine tailing piles and ponds.

ADEQ regulates tailing dams to protect the state's aquifers from the seepage. The agency also is concerned with dam stability, to ensure that dams do not fail and spill pollutants into surface waters. ADEQ, unlike ADWR, is not specifically empowered to regulate potential downstream physical hazards that might cause loss of life and property.

ADEQ and ADWR interests in dam stability are from different perspectives. As mentioned, ADWR is concerned about the loss of life and property resulting from dam failure. Dam stability is important to ADEQ because a failed dam could impact surface water and groundwater quality. This then would threaten human health and the environment.

ADEQ's proposed *Mining BADCT Guidance Manual* refers mostly to tailing impoundments or embankments rather than just to tailing dams. This is to emphasize that the agency's concern is broader than just with the structure, but also includes the quality of water behind it.

ADWR and ADEQ might both regulate the same dam if, for example, the dam serves a discharging facility – and is not a mine tailing dam exempted from ADWR jurisdiction. For example, both agencies regulate Sedona's effluent pond dams, ADWR concerned with dam safety and ADEQ with water quality.

Arizona Department of Emergency Management

The Arizona Division of Emergency Management plans response and recover activities in the event of an uncontrolled release of water, such as would occur if a dam failed. Because of its interest in emergency preparation, ADEM is involved in a project to secure federal recovery assistance in the event of the failure of a flood control work.

Various flood control works, including levees, channels, and dams, protect Arizona citizens from the threat of flood damage. The Federal Emergency Management Agency once provided recovery assistance support in the event a flood control work failed. In 1993 FEMA enforced a policy that flood control works were no longer eligible for its assistance following a major disaster.

Unless another funding source is identified, the state could be liable for costly damages. The U.S. Army Corps of Engineers through P.L. 84-99 is a possible funding source.

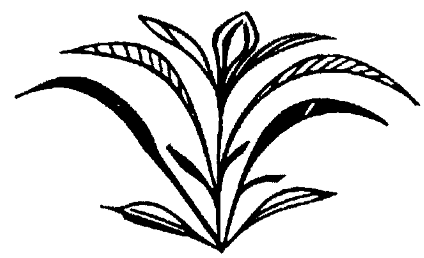
Under P.L. 84-99 the Corps is responsible for repairing flood control works that it constructed or that are within its Flood Control Works Identification Program. The Corps, however, does not have a P.L. 84-99 program in Arizona and lacks the personnel to identify and inspect structures in the state that could be included in such a program.

ADEM is cooperating with the Corps to establish a P.L. 84-99 program in Arizona. Part of the process includes compiling a list of all dams in the state, with available information, to include in a database. Once this information is gathered it will be submitted to the Corps as part of a P.L. 84-99 program application. The database is expected to be the most complete source of information about dams in the state.

To include structures in the database, Arizona dam owners or operators should contact Darlene Baca, Arizona Division of Emergency Management, 5030 S. Mill Avenue, Tempe, Arizona 85257; 602-831-8934.

U.S. Forest Service Dams

Many dams are located on U.S. Forest Service lands in Arizona: 36 dams in the Apache-Sitgreaves National Forest; 16 in the Coconio N.F.; 12 in the Coronado N.F.; 12 in the Kaibab N.F.; 23 in the Prescott N.F.; and seven in the Tonto N.F. Not included in the above listing are most of the stockwater ponds often built by ranchers with grazing permits on USFS lands. Referred to as dugout stockponds, these are made by digging a hole and banking it with the removed dirt, to be filled by rainfall or groundwater. USFS considers dugout stockponds as dams because they are rimmed with dirt. Over a thousand are located on USFS lands in Arizona.



San Ildefonso pottery plant design

Most dams located on USFS lands are not owned by the service but by the persons, organizations or agencies having built the dams. These include ranchers, farmers, Arizona Game and Fish Department, irrigation companies, Phelps Dodge Corporation and city governments. The owners build the dams to serve their particular interests; e.g., irrigation, stockwatering, flood control, wildlife, etc. Arizona Game and Fish owns several of the larger dam facilities on USFS land and operates them mainly for recreation and wildlife. The U.S. Bureau of Reclamation's Roosevelt Dam is located in the Tonto National Forest.

Serving various purposes, the dams vary greatly in size, from the dugout stock ponds described above to Woodland Dam with a storage capacity of 100 acre-feet to the multi-use Roosevelt Dam with a recently expanded storage capacity of 1.6 million acre feet. Woodland Dam is located in the Apache-Sitgreaves National Forest and is owned by the Woodland Irrigation Co.

Persons building dams on USFS land are responsible for all construction costs. First, however, they must demonstrate they have the necessary water rights, a prerequisite that has stymied many would-be dam builders in Arizona. An environmental analysis of the project needs to be done to determine if any endangered species will be affected. An archeological clearance is required to ensure that no cultural artifacts will be disturbed.

Bureau of Indian Affairs Dams

In Arizona about 145 dams are located on Indian reservations. Various federal agencies work to ensure the safety of these dams, with the Bureau of Indian Affair's Safety of Dams Program taking a lead role. The BIA divides Arizona into two jurisdictions. The Phoenix area office is responsible for reservations in Utah, Nevada, and all of Arizona, except for the Navajo Reservation. The vast Navajo Reservation makes up its own BIA administrative area.

Reservation dams serve various purposes. Coolidge Dam, located on the San Carlos Reservation and the largest reservation dam in Arizona, provides water to irrigate over 100,000 acres on the Gila Indian Reservation as well as private land in the Florence and Coolidge area. The Coolidge Dam also has power generation capabilities. The primary use of a number of dams on the Fort Apache reservation is fishing, recreation and stockwatering.

Most reservation dams are small, earth-filled dams posing little danger to human life in the event of failure. Indian lands, however, also have their share of significant and high hazard potential dams, with about 100 located on U.S. tribal lands. Of this number, about 34 are within Arizona.

The BIA's Safety of Dams Program mainly is concerned with significant or high hazard potential dams. In Arizona these dams range in size from Coolidge Dam on the upper Gila River, a large concrete structure with a million acre-feet of storage, to some relatively small earth-filled dams also classified as potentially hazardous.

The Indian Dams Safety Act of 1994 established a separate funding authority for the BIA Safety of Dams Program. The act also provides funds for minor repairs and annual maintenance on reservation dams.

BIA officials estimate that to fix all 100 high hazard dams located on U.S. Indian reservations would require between $400 and $500 million. With present BIA annual allocations for dam repair at $18 million the completion of needed work on all BIA dams clearly is a long-term commitment.

Several reservation dams in Arizona that recently benefited from the funding process are Round Rock and Ganado dams on the Navajo Reservation. Also BIA recently completed a $45-million project to improve the safety of Coolidge Dam. A dam on the San Carlos reservation currently is in line for repairs and modification.

Dams and History

Dams are artifacts of history. To study a dam's construction at a particular time and place, whether five, 20 or 150 years ago, is to gain some understanding of the society at that time, its politics, economics, and social values, not to mention its level of technical proficiency. More than stone and concrete go into the construction of a dam.

For example, Roosevelt Dam exists because of the expanding power of urban and agricultural interests in central Arizona and the federal government's willingness to construct large-scale water projects. Encapsulated in that very brief statement is a lot of Arizona history.

It tells of the state's transition from its frontier beginnings to a place in the national economy, and it foretells of Arizona's reliance on federally sponsored water projects to transcend its natural resource limitations and pursue its chosen destiny of growth and development. Is it any wonder that Roosevelt Dam appears on the Arizona State Seal?

Aside from whatever historical insights a study of dams provides, dams also have their own story to tell. A history of Arizona dams would include all the elements of good story telling—humor, human interest, heroes and villains, achievements and tragedy. It would tell of Arizona Governor B.B. Moeur calling out the National Guard to thwart completion of Parker Dam for delivering water to California. The action represents the last time one state raised arms against another.

Such a history also would include an account of the bursting of the Walnut Grove Dam on the Hassayampa River that killed about 150 people and left scores missing. After listing the names of the dead and missing, a contemporary news account demonstrated the callousness of the period by adding, almost as an afterthought, "and seven Chinamen."

A recent book that focuses on dams to reconstruct history is *Raising Arizona's Dams*. The authors, A. E. Rogge, D. Lorne McWatters, Melissa Keane and Richard P. Emanuel, set out to reconstruct the work-a-day lives of the many construction workers who wielded pick and shovel and moved dirt, stone and debris to actually build the dams of central Arizona.

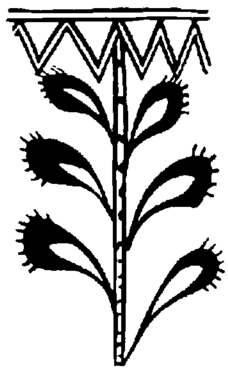
Railroad Dams

Railroad dams would be a chapter in a history of Arizona dams. The lack of water in northern Arizona was not conducive to the running of a railroad which needed regular sources of water for its steam engines. With flowing springs and streams few and far between, nature was not living up to the fixed schedules and demands of human institutions. To confront this inconvenience and to avoid having to haul water, the Santa Fe Pacific Railway built dams for impounding water at strategic points along its line. Some of these railroad dams also served towns that grew up around the stations.

The first of the series of railway-constructed dams was a dam built near the town of Williams in 1884. Its height was 46 feet and it extended 385 feet along the crest, with a storage capacity of 388 acre-feet. Other dams built by the railway included a dam constructed in 1897 one mile west of Kingman. This masonry dam was two feet thick at the top, 6 feet thick at the base and 16 feet high.

The Seligman Dam was begun in 1898, three miles southwest of Seligman. A contractor built the dam, with the railway delivering stone, sand and cement on its cars. Sandstone was hauled 43 miles from Rock Butte, the facing stone came from Holbrook 175 miles away, and sand was shipped 150 miles from Sacramento Wash. The dam, its total cost in excess of $150,000, had a storage capacity of 703 acre-feet.

The USFS recently acquired Ash Fork Steel Dam, located in Kaibab National Forest, through a land exchange. Built in 1897 to serve the Santa Fe Pacific Railway, the dam is the first fixed steel dam erected in the United States. Very few others were constructed. A professional journal wrote in 1902 that Ash Fork Dam "has so many novel features of an experimental character that it is specially interesting and instructive to the engineering profession." Ash Fork Steel Dam remains one of only two steel dams still standing in the United States.



San Ildefonso pottery plant design with lightning

Nontraditional Dams

Stuart A. Hoenig, professor emeritus, University of Arizona's Department of Electrical and Computer Engineering, is involved in a project to construct a dam made of old tires. If successful, the dam would help solve two problems. A dam would be in place to halt erosion, and a use would be found for old tires, of which there is a plentiful supply. California had 30 million old tires in 1995; Pima County has 100,000.

Hoenig believes dams constructed of old tires filled with rocks are suitable for use in arroyos. Arroyos are dry most of the year but can flow very vigorously during periods of heavy rain. Sand, tree trunks and even boulders can be carried by the heavy flow and block roads and litter land areas. The tires in the dam will catch the debris and allow water to flow through.

Hoenig does not anticipate any environmental problems using the rubber tires which are classified as hazardous waste. Previous studies, including work done at the UA, as well as experience at Elephant Butte Dam indicate that tires are safe to use as dam material in this situation.

The U.S. Army Corp of Engineers and the Arizona Department of Environmental Quality have approved the first dam, which will be constructed using about 1,200 passenger car tires. It is to be built this spring on King Anvil Ranch in the Pima County Natural Resource Conservation District. The Goodyear Tire Company and Phelps Dodge provided financial support for the project. Phelps Dodge hopes to find a use for the worn-out 13-foot diameter tires from its mining vehicles.

The dam, measuring 30-feet long and 6-feet high, will cost about $5,000, not counting the cost of donated labor and tires. Hoenig figures a concrete dam would cost at least $35,000.

An inflatable rubber dam, also undoubtedly a nontraditional structure, is designed for conditions in the West. The dam consist of one or more bladders of nylon-reinforced rubber, usually anchored to a concrete foundation set in a river bed. Cost is estimated to be about half as much as a conventional dam.

An especially attractive feature is that the dams can deflate in about 15 minutes in the event of a flood. The dam then can be reinflated within an hour and a half as the flood subsides to refill the detention pond. Inflatable dams might also be used to detain flows of water to create shallow ponds for recharge of groundwater.

The final design of the Rio Salado Project on the Salt River in Tempe includes the use of two rubber dams to create a lake. Before deciding on the inflatable dams, CH2M Hill engineers and hydrologists evaluated various other configurations such as movable gates and fixed weirs. They settled on inflatable dams as best for their purposes.

Construction of the dams, which

are first inflatable dams in Arizona, is tentatively scheduled for November. At 16 feet by about 800 to 900 feet, the downstream dam will be the largest inflatable dam in the United States. The resulting impoundment or lake will be about 2 miles long, 900 to 1,000 feet wide, with an area of 2,200 surface acres.

The Impacts of Dams

The catalog of environmental abuses attributed to dams is vast. Dams, however, come in many sizes, from the huge Glen Canyon Dam to a small stockwatering pond on the Apache Sitgreaves National Forest. The environmental effects of dams likewise vary, from minimal impact to major environmental disruption.

At one time, whatever environmental impacts occurred were considered of secondary importance to the perceived benefits gained by building the dam in the first place, if environmental impacts were even noticed. Of late, however, a public voice critical of environmentally damaging dams is gaining volume and credence. The natural benefits of a free-flowing river increasingly are being balanced against the advantages of dams, and the latter often are found wanting.

The list of possible dam-related upstream and downstream impacts should give officials due pause whenever they gather to discuss dam building. Upstream may change from a narrow flowing watercourse to a wide, slow-moving lake. Native vegetation and wildlife habitat may drown, with conditions forming that favor the growth of saltcedar and other exotic plants. Surface water temperatures may rise. Decreased oxygen and nutrient levels could cause fish to die. Increased water evaporation not only represents a loss of water but also raises salinity levels.

Downstream impacts include reduced water levels and even dewatered streams. Stagnant pools are formed. A dammed river blocks the downstream flow of silt and debris. This is a needed source of new sediment for beaches, alluvial soil or nutrients. The natural cycle of heavy spring flow is disrupted, with environmental consequences.

Other possible ill effects of dams include the spreading of diseases like malaria and schistosomiasis, the danger of their structural failure and their lack of sustainability since all dams eventually fill up with sediment.

Of all the various environmental effects attributable to dam building, however, none may threaten more far-reaching, and quite literally, earth-spinning consequences than one described by scientists at the National Aeronautic and Space Administration. They say dam construction in temperate regions of the earth during the last 40 years is causing the Earth to spin more rapidly.

The scientists claim that dams and their reservoirs have shifted vast stores of the earth's water, with a cumulative weight of 10 billion metric tons, to mid-latitudes in the northern and southern hemispheres. This redistributing of the earth's weight in relation to the equator has caused the increase spin to the earth. If a lunar tidal drag did not counteract this effect, the length of a day would have been reduced by 0.2 millionths of a second a day over the last 40 years.

The Metaphysics of Dams

Dams and bridges, especially bridges that span bodies of water, seem to attract more interest and fascination than other types of human-made structures, certainly more than a highway or an office building. Hoover Dam or the Golden Gate Bridge appeal and fascinate not just because of the engineering skills involved or the surrounding natural setting, but because both represent projects in which human creativity and resourcefulness is challenged and engaged by water, an element of aesthetic, psychological and even spiritual appeal.

Bridges allow humans to transcend water as a barrier, providing them passage seemingly to walk on water. Dams enable humans to exert power over the flow of water, to control water and direct it. Dams, therefore, are much more than a strictly water resource issue. Dams express a philosophy.

This helps explain the intense aversion some people feel towards dams. That dams interfere with the physical flow of a river is viewed by some not just as an environmental trespass, but also as a metaphysical transgression. To such people the metaphorical significance of a river is not to be underestimated. Rivers represent the passage of time and the flow of life itself. A dam not only blocks the flow of water, but also violates an essential principle of our existence.

Dams especially incur the wrath of those committed to environmental ideals with a particular righteous fervor or religious intensity. In Ed Abbey's book, *The Monkey Wrench Gang*, saboteurs view the destruction of Glen Canyon Dam as a cause triumphant and a blow against the forces of darkness and evil threatening the earth. In *Encounters With the Archdruid*, author John McPhee quotes David Brower, former director of the Sierra Club, telling an audience, "I hate all dams, large and small."

Conclusion

One way to understand dams is to view each dam as an individual project in a particular setting serving one or more designated purposes. Its success then is determined by how well it serves the purpose or purposes for which it was built – whether generating power, controlling floods, irrigating crops – without causing undue environmental harm.

The Charles Wilkinson quote provided at the beginning of the discussion suggests another way to interpret dams. He said that all dams, regardless of their size and operation, are linked together, along with other water diversion strategies, as part and parcel of a comprehensive strategy to develop the water resources of the country.

With this in mind, to see that BuRec dams, county flood control dams and stock watering dams all are linked encourages an understanding of the workings of a national water resource system. One then looks for the interconnectedness of the parts. For example, that BuRec has ceased to build dams, in the face of controversy, is well known. But an important point might be missed if the controversy is seen as only involving BuRec, without implications to the broader water resource system, even at the local level.

BuRec then might be pointing the way to the future. Its alternatives to dam building is conservation, demand management, improvement in water use efficiency and water reuse. This might be a message to be heeded by all components of the water resource system, from irrigators, to the mining industry, to utilities planning to drill additional groundwater for development. This message, more than the lack of suitable dam sites, should decide the future of dam building.

The writer thanks all the people and organizations contributing information to this newsletter, especially the following: Darlene Baca, *Arizona Department of Emergency Management*; Ken Clauser, *U.S. Bureau of Indian Affairs;* Bill Hawes, *State Mine Inspectors Office;* William Jenkins, Mike Greeenslade, *Arizona Department of Water Resources*; Ken Kilpatrick, *U.S. Forest Service*; Chuck Monfoot, *U.S. Bureau of Reclamation;* Dennis Turner, *Arizona Department of Environmental Quality;* Steve Walker, *CH2M Hill.*

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