

University of Colorado Law School

Colorado Law Scholarly Commons

Dams: Water and Power in the New West
(Summer Conference, June 2-4)

1997

6-2-1997

Dams: Their Costs and Benefits

Daniel F. Luecke

Follow this and additional works at: <https://scholar.law.colorado.edu/dams-water-and-power-in-new-west>



Part of the [Administrative Law Commons](#), [Energy and Utilities Law Commons](#), [Energy Policy Commons](#), [Environmental Indicators and Impact Assessment Commons](#), [Environmental Law Commons](#), [Environmental Policy Commons](#), [Hydraulic Engineering Commons](#), [Hydrology Commons](#), [Land Use Law Commons](#), [Natural Resources Law Commons](#), [Natural Resources Management and Policy Commons](#), [Water Law Commons](#), and the [Water Resource Management Commons](#)

Citation Information

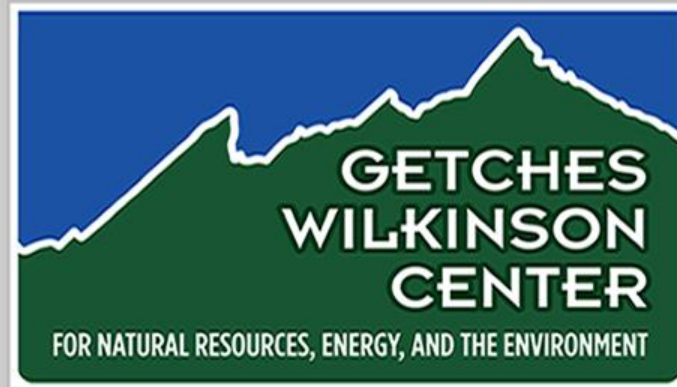
Luecke, Daniel F., "Dams: Their Costs and Benefits" (1997). *Dams: Water and Power in the New West (Summer Conference, June 2-4)*.

<https://scholar.law.colorado.edu/dams-water-and-power-in-new-west/3>

Reproduced with permission of the Getches-Wilkinson Center for Natural Resources, Energy, and the Environment (formerly the Natural Resources Law Center) at the University of Colorado Law School.



William A. Wise Law Library
COLORADO **LAW**
UNIVERSITY OF COLORADO **BOULDER**



Getches-Wilkinson Center Collection

Daniel F. Luecke, *Dams: Their Costs and Benefits*, in DAMS: WATER AND POWER IN THE NEW WEST (Natural Res. Law Ctr., Univ. of Colo. Sch. of Law, 1997).

Reproduced with permission of the Getches-Wilkinson Center for Natural Resources, Energy, and the Environment (formerly the Natural Resources Law Center) at the University of Colorado Law School.

DAMS: THEIR COSTS AND BENEFITS

Daniel F. Luecke
Rocky Mountain Regional Director
Environmental Defense Fund
Boulder, Colorado

DAMS: WATER AND POWER IN THE NEW WEST

June 2-4, 1997

Natural Resources Law Center
University of Colorado
School of Law
Boulder, Colorado



by Daniel F. Luecke

I. The Benefits of Large Dams

Reservoir storage in the United States exceeds 500 million acre feet (af, approximately 600 billion cubic meters, m³), the vast majority of which is found in large federal dams in the West (Graf, 1993). The largest individual structures are located in the Colorado and Missouri River basins, while the largest total number of structures is found in the Columbia. Table 1 lists the 20 largest storage structures west of the Mississippi. Five major dams in the Colorado and Missouri account for more than twice as much storage than the next 15 dams combined. Not one was completed after 1982 (Truman dam, Missouri) and over half were built in the 15 year period between 1950 and 1965.

Table 1. Storage Capacity of Large Dams in the Western United States (Graf, 1993)

DAM	RIVER	STATE	CAPACITY (MIL. AF)	DATE CLOSED
Hoover	Colorado	AZ/NV	28.50	1936
Glen Canyon	Colorado	AZ	27.00	1964
Garrison	Missouri	ND	23.92	1956
Oahe	Missouri	SD	23.34	1962
Fort Peck	Missouri	MT	18.91	1940
Grand Coulee	Columbia	WA	9.39	1942
Libby	Kootenai	MT	5.81	1972
Fort Randall	Missouri	SD	5.60	1953
Bull Shoals	White	AK	5.41	1952
Denison	Red	TX	5.31	1944
Truman	Osage	MO	5.20	1982
Shasta	Sacramento	CA	4.55	1945
Rayburn	Angelina	TX	4.00	1965
Eufaula	Canadian	OK	3.83	1964
Flaming Gorge	Green	UT	3.79	1964
Hungry Horse	Flathead	MT	3.47	1953
Table Rock	White	MO	3.46	1959
Dworshak	Clearwater	ID	3.45	1972
Grears Ferry	Little Red	AK	2.84	1962
Blackley Mt.	Ouachita	AK	2.77	1955

Notwithstanding the never-ending debate about the magnitude and distribution of the benefits of these projects (in national economic terms), there can be no doubt that they have brought substantial benefits to the regions in which they are located. To illustrate this, Table 2 contains an example from the Missouri system of the benefits associated with the operation of the U.S. Army Corps of Engineers mainstem reservoirs. The largest single benefit category is hydropower, followed by water supply. The least important category, in terms of benefits, is navigation, despite the fact that the dams are operated to ensure adequate flows to support a nine foot navigation channel in the lower river during the navigation season.

Table 2. Benefits (in \$ millions) by Category of Mainstem Dams in Missouri River (COE, 1994)

	FLOOD CONTROL	NAVIGATION	HYDRO-POWER	WATER SUPPLY	RECREATION	TOTAL NED*
MAXIMUM	44.7	17.7	643.8	549.2	81.3	1336.7
CURRENT	44.4	17.7	619.8	546.2	75.7	1303.8
PREF. ALT.	42.6	15.0	620.6	546.7	77.7	1302.6

* According to the Corps, NED is national economic development account.

The regional economic impacts of dams and associated water use systems can also be seen in a study by Howe of the regional versus national benefits of the Colorado-Big Thompson Project (a system that stores and takes water from the Colorado River and delivers it to the Platte River east of the Continental Divide) (Howe, 1986). Table 3 contains the estimates of the national and regional benefits and costs of the project. It is clear from the table that the regional benefits (both primary and secondary) are very significant, particularly when the repayment requirements offer very substantial subsidies to certain of the project beneficiaries.

Table 3. Present Value of Net Benefits (in millions of 1960 dollars) from National and Regional Perspective for Colorado-Big Thompson Project (Howe, 1986)

	BENEFITS	COSTS	NET BENEFITS	B/C RATIO
NATIONAL:				
20 YEARS	209.3	550.7	-341.4	0.38
TOTAL	354.8	591.8	-237.0	0.60
REGIONAL:				
20 YEARS	874.8	107.9	766.9	8.11
TOTAL	1305.3	117.5	1187.8	11.11

Concentrating for a moment only on hydropower, Table 4 presents estimates of the percentage of regional capacity of the several federal power marketing administrations (PMA) and the portion of total capacity that each PMA represents. As the table shows, the Bonneville Power Administration (BPA) is larger than all others combined and represents the largest single system in the Northwest. Like the Missouri (part of Western), hydropower tends to be the most important economic benefit of the dams in any of the basins.

Table 4. Power Marketing Administrations Portion of Regional Capacity (from Wahl, 1994)

	PERCENT OF TOTAL PMA CAPACITY	PERCENT OF POWER IN THE REGION
Bonneville	58 percent	50 percent
Western Area	26 percent	10 percent
Southeastern	9 percent	3 to 5 percent
Southwestern	6 percent	2 percent
Alaska	1 percent	n/a
Total U.S.	100 percent	6 percent

Estimates have also been made of the value of the water associated with these hydropower systems. Table 5 offers a comparison of short-run values of an acre-foot of water in

generating electricity for the Columbia, Snake and Colorado River systems. The estimates are given for both base load and peaking power and are derived from an alternative cost analysis (i.e., the cost per unit of power from a coal-fired steam electric plant) (Gibbons, 1986).

Table 5. Comparison of Water Values for Hydropower (in 1980 dollars) (Gibbons, 1986)

RIVER REACH	CUMULATIVE HEAD (FEET)	SHORT-RUN MARGINAL VALUE, FIRM (DOLLARS/AF) ^a	SHORT-RUN MARGINAL VALUE, PEAK (DOLLARS/AF) ^b
COLUMBIA, from Grand Coulee to sea level	1178	17	44
SNAKE, from American Falls to sea level	2159	32	80
Colorado, from Shosone to the mouth	1555	23	57

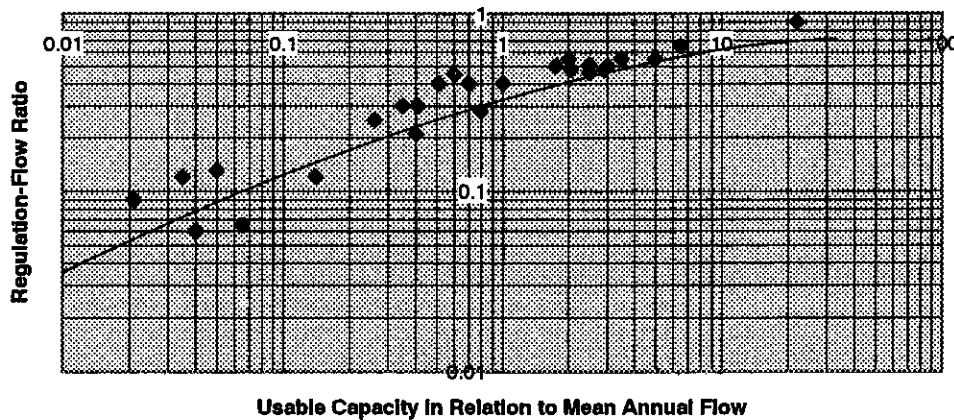
^a Short-run marginal values calculated using 18.52 mills per kilowatt-hour

^b Short-run marginal values calculated using 44.01 mills per kilowatt-hour

In the midst of the dam building era, Walter Langbein, a hydrologist with the U.S. Geological Survey, suggested that, from a physical supply perspective, the storage in some systems had reached the point of diminishing returns (Langbein, 1959). He used a simple mathematical model to demonstrate that each new unit of storage in a given river system produced a smaller unit of reliable supply than the last and, that for some rivers (e.g., Colorado), when evaporative losses were added to the equation each new unit of storage actually reduced the reliable physical supply. Figure 1 presents some of Langbein's data in a graphical form. In a log-log plot, the figure shows the relationship between the ratio of storage to mean flow (usable capacity to mean flow) and reliable supply (regulation-flow ratio). The trend-line in the figure shows that in a relatively undeveloped basin (e.g., a storage-mean flow ratio of 0.1) a doubling of storage capacity (i.e., increasing the storage-flow ratio to 0.2) increases reliable supply by as much as 25 percent, whereas a comparable increase in storage in a developed system (storage-flow ratio 1.0) only

increases reliable supply by 2.5 percent. The circumstances illuminated by this simple but clear relationship, particularly when translated into economic terms, played a role in the rapid drop-off in large dam construction activity that was seen in the 1960s.

Figure 1. The relationship between River System Storage and Reliable Supply (Langbein, 1959)



II. The Environmental Costs of Large Dams

Describing and estimating the benefits of large dams require the treatment of rivers as commodities. Describing and assessing the environmental costs requires viewing the rivers as integral systems. More than 600,000 miles of free flowing rivers and streams have been inundated by dams (Echeverria, 1989). In the West, where most of the large dams are located, the loss of riverine habitat is particularly important, both because it constitutes such a small portion of the landscape (five to ten percent) and is, at the same time, home to 60 to 70 percent of native species.

The impacts of dams extend well beyond inundation. They act as sediment and nutrient traps, obstacles to movement of migratory aquatic species, and evaporation ponds. They also change the natural temperature of the water, modify hydrographs, change flow

velocities, induce supersturation of outflows with gases that adversely affect native aquatic species, and, through a combination of several of the above effects, they change the geomorphology (and thus the aquatic habitat) of the river downstream from a dam. Further, dams can interact with non-native species to further change the natural environment.

The impacts of the Columbia-Snake dams can be seen most dramatically in the loss of habitat measured in river miles and the associated declines in populations of anadromous species. Table 6 contains data on the loss, between 1850 and 1975, of river miles of salmon and steelhead habitat for both the Columbia and Snake. Associated with these

Table 6. Salmon and Steelhead Habitat (in river miles)^a in Columbia Basin between 1850 and 1975 (Volkman, 1997)

RIVER	HABITAT pre-1850	HABITAT 1975
COLUMBIA		
Spring chinook	4854	2604
Summer chinook	909	434
Fall chinook	1416	1363
Coho	2073	2829 ^b
Steelhead	5729	4795
SNAKE		
Spring chinook	5764	2813
Summer chinook	4063	1865
Fall chinook	1045	371
Coho	481	0
Steelhead	7212	0

^a Natural spawning and rearing areas.

^b Fishway constructed at Willamette Falls increased habitat.

habitat losses, the commercial landings of salmon and steelhead decreased by close to an order of magnitude, dropping from annual average that exceeded 30 million tons near the end of the 19th century to less than 10 million tons in recent years (Volkman, 1997).

While it is clear that the dams are not the only factor in the salmon's precipitous decline, they are certainly one of the primary causes.

The impact of the Flaming Gorge dam on the geomorphology of the Green River, a major tributary of the Colorado, offers an example of the interplay between dam operations and exotic species. In a report on instream flows for endangered fish, Stanford suggest that not only did the dam's pattern of releases (dictated until recently almost entirely by hydropower output) eliminate important backwater habitat and the productivity in the "varial zone" of the river (i.e., the shallow near shore area that is inundated and dewatered by peak flows), but also restricted the redistribution of alluvium allowing encroachment of vegetation (some non-native) into the river channel (Stanford, 1993). Stanford and others (e.g., Hawkins, 1991) also see a relationship between the altered hydrograph and the ability of non-native fishes (that compete with and prey on natives) to flourish.

III. Reversing Dam Impacts, Two Important Federal Laws, and the Role of Science

With the dam-building era only a memory, there are efforts underway in most major western river basins to repair some of the environmental damage done by large dams. Driven, at least in part, by the requirements of the Endangered Species Act, the Columbia, the Colorado, the Platte, the Missouri, the Sacramento-San Joaquin, and the Missouri rivers all have programs or processes in various states of progression that have as their goal the restoration of some pre-dam conditions and associated responses by native species. (The Federal Energy Regulatory Commission process is also important and will be discussed below.) In no case is there any intention to recreate river systems' natural conditions. Rather, the intention in almost every case is to identify just how much must be done to restore "nature" while at the same time allowing the rivers' commodity values to be enjoyed. This is certainly true in the Upper Colorado River Endangered Fish Recovery Implementation Program, in the Platte River Memorandum of Agreement process, and in the Missouri River Master Manual EIS process.

Finding the middle course has proven to be a challenge that has tried the patience of all parties. Also, given the fact that the benefits associated with current conditions are being

enjoyed by powerful stakeholders, the processes have placed a special burden on the scientists who are being asked to identify, describe, and quantify (all with proper documentation) exactly what the minimum requirements for nature are.

The Federal Power Act came to play a more important role when, in 1986, Congress passed the Electric Consumers Protection Act, requiring the Federal Energy Regulatory Commission (FERC) to give "equal consideration" to power development and the preservation of recreation, ecology, and other values of natural rivers when issuing licenses for non-federal power projects (Echeverria, 1989). It also gave resource agencies like the U.S. Fish and Wildlife Service a stronger hand in setting license conditions and, by so doing, gave the public a greater role in the licensing process.

The "equal consideration" mandate applies to conditions in relicensing as well. About 275 expiring licenses, many of them in the West, are due for review by the end of this decade. One of the more prominent is the Kingsley Dam relicensing procedure on the Platte River. The dam sits upstream of the Big Bend reach of the Platte, critical habitat for the endangered whooping crane, interior least tern and piping plover. The Kingsley relicensing process has been underway for ten years and its critics have argued that by dealing only with one dam rather than the river system "...the proceedings...have demonstrated the inefficiency and ineffectiveness that such procedures offer for resolving water resources conflicts." (McLaughlin, 1997).

IV. Major Unknowns on the Horizon

Two major unknowns that will affect the operation of hydropower dams in the future are the deregulation of electric utilities and the sale of federal assets. Hydropower is generally considered a preferred power source both because of its low cost and its loading-following capability. The privatization of federal assets as part of deficit reduction has looked to the sale of PMAs as part of a broader strategy (Freedman, 1995). If such sales eventually occur, the conditions of these sales (e.g., the presence or absence of

habitat restoration funds and requirements to comply with federal environmental laws) will have a profound effect on riverine habitat restoration. To stake out a position providing some measure of protection for the environment and some hope of habitat restoration, a group of national and regional environmental organizations that includes the Environmental Defense Fund, American Rivers, the Natural Resources Defense Council, the Grand Canyon Trust, and the Land and Water Fund of the Rockies have established a principles that they think should govern any transfer of federal water and power assets to non-federal interests (American Rivers, 1996).

References

Allred, T.M. and J.C. Schmidt, "Channel Change of the Green River near Green River, Utah: Analysis of Geomorphic Form and Process," Report to the Utah Division of Wildlife Resources, Utah State University, Logan, Utah (November 1996).

American Rivers, et al, Statement of Principles for Transfer of Federal Water and Power Assets (1996).

Collier, M., R.H. Webb, and J.C. Schmidt, "Dams and Rivers: A Primer on the Downstream Effects of Dams," U.S. Geological Circular No. 1126, Tucson, Arizona (June 1996).

Echeverria, J.D., P. Barrow, R. Roos-Collins, **Rivers At Risk: The Concerned Citizen's Guide To Hydropower**, Island Press, Washington, D.C. (1989).

Eschner, T.R., R.F. Hadley and K.D. Crowley, "Hydrologic and Morphologic Changes in Channels of the Platte River Basin: A Historic Perspective," U.S. Geological Survey Report No. 81-1125, Denver, Colorado (1981).

Freedman, A., "Plans to Sell Power Agencies are Beginning to Catch On," *Congressional Quarterly*, Washington, DC (September 16, 1995).

Gibbons, D.C., **The Economic Value of Water**, Resources for the Future, Washington, DC (1986).

Government Accounting Office, Federal Electric Power: Pricing Alternatives for Power Marketed by the Department of Energy, Washington, DC (September 1986).

Graf, W.L., "Landscapes, Commodities, and Ecosystems: The Relationship Between Policy and Science for American Rivers," in **Sustaining Our Water Resources**, National Academy of Sciences, National Academy Press, Washington, D.C. (1993).

_____, "Geomorphology and Policy for Restoration of Impounded American Rivers: What is 'Natural'?" in The Scientific Nature of Geomorphology: Proceedings of the 27th Binghamton Symposium in Geomorphology, Rhoads, B. L. and C. E. Thorn (eds.), John Wiley, and Sons Ltd. (1996).

Grams, P.E. and J.C. Schmidt, "Geomorphology of the Green River in the Eastern Uinta Mountains, Colorado and Utah," submitted to **Varieties of Fluvial Form**, A. J. Miller (ed.) (1997).

Hawkins, J.A. and T.P. Nesler, "Nonnative Fishes in the Upper Colorado River Basin," Issue Paper of the Colorado State University Larval Fish Laboratory and the Colorado Division of Wildlife, Fort Collins, Colorado (1991).

Howe, C.W., "Project Benefits and Costs from National and Regional Viewpoints: Methodological Issues and Case Study of the Colorado-Big Thompson Project," *Natural Resources Journal*, Vol. 26, No. 4 (1986).

Langbein, W.B., "Water Yield and Reservoir Storage in the United States," U.S. Geological Survey Circular No. 409, Washington, D.C. (1959)

Ligon, F.K., W.E. Dietrich, and W.J. Trush, "Downstream Ecological Effects of Dams: A Geomorphic Perspective," *BioScience*, Vol. 45, No. 3 (March 1995).

Luecke, D.F., "The Role of Markets in the Allocation of Water among Agricultural and Urban Users," University of Barcelona Environmental Symposium, Barcelona, Spain (1992).

McLaughlin Water Engineers and J.D. Aiken, "Platte River Basin Study," Draft Report to the Western Water Policy Review Advisory Commission, Denver, Colorado (1997).

Minckley, W.L. (ed.), Aquatic Ecosystem Symposium: A Report to the Western Water Policy Review Advisory Commission, Arizona State University, Tempe, Arizona (February 17, 1997).

National Research Council, **Restoring Aquatic Ecosystems**, National Academy Press, Washington, DC (1992).

Schmidt, J.C. and J.B. Graf, "Aggregation and Degradation of Alluvial Sand Deposits, 1965 to 1986, Colorado River, Grand Canyon National Park, Arizona," Report of the U.S. Geological Survey, Tucson, Arizona (1988).

_____, et al, "Comparison of the Magnitude of Erosion Along Two Large Regulated Rivers," *Water Resources Bulletin*, Vol. 31, No. 4, (August 1995).

Stanford, J.A., Instream Flows to Assist the Recovery of Endangered Fishes of the Upper Colorado River System: Review and Synthesis of Ecological Information, Issues, Methods and Rationale," Report to the Upper Colorado Endangered Fish Recovery Program and U.S. Fish and Wildlife Service, Denver, Colorado (1993).

Stevens, L.E., et al, "Flow Regulation, Geomorphology, and Colorado River Marsh Development in the Grand Canyon, Arizona," *Ecological Applications*, Vol. 5, No. 4 (1995).

U.S. Army Corps of Engineers, Draft Environmental Impact Statement: Master Water Control Manual -- Missouri River, Omaha, Nebraska (July 1994).

_____, Floodplain Management Assessment of the Upper Mississippi and Lower Missouri Rivers and Tributaries, Washington, DC (June 1995).

U.S. Department of the Interior, *Quality of Water: Colorado River Basin (Progress Report No. 17)*, Washington, DC (1995).

Volkman, J.M., "A River in Common: The Columbia River, the Salmon Ecosystem, and Water Policy (Draft)," Draft Report on the Columbia River Basin to the Western Water Policy Review Advisory Commission, Denver, Colorado (1997).

Wahl, R., "Subsidies for Federal Hydropower and Options for Reform (Draft)," Boulder, Colorado (February 22, 1994).

Williams, G.P., "The Case of the Shrinking Channels--the North Platte and Platte Rivers in Nebraska," U.S. Geological Survey Circular No. 781, Washington, DC (1978).

Young, R.A. and R.H. Haveman, "Economics of Water Resources: A Survey," Kneese, A.V. and J.L. Sweeney (eds.), *Handbook of Natural Resource and Energy Economics*, Vol. 2, Elsevier Science Publishers (1985).

