Beyond Dams

Options & Alternatives

A report by American Rivers & International Rivers Network.

American Rivers is a national non-profit conservation organization dedicated to protecting and restoring healthy natural rivers and the variety of life they sustain for people, fish, and wildlife.

American Rivers

American Rivers delivers innovative solutions to improve river health, raise awareness among decision-makers, and serve and mobilize the river conservation movement.

By changing how dams operate and removing dams that are old, unsafe, and harm the environment, we bring back native fish and wildlife. By promoting natural alternatives to levees, dikes, and dredging, we restore natural functions of rivers and wetlands. We help keep enough unpolluted water in our rivers for the freshwater species and communities that depend on this water and its natural flow. We help communities protect their rivers from upstream water withdrawals, pollution, and the insidious effects of sprawl.

We put special emphasis on protecting wild rivers and the rivers of Lewis and Clark, as the bicentennial of their expedition approaches.

International Rivers Network supports local communities working to protect their rivers and watersheds. We work to halt destructive river development projects, and to encourage equitable and sustainable methods of meeting needs for water, energy and flood management.

International Rivers Network seeks a world in which rivers and their watersheds are valued as living systems and are protected and nurtured for the benefit of the human and biological communities that depend on them. This vision can be achieved by developing worldwide understanding of the importance of rivers and their essential place in the struggle for environmental integrity, social justice, and human rights.

International Rivers Network

International River Network's mission is to halt and reverse the degradation of river systems; to support local communities in protecting and restoring the well-being of the people, cultures and ecosystems that depend on rivers; to promote sustainable , environmentally sound alternatives to damming and channeling rivers; to support the worldwide struggle for environmental integrity, social justice and human rights; and to ensure that our work is exemplary of responsible and effective global action on environmental issues.

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Introduction and Overview

Introduction

Rivers weave in and out of our lives, providing innumerable benefits to communities across the world. In the United States, we rely on our rivers for drinking water, irrigation, aquatic habitat, fisheries, energy, navigation, recreation and simply the natural beauty they bring to our landscapes. Humans have been building dams and other river blockages to harness and control water for centuries, attempting to secure its benefits for human use. Estimates put the number of dams in the United States anywhere between 76,000 to 2.5 million.[1]

However, as society has come to understand, dams can cause significant social and environmental impacts that outweigh the benefits they provide.

The consensus among river ecologists is that dams are the single greatest cause of the decline of river ecosystems.[2]

By design, dams alter the natural flow regime, and with it virtually every aspect of a river ecosystem, including water quality, sediment transport and deposition, fish migrations and reproduction, and riparian and floodplain habitat and the organisms that rely on this habitat.[3] Dams also require ongoing maintenance. For example, reservoirs in sediment-laden streams lose storage capacity as silt accumulates in the reservoir. In arid climates reservoirs also experience a high rate of water loss to evaporation.[4]

1. The U.S. Army Corps of Engineers National Inventory of Dams lists 76,000 dams in U.S. rivers that have one of the following criteria: (1) high hazard (failure would likely cause loss of life and significant property damage); (2) greater than 6 ft in height and impoundment greater than 50 acre-feet; or (3) greater than 25 ft in height and impoundment greater than 15 acre-feet. The National Research Council has estimated the number of small dams in the United States may be as high as 2.5 million. National Research Council. *Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy.* Washington (DC): National Academy Press, 1992.
2. World Commission on Dams. *Dams and Development: A New Framework for Decision-Making.* Cape Town, 2000.
3. Raphals, Philip. *Restructured Rivers: Hydropower in the Era of Competitive Markets.* Berkeley: International Rivers Network, 2001.
4. Price, T. "Queen of the Dammed." *Outside Magazine*, November 2002.

Dams also can have significant economic impacts on dam owners, the surrounding community and society in general.[5] As dams age, maintenance costs and safety hazards often increase, resulting in an increasing financial burden and liability on the dam owner. Depending on the river and the fisheries being impacted by the dam, an owner may also be required to retrofit the structure with fish passage facilities or make other upgrades to comply with water quality standards. When dams diminish fisheries, communities can lose jobs and sustenance, or the source of their cultural or spiritual life. Because of these and other concerns, some dam owners and managers are finding that it makes more sense to remove certain dams, often benefiting the community ecologically and socially, rather than make costly repairs or upgrades. However, when such dams still provide valuable services, alternatives to replace the dams' functions should be considered.

The purpose of this report is to provide stakeholders and decision-makers with an overview of low-impact and non-structural alternatives to dams.

The purpose of this report is to provide stakeholders and decision-makers with an overview of low-impact and non-structural alternatives to dams. It is designed as a reference for anyone interested in exploring options for replacing a function served by an existing dam or replacing a function to be served by a proposed dam.

5. The term *community* is often used in this report. The scope of this term depends on the particular circumstances of the dam. For example, for a small dam that does not affect many people or much fish and wildlife habitat, the local neighborhood directly affected by the dam may be the appropriate community. But for a large dam with many broad ecological, economic, and social impacts, the community may be a broader region or even the whole nation.

The primary motivation for preparing this resource is the frequency with which river restoration and protection advocates are asked, "What will people do for water, energy, etcetera, without a dam?" Clearly, there is no single solution that applies in every case. As rivers and dams vary, so do the best solutions. To restore or protect a free-flowing river, communities often rely on a combination of the alternatives presented here. Other communities may find that none of these alternatives is applicable to their situations.

The *Alternatives to Dams* report is divided into two sections. Section 1 presents an introduction and overview that outlines the dam functions that will be addressed in the report and their corresponding alternatives. It serves as the executive summary and will hopefully help audiences to better utilize the report.

Section 2 provides an in-depth description of options that can be used to replace the function of dams. Each alternative includes a discussion of the advantages and disadvantages of implementing the alternative, along with case studies in which these alternatives have been implemented. Both the advantages and disadvantages and the case studies attempt to look at the alternative from a variety of angles and often go beyond impacts associated with replacing an existing or proposed dam. An outline of potential costs also accompanies each alternative. When reviewing each section on cost, it is essential to note that these costs are only meant to serve as a starting point for your own research; many estimates reflect costs for a specific project. Costs may vary widely depending on the scope of the project, the characteristics of the river, the region of the country the project is in, and many other factors.

The report focuses on main functions that dams can serve and alternative means of fulfilling those uses: water diversion and supply, flood management, and energy.

Water supply – These alternatives focus on the use of water for irrigation and other agriculture, landscaping, drinking water and other municipal uses, and industrial use.

Flood management – Flood management examines alternatives to dams currently being used or proposed for the management of flooding and protection of life and property.

Energy – The energy section examines alternatives to hydropower dams.

This report does not address two functions dams can serve, recreation and navigation. We chose not to include recreation because, unlike the other functions addressed in the report, reservoir-based recreation cannot always be replaced by non-reservoir means (*e.g.*, a free-flowing river does not provide a houseboat owner the same boating opportunity as a reservoir). Similarly, navigation is also excluded because it is an activity that could be replaced only by some type of land transportation such as rail or truck transport.

Deciding whether or not to remove a dam can be difficult. The complexity of the decision is compounded when the dam still serves a purpose, such as facilitating water diversions. Several tools exist to assist communities and decision makers in evaluating the option of removing a dam, such as *Exploring Dam Removal: A Decision-Making Guide*; *Taking a Second Look: Communities and Dam Removal*; *Dam Removal Success Stories*; *Dam Removal: A Citizen's Guide to Restoring Rivers*; and *Paying for Dam Removal: A Guide to Selected Funding Sources*.[6] While dam removal may not be the right decision for every situation, hundreds of dams have been removed from rivers and creeks across the country, and, when necessary, were replaced with one or more of the numerous non-structural and low-impact options described in this report.

Though dam building has slowed in the United States, dams continue to be thought of as a solution to many of our societal demands. This report is also designed to help those looking for alternatives to a proposed dam.

While this report offers numerous suggestions for lower impact and non-structural alternatives to dams, it is not intended to be a complete list. Certain sections of this report, such as water and energy conservation strategies, merely scratch the surface of an extensive body of literature and experience, while others, such as alternative diversion methods, cover much of what has been put into practice. It is important to remember that replacing something such as a large water supply dam may require implementing a number of alternatives to "make up the difference."

While dam removal may not be the right decision for every situation, hundreds of dams have been removed from rivers across the country.

[6] These and other dam removal resources can be found at American Rivers' website www.americanrivers.org, and at International Rivers Network's website www.irn.org.

As an Austin, Texas water conservation expert puts it, "We need a whole lot of one and two percent solutions to avoid having serious water problems in the future." Whereas other alternatives may require one relatively simple solution, such as building an infiltration gallery to replace a diversion dam. However, in researching and writing this report, it became abundantly clear that the *real* alternative to many dams in the United States involves long-term policy and behavioral changes that reduce the fundamental demand for the services that dams can provide.

We hope this resource will provide readers with ideas, points of contact, and resources to identify alternatives for obtaining the benefits of water without forfeiting the benefits provided by healthy rivers. For more information or questions about any aspect of this report, please contact American Rivers or International Rivers Network at the below locations.

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Introduction and Overview

Overview

Dams are built to store water, irrigate crops, provide flood management, generate electricity, provide recreation or ease navigation. The most common purposes for building dams are flood management (25 percent) and water supply (18 percent). Table 1 illustrates the percentage of dams by use in the United States.[1] Below we discuss the functions of dams and briefly identify how those purposes might be met without a dam.

Table 1. Listed purposes of dams in the US Army Corps of Engineers' National Inventory of Dams.

Purpose	*Percentage*	*Number*
Recreation	31.3	23,185
Fire & farm ponds	17.0	12,557
Flood control	14.6	10,801
Irrigation	13.7	10,176
Water supply	9.8	7,226
Tailings & other	8.1	5,967
Hydroelectric	2.9	2,166
Undetermined	2.3	1,732
Navigation	0.3	243

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Water Supply

For decades dams have been built in the United States to store or divert water for irrigation, residential use, industry, and a host of other consumptive uses. The common perception among water engineers was that any water flowing freely into the ocean was wasted. According to the U.S. Army Corps of Engineers' (Army Corps) National Inventory of Dams (NID), nearly 25 percent of the 76,000 dams listed are used for the primary purposes of water supply and irrigation. The NID does not include hundreds of thousands of small dams and weirs that block rivers and streams in the United States for one purpose or another.

1. International Commission on Large Dams (ICOLD). *World Register of Dams.* 1998.

Alternatives, Water Supply

As communities face increasingly stressed water supplies, decision-makers must continue to seek out sustainable water sources and methods of use that can meet both human and environmental needs. If there is a water supply dam or diversion causing unjustifiable harm to the river ecosystem in your community, or a new storage facility is being planned, there are several alternatives your community can implement to reduce demand and secure water supplies in less damaging ways, including water conservation, infiltration galleries[2], and desalination plants. Of course, lower-impact alternatives cannot replace water supply structures in every case. For example, no infiltration gallery could single handedly replace dams that allow for the diversion of tens of millions of gallons each year from large rivers; nor could rainwater harvesting and gray-water systems replace the need for a water distribution system in many communities. However, the methods listed below and described in more detail in the second section of this report, can stretch existing water supplies, thereby reducing or eliminating the impacts of traditional water supply strategies; or they can delay or eliminate the need for new water supply structures.

As communities face increasingly strained water supplies due to rapid development and pollution, decision-makers must continue to seek out sustainable water sources and irrigation methods that can meet both human and environmental needs.

- Water diversion and irrigation methods
- Water management alternatives

2. Infiltration galleries, or Ranney wells, involve placing perforated pipes under streambeds to allow water to be withdrawn by pumping or gravity flow.

Flood Management

Floods are the most common and costly natural disturbances affecting the United States. Approximately nine of every ten presidential disaster declarations are associated with floods.[3]

Despite spending billions of dollars trying to control floods by building dams, levees, and other structures, floods took nearly 1,000 lives and cost over $45 billion between 1990 and 1999.[4]

The relentless rise in flood costs despite increased spending on flood protection, punctuated by devastating floods in the Midwest in 1993, forced the United States to rethink long-held flood management policies that focused on dams and other engineered structures. The many technical evaluations of flood disasters unanimously call for a new response to the threat of floods.[5] The new approach calls for integrated management of the watershed, river, and floodplain, and incorporates non-structural strategies in addition to other traditional flood management structures.

3. Faber, S. "Flood policy and management: a post-Galloway progress report." *River Voices* 8, no. 2 (1997).
4. Federal Emergency Management Agency, *FEMA Disaster Costs 1990 to 1999*, 19 February 2002, ‹www.fema.gov/library/df_7.htm› (19 February 2002).
5. For example, see *Sharing the Challenge: Floodplain Management into the 21st Century* by the Interagency Floodplain Management Review Committee (1994); Final Report of the California Flood Emergency Action Team, available at ‹rubicon.water.ca.gov/FEATReport120.fdr/featindex.html›; or *Flood Risk Management and the American River Basin: An Evaluation* by the National Research Council (1995).

Flooding is part of the dynamic nature of healthy river ecosystems. Many species depend on seasonal droughts or pulses of water or nutrients as signals to start reproduction, migration, or other important lifecycle stages. High flows and floodwaters help shape rivers, produce rich agricultural soils, sustain riparian habitat, and import spawning substrate for fish. Inundated floodplains provide important habitat for numerous commercially significant fish, waterfowl, and wildlife species. In addition, floodplains serve as temporary flood water storage, thereby decreasing flood levels downstream.

The accumulated experience of the thousands of flood management dams in operation over many decades has produced a wealth of knowledge. Two important lessons underpin modern flood management strategies. First, our understanding of the frequency and magnitude of flooding, and therefore the measures necessary to protect life and property, is imperfect and evolving. Second, the traditional approach of building dams and other structural flood management measures has not prevented flood damage from increasing.

In the past five years alone, flood damage has exceeded $40 billion in the United States. Even along rivers with extensive systems of dams and levees, devastating floods occur with disturbing frequency. Indeed, some scientists argue that flood management structures have increased flooding on certain rivers.[6] One fundamental cause of the rising toll of floods is that communities and businesses are lured onto floodplains by a false sense of security created by dams and levees, and enticed by regulatory and financial incentives such as publicly subsidized flood insurance. Today, nearly 10 million homes are located in flood-prone areas in the United States, placing $390 billion in property at risk. As the nation's population grows, shrinking availability of new land will intensify pressure to build in more flood-prone areas.

Alternatives, Flood Management

As watershed planners and government agencies like the U.S. Army Corps of Engineers continue to manage rivers for flooding, their decisions should take into account both structural and nonstructural methods that will allow a river to maintain its natural function. Relocating communities out of the floodplain is not always feasible, but strategic use of alternatives such as setting back levees, restoring river meanders, and flood proofing can reduce flood risk or protect against flood damage. The new flood management approach aims to reduce flood risk or flood damage without the construction of new dams by accomplishing the following three integrated goals, which are discussed in more detail in the second section of this report:

- Reducing runoff
- Riparian & in-river flood management
- Separating the people & the threat

Energy

Demand for power in the United States is increasing rapidly, with the Energy Information Administration (EIA) forecasting a 1.8 percent average annual growth in electricity sales through 2020. Total global hydroelectricity production exceeds 2 million gigawatt hours (GWh) annually, of which the United States and Canada account for more than 30

6. Pinter, N., Heine, R.A. (2001). *Hydrologic History of the Lower Missouri River*. Southern Illinois University, Carbondale.

percent. Hydropower supplies about 10 percent of U.S. electricity and hydropower dams account for approximately 2,500 of the 76,000 large dams in the United States. The Federal Energy Regulatory Commission (FERC) is the federal agency responsible for licensing the approximately 2,300 nonfederal hydropower dams in the United States.

Of these FERC-regulated dams, 80 percent generate less than 50 megawatts (MW) of power, which is enough electricity to power approximately 50,000 homes.[7]

The design and operation of hydropower dams have the potential to cause particularly serious impacts to rivers. Hydropower dams are designed to operate in either a "run-of-river" or peaking mode. Run-of-river hydropower dams generally operate such that the amount of water flowing into the reservoir is equal to the amount of water flowing out of the reservoir through generating turbines or other outlets.[8] Peak hydropower dams typically store water during "off peak" periods and release water through turbines to produce power during daily, weekly or seasonal periods of peak power demand. Hydropower operations can result in higher water temperatures, lower dissolved oxygen levels, altered pH levels, reduced habitat and species diversity and reduced macro-invertebrate and native fish populations and productivity.

Daily peak-power flow fluctuations also can strand juvenile and adult fish, flush macroinvertebrates downstream and disrupt or prevent reproduction of a host of aquatic species, including federally listed amphibian and fish species.

Alternatives, Energy

The alternatives to hydropower dams examined in this report focus on two different aspects of energy: consumption and renewable energy sources. Energy experts believe energy consumption in the United States could be reduced through existing efficiency measures by 30 to 50 percent or more.[9] Given hydropower's small percentage in the energy portfolio of many communities, minor adjustments to consumption could potentially (1) replace the need for a planned hydropower dam or (2) allow for the removal of a small-scale hydropower facility. Depending on the scale of the project, renewable forms of energy such as wind or solar power have the potential to greatly reduce the impacts of power generation and could allow for an existing hydropower facility to be decommissioned and removed. Environmentally sound alternatives to hydropower that are described in more detail in the second section of this report, include:

- End-use efficiency
- Emerging technologies

7. World Commission on Dams, *Dams and Water Global Statistics*, ‹www.dams.org/global/namerica.htm› (3 October 2001).
8. A true run-of-the-river dam is where instantaneous inflow equals instantaneous outflow, although dams with weekly, daily or hourly inflow equaling weekly, daily or hourly outflow may also be called run-of-the-river.

9. Pottinger, Lori. *River Keepers Handbook: A Guide to Protecting Rivers and Catchments in Southern Africa*. Berkeley: International Rivers Network, 1999.