Dam Removal ■ *A New Option For a New Century*

THE ASPEN INSTITUTE

PROGRAM ON ENERGY, THE ENVIRONMENT, AND THE ECONOMY

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Savage Rapids Dam ■ Rogue River, Oregon, USA
Currently slated for removal
Cited in *Lessons Learned*, Sediment, Lesson 3; Case example B;
also cited in *Lessons Learned*, Sediment, Lesson 8, Case example A

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Foreword

Can dams have both positive and negative effects, especially over time? Should removing a dam be an option in managing river systems in the United States? Can removing a dam offer the equivalent or increased benefits to services that a dam currently provides? Does the existing institutional framework for managing dams and water resources provide for effective consideration and implementation of dam removal as an option? How do those responsible for dams and rivers fairly evaluate and make timely decisions about options, including dam removal? Honoring the complexity of issues and communities involved, what can be done to improve policy and decisionmaking, practice, and public involvement?

In September 2000, The Aspen Institute's Program on Energy, the Environment, and the Economy invited a group of experts to take on these questions. Committed to fostering enlightened leadership and policy through dialogue among policymakers and practitioners, the Institute is recognized also for its convening power of leaders with diverse and often conflicting values. Using an intentional, values-based method of dialogue, the group of twenty six participants engaged in a series of eight, three-day meetings over a period of two years. The intention was to express, inform, and integrate their values, knowledge and understanding, and to create new thinking to guide policy and practice around the issues of dams and rivers.

The participants contributed their wide-ranging expertise in dam safety, ownership, construction, operation, re-operation, removal, modification; federal, state, and local government regulation, permitting, and tribal issues; hydropower generation and dam relicensing; engineering, aquatic biology, water supply, fish and river management and restoration; and resource management, policy, planning, and conservation.

Given this comprehensive range of expertise, and the diversity of their values and interests, it was significant that the participants discovered a shared premise early on -- while valuing the benefits dams can offer, they agreed that dam removal can be a reasonable approach to addressing problems relating to dams and rivers, and should be among the river management options considered by policy and decisionmakers.

The group began by focusing on learning from one another more about the issues of removal, and about their own and each other's values, perspectives, objectives, and needs as they sought new ways of thinking about dams and rivers. The very diversity of their convictions and interests provided the ground for and enriched the group's conceptions, collaborative analyses, and recommendations.

In applying this multi-dimensional method, Aspen focuses also on developing the skills required for effective dialogue; to achieve the intended outcomes, therefore, participants met substantial commitments to learn and improve their practice of dialogue and to contribute the time and effort required over the life of the project. As a result, the dialogue evolved as mutual understanding and communication deepened regarding the more complex aspects of dams and rivers issues and communities.

Although the success of dialogue depends on its participants, a professional and multi-talented staff is essential. In recognition of their proficiencies and dedication to this endeavor over the last two years, I thank Jack Riggs, executive director of the program on energy, the environment and the economy; Silvia Woodard, program coordinator; Lee Langstaff, consulting facilitator; and Laura Ost, consulting editor.

With gratitude, I acknowledge also the financial contributions of the Charles Stewart Mott Foundation, the Compton Foundation, the National Fish and Wildlife Foundation, the Department of the Army, the Department of Commerce/NOAA/NMFS, and the Department of Interior. Their support helped sustain this dialogue.

Finally, I thank the participants especially for their curiosity, commitment, and abiding good will. It is dynamic collaborations such as theirs that can help improve policy and the management of U.S. dams and rivers, and simultaneously individual leadership and civic action. In this spirit, the Aspen Institute offers the recommendations and guidance in this report to policy and decisionmakers and to interested organizations and individuals.

Susan OMalley Wade
Project Director
Associate Director, Program on Energy, the Environment, and the Economy

Executive Summary

The United States relies on dams and reservoirs. From the earliest settlements to today, communities have diverted and stored water for many uses. Now, however, along rivers and lakes from New England to California, some of the tens of thousands of dams in the United States are aging beyond their expected lifespan, and some are causing a variety of safety, environmental, and other problems. Dealing with these situations can be a costly and controversial task, complicated by society's changing views of dams. Once perceived as almost entirely beneficial, dams are seen more realistically today as having both positive and negative effects, some obvious and quantifiable, and others less so.

One possible solution to these dilemmas—and in some cases the best solution—is dam removal. The removal of some dams can be straightforward and inexpensive. But for many dams, evaluating and implementing this option can be difficult. This Aspen Institute report offers a series of recommendations and practical advice aimed at making it easier to integrate the consideration of dam removal into river management decisions, to evaluate it fairly and, if appropriate, to implement it effectively, thereby reducing the overall costs and controversies associated with aging and/or problematical dams.

This report is the product of a group of people with expertise in various disciplines required in the management of dams and rivers, who represent the full range of interests and who work daily with responsible government agencies, dam owners, nongovernmental organizations, and dam users and beneficiaries. The imprimatur of this diverse group, with interests that are often at odds, lends a unique weight to the recommendations.[1]

The recommendations are based on the group's diverse values, extensive knowledge, and collective assessment of the current state of affairs. They recognize that, until now, dam removal has not been adequately considered as an option in decisionmaking processes regarding dams. Among the barriers are inadequate inventories of existing and removed dams as a basis for decisionmaking; the absence of periodic, comprehensive evaluations of all dams; the inappropriateness of current regulatory regimes and levels of analyses required for permitting; lack of clear guidance on the rights and responsibilities of dam owners and other beneficiaries; and a shortage of funding, especially for "soft" costs such as inclusive decisionmaking processes involving all stakeholders.

[1] The areas of expertise covered by the group, as well as the process and method of dialogue used, are described further in the Foreword to this report. A list of the participants is an appendix to this report.

Even when dam removal is considered, there are difficulties, such as a tendency to use inappropriate or one-size-fits-all analyses; a lack of centralized information about the dam removal option; a lack of technical studies on dam removal impacts, benefits, and techniques; and a lack of public understanding of dams and dam removal. Every dam exists in a unique context of physical, ecological, social, economic, regulatory, and legal constraints. Methods for assessing the full range of the costs and benefits of river management options, including those not easily quantified, such as social, ecological, and historic[2] values, are sometimes difficult and costly to apply and are also subject to disagreements.

To help surmount barriers to consideration of the dam removal option, the Aspen group recommends to policymakers and practitioners the following:

- Reflect the scale of the project and scope of the project's impacts in the depth and type of analysis associated with a decision about any dam.
- Integrate dam removal at appropriate levels as an option in decisionmaking regarding dams, including the regulatory process, watershed planning, and community decisionmaking.
- Review all dam structures and operations periodically and within a reasonable time frame; reviews should address environmental, economic, and social benefits and impacts in addition to dam safety.
- Provide public notice and opportunity for comment regarding dam removal decisions when public resources are affected.
- Consider social, ecological, and historical values in decisionmaking about dam removal.
- Address the rights of dam owners and beneficiaries of dam services.
- Revise permitting processes to ensure that shortterm impacts of dam removal do not preclude projects for which restoration benefits outweigh those impacts.
- Coordinate policies and regulatory programs affecting dam removal.
- Expand, integrate, and where necessary establish dam inventories so that a comprehensive inventory of all dams (regardless of size) is available.
- Develop technical guidance and site-appropriate practices for implementing dam removal.
- Increase scientific research and educational curricula on dam removal.
- Provide public education on dams and dam removal.
- Establish and maintain a user-friendly, centralized, Web-based clearinghouse for dam removal information.
- Establish financial responsibility for dam removal.
- Improve funding opportunities for dam removal.

[2] The words historic and historical are intended to encompass all past (including pre-dam) conditions at a site. The use of these words does not represent an interpretation of the National Historic Preservation Act.

During the initial meetings of the dialogue that produced this report, the Aspen group agreed on a set of shared premises, which provided grounds for further exploration and eventually for the recommendations (detailed in Part I of the report). This agreement was reached only after consideration of the full range of dams, from abandoned mill dams to large, multipurpose dams. The understanding that the term "dam" covers many types of structures with varied utility allowed the group to work through preconceptions. The group also developed a list of opportunities that can set the consideration of dam removal in motion, priority issues to consider in dam removal, and lessons learned in the collective experience of the group in implementing dam removal (described in Part II of the report).

Introduction

The United States has been—and will continue to be—reliant on dams. Yet the nation is facing the reality that these structures, however useful, do not last forever and can have unforeseen impacts. What to do about aging or problematical dams is an issue that arises with increasing frequency, affecting governments at all levels, dam owners and beneficiaries, nongovernmental organizations, and the public.

From its earliest days to the present, the United States has relied on dams to divert and store water from seasonal and permanent streams and rivers for many uses, including water supply, irrigation, flood protection, fishing, log driving, electrical and mechanical power generation, recreation, transportation, and more. However, some of the tens of thousands of dams that exist today are approaching or have exceeded their useful lives, some pose risks to public safety, and some have environmental and other impacts that no longer are perceived to be balanced by the benefits offered. In addition, some community needs and values have changed over the years, and people have learned more about dams and nonstructural alternatives.

Benefits and Adverse Effects of Dams

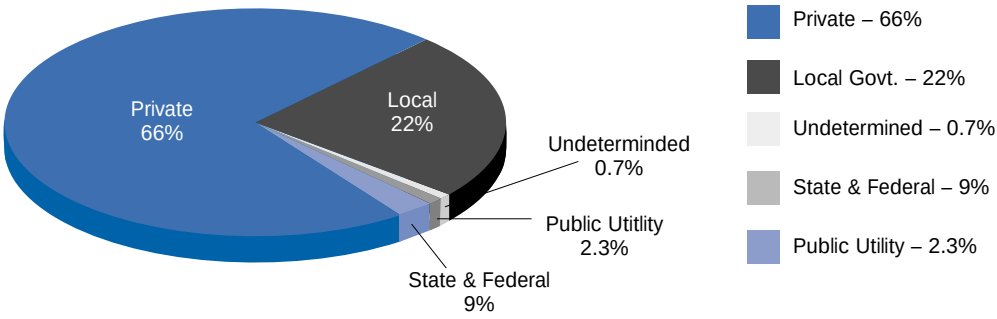
Most dams were designed to provide one or more economic or social functions; in some cases, corollary benefits have evolved. These functions and benefits include hydropower generation, flood control, water diversion and storage for irrigation and for human consumption, navigation, recreation, socioeconomic, community, and aesthetic benefits.

On the other hand, dams can have adverse effects on river systems that include inundation or alteration of important terrestrial and aquatic habitats and threats to some species; blocking of fish movement; blocking, diversion, or altered timing and quantity of river flow; altered water quality, including temperature; collection of sediment, debris, and nutrients; disruption of natural ecosystem functions and connectivity; hindrance of recreational opportunities; and altered aesthetics and traditional values of natural settings and communities.

Accordingly, a new way of thinking about dams and related problems is needed to make optimal decisions. While the nation invests the resources of time, people, technology, and money in the continuing effort to maintain and gain the benefit of most dams, it is time

to examine the nearly 77,000 dams in the national inventory[3] and tens of thousands of other dams included in state inventories and regulatory programs as well as undocumented and unregulated dams.[4]

FIGURE 1 Ownership of Dams Included in National Inventory of Dams



Over 66 percent of dams in the National Inventory of Dams (NID) are privately owened; nearly 22 percent are owned by local governments; 3 percent are owned by the federal government; 6 percent by state governments and over 2 percent are owned by public utilities. Most state inventories list hundreds to thousands of dams that do not meet the size criteria for inclusion in the NID (e.g., Wisconsin lists more than 3,700 active dams, of which only 1,200 are reported to the NID). It is also estimated that tens of thousands of dams are unregulated by state or federal laws and therefore are not documented in any government inventory.

FIGURE 2 Wisconsin Dams Included in the National Inventory of Dams

(Note: Clearer images of Figure 2 and Figure 3 are provided in the hardcopy of this report)

3 The National Inventory of Dams (NID) lists 76,953 dams that are 6 feet high or greater and impound at least 50 acre-feet, are 25 feet high and impound at least 15 acre-feet, or pose a serious downstream hazard. (See Figure 1.)

4 Most state inventories list hundreds to thousands of dams that do not meet the size criteria for inclusion in the NID (e.g., Wisconsin lists 3,700 active dams, of which only 1,200 are reported to the NID. See Figures 2 and 3).

FIGURE 3
Wisconsin Dams Included In the State Inventory

Where structural or ecological concerns exist, the slate of possible remedies includes repair, replacement, re-operation, redesign, addition of new facilities to mitigate problems or add benefits—and, increasingly, dam removal.[5]

Hundreds of dams have been removed in the United States, but only recently has pressure mounted for more openness in the related decisionmaking processes. These decisionmaking processes pose challenges in how to consider properly the pros and cons of dam removal, and how to remove dams safely.

Dam Removal as an Option

The concept of dam removal can arouse strong emotions, leading to polarized and entrenched positions on all sides of the issues. Although it is important that the concerns behind the emotions be expressed and considered, a decision about whether or not to remove a dam needs to be based on a balanced and rational analysis of the pros and cons of both dam removal and dam retention. It is in this evolving context that the Aspen Institute dialogue was convened to hear and reflect on key underlying values and interests in order to re-think and recommend how dam removal decisions can be improved.

5 A dam is defined in this report as any barrier that impounds water; this is a broader definition than the size-based criteria typically used by states. Dam removal is defined in this report as the removal of an entire dam, or so much of it that the dam neither poses a safety hazard nor affects river ecosystems.

Several converging trends pointed to the need for the Aspen dialogue. First, dams across the country are continuing to age, and an increasing number are in need of substantial repair. Many communities are dealing with significant infrastructure costs for public facilities, and aging dam costs need to be weighed against all of these other needs. Second, people have learned that, in many cases, there are alternatives to dams for accomplishing the same benefits and services. Third, people have learned more over time about the effects of dams on river ecosystems and neighboring communities. And fourth, since many dams were built, some community contexts and values have changed so that a greater value may be placed on alternatives to an existing dam. As a result, many communities, dam owners, and agencies across the United States are finding that, in some circumstances, dam removal can serve as an effective river management option while also providing a variety of benefits.

When appropriate, dam removal can provide environmental, economic, and social benefits. Dam removal may result in environmental improvements by restoring natural flows to a river, removing blockages to fish movement, reestablishing healthy river habitat for fish and wildlife, exposing submerged river rapids and riverside lands, and improving water quality. Dam removal may provide social benefits by eliminating safety hazards, providing river recreation opportunities such as fishing and boating, revitalizing community riverfronts, or providing mitigation for the continued operation or building of other dams. And dam removal may provide economic benefits by avoiding costs associated with dam safety improvements and environmental impact mitigation, and by generating revenue associated with the social benefits of a restored river.

Although many benefits have been realized through the removal of dams, this does not mean that all dams are candidates for removal. In fact, very few documented dams in the United States are even being considered for removal. The removal of more than 400 dams over 6 feet tall has been documented in the United States since the 1920s.[6] This is equivalent to just over 0.5 percent of the nearly 77,000 dams identified in the national inventory.

Many dams are simply too economically and socially valuable to society to be considered for removal. Many dams continue to serve important public or private functions, such as flood control, water supply, irrigation, hydropower generation, and recreation. In some cases, changing the way a dam operates could improve the ecological conditions of a river while continuing to generate the benefits of the dam, providing a balance between competing interests. In other cases, removing a dam could have adverse ecological effects that are too costly to mitigate. And in some cases, dams are retained because they represent a part of a community's history. Nevertheless, even if a decisionmaking process concludes that a dam should not be removed, the inclusion of dam removal in the slate of options considered likely will improve the quality of the final decision.

6 Pohl, Molly. 2000. Constructing knowledge on american dam removals. Pp. 501–509 in The Future of Dams and Their Reservoirs. U.S. Society on Dams, Denver, CO.

Focus of this Report

This report offers recommendations and practical advice in three areas:

- when and how to integrate dam removal as an option in overall river resources management,
- what key issues should be considered when making decisions about the dam removal option, and
- lessons learned regarding how to plan and implement a dam removal once a decision has been made to remove a dam.

In Part I, the Aspen group offers 15 overarching recommendations for actions that need to be taken by government and private actors at the national, state, and local levels so that dam removal can be integrated effectively into river resources management and removal decisions and implementation can be successful. The primary audience for these recommendations is policymakers who are addressing issues about dams and river management. The recommendations also may be of interest to other decisionmakers, affected parties, and practitioners involved in dam removal. Part I also lists the premises, or foundational principles, that grounded and guided the group to its recommendations and advice.

In Part II, the group provides practical advice in each of the three key areas based on its extensive experience with dam removal decisionmaking and implementation. For the most part, this advice is aimed at decisionmakers, affected parties, and practitioners involved in dam removal decisions or projects, although advice is aimed also at policymakers, especially in the section, Opportunities for Considering Dam Removal.

Nationally, expertise in and experience with the technical and public policy aspects of dam removal are growing. The group believes that, as people learn more about dam removal, the appropriate analytical and decisionmaking processes will evolve, and the experience gained in each case will help inform future dam removal decisions. [7]

Key Concept: Scale and Scope

The Aspen group wishes to emphasize a key premise underlying each of its recommendations—that every dam and every river is unique, and there is no simple formula for making every decision about any dam. An inappropriate level of analysis can result in unnecessary delays and increased costs. Thus, the breadth of analysis necessary to consider the dam removal option properly varies from case to case, and it needs to be commensurate with the scale of the project and scope of the

Analysis According to Scale and Scope

As an example, the removal of a defunct mill dam by the owner because of a public safety concern may require only minimal analysis, whereas the removal of a major, functioning hydropower and water supply dam for the purpose of ecosystem restoration would require a comprehensive analysis.

7 Because the dialogue focused on existing dams, this report does not address the building of new dams. Note also that not every recommendation or piece of practical advice contained in this document can be applied in every dam removal situation.

project's impacts. The appropriate level of analysis depends on each of the following factors and their interrelationships:

- ecological, physical, economic, legal, and social setting of the dam;
- objectives of, and constraints on, decisionmakers and stakeholders; and
- consequences of delaying the decision while the analysis is performed.

Premises

The Aspen group used the significant diversity of participants' perspectives to come to agreement and build its recommendations on the following premises. Some of these premises may seem to be self evident or obvious, but consider the sources. For instance, participants who have opposed efforts to build dams agree to the statement that dams can serve useful societal purposes. Participants who have been building, repairing, and operating dams agree to the statements about the problems dams can cause. All agree that some dams are no longer appropriate, that removal may be challenging, and that creative solutions are required to overcome obstacles.

1. **Because every dam and river is unique, it is not appropriate to handle decisions about every dam in the same manner.**

   The extent and types of processes appropriate to decisionmaking about whether to remove a dam, as well as permitting and implementing such an action, must be tailored closely to the characteristics of the dam, including site, type, ownership, setting in the landscape, history, uses, benefits, impacts, and interests affected.

2. Dam removal can be a reasonable approach to meeting a variety of economic, ecological, water resource management, public safety, and owner objectives.

   Currently, dam removal is often thought to be a fairly extreme measure and therefore is not considered as a real option. However, dam removal may be a reasonable option when considering the future of a dam because it may be the best, most cost-effective, or most appropriate way to meet a variety of needs. Also, the dam may no longer be useful or economically viable, or may no longer meet safety criteria.

3. Decisions about the future uses or significant modifications of a dam need to consider a full range of options, including dam removal.

   Until now, dam removal has not been adequately included or analyzed as an option in decisionmaking processes regarding dams. Options to be considered include dam removal, repair, replacement, re-operation, and redesign, as well as addition of new facilities to mitigate problems or add benefits.

4. In general, dam removal decisions are made best in the context of river systems and watershed management activities.

   Because a dam and its removal affect the ecology of the river system and communities in the watershed, potential removal should be analyzed, where possible, in the context of all

aspects of the river system and watershed management. The effects—on amount of water available, uses of the river (and reservoir if appropriate), fish and wildlife, and safety, for example—may be good or bad, but they need to be evaluated.

5. Many dams have provided, and continue to provide, benefits to society.

   Dams have many uses, including water supply, flood control, irrigation, and hydroelectric power. These uses were valuable to society when the dams were built and may still be valuable today.

6. Many dams have had adverse effects in the past and continue to have adverse effects on the use, function, and ecology of river systems.

   Dams may have adverse effects on river systems in a number of ways, including altering stream flow downstream of the dam, transforming the river above the dam to a reservoir, preventing fish movement, changing the structure of the fish community, changing sediment transport, and causing temperature and other water quality changes in the river.

7. The uses, values, and conditions under which a dam was constructed may change, and in some cases, may no longer apply. In addition, some dams may be structurally or functionally obsolete.

   Dams can have long life spans and, during this time, the reason for their construction may cease to be valid. An example is a small dam built to provide power to run a mill, but the mill is long gone. Additionally, the dam may be in such a state of disrepair that it would cost more to fix it than to remove it.

8. Dam removal decisionmaking works best when the process is open and accessible to everyone who is interested or affected, and decisionmakers can take all interests into account.

   Dams are property, and dam owners have a right and responsibility to manage and maintain their property. However, rivers by history and law are typically public in the United States. Decisions affecting the use of rivers with dams need to be subject to an open decisionmaking process consistent with the scale of the project, ownership, and the public interest involved.

9. In many instances, the current institutional framework for managing dams and water resources does not provide for the effective consideration and implementation of the dam removal option.

   Local, state, and federal regulatory frameworks for managing dams and water resources are often either inconsistent or barriers to dam removal. As with any rapidly developing science or practice of engineering and development, the state of the art is evolving; consistent dissemination of the approaches taken and lessons learned (combined with flexible regulations and adaptive management principles) will help to advance the art efficiently and minimize adverse outcomes.

10. The current regulatory framework may preclude the effective implementation of dam removal decisions by weighing shortterm detrimental effects more heavily than longterm benefits.

    The legal and regulatory regimes developed over the last forty years, along with a growing emphasis on environmental concerns, were intended largely to force consideration of the environmental impacts of development projects. These regimes may not be well suited to considering impacts of what amounts to environmental restoration or engineering. For example, dam removal has a direct effect on riverbeds and typically involves shortterm releases of sediment to spawning areas, yet there may be greater environmental benefits over the longterm as a result of new access to increased habitat upstream. The regulatory regimes designed to balance economic development and environmental damage may weigh too heavily the shortterm detriment, and may not adequately consider the longterm environmental benefit of restoration projects.

Recommendations

The following recommendations of the Aspen group focus on actions that need to be taken by government and private actors at the national, state, and local levels so that dam removal can be integrated effectively into river resources management, and removal decisions and implementation can be successful. The recommendations are aimed primarily at policymakers at the local, regional, and national levels who are addressing issues about dams and rivers, and also may be of interest to practitioners and other decisionmakers dealing with dam removal issues.

Each recommendation has specific action items associated with it, except for the first one, which deals with how decisionmakers should think about these issues. No rank or priority is intended in the order of the recommendations and action items. Although some relevant organizations, agencies, and individuals are implied or suggested, no specific recommendations are made with regard to who should carry out each action item, in the hope that innovative and collaborative leadership arrangements will emerge.

Recommendation 1

Ensure Appropriate Level of Dam Removal Analysis

The depth and type of analysis associated with a decision about any dam, including a decision to remove a dam, should reflect the scale of the project and scope of the project's impacts.

Rationale

Every dam exists in a setting with a unique set of characteristics (e.g., physical, ecological, social, economic, regulatory, and legal). As a result, applying the same depth and type of analysis, engineering, environmental mitigation, or permitting procedures to each potential dam removal project may not be appropriate, and in some cases it may unnecessarily delay or increase the costs of project implementation.

Recommendation 2

Integrate the Dam Removal Option in Dam Decisionmaking

Dam removal should be integrated as an option in decisionmaking regarding dams at appropriate stages, including the regulatory process, watershed planning, and community decisionmaking.[8]

Rationale

Dam removal has not been adequately included or analyzed as an option in decision-making processes concerning dams. In some cases, it is never considered; in other cases, it is given only cursory or *pro forma* consideration. Other options to be considered include repair, replacement, re-operation, redesign, and addition of new facilities to mitigate problems or add benefits. The depth of the analysis should be commensurate with the scale of the project and scope of the project's impacts.

Recommended Actions

- Amend relevant laws, regulations, policies, and mission statements to provide a means to appropriately consider dam removal as an option in decisions about dams.
- Develop guidance or issue executive orders calling for all agencies to require that dam removal be appropriately considered as an option in decisionmaking regarding dams.
- Amend, re-evaluate, and/or create new river basin and land management plans, as needed, to incorporate the possibility of dam removal.
- Develop guidance and training for the consideration of dam removal as an option in decisionmaking about dams, in consultation with experienced dam removal practitioners. This could be accomplished by professional organizations and associations, such as the American Society of Civil Engineers, Association of State Dam Safety Officials, U.S. Society on Dams, American Fisheries Society, and the Advisory Council on Historic Preservation.
- Provide to dam owners, and inform them about, the option of removal to alleviate safety problems at a dam.

8 See Part II for opportunities for considering dam removal.

Recommendation 3

Conduct Periodic Reviews of Dams

Conduct reviews of all dam structures and operations (and changes thereto) within a reasonable time frame (e.g., every 15–30 years), commensurate with their present use, condition, size, and impact, and address positive and negative environmental, economic, and social effects in addition to dam safety.

Rationale

Although the functions and values associated with rivers and dams may change, there are limited opportunities for comprehensive periodic re-evaluations of dam structures and operations. Absent periodic review, issues may not be addressed in a pragmatic manner—or at all—until significant problems arise, reducing the benefits of a dam and river and increasing the risk of significant future consequences. Current regulations in many states exclude some dams from regulation (usually those under 4 to 6 feet high). Moreover, regulations generally address only dam safety concerns and not operations, environmental impact, or project economics. In addition, many state and federal dam permits (with the exception of Federal Energy Regulatory Commission [FERC] licenses[9]) are issued for the life of a structure, with no provisions for periodic review of the dam for other than safety issues.

Recommended Actions

- Review nonjurisdictional[10] dams and consider the need to change their jurisdictional status or otherwise require that they be maintained or removed.
- Increase dam safety funding to ensure regular safety inspections and enforcement for all jurisdictional dams.
- Coordinate dam safety programs with environmental protection programs to ensure that the threat to environmental resources due to potential dam failures is assessed.
- Establish and fund a comprehensive periodic review process for all dams that are federally owned, are under federal jurisdiction, or receive federal funds.
- Establish and fund a comprehensive periodic review process for all dams that are state owned, are under state jurisdiction, or receive state funds.
- Develop model processes for periodic review of dams commensurate with their present use, condition, size, and impacts.

9 The regulation of nonfederal hydropower dams requires a comprehensive periodic review of a licensed dam's operations, environmental impacts, project economics, and public value every 30 to 50 years.

10 As used in this report, the term jurisdictional indicates that a dam is subject to federal and/or state dam safety regulation, and the term nonjurisdictional indicates that it is not.

Recommendation 4

Ensure Public Notice and Input for Dam Removal Decisions

Public notice should be provided for dam removal decisions when public resources are affected. In addition, to take public opinion into account, dam removal decisionmaking processes should include appropriate opportunities for public comment, commensurate with the scope and complexity of the project.

Rationale

Many dam regulatory authorities lack sound dam removal decisionmaking processes that ensure that stakeholders are aware, have access to information, and have an opportunity to comment.

Recommended Actions

- Develop guidance on the appropriate types and levels of public notice, education, and involvement for decisionmaking processes regarding dam removal projects of differing scales and scopes of impact.
- Develop guidance on appropriate outreach and education plans for dam removal decisionmaking.

Recommendation 5

Consider the Full Spectrum of Issues in Dam Removal Decisionmaking

Ensure that social, ecological, and historical values are effectively considered in dam removal decisionmaking.

Rationale

The process of deciding whether or not to consider dam removal as an option relies in part on quantified variables, such as engineering and construction costs. But decisionmaking often is limited to standard cost–benefit analysis, which does not adequately capture social, ecological, and historic values. Particularly in complex cases or when decisionmaking is very difficult and the best outcome is not obvious, there is a need to address more systematically non-economic or non-quantifiable values.

Recommended Actions

- When performing qualitative analyses of relatively simple projects, look to existing information (e.g., the priority issues and implementation sections of Part II of this report) for guidance on how to consider "soft" issues such as social, ecological, and historic values.
- When costs and benefits are quantified in more structured analyses for larger and/or more complicated projects, evaluate the possible application of existing methodologies, such as

natural resources damage assessment and calculation of the economic benefits of fisheries and recreation. When needed, these techniques should be modified to apply to dam removal analysis. Social, ecological, and historical values should be integrated into the process somehow, not necessarily dollar for dollar.

- Refine existing methodologies, or develop new ones, that enable social, ecological, and historic values to be characterized in a manner that allows comparison with more easily quantified values.

Recommendation 6

Address Rights of Dam Owners and Beneficiaries of Dam Services

Regulations and processes should support a dam owner's decision to remove a dam, consistent with legal requirements, when the beneficiaries of that dam are not willing to assume the legal and financial responsibilities associated with retaining it. In appropriate cases, alternatives to services or compensation for lost services that a dam owner is legally required to provide (e.g., power or water supply[11]) should be considered.

Rationale

Many dams have direct and/or incidental beneficiaries who would be, or perceive they would be, adversely affected by dam removal. Currently, when dams are removed, it is not clear who should be financially or otherwise compensated, a situation that can impede or prevent the appropriate consideration of dam removal. Decisionmakers need to heed legal contracts and follow fair guidelines in deciding whether and how beneficiaries should be made whole. It is unfair to force a dam owner to maintain a dam in perpetuity for the benefit of others, provided that legal obligations are met.

Recommended Actions

- Clarify the rights of dam owners, legal beneficiaries, and incidental beneficiaries at the beginning of a dam removal decisionmaking process, and consider these rights in finding a way to resolve and meet obligations.
- Develop and disseminate information on alternatives to services provided by dams, and dam owner rights and obligations associated with providing alternative services if a dam is removed.

11 Examples of services that a dam owner is not legally required to provide include contributing to a local tax base and high values for property fronting on the reservoir.

Recommendation 7

Revise Permitting Requirements to Accommodate Dam Removal

Review and revise permitting processes to ensure that shortterm impacts associated with dam removals do not preclude dam removal projects for which the restoration benefits outweigh those impacts.

Rationale

Existing regulatory programs were not developed with dam removal in mind. For instance, dam removal projects designed to restore a river system are often reviewed in the same fashion as development projects that do not provide restoration benefits, and the shortterm impacts of a dam removal are not weighed against the longterm restoration benefits.

Recommended Actions

- Revise permitting standards and/or regulations (or provide interpretive guidance) to achieve parity in the weighing of shortterm impacts associated with a dam removal against the removal's longterm benefits, while still adequately protecting the environment. As part of this process, review laws, rules, and regulations dealing with water quality certification, wetlands, historic preservation, and endangered species (among others).
- Review programs and regulations to identify and reconcile inconsistencies and conflicts in goals, procedures, and requirements for permitting dam removal.
- Ensure that inflexibility in permitting requirements does not encourage over-engineering of removal methods or final site design.
- Ensure that the costs of maintaining a dam are included in determining the net value of the benefits provided by the dam and its reservoir (e.g., when a reservoir has created wetlands habitat, the net value of those wetlands should take into account the cost of maintaining the dam).
- Develop a Clean Water Act Section 404 nationwide permit for dam removal for certain sizes and types of dams.

Recommendation 8

Coordinate Regulatory Programs Affecting Dam Removal

Review and revise policies and regulatory programs affecting the analysis and implementation of a dam removal and coordinate with other agencies to ensure that regulatory processes and requirements are commensurate with the scale of the project and scope of the project's impacts, and are not unnecessarily complicated, time consuming, or expensive.

Rationale

Dam removal decisions often fall under the jurisdiction of multiple agencies. The review of a project by multiple agencies, especially in smaller-scale projects, can result in unnecessarily lengthy and costly processes, and can delay, limit, or preclude appropriate consideration and implementation of the dam removal option.

Recommended Actions

- Streamline and coordinate the dam removal permit review process and provide flexibility in its application, commensurate with the scale of a project and scope of the project's impacts, to minimize costs and simplify and speed up the process where appropriate (e.g., consider developing a single application for all permits, waiving or reducing permitting fees, providing technical assistance, or providing guidance to applicants seeking dam removal permits).
- Develop memoranda of understanding between state and federal agencies involved in federally conducted, planned, or assisted dam removals.
- Consider model programs or guidance for the establishment of statewide dam removal task forces to coordinate communication between or among agencies in permitting dam removal.
- Provide information about existing state dam removal task forces to dam removal clearinghouse (see recommendation 13).
- Develop more explicit procedures and guidelines for the permitting of the removal of FERC-regulated dams (e.g. surrender, non-power license).

Recommendation 9

Expand and Integrate Dam Inventories

Inventories of dams should be expanded, integrated, and when necessary established, so that a comprehensive inventory of all dams (regardless of size) is available.

Rationale

Dams of all sizes in rivers have ecological and physical impacts on fish and other organisms, water flow, and sediment transport. In setting priorities for watershed restoration activities, as well as analyzing the impacts of any specific dam and its possible fates, a reasonable knowledge of the structural barriers in the watershed is important. Existing dam inventories are deficient. The largest single inventory (which is not comprehensive but is at least nationally consistent), the National Inventory of Dams, includes only dams with the potential for risk to life, health, and property. Countless other, generally smaller dams do not appear on the NID lists. The National Dam Safety Information Technology Committee of the National Dam Safety Review Board is coordinating dam safety inventories, but is currently not looking at environmental and other impacts unrelated to safety. The limited scope of data sources, and the incompatibility of the data that are available, pose significant challenges to the efficient and effective evaluation of the dam removal option.

In most watersheds, simply determining what dams or other significant structural barriers exist is a daunting task. Where possible, dams of all sizes as well as other structural barriers (e.g., even culverts and bridges) should be inventoried.

Recommended Actions

- Develop a national dams database task force to identify the existing databases, develop national data standards (i.e., output formats) to facilitate the integration or linking of existing databases, establish data development protocols, and serve as a repository of information about relevant databases.
- Incorporate environmental and administrative data into the ongoing collection of dam safety information by coordinating the Dam Safety Information Technology Committee's efforts with the work of the new task force recommended in the action item above.
- Increase efforts to develop complete databases of all dams, regardless of size.
- Fund programs to expand the collection of data on all dams. Where possible, personnel in the field should collect data on other structural barriers in rivers.
- Identify abandoned dams and those dams that are not maintained.

Recommendation 10

Develop Technical Guidance for Implementing Dam Removal

Site-appropriate practices and technical guidance for engineering issues should be further developed using the knowledge of a multidisciplinary group of professionals familiar with dam removal. Regulatory agencies should ensure that engineering and technical activities are appropriate to the scale of a project and scope of the project's impacts.

Rationale

Engineering (including planning, design, and implementation) of dam removal is relatively new, and the science and body of knowledge is evolving. At the same time, the uncertainty that emerges from the permitting process often encourages the approval of over-engineered solutions that are costly and rigid and do not accommodate the dynamics of natural systems. It is preferable to understand natural systems and work with them instead of against them, seeking an acceptable solution that minimizes cost. The challenge for the engineering profession and educational institutions is to accumulate knowledge and experience and assimilate site-appropriate dam removal design and technology into engineering practices.

Recommended Actions

- Establish working committees to develop site-appropriate engineering practices and disseminate information on dam removal in professional/academic journals. Professional engineering and other technical associations could accomplish this.
- Develop multidisciplinary technical guidance to help ensure that the intended outcomes of dam removal projects are achieved. An example of this type of document is *Stream Corridor Restoration: Principles, Processes, and Practices*.[12]

12 Federal Interagency Stream Restoration Working Group. 1998. Stream Corridor Restoration: Principles, Processes, and Practices. CD-ROM distributed by National Technical Information Service (1-800-553-6847). PB98-502487/ISBN-0-934213-60-7.

Recommendation 11

Increase Scientific Research and Education on Dam Removal

Curricula and research opportunities related to dam removal should be provided to increase the body of knowledge and analyze new or improved technologies.

Rationale

Too little scientific research has been conducted on the benefits and impacts of dam removal. This lack of scientific analysis increases the uncertainty in dam removal decisionmaking and hinders improvements in existing methods of dam removal and the development of new methods. Also, issues and techniques related to dam removal are not addressed in professional training and educational institutions.

Recommended Actions

- Sponsor research, training, and education related to dam removal, and add dam removal research as a funding category.
- Develop curricula on dam removal or incorporate it into existing, related courses.

Recommendation 12

Provide Public Education on Dams and Dam Removal

Individuals, organizations, and agencies experienced with dam removal should develop and broadly disseminate information about actual experiences to increase public awareness and understanding of dams and dam removal.

Rationale

Limited public awareness and understanding of the functions and impacts of dams and dam removal impedes consideration of the dam removal option. The challenge is to increase understanding and awareness through information, outreach, and dialogue.

Recommended Actions

- Collect information and experiences from individuals, organizations, and agencies experienced in dam removal, and disseminate this information broadly.
- Develop and disseminate to dam owners—including owners of nonjurisdictional dams—information on the responsibilities and liabilities of dam ownership, as well as information about the option of dam removal.

Recommendation 13

Establish a Clearinghouse for Dam Removal Information

Establish and maintain a user-friendly, centralized, Web-based clearinghouse for dam removal information that is publicly available for reference.

Rationale

Information reflecting actual experiences with dam removal is not housed in a centralized clearinghouse that is available for reference. In particular, the NID does not contain any information on decommissioned or unregulated dams. A clearinghouse would allow agencies to share experiences, learn successful techniques, and avoid repeating mistakes. A clearinghouse could contain resources such as relevant Web site links; summaries of completed or proposed projects (including dams analyzed but not removed); experiences with engineering design, dam removal costs, permitting, monitoring, and predictive models; scientific studies; symposia and conference plans and proceedings; and reports/papers.

Recommended Actions

- Establish a national committee to create and guide the establishment and maintenance of a clearinghouse for dam removal information, building upon existing data and resources[13] and efforts under way to establish a National Dam Information Portal by the National Dam Safety Information Technology Committee.
- Contribute information about experiences with dam removal to the clearinghouse, once established.

13 See Appendix for a list of selected resources.

Recommendation 14

Establish Financial Responsibility for Dam Removal

Dam owners normally should accept and plan for financial responsibility for removing their dams at the end of the structures' useful lives when removal is appropriate. In some circumstances, the dam owner does not have legal liability for all removal costs, and in other circumstances it may be necessary, regardless of responsibility, to consider other sources of dam removal funding. Other sources that should be considered include the beneficiaries of a dam and/or dam removal, and public funds where there is a public benefit to the removal.

Rationale

This concept of responsibility and liability for structures on a property is consistent with other forms of property ownership. Historically, when dams were built, financial responsibility for the end of the useful life of a dam was not considered. Recognition of dam owners' responsibility is relatively new, and most owners have not adequately planned financially for dam removal. In some cases, there are multiple and diverse beneficiaries of a dam and dam removal, and in others there may be no identifiable owner, operator, or beneficiary, therefore requiring a shared responsibility for removal.

Recommended Actions

- When dam owners' financial responsibility is already established, ensure that they are informed of the responsibility for the removal of a dam at the end of its useful life when removal is a desirable option.
- When dam owners' financial responsibility is not clear, establish this responsibility in law or policy. Establish mechanisms to ensure that federal, state, and local regulators implement these provisions.
- In some cases, dam owners should provide assurances that adequate funds will be provided for dam decommissioning and associated environmental restoration. An example of a mechanism for carrying out this recommendation is real estate transactions: When property containing a dam is transferred, the presence of the dam and the owner's associated responsibility and liability could be disclosed to the new owner. The new owner could be required to show adequate resources to assume financial responsibility and liability for the dam.

Recommendation 15

Improve Funding Opportunities for Dam Removal

The amount of money available from existing funding sources for dam removal should be increased, and new funding sources should be created. In addition, dam removal should be made eligible for funding from existing programs that support related work, such as dam repair or rehabilitation. Federal, state, local, and private sources of funding should support not only dam removal, but also project decisionmaking, design, site restoration, and pre- and post-removal monitoring and evaluation.

Rationale

Most dams were built without plans or funding for their eventual removal. Dam removal and the requisite studies associated with it can be expensive, and may exceed the resources of a single owner or operator.

Recommended Actions

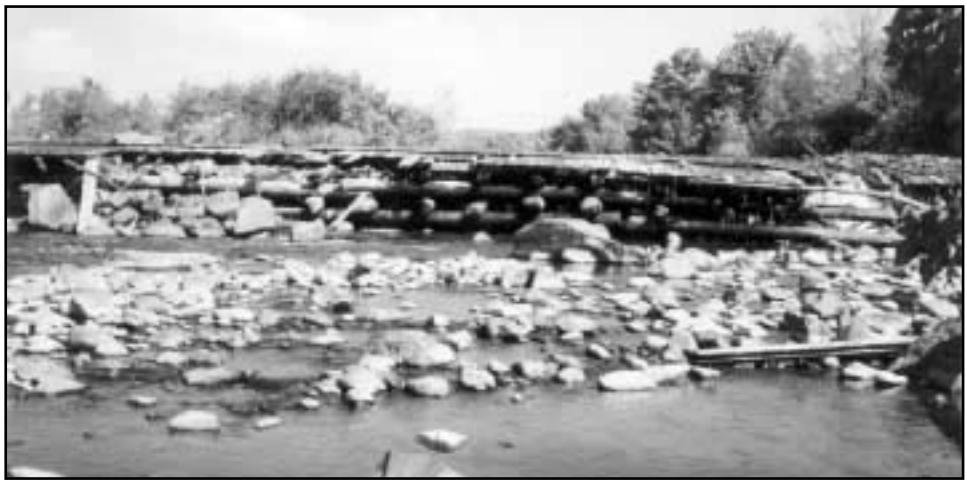
- Increase the amounts of money available in existing funding programs for dam removal and associated planning, restoration, and monitoring.
- Review existing funding programs (e.g., dam safety, hazard mitigation, water management, watershed management, fish and wildlife management, water quality assessment and improvement) to determine whether they can be adapted to allow funds to be used for dam removal and associated planning and restoration, and publicize the availability of this funding. In particular, appropriate laws, regulations, and/or policies should be amended to allow disaster relief funding to be applied not only to dam repair and reconstruction, but also to dam removal.
- Develop a framework for assuring that adequate funding will be available for future dam decommissioning at the end of the useful life of a dam. Dam owners and other interested parties should be involved. Mechanisms to consider include bonding, insurance, and individual or pooled decommissioning accounts.
- Develop new sources of funding for dam removal and associated planning and restoration, through both traditional sources and creative approaches, such as tax incentives, corporate donations, mitigation funds, partnerships, and decommissioning funds.
- Ensure that within existing or new sources of dam removal funding, match-free seed monies are made available that can fund the decisionmaking process at the community level and/or initial project design stage.

Woolen Mills Dam ■ Milwaukee River, Wisconsin, USA
Before Removal
Cited in *Lessons Learned*, Public Involvement, Lesson 1, Case example A; also cited in *Lessons Learned*, Site Restoration & Land Management, Lesson 3; also cited in *Lessons Learned*, Site Restoration & Land Management, Lesson 2

Woolen Mills Dam ■ Milwaukee River, Wisconsin, USA
After Removal

Edwards Dam ■ Kennebec River, Maine USA
Before Removal
Cited in *Lessons Learned*, Sediment, Lesson 3, Case example A

Edwards Dam ■ Kennebec River, Maine USA
After Removal



Anaconda Dam ■ Naugatuck River, Connecticut, USA
Before Removal
Cited in *Lessons Learned*, Engineering & Design, Lesson 10, Case example F;
also cited in *Lessons Learned*, Sediment, Lesson 4

Anaconda Dam ■ Naugatuck River, Connecticut, USA
After Removal

Matilija Dam ■ Ventura River, California, USA
Slated for removal
Cited in *Lessons Learned*, Sediment, Lesson 2; also cited in *Lessons Learned*, Sediment, Lesson 7

Opportunities for Considering Dam Removal

One of the Aspen group's overarching recommendations is that dam removal should be integrated at appropriate stages as an option in decisionmaking regarding dams (see Premise 3 and Recommendation 2). In most cases, dam removal has not been adequately included or analyzed as an option. In some decision-making processes, it is never considered; in other cases, it is given only cursory or *pro forma* consideration.

This section identifies some of the more frequent opportunities for considering dam removal as an option. In some cases, integration of the dam removal option into these decisions is simply a matter of discretion for the decision maker(s) and/or participants. In other cases, policy changes are needed, either to enable any consideration of dam removal at all or to facilitate the effective consideration of the dam removal option. Thus, this section is aimed at policymakers developing policy about dams and rivers management and at decisionmakers and affected parties participating in an individual dam removal decision.

1. **Regulatory and/or Programmatic Review**
   Re-licensing, permit renewals, dam safety inspections, and operational reviews may be appropriate times to consider dam removal as an option.

2. **Enforcement/Compliance Actions**
   Dam operators' obligations to comply with public safety or environmental laws may trigger the consideration of dam removal. In addition, dam removal as a mitigation measure may be an option for compliance with environmental laws affecting other dams, land use activities, or proposed actions in the watershed.

3. **Dam and Public Safety Concerns**
   When a dam fails or is determined to be unsafe, does not meet current dam safety standards, ceases to be maintained because of abandonment or lack of funds, or poses a significant increase in risk due to changes in upstream or downstream conditions, dam removal should be considered as an option.

4. Environmental Considerations

Dam removal should be considered to address direct environmental impacts caused by a dam (e.g., impediments to fish passage) or to meet broader watershed objectives (e.g., water quality or fisheries restoration goals). These considerations could be in the context of voluntary actions, public or agency pressure, or legal proceedings. If new information becomes available, conditions change, or new actions are being considered to remedy a dam-induced environmental impact, dam removal should be considered as an option.

5. Changes in Community Interests

If a dam is no longer considered a benefit to the community, or the community is considering new ways to revitalize its waterfront, then dam removal should be considered.

6. Legal and Financial Liability Concerns

If a dam owner/operator is concerned about liability or the cost of maintenance and operations, then dam removal should be considered as an option.

7. Watershed Management Planning

If a dam is hindering the achievement of watershed management plan goals, then dam removal should be considered as an option.

8. Changes in Use of a River

When the use of a river, cultural value of a river, or desired benefits of a water resource change, dam removal should be considered as an option.

9. Changes in Use, Ownership, or Operation of a Dam or Reservoir

When there are changes in use or operations of a dam or reservoir, or beneficial uses have ceased, dam removal should be considered as an option.

10. Determination of Dam Abandonment

When a dam is determined to be abandoned (i.e., no responsible party to operate and maintain the structure can be identified), dam removal should be considered as an option.

11. Efforts to Meet Dam Owner Goals and Objectives

Dam removal should be considered as an option when a dam owner wishes to do so.

Priority Issues When Considering Dam Removal

The Aspen group identified fourteen priority issues that should be considered and, when appropriate, addressed when deciding whether or not to remove a dam. This practical advice is based on the group's experience with dam and river management issues, and is aimed primarily at decisionmakers, affected parties, and practitioners involved in dam removal decisions or projects.

This is not an exhaustive list, and some of these issues may not be applicable to all situations, but they should be considered when appropriate. The extent to which the issues should be evaluated will vary according to the scale of a project and scope of the project's impacts. The following discussion of each issue includes an explanation of its scope, a description of why the issue is important, and practical advice to guide consideration when making a dam removal decision. The issues are not listed in priority order.

The Appendix lists additional resources offering further information and advice on what issues to consider in deciding whether or not to remove a dam.

1. Process of Decisionmaking

Scope of Issue

The process of decisionmaking includes the people who participate in a decision, the information that is considered, the steps in the process, and how the decision is made.

Importance of Issue

A transparent, predictable, and rational decisionmaking process helps to (a) ensure the fairness and structure of the analysis, (b) ensure that the public obtains necessary information, (c) establish trust, and (d) save time and money by preventing duplicative processes. Addressing dam removal decisions in a manner that ensures broad input into the decisionmaking process enhances the quality and acceptability of the decisions and legitimizes the outcomes. Without such a decisionmaking process, decisions may not be acceptable to all affected parties, which increases the risk that the decisions will be derailed through litigation or other means.

Relevant Considerations

- The decisionmaking process needs to be transparent, predictable, and rational. The depth of the process needs to be commensurate with the scale of a project and scope of the project's impacts.
- Public notice should be provided of dam removal decisions where public resources may be affected. In addition, to take public opinion into account, dam removal decisions need to include appropriate opportunities for public comment, commensurate with the scale of a project and scope of the project's impacts. In complex cases, affirmative public outreach and education may be appropriate.
- Every situation is unique; decisionmaking processes need to be tailored to the individual situation. However, once the decisionmaking procedures for a particular dam are established, they need to be followed throughout the process.
- The decisionmaking process needs to consider and incorporate the appropriate range of available analytical frameworks (e.g., economic, social, scientific), commensurate with the scale of a project and scope of the project's impacts. To the extent possible, the process needs to identify early on all studies and analyses necessary for the decision, thereby ensuring that needed information is developed.
- The decisionmaking process needs to make clear how the final decision will be made, including how all analyses (e.g., economic, social, scientific) deemed necessary will be incorporated into the decision.

2. Original, Existing, and Future Purposes of a Dam and Functions and Uses of a River

Scope of Issue

It is important to have a thorough understanding of the original, existing, and possible future purposes of a dam and functions and uses of a river when considering the options of dam repair, modification, and removal.

Importance of Issue

Information about the original, existing, and potential future purposes of a dam and functions and uses of a river provides essential background for decisionmaking. The purposes, conditions, and uses of a dam and river may have changed over time, along with environmental conditions, public values, and relevant laws and policies. Understanding of a dam's benefits and impacts also may have changed, along with understanding of the benefits and impacts of the river without the dam. In short, physical, ecological, institutional, economic, and societal changes happen, and stakeholders need to be able to recognize them and provide mechanisms for responding.

Relevant Considerations

- Past, current, and potential future uses of both a dam and a river (with and without the dam) need to be identified and evaluated. Dams often have more than one purpose and rivers more than one use.
- The decisionmaking process may provide an opportunity to identify alternative (non-dam) ways of carrying out the original, existing, and possible future purposes of a dam.
- When river restoration is a consideration in a dam removal decision, the focus needs to be on restoring the natural riverine processes and functions rather than on attempting to restore all of a river's pre-dam conditions.

3. Dam Safety and Public Safety

Scope of Issue

Dam safety has to do with the condition of a dam and the consequences to life, health, property, and the environment if the dam were to fail. Public safety has to do with the potential for harm to those who play, work, or live near a dam and are not careful when they are on or near the structure.

Importance of Issue

Dams can pose a threat to human life and property, as well as the natural environment, especially when they are unsafe and need repairs. This is an issue that speaks clearly to the public and is readily understood. Safety issues also create liability concerns for a dam owner.

Dam safety and public safety concerns are often the triggers for serious consideration of what to do with a dam. Safety concerns often add a sense of urgency to the need to take action, which may have significant implications for the time frame of the decisionmaking process. The cost of addressing safety considerations can be a driving force for seriously considering the dam removal option.

Relevant Considerations

- The protection of human life, health, property, and the environment needs to receive appropriate consideration in the decisionmaking process.
- Dam owners and stakeholders need to be well-informed regarding the safety issues related to a dam, so that the risks, liability, and responsibilities associated with the existence of the dam can be considered along with the benefits of the dam.
- Although shortterm financial considerations are important in any decisionmaking process, they cannot be the sole factors when making decisions about resolving dam safety and public safety problems.
- When a formal cost–benefit analysis is conducted, it needs to account for the long and shortterm costs of dam repair and maintenance as compared to dam removal.

4. Compatibility with Existing Plans

Scope of Issue

This issue does not focus on planning for a particular dam removal project, but rather on the placement of such a decision in a wider land and watershed context. The issue of compatibility with existing plans addresses the regional, watershed, or community planning processes and/or resulting reports that provide a context in which to consider dam removal and/or provide data to use during decisionmaking. This can include for instance, watershed, regional, community, recreational, water supply, water quality, fisheries management, and fisheries and other restoration plans.

Importance of Issue

The consideration of existing regional, watershed, and community plans enables a dam removal decision to reflect community, watershed, and regional goals. This approach incorporates myriad stakeholders' interests and values and helps to prioritize the use of limited financial and other resources. The consideration of dam removal in the context of existing plans can highlight inconsistencies in planning goals and help to identify opportunities for addressing them. It also can help to build bridges between potentially inconsistent or incompatible regulatory mandates. Building on previously adopted plans also can take advantage of existing data, increasing the efficiency of the decisionmaking process.

Relevant Considerations

- When necessary, consideration of the benefits and impacts of the dam removal option needs to extend beyond an immediate dam area to include a more expansive watershed area.
- Where there are existing plans (e.g., watershed, regional, community, recreational, water supply, water quality, fisheries management, and/or fisheries and other restoration plans), dam removal needs to be considered in that context. However, a lack of available plans is not grounds to delay a decisionmaking process or eliminate consideration of potential options.
- When developing plans (e.g., watershed, regional, community, recreational, water supply, water quality, fisheries management, fisheries and other restoration plans), planners need to consider the desired future conditions of dams and rivers. Do not assume that dams will remain as they are. Where appropriate, an analysis of the future status of a dam needs to be included in the planning effort.

5. Ecological Issues

Scope of Issue

Ecological issues involve the interactions among biological, physical, and chemical aspects of the environment, including the characteristics and associated functions and values of a river and surrounding area under existing conditions (with a dam) and proposed options (dam repair, modification, or removal).

Importance of Issue

Rivers support critical ecological functions and values, many of which (e.g., water quality and recreation) are important to the human community. The construction of a dam can fundamentally alter a riverine ecosystem and its associated natural functions and values. Likewise, the removal of a dam can alter the functions and values of a river system that were created by that dam. The functions and values of a river that are lost as a result of dam construction seldom were considered at the time of construction. Restoration of the functions and values that a river system possessed without a dam can be a driver when considering dam removal. Laws and regulations vary by location and jurisdiction, but they generally require that ecological issues be considered in all decisions regarding dams.

Relevant Considerations

- Ecological issues need to be given serious consideration during the decisionmaking process. The scale and scope of the consideration varies depending on the ownership and size of a dam, ecological impacts of the dam, potential impacts of dam removal, and whether the dam is under the jurisdiction of state or federal laws and regulations.
- Statutes and regulations, such as the National Environmental Policy Act, provide a legal foundation for how ecological impacts must be evaluated. Other statutes, including the Clean Water Act, Endangered Species Act, Magnuson-Stevens Fishery Conservation and Management Act, and Fish and Wildlife Coordination Act, as well as tribal obligations, are also important in evaluating proposed changes to the environment.
- Where possible, dam removal needs to be evaluated in the context of the larger watershed or basin in which it is located.
- The best available ecological information needs to be used in decisionmaking, while recognizing that ecological conditions and changes in those conditions are often difficult to quantify, predict, and evaluate.
- The longterm ecological benefits of a proposed dam removal action need to be considered when evaluating the shortterm ecological impacts of the action.
- Short and longterm monitoring of existing conditions and future changes is desirable and needs to be conducted and documented whenever possible.

6. Social Values and Community Interests

Scope of Issue

The values and interests of individuals and communities affect and are affected by a decision to remove a dam.

Importance of Issue

Dam removal can affect a wide range of community interests. It can result in both direct and indirect changes to a community (some positive and some negative). By evaluating and, where appropriate, addressing potential community changes, decisionmakers can obtain community support for the selected option, which can contribute to successful outcomes.

In addition, social values influence preferences for certain alternatives or options. Different communities and cultures have different values. This diversity of values—including issues of tribal rights, traditional cultural values, and environmental justice—needs to be captured and considered in the decisionmaking process.

An adequate understanding of social values and community issues—and an understanding of who benefits from, and who bears the impacts of, each option—can facilitate an informed evaluation of options during the decisionmaking process.

Relevant Considerations

- Social values and community concerns need to be identified, adequately considered, and, where appropriate, addressed.
- Early and continuing involvement of stakeholders representing diverse interests and values can be a vital component of a well-informed decisionmaking process.
- A dam removal decision's effects on a community vary with the scale of a project and scope of the project's impacts.
- The relationships among a community, dam, and river over time need to be recognized, because the suite of a community's values and interests may have changed and likely will continue to change.
- To evaluate all options fully, decisionmakers need to identify and consider those who will bear the costs and receive the benefits of each option.
- Expressed fears and concerns about the dam removal option need to be adequately considered and addressed throughout the process, and not dismissed.
- Creative solutions often can be identified to address social values and community concerns.

7. Economics

Scope of Issue

This issue focuses on the relationship of economics to decisionmaking, including the collection and analysis of both readily quantifiable costs and benefits (e.g., lost operating revenue), and costs and benefits that are more challenging to assess (e.g., ecological, aesthetic, and historic values). It does not directly address how a dam removal is financed.

Importance of Issue

When performed correctly, economic analyses can provide decisionmakers and stakeholders with a common metric for evaluating options. Economic analyses can monetize benefits and costs, help to identify the affected parties, and quantify the effect on those parties. Economic analyses can help to determine unintended consequences and further define options. Economic analyses also can demonstrate the distribution of costs and benefits of various options, which in turn may influence the choice of alternatives, selection of mitigation measures, and ultimate sources of project funding.

It is important to ensure that an appropriate and accurate economic analysis is performed. An economic analysis can be skewed, and the ultimate decision biased, when only certain costs and benefits are monetized, and other costs and benefits that are not easily monetized (e.g., ecological, aesthetic, and historic values) are ignored.

Relevant Considerations

- All costs and benefits need to be identified and acknowledged, whether or not they can be easily monetized or quantified. The extent to which these benefits and costs need to be analyzed depends on the scale of a project and scope of the project's impacts.
- While attempting to quantify costs and benefits (especially those that are most difficult to quantify), decisionmakers need to clearly identify and consider the limitations of any cost–benefit analysis.
- Early on, when the potentially affected parties have been brought into the information-gathering process, it is helpful to have all parties agree to, or accept, the method of economic analysis to ensure that the results are both useful and acceptable.
- When an in-depth economic analysis is warranted, a thorough comparison of the economic effects of all options requires the systematic, balanced consideration of the full breadth of possible costs and benefits (e.g., types, recipients) and needs to consider these costs and benefits across an area that is geographically relevant (e.g., a watershed).
- The likely mitigation costs associated with each option need to be considered to ensure that each option is compared equitably and fully to the others.
- Costs and benefits need to be analyzed over a time frame that encompasses the design life of a dam. Longterm benefits and costs need to be discounted using a "present value" analysis.
- The lost opportunity costs of feasible alternatives (e.g., restored fish runs, recreational opportunities, future hydropower) need to be considered.
- The mere consideration of dam removal may impose costs on some parties (e.g., decreased value of businesses dependent on the reservoir). A concerted effort needs to be made to recognize and minimize such costs.

8. Legal Requirements

Scope of Issue

Laws and regulations pertaining to dam removal are key to considering it as an option. Challenges may be encountered in either following legal requirements or proceeding in the absence of clear legal requirements.

Importance of Issue

Statutory and regulatory requirements provide boundaries for what can be accomplished within the existing legal framework. References to existing statutes and regulations can help to clarify and communicate what needs to be done and by whom, with regard to both the decisionmaking procedures that must be followed and the substantive legal standards that must be met.

Legal requirements help to even the playing field and help to ensure that both public interests (e.g., in safety and the environment) and a dam owner's interests are considered. An understanding of the applicable statutes and regulations also may help to streamline the process of deciding whether or not a dam needs to be removed. By following legal requirements, participants can minimize missteps and thereby help to ensure that the decisionmaking process proceeds smoothly.

In some circumstances, legal requirements may provide an impetus to take action. In some situations, enforcement (or the threat of enforcement) of existing laws or regulations (e.g., concerning dam safety, fish passage, water quality) may provide the primary motivation to engage in a dam removal decisionmaking process. In some circumstances, such as those involving dams licensed by the Federal Energy Regulatory Commission (FERC), periodic reviews of a license may provide opportunities to consider removal alternatives (although the legal authority of FERC to order involuntary dam removal has not been resolved by the courts).

Most existing regulatory programs were not developed with dam removal in mind. As a result, making a dam removal decision within the framework of existing laws and regulations can be challenging. For instance, dam removal projects designed to restore a river system are often viewed in the same fashion as development projects that do not provide restoration benefits. In addition, dam removal decisions often fall under the jurisdiction of multiple agencies. The review of a project by multiple agencies can result in lengthy and costly processes, which may be particularly onerous for smaller-scale projects. This can delay, limit, or preclude the appropriate consideration of the dam removal option.

Relevant Considerations

- Early in the process, identify the procedural requirements and substantive legal thresholds that must be met to complete the consideration of dam removal.
- Early in the process, meet with regulatory officials to discuss the procedural requirements and substantive legal thresholds that must be met. If legal requirements are confusing or inconsistent, request that regulatory officials clarify and/or resolve the inconsistencies.
- Ensure that the decision and decisionmaking processes are in compliance with applicable laws and regulations.
- The alignment of the planning process with legal and regulatory timetables improves the decisionmaking process.

9. Scientific Information

Scope of Issue

It is important to develop acceptable and reliable scientific information about the options under consideration.

Importance of Issue

Scientific information based on accepted scientific methods provides a consistent basis for making decisions. Sound, acceptable, and reliable science can reduce disagreements about

the facts underlying a decision and can enable the decisionmaking process to focus on values and policy issues. Science can also provide facts about the assumed and purported features of various options, help to evaluate the effects of different options, and add credibility to the decisionmaking process. And, where appropriate, science can help assign quantitative values for evaluations of the risk and uncertainty associated with decisions that need to be made.

Relevant Considerations

- Early agreement among stakeholders on the scientific methods and principles to be used for gathering information, conducting and interpreting studies, and making decisions can ease tensions and reduce disputes over study results.
- Accurate cost and time estimates for the development of needed scientific information help in accurately budgeting and planning for the decisionmaking process.
- The development of scientific information needs to be completed within funding, legal, and regulatory timetables.
- The best available information and best professional judgment need to be used in analyzing options and making decisions.

10. Technology and Engineering

Scope of Issue

Technology and engineering can be used to delineate options for the removal, repair, or modification of a dam.

Importance of Issue

Engineering can identify the range of technical options available for achieving stated goals, and can separate technically viable options from unrealistic ones. The engineering process also applies technology to analyze the costs and benefits of removing, repairing, or modifying a dam and the risk of adverse consequences associated with each option.

Relevant Considerations

- A preliminary analysis of engineering options needs to be performed early in the decisionmaking process, because it can be an important component in determining both the cost and technical feasibility of different river management options.
- Engineering and other technological solutions need to be appropriate to the scale of a project and scope of the project's impacts.
- The entire range of engineering options, both structural (e.g., installation of riprap) and nonstructural (e.g., vegetative bank stabilization), for dam removal and associated site restoration needs to be considered.
- The engagement of competent and experienced people to deal with engineering and technical issues increases the likelihood of realistic cost estimates, reduced uncertainty, and superior outcomes.

- Because existing technologies are limited, an engineering solution may not exist for every problem. For example, certain migratory fish cannot use traditional fish passage designs.

11. Risk and Uncertainty

Scope of Issue

Often there is uncertainty in predicting outcomes of a dam removal or other option. Added to this uncertainty are the political, legal, and environmental consequences of unanticipated outcomes and the inability to predict such consequences. For the purposes of this section, uncertainty implies incomplete knowledge or information, such that some or all of the relevant information is missing or unattainable. Risk implies that there is an ability to calculate probabilities from available information; this ability may be limited by a lack or shortage of information.

Importance of Issue

Uncertainty is involved in every option available for dealing with a dam (including the no-action alternative). However, dam removal currently tends to involve more uncertainty than do other options because of the limited experience with it. Paradoxically, this lack of familiarity tends to cause decisionmakers and stakeholders to want a greater level of certainty for a dam removal than for other river management options.

Dam removal and other river management options often involve factors that increase uncertainty and have inherent perceived risk. For example, if an activity is proposed to take place in a naturally dynamic river environment, the effects may be long lasting, significant, and difficult to reverse, and the activity may require advanced technology and involve new ideas rather than familiar approaches.

As a result, risk and uncertainty can have a significant effect on the identification and comparison of river management options. By being explicit about these uncertainties—and about the level of uncertainty that stakeholders and decisionmakers can tolerate—decisionmakers can clarify expectations, ensure more equitable comparisons of alternatives, and enhance the acceptability of the final decision.

Relevant Considerations

- The risks and uncertainties associated with all river management options under consideration need to be articulated, commensurate with the scale of a project and scope of the project's impacts. Consideration of the options needs to include evaluations of what is known, what is unknown, and what is uncertain. Unintended outcomes, their likelihood, and their possible consequences also need to be identified.
- The uncertainty of results, by itself, is not a reason to reject a given option. Levels of risk and uncertainty need to be considered as one factor in decisionmaking.
- Information on risk and uncertainty needs to be disseminated to all stakeholders in an understandable manner. To enable all stakeholders to participate meaningfully in discussions concerning risk and uncertainty, analyses and results need to be translated into a common base of information that everyone can understand.

- Risk and uncertainty may vary based on the scale of a project and scope of the project's impacts. Proposals for small projects that are very similar to successfully completed projects may involve little or no uncertainty or risk. Conversely, large, complicated, and/or innovative projects are likely to involve greater uncertainty or risk.
- Acceptable uncertainty increases as the consequences of unintended outcomes decrease. That is to say, in some cases the possible unintended outcomes may have little effect on matters of concern and, therefore, uncertainty is more acceptable. For example, a certain option might involve in-river work and involve the risk of being delayed from fall to winter. At some sites, this would be of little consequence and thus be acceptable. At other sites, it might mean severe working conditions, risk of flooding, or an unintended interruption in critical water deliveries. In the latter case, the risk of delay is likely to be less acceptable.
- Look to the evolving science of dam removal engineering to reduce uncertainty.

12. Information Exchange and Stakeholder Education

Scope of Issue

Information exchange involves the collection, and sharing with decisionmakers and stakeholders, of all information needed for a decision. Stakeholder education involves identifying all affected stakeholders, educating them about the issues involved in a decision, and, where appropriate, providing an opportunity for stakeholder input into the decision.

Importance of Issue

The open exchange of information and active education of stakeholders helps to identify the range of river management options to consider and ensure early identification of concerns about, or problems with, the various options. Early review of this information also can identify information gaps that need to be filled prior to making the decision.

The promotion of a shared knowledge base and stakeholder education provide the opportunity for informed and early involvement of stakeholders and decisionmakers and allow all stakeholders to participate on an equal footing. This serves as a first step toward mutual understanding of the issues and the associated costs and benefits of the options being considered. This encourages the re-evaluation of preconceived beliefs and increases the opportunity for parties to engage in problem solving.

Contributions to a shared knowledge base help to make use of a wide variety of experiences and avoid duplication of effort, resulting in a more efficient decisionmaking process. A well-planned and well-documented exchange of information also can aid in the evaluation of other nearby dams on the river, or even the same dam if a decision is revisited at a later time. The sharing of other experiences with dam removal and repair also can affect opinions about the dam removal option. Lastly, a good information exchange adds to the body of science and knowledge related to dam removal and increases experience with the process of evaluating the dam removal option.

Relevant Considerations

- Even though there is a public interest in river resources, a private decision maker is not always legally obligated to engage the public. Nevertheless, to the extent possible, the affected public needs to be informed and, where appropriate, consulted. This stakeholder outreach needs to occur not only during a dam removal decisionmaking process, but also during the implementation of a dam removal.
- When conducting public outreach and education, use relevant and reliable information, when available. When feasible and practical, place priority on the use of site-specific information to facilitate communication and promote understanding.
- Decisions made regarding a dam removal or retention need to be understandable to the public. Where possible, draft in plain language studies, status reports, and other public documents so that the content is accessible.
- The information developed for any given project also needs to be made available to a national dam removal information clearinghouse, to build on the record and the science to be used in other projects in which the dam removal option is considered. Where possible, develop information to be consistent with, and contribute toward, this national information clearinghouse.

13. Political Context

Scope of Issue

Political factors that can influence dam removal decisions comprise the policies, positions, views, and attitudes regarding dam removal of national, state, and local interests, including elected and other public officials, influential community members, corporations, and non-governmental organizations.

Importance of Issue

Politics at all levels can greatly influence a decisionmaking process. The political context can affect the consideration of dam removal as an option; help define the need for, and scope of, public education and participation; influence the feasibility, funding, and implementation of options; and magnify the challenges of the decisionmaking processes. Politics can override not only specific considerations in a dam removal decision, but also an entire decision made in a formal process. Depending on the context and how a political decision is made, this reality can improve or undermine a sound decisionmaking process.

Relevant Considerations

- Understand and be aware of the political context for each project being considered.
- Inform interested and influential politicians and community leaders early and often regarding the status of a decisionmaking process and basic content of a decision. The information provided needs to address all sides of the issues including any myths that underlie political positions, views, and attitudes.

- In certain circumstances, influence or effect change in appropriate ways in the political landscape to ensure the proper consideration of all river management options, including the dam removal option.
- Expect and be ready for change, because the political context is dynamic.

14. Funding

Scope of Issue

Funding sources are critical both for the process of deciding whether or not to remove a dam and for the implementation of a dam removal.

Importance of Issue

Virtually all dam removal, repair, or modification proposals require some level of funding. The source and amount of available funding are therefore an integral part of the decision-making process and may be critical factors in evaluating the viability of options.

In addition, funding is often needed to support the dam removal decisionmaking process itself. Funds may be needed not only to conduct studies (e.g., resource inventories, alternative and feasibility analyses, preliminary environmental impact assessments), but also for stakeholder outreach and involvement activities.

Relevant Considerations

- When identifying funds for dam removal, look first to the dam owner or operator (particularly for dams that generate revenue), recognizing that many dam owners have not planned financially for dam removal. Next, look to the beneficiaries of the dam and/or dam removal.
- For complex dam removals, a creative spectrum of funding sources may need to be used.
- Dam removal needs to be made eligible for existing private and public programs that support similar work, such as dam repair or modification. Federal, state, local, and private sources of funding need to support not only dam removal, but also project decisionmaking and design, site restoration, and pre- and post removal monitoring and evaluation.
- Often, creative approaches can be used to identify funds for dam removal. Examples include (a) using funding available for fish restoration or water quality improvement projects, (b) allowing dam removal to be used as a mitigation measure for other water resources related developments in the same watershed, or (c) seeking funds for projects that are part of, or that advance, comprehensive watershed plans.
- Where available, comprehensive watershed plans may help in setting funding priorities for dam removal and other options.
- In appropriate cases, paying for alternatives to services that a dam owner is legally obligated to provide (e.g., power, irrigation), or compensating users for these lost services, needs to be considered. (Examples of services that a dam owner would not be legally obligated to provide include a local tax base and high values for property fronting on the reservoir.)

Lessons Learned in the Implementation of Dam Removal

The Aspen Institute provided a unique forum for dialogue on a variety of first-hand experiences with dam removal. As the participants worked together over two years developing their recommendations, the lessons of their experiences came to bear. This section offers practitioners some of these basic lessons learned in the implementation of dam removal projects once the decision to remove a dam has been made. The lessons are organized in general categories that represent components of project implementation.

The lessons are suggestions only and are based solely on the perspectives of dialogue participants; this compendium is not comprehensive and was not reviewed by others who were involved in the projects cited. The case examples were selected because they provided meaningful learning experiences; almost all were part of successful dam removal projects. Readers also should note that, consistent with a theme throughout this entire publication, all lessons do not apply to all projects; they should be considered in relation to the scale of a project and scope of the project's impacts.

The process of deriving and applying lessons learned from past projects will lead to more efficient and effective projects in the future. The Aspen group hopes that practitioners and other interested readers will find these lessons helpful in planning and carrying out future dam removal projects.

1. Engineering and Design

■ Lesson 1

Gather all existing data appropriate to the scale of a project prior to beginning the analysis. Many sources of hydrologic, hydraulic, and sediment data are available (e.g., stream gages, data previously collected by state agencies, Federal Emergency Management Agency water surface profiles). Be aware that these information sources exist; use them when possible.

■ Lesson 2

If a dam proposed for removal provides flood attenuation, then flood control alternatives should be explored to replace this function. Flood-proofing of structures, relocation of structures from the floodplain, or periodic flooding of undeveloped

areas are examples of measures that can mitigate flood damage potential while accommodating natural riverine processes.

Lesson 3

Be alert for dated flood control assessments, which may not accurately reflect changes in the watershed, such as the conversion of native vegetative cover to urban or agricultural land uses, construction of other flood control structures such as levees, or the latest hydrologic data and/or models.

Lesson 4

Know the dam site and surrounding environs well. Walk the entire length of the affected river, if possible, or travel by boat if the water is too deep, and probe the riverbed. Look for potential impacts, substrate changes, questionable sediment, and problems of potential community concern. Be aware that any problem in a river in the vicinity of a dam removal project is likely to be viewed as caused by that project, so it is important to document pre-removal conditions.

Case example

Observations during planning for the removal of Homestead Woolen Mills Dam (14 feet high) on the Ashuelot River in West Swanzey, New Hampshire, suggested the presence of a natural water level control (e.g., a cascade or small waterfall) in the area. Historical accounts also mention a falls in the vicinity of the dam. Geotechnical investigations are under way to determine whether a falls exists. This information will help in projecting the extent to which the dam removal will affect upstream infrastructure, providing the community with a more accurate description of what the restored river stretch will look like.

Lesson 5

Review historical changes to the site, such as alterations in stream alignment and in hydrology and sediment resulting from land use changes. This information will help in understanding spatial and temporal aspects of the dam and river and contribute to the design of post-removal conditions.

Lesson 6

Identify infrastructure upstream and downstream of the dam that must be modified before the dam is removed. Do not underestimate the time and money that will be required to mitigate these infrastructure issues.

Case example A

The cost of removing Old Berkshire Mill Dam (15 feet high, 120 feet long) on the East Branch of the Housatonic River in Dalton, Massachusetts, was increased significantly by measures taken to protect an upstream bridge and waterline. The cost of constructing utilities protection was $336,000; the cost of physically removing the dam was $133,000.

Case example B
Prior to the removal of Elwha Dam (105 feet high, concrete gravity design) and Glines Canyon Dam (210 feet high, concrete arch design) on the Elwha River in Port Angeles, Washington, extensive downstream infrastructure modifications will be required to maintain existing water supply capabilities.

Case example C
An alternative water supply design eliminated the need for Quaker Neck diversion dam (7 feet high, 260 feet long) on the Neuse River near Goldsboro, North Carolina. The U.S. Army Corps of Engineers, working through the Coastal America Partnership, identified the new design—a 75-foot-long weir dam constructed at an intake canal that does not block the river.

Case example D
Good Hope Dam (7 feet high, 400 feet long) on Conodoguinet Creek in Cumberland County, Pennsylvania, was removed for $38,000. However, an additional $200,000 was required for riparian restoration and mitigation for the affected infrastructure, such as docks and retaining walls.

■ Lesson 7
The cost of dam removal can be difficult to estimate because of the many unknowns at the initiation of a removal project. It is helpful to look at actual costs of other removal projects for guidance and to include contingencies in the estimate. When comparing costs, compare the same components.

■ Lesson 8
Include individuals with a full range of relevant expertise and experience on the design team (e.g., ecologists, fish biologists, engineers, land use planners, archaeologists, historians, architects).

■ Lesson 9
Keep the overall goals of the project in mind when designing a dam removal. For example, if one goal is to restore a river, be careful not to create a river reach that would be excessively stabilized or channelized and void of aquatic habitat. Avoid over-engineering the removal of a dam (or the restoration of the reservoir shoreline); to the extent possible, allow natural physical and biological processes of the river and upland riparian environment to restore the site.

Case example A
On the Mad River in Connecticut, a dam 15–20 feet high was removed for the purposes of fish passage and river restoration. The river in this area normally varies in bank full width from approximately 20 to 30 feet. The final channel design through the dewatered impoundment was a 100-foot-wide, riprap-lined trapezoid with little to no habitat value. In addition, because the final design did not incorporate a defined low-flow channel, the shallow water depths through this section under certain flows may create an additional challenge to fish passage.

Case example B

During the removal of Waterloo Dam (11 feet high) on the Maunesha River in Jefferson County, Wisconsin, a heavily riprapped channel was designed to provide a transition between the former millpond and the downstream channel. The geomorphology of the historic channel had not been thoroughly investigated, and the new transition channel did not have the capacity to carry extreme flood flows. During a subsequent flood event, the river cut a new channel and rerouted itself around the engineered channel, leaving the latter dry under most flow conditions.

Lesson 10

Expect the unexpected. Provide flexibility in the design to accommodate unforeseen obstacles. Coordinate the project to allow for maximum flexibility during the implementation process so that unexpected situations can be addressed. Include contingency costs in budgeting to help lessen financial burdens imposed by unexpected challenges. If a low-level outlet is operable on the dam, a dewatering test prior to removal can reveal unexpected issues and demonstrate how the channel might reform. Although it is not possible to foresee every possible contingency in every dam removal project, the case examples below may help to raise awareness of the types of issues that may arise.

Case example A

During the breach of Old Berkshire Mill Dam (15 feet high, 120 feet long) on the East Branch of the Housatonic River in Dalton, Massachusetts, a large boulder was exposed in the path of the proposed low-flow channel. Instead of removing or relocating this natural feature, project participants altered the final channel alignment within the dam footprint to circumvent the large rock. If the designer, contractor, owner, or regulators had not been flexible, then costly and needless relocation and blasting of a natural stream feature might have been undertaken.

Case example B

During the removal of Freight Street Dam (4 feet high, 150 feet long, concrete) on the Naugatuck River in Waterbury, Connecticut, workers found that the dam's core was reinforced with a steel sheet pile wall, rather than rebar. Surprises such as this can be avoided by coring a dam before preparing the design plans. In this project, the worst-case scenario had been anticipated and incorporated into the project's cost estimate. Access to the dam site was problematic because of its location between a high retaining wall and steep embankment. Access plans were made but then changed because of a vehicular accident that required the construction of an emergency access downstream from the dam. Regulators were flexible enough to allow the contractors to use this new access road, which crossed a short portion of the heavily cobbled riverbed to reach the site. This alternative saved money and minimized the need for clearing and grading, thereby reducing the impacts on the surrounding site.

Case example C

The removal of Billington Street Dam (11 feet high, 30 feet long), a small earthen dam on Town Brook in Plymouth, Massachusetts, was unexpectedly

delayed by the discovery of remnant asbestos material during environmental review. The required asbestos abatement plan and remediation and disposal added $100,000 to the cost of dam removal.

Case example D
A pocket of contaminated sediment was uncovered during the removal of Platts Mill Dam (10 feet high, 231 feet long) on the Naugatuck River in Waterbury, Connecticut, even though the sediment tests performed prior to project design had come back clean. However, a contingency plan for contaminated sediment, if uncovered during the removal, had been incorporated into the project plans, specifications, and cost estimates, thus enabling the project to proceed without significant delay.

Case example E
During the removal of Union City Dam (7 feet high, 190 feet long) on the Naugatuck River in Waterbury, Connecticut, a riprap berm significantly upstream of the dam was uncovered as the impounded sediments started to move downstream. This berm was not found during the numerous borings taken upstream. When exposed, it greatly altered the path of the upstream river, spreading out the flow over a wide area and creating a severe scour hole along one side of its downstream face. The scour hole, in turn, started to erode the stream bank. This series of related impacts could have been prevented if the contractor had been allowed to drive the excavator upstream and break through the riprap berm as soon as it was noticed. Because of regulatory constraints, this work was considered outside of the permit's limits of disturbance; as a result, the work was not completed in a timely fashion and the vegetated stream bank was seriously undermined. If possible, it is important to identify all potential areas where upstream adjustments may be needed in the limits of disturbance covered by permits.

Case example F
The alignment and slope (including bedrock outcrops) of a pre-dam riverbed is one of the most common unknowns in dam removal projects. Bedrock outcrops may completely change the final channel configuration, block anticipated fish passage, change impacts on upstream structures, and/or expose a natural waterfall or cascade that would best be retained. These unknowns were reduced prior to removal of the Naugatuck River dams (Union City, Platts Mill, Freight Street, and Anaconda dams) in Connecticut because numerous hand borings were taken upstream to determine the depth to consolidated material.

Case example G
Following the removal of Castle Finn Dam (5 feet high, 300 feet long) on Muddy Creek in York County, Pennsylvania, a smaller timber crib dam was exposed when the impoundment was dewatered. State regulators allowed removal of the timber crib dam while the demolition equipment was on site, and amendments to the original design and permit were submitted after the fact. In addition, the demolition contract was amended with a quick-change order to allow for additions to the scope of work.

2. Sediment

Lesson 1

Conduct research on historical upstream industrial and agricultural activities and/or adequately sample and analyze sediments to determine the contamination level, if any, and gradation and distribution. Upstream industrial and agricultural activities are factors to consider in determining whether testing should be required and, if so, what to test.

Case example A

Because of an aspirin manufacturing plant located upstream, concerns were raised regarding possible arsenic contamination of sediments during the design for removal of Charming Forge Dam (6 feet high, 150 feet long) on the Tulpehocken River in Berks County, Pennsylvania. The sediment was tested and proved to be free of arsenic.

Case example B

If sediment quality is not adequately investigated beforehand, a dam removal project can result in a costly cleanup. When Fort Edward Dam (31 feet high, 586 feet long) on the Hudson River in Fort Edward, New York, was removed in 1973, sediments laden with polychlorinated biphenyls (PCBs) that had accumulated behind the dam were released downstream. Years of remediation followed, including the dredging of approximately 180,000 cubic yards of contaminated sediments in 1977 and 1978. Full remediation has yet to be completed.

Lesson 2

Dealing with sediment can be expensive, especially if there is a concern about contaminants, but even if it is clean. Costs include sampling, testing, removing, and disposing of sediments. Make sure cost estimates and sampling plans include reasonable contingencies for these activities.

Case example

The cost of sediment removal can be greater than the cost of dam removal. For the removal of Matilija Dam (200 feet high, 620 feet long) on the Ventura River in Ventura, California, the cost to remove approximately 6 million cubic yards of uncontaminated sediment is estimated at $21.6 million to $179.4 million, depending on the method used to transport material from the dam site to the ultimate receiver sites. Although costs vary, depending primarily on the method of sediment management selected, substantial savings may be realized by taking advantage of the natural erosion option

■ Lesson 3

Determine early in the planning process the amount and characteristics (i.e., quality, organic content, moisture content, and grain size) of the sediments stored behind a dam. Regardless of dam size, there may not be any stored sediment. This information will be needed for both the design and regulatory analysis.

Case example A

During the review of Edwards Dam (24 feet high, 917 feet long) on the Kennebec River in Maine, it was determined that very little sediment had accumulated behind the dam. Thus, no sediment management actions were needed during the dam removal.

Case example B

A preliminary assessment of the amount and characteristics of sediment behind Savage Rapids Dam (39 feet high, 500 feet long) on the Rogue River at Grants Pass, Oregon, was performed by the U.S. Bureau of Reclamation (USBR) in its review of alternatives for solving fish passage problems. The USBR determined that the sediment could be transported safely and naturally during high-flow events. Opponents of dam removal raised issues of contamination and potential adverse impacts of sediment releases. The USBR then did a more thorough analysis, which showed that less sediment was stored than originally believed, detected no contamination, and confirmed the sediment could be handled naturally with minimal adverse impacts. This approach eliminated early on one of the biggest objections to dam removal.

Case example C

The planning for removal of Fort Edward Dam (31 feet high, 586 feet long) on the Hudson River in Fort Edward, New York, did not include adequate evaluations of the amount of sediment behind the dam that would be distributed gradually downstream. During the year after the dam was removed (1973), accumulations of silt in sections of the river effectively closed the Hudson River navigation channel. Sediment deposits also clogged a marina, a recreational park, several industrial sites, and other downstream areas. In addition to the contaminated sediments that were dredged, New York dredged 615,000 cubic yards of sediment from 1974 to 1976 to restore the navigation channel.

■ Lesson 4

Where impounded sediment is deep and likely layered, take core samples throughout the sediment column, when possible, to characterize particle size, distribution, possible sorting, and quality of different layers. This task is significantly easier if a low-level outlet or another means of temporarily dewatering the impoundment is available.

Case example

Before the removal of Anaconda Dam (11 feet high, 327 feet long) on the Naugatuck River in Waterbury, Connecticut, core samples of sediment were taken throughout the impoundment to test for quality in different layers.

The results of these initial tests were clean. However, the coarse material could not be collected in solid cores, so it was not possible to readily identify sediment layers, and the samples were essentially composites of the various layers. The dam partially failed prior to removal and the remainder of the dam was removed under emergency order. Once dewatered, the exposed sediment that remained behind showed obvious layering, including a concentrated layer contaminated with motor oils. This layer had not been well identified previously because the contamination had been dispersed throughout the composite samples. If the site could have been dewatered prior to testing, or if the material had been small-grained and the core samples had been representative of the full sediment column, then the coring technique would have been helpful in identifying the layer of contaminated sediment early on. Fortunately, in this case, the contamination level was low and there were no documented adverse downstream impacts as a result of the sediment release during the dam breach.

■ Lesson 5

If coastal beaches are potential receiver sites for large amounts of sediments impounded behind a dam, then the existing sediment on beaches should be characterized (i.e., type, particle size, and distribution) to determine whether the beach would respond appropriately to the deposition of new sediment materials into or near the littoral zone.

Case example

Beach nourishment has been identified as a potential major benefit of the removal of Matilija Dam (200 feet high, 620 feet long) on the Ventura River in Ventura, California. The dam stores approximately 6 million cubic yards of sediments. However, the response of the beaches to the artificially accelerated deposition of these materials will be significantly influenced by the range and distribution of grain sizes on the existing beaches, which will dictate the rate and method of transport of the sediments to the littoral zone.

■ Lesson 6

Compare the quantity of impounded sediment to the river's natural ability to transport sediment. Often the potential impact of dam removal can be placed in perspective by comparing the projected sediment release to the effects of a natural storm event in the basin. Sometimes the quantity of sediment impounded behind a dam may appear significant, but may in fact be less than the quantity of sediment transported in the system during a single annual storm event. Sometimes the opposite is true; the quantity of impounded sediment may appear small, but the river system's sediment-carrying capacity may be such that it will take decades to move that quantity through the system naturally.

Case example A

Prior to the removal of any small, run-of-river dams in Pennsylvania, stream bottom elevations in the impoundment and free-flowing sections are often determined using simple surveying techniques to obtain crude estimates of sediment volume behind the dam. These estimates are compared to sediment volumes transported during typical high-water events to help predict potential impacts to downstream reaches after dam removal.

Case example B

During analysis of the potential removal of South Batavia Dam (4 feet high, 686 feet long) on the Fox River in Batavia, Illinois, local regulators initially thought that a large quantity of sediment was impounded behind the dam. However, the analysis of the entire river system showed that the impounded sediment (20,000 cubic yards) was less than half of the quantity transported by the river through this reach annually (approximately 46,000 cubic yards average annual suspended load). These figures indicate that the river system is capable of transporting the impounded sediment, and that the aquatic life is already accustomed to dealing with more sediment during a normal year than would be released if the dam were removed.

■ Lesson 7

If appropriate to the scale of a project, it is helpful to model the river without the dam to predict new water surface levels, water velocities, and sediment movement. Some general modeling tools are available, and several others are under development. Choose a method or model that suits the size and complexity of the project. If hydraulic and sediment models are constructed, the results can be used as tools for assessing risk.

Case example A

Matilija Dam (200 feet high, 620 feet long) on the Ventura River in Ventura, California, stores approximately 6 million cubic yards of sediment, the removal and disposition of which constitutes the largest challenge to the dam's removal. One method of removal includes phased natural transport of the sediments downriver to the coastal beaches. Modeling of the movement of these sediments will be necessary to evaluate all aspects of this alternative, including impacts on aquatic habitats, flooding of adjacent developed lands, and project timing and costs. If modeling demonstrates that some portion of the sediment can be safely and efficiently transported via the natural channel, this method could result in considerable cost savings.

Case example B

Extensive modeling and interdisciplinary evaluations and discussions led to a consensus-based decision to allow the Elwha River to erode naturally accumulated sediments after the Elwha Dam (105 feet high) and Glines Canyon Dam (210 feet high) are removed in Olympic National Park in Washington. The selected natural erosion alternative will cost $113 million, compared to $130 million for the dredge and slurry alternative. Natural erosion also will restore sediments eroded from the river below the dam.

■ Lesson 8

Select a sediment management option (i.e., natural erosion, dredging, stabilization in place, relocation on or off the site, or a combination of these methods) that best suits sediment quality, quantity, and physical characteristics, as well as the sensitivity of downstream reaches and/or the river's ability to transport sediment. Do not assume that full sediment removal is the "lowest risk" option. Sometimes natural erosion can be the least costly method and also have the least impact on the river system, provided the sediment is clean and the system is capable of transporting this load.

Case example A
Natural erosion has been determined to be the most viable alternative to handling the 200,000 cubic yards of sediment behind Savage Rapids Dam (39 feet high, 500 feet long) on the Rogue River in Grants Pass, Oregon.

Case example B
Following the removal of a small dam (6 feet high, 150 feet long) on Hammer Creek in Lancaster County, Pennsylvania, downstream habitat was adversely affected by accumulations of sandy sediment, which has grain size and transport characteristics that are difficult to manage. A determination of sediment characteristics and appropriate management practices prior to the removal of the dam would have been beneficial in developing engineering designs to mitigate impacts.

■ *Lesson 9*

The presence of contaminants in sediment does not mean that a dam should not be removed. Dam removal may present an opportunity to stabilize, neutralize, or effectively remove sediments of concern, especially if the sediments are localized. For example, if a contaminant is highly bioavailable, then leaving it in place behind a dam will not lessen the environmental hazard. However, sometimes the cost and potential environmental impact of resuspending contaminated sediment can lead to a decision to retain the dam.

Case example A
In the Oak Street Dam (14 feet high, 270 feet long) removal project in Baraboo, Wisconsin, sediments contaminated with polyaromatic hydrocarbons (PAHs), a fossil fuel by-product, were discovered during the planning process. The discovery delayed the dam's removal by about a year but also provided a vehicle to address the contamination. The current owner of the property from which the contaminants originated paid for the testing, removal, and proper disposal of the sediments, allowing the dam to be removed as planned.

Case example B
Because impounded sediment was contaminated with PCBs, the owner of Rising River Dam (35 feet high, 420 feet long) on the Housatonic River in Great Barrington, Massachusetts, decided it was less expensive to repair the dam than to remove both the dam and the contaminated sediment.

Case example C
Portions of North Avenue Dam (19 feet high, 400 feet long) in Milwaukee, Wisconsin, were deliberately retained so that localized PCB-laden sediments could be stabilized in place and capped, and thus prevented from entering the Milwaukee River ecosystem.

Case example D
Prior to the removal of an unnamed dam (7 feet high, 250 feet long) on Manatawny Creek in Montgomery County, Pennsylvania, sediment analyses determined there were higher-than-normal quantities of PAHs behind the dam. Evaluations of sediment upstream of the impoundment and downstream of the

dam revealed similar concentrations of PAHs. It was determined that release of the sediment from behind the dam would not increase contaminant levels in the river above the concentrations that are acceptable under state regulations.

■ Lesson 10

Do not overlook potential beneficial uses of stored sediments (e.g., commercial aggregate, road sub-base, clean fill, landfill capping, reuse on site, gravel recruitment for fish spawning habitat, soil amendment, coastal beach nourishment). These uses vary depending on sediment quality.

■ Lesson 11

Consider drawing down the impoundment during a time when exposed sediments will have an opportunity to stabilize and revegetate before structural removal of the dam.

Case example

Rockdale Dam (14 feet high, 200 feet long) on Koshkonong Creek in Dane County, Wisconsin, was breached in the fall of the first year of dam removal implementation, and the drained impoundment was seeded. The sediments partially revegetated in the remaining fall months, consolidated in the winter, and revegetated further in the following spring. The structural dam removal was completed later in the second year. This process allowed a high percentage of the sediments in the impoundment to be stabilized on site.

3. Contracting and Construction

■ Lesson 1

Make sure the contractor understands the process and limitations of permit requirements and that regulators and scientists understand the demolition processes and equipment.

Case example

Many dam removal projects in Maine used a contractor who understood all the permit requirements before bidding. One of the contractor's responsibilities under the contracts was to perform to permitting standards and conditions. The contractor explained the demolition and removal methods to the regulators, scientists, and engineers. This reduced costs and increased understanding of the dam removal process. All dam removals were completed within budget and date targets.

■ Lesson 2

If key individuals are hired for design or construction, provide language specifying that those individuals will be adequately involved in the job and will remain on retainer if they leave the business unless a satisfactory substitute is found.

■ Lesson 3

The use of a well-qualified contractor can reduce costs significantly. The use of a prequalified contracting process can facilitate bidding and result in more realistic estimates of removal costs and a better project outcome. Ensure that the contractor is bonded

(or similarly fiscally accountable) and has done in-river work before. Check with previous employers; require performance bonds.

Case example A
An effective process that is equivalent to bonding has been used for the removal of four dams in Maine. The contractor posts to the landowner a sum of money equal to the contract amount, which is held in an escrow account until the project is completed to acceptable standards. This negates the need for bonding.

Case example B
To reduce total costs, contractors in Maine have been given opportunities to bid on a project based on descriptions of existing and desired future conditions. They were asked to provide a total project price within permit requirements and conditions.

■ Lesson 4

Some experienced and knowledgeable contractors have planned and implemented dam removal based on performance specifications without complex and expensive designs. When this approach is used, the contractor should be fully accountable for completing the project to desired conditions and permit requirements.

Case example
Pleasant River Dam (10 feet high, 275 feet long) in Brownville, Maine, was removed successfully within budget and ahead of schedule. The formal planning and design costs were avoided, significantly reducing the overall cost of the project. Significant unforeseen conditions arose, including the presence of railroad rails instead of rebar and the presence of two log crib dams behind a concrete structure, but no price increases or schedule delays occurred. The contractor had incentives to be creative and adjust techniques to compensate (e.g., the dam was crushed in place and used as a work platform and natural sediment barrier).

■ Lesson 5

Consider phasing a project to minimize shortterm impacts on the environment. Start out-of-channel work early in the phasing to accelerate and facilitate the removal process. Avoid scheduling the removal of a dam or in-stream structures during key fish spawning, bird nesting, winter hibernation periods for reptiles and amphibians, and other important life history phases of sensitive species that could be affected by the project.

■ Lesson 6

Avoid scheduling in-stream work during periods that could be interrupted by high flows or other conditions that could endanger workers. Schedule work for the permissible in-water work period. Make it clear in project specifications that the contractor will need to adjust work in accordance with flow levels and will only be paid for high water periods when a predefined, agreed-upon water surface elevation or flow rate occurs. Develop contingency plans to deal with changes in conditions such as weather.

Case example A
During the removal of Freight Street Dam (4 feet high, 158 feet long) on the Naugatuck River in Waterbury, Connecticut, the contractor requested an

amendment to the contract fee for additional monies for days they were unable to work due to high water because water controls were minimal.

Case example B
During the removal of Grist Mill Dam (14 feet high, 75 feet long) on the Souadabscook River in Hampden, Maine, and Pleasant River Dam (10 feet high, 275 feet long) in Brownville, Maine, the contractor understood his responsibility to adjust timing, techniques, and equipment to match flow conditions. Flexibility was provided for modifications in extreme conditions agreed to by the landowner and contractor, but all dams were still removed within budget and ahead of schedule, without the need for adjustments due to unforeseen conditions and flows.

4. Public Involvement

■ Lesson 1

Recognize that public understanding is a critical component in dam removal projects involving public expenditures or the exercise of local, state, or federal regulatory authority. The need to provide the public with information about a project does not cease with the decision to remove a dam, but continues through the physical removal process; this is particularly true of large, multi-year removal projects. After a decision has been made to remove a dam, provide throughout the removal, an accessible process for public participation in, and education about, the project and procedures. Elected officials at the local, state, and federal levels should receive regular project updates.

Case example A
The city's decision to remove Woolen Mills Dam (18 feet high, 350 feet long) on the Milwaukee River in West Bend, Wisconsin, was followed by a community visioning process to develop plans for the restoration of approximately 62 acres that would be exposed by the dam's removal. Landscape architecture students assisted the community in developing artistic renderings for the site, which helped the community envision the eventual result of the project. The community decided to develop a portion of the exposed land into a park with a mowed area, soccer fields, and other traditional amenities. The rest of the exposed land was restored to native prairie habitat with a footpath meandering through grasses and wildflowers, and several footbridges crossing the restored river.

Case example B
In South Lake Tahoe, California, public education about the plan to remove Lake Christopher Dam (10 feet high, 400 feet long) and restore Cold Creek did not begin early enough. The project came to a halt when residents learned that trees had to be cut, and that a diversion ditch enjoyed by neighbors had to be relocated. Through numerous public hearings and site walks, citizens were able to get the facts and have their concerns addressed. After almost a year of delay, public trust was reestablished and the project was able to move forward. The project was completed and has functioned as planned for many years. Some citizens initially opposed to the project have acknowledged that public education about stream restoration was a critical component in their eventual support of the project.

Lesson 2

In appropriate cases, make use of questionnaires, focus groups, and surveys to get information on community opinions regarding cultural and social issues associated with dam removal. This information can help shape the process for involving the public in site restoration decisions.

Lesson 3

Some concerns about dam removal are based upon a lack of adequate information and can be addressed by providing information on an ongoing basis to the affected community. Be prepared to address misinformation in a straightforward, easy-to-understand, and rational manner. However, do not assume that disputes are based upon factual disagreements. It may not be possible to reconcile some concerns and values, because the removal of the dam represents a fundamental change to what is familiar.

Case example A

Several residents owning property around the impoundment formed by Ward Paper Mill Dam (21 feet high, 600 feet long) on the Prairie River in Merrill, Wisconsin, were strongly opposed to the dam's removal, citing the loss of lake-based recreation and a resource they found aesthetically pleasing. But after the dam was removed, a piece of property along the restored river was sold for the asking price to a purchaser who specifically cited the restored river-based recreation as an amenity.

Case example B

During a public hearing on the removal of Ward Paper Mill Dam (21 feet high, 600 feet long) on the Prairie River in Merrill, Wisconsin, opponents argued that the dam's removal would greatly increase the incidence of blastomycosis, an uncommon but potential serious fungal infection that primarily affects the lungs and skin. The fungus resides in the soil in decaying foliage and vegetation. A local doctor testified that this outcome was highly unlikely, saying that conditions similar to those that would be created by the dam's removal already existed in several locations in the community without any increased incidence of the fungal infection. He testified that only under very specific conditions of humidity, temperature, and nutrition can the fungus grow and produce the infecting spores. Concerns about blastomycosis might have been addressed earlier in the process, before misinformation had spread throughout the community.

Lesson 4

Do not underestimate the degree of public concern regarding flooding issues. Recognize that even when dams slated for removal have no flood control function, flood control and flooding are issues that must be addressed early in the planning process and throughout the design process. Provide accurate information about past flooding before and after dam construction, current flood conditions, and flooding potential (if any) following dam removal or modification.

Case example

The removal of a small dam (4 feet high, 75 feet long) on Fishing Creek in Clinton County, Pennsylvania, increased the channel's water storage capacity and thereby helped to reduce flooding of upstream properties and a section of road.

■ Lesson 5

Keep the dam owner and other affected parties up to date on the schedule for carrying out the physical removal of a dam. When plans, procedures, or approaches change, whenever possible explain the changes to the affected parties before the work is undertaken.

■ Lesson 6

Try to anticipate the strong convictions of community members and others who may support the retention of a dam. The dam's actual removal may attract people who wish to protest the action. If there are indications that this could happen, prepare workers for the likelihood and discuss ways of diffusing the situation. In some cases, it may be necessary to have law enforcement officers present and/or appropriate persons who can regularly inspect the site and equipment for deliberate acts meant to interfere with the deconstruction process.

Case example

Graffiti threatening a member of the state natural resources agency working on a Wisconsin project was found at a dam shortly before it was removed. The employee's nearby cabin had been broken into previously, during deliberations on the dam's removal. Such acts may necessitate special vigilance during the actual removal of the dam to prevent disruption of the project and protect workers.

5. Site Restoration and Land Management

■ Lesson 1

Newly exposed riparian lands can restore themselves relatively rapidly. In most situations, exposed mudflats can be allowed to revegetate naturally. Extensive replanting is usually unnecessary, although steps may need to be taken to promote the growth of native vegetation and discourage undesirable invasives.

Case example A

Wilder Dam (15 feet high) on Wilder Creek near Santa Cruz, California, was an old, earth-filled agricultural water supply dam that was sediment-laden and defunct. Gullying from flows circumventing the dam was eroding a field in the nearby state park. Parks officials initially suggested armoring the gullies but were persuaded to allow dam removal instead. During restoration of the channel upstream of the dam site, several grade controls constructed of native materials were placed to stabilize the channel, and extensive willow staking was done, but much of the channel was intentionally left with rough grading to reduce erosion. At the end of the deconstruction process, the project had a "raw" look, and even natural resource biologists and regulators expressed concern about bank stability and erosion due to lack of grading and vegetation. After one year, however, many sections showed significant growth. Some reaches had willows over eight feet high, and the restored stream reach was being used for rearing habitat by juvenile steelhead trout.

Case example B

Deerskin Dam (9 feet high) on the Deerskin River in Vilas County, Wisconsin, was removed in late spring. Within weeks, the latent seed base in the sediments germinated and began to revegetate the exposed mudflats. This natural process was cost effective and has allowed native wetland and upland vegetation to grow back in the former impoundment area.

Lesson 2

Land use may change and evolve as a result of the removal of a dam and the associated reservoir. That is, the type and intensity of recreational uses, land use practices, and development patterns appropriate to a reservoir setting may be displaced by restoration of the natural riverine environment. Analyze potential new land use changes (e.g., in flood patterns and frequency, off-road vehicle use, or agricultural practices such a cattle grazing) and potential conflicts associated with dam removal. Incorporate land use management (e.g., access and recreational planning, outdoor education opportunities, grazing practices, farming, zoning restrictions) into the project. If the land management plan does not call for natural vegetation, then affirmative steps need to be taken to revegetate the newly exposed lands.

Case example

In the Woolen Mills Dam (18 feet high, 350 feet long) removal project on the Milwaukee River in West Bend, Wisconsin, the planned use for the former millpond bed included a multipurpose park with athletic fields and a restored prairie. Immediately after the dam was removed, the impoundment was seeded with an annual grass mix to prevent growth from the latent seed base in the sediments. In subsequent growing seasons, plantings were tailored to the athletic fields and prairie restorations.

Lesson 3

As appropriate, identify public access to, and recreational opportunities along, the river or stream and adjacent land created by the removal of the dam.

Case example

After the removal of Woolen Mills Dam (18 feet high, 350 feet long) on the Milwaukee River in West Bend, Wisconsin, 62 acres of exposed land were developed into a multipurpose park that is used by the surrounding neighborhoods and the community at large. Riverfront and music festivals, athletic events, paddling, nature trails along the river and through a restored prairie, and fishing opportunities are just a few of the uses created through the dam's removal. Recent public opinion surveys have shown that the park is considered to be one of the community's greatest assets.

Lesson 4

Do not overlook the opportunities that dam removal may provide for resolving issues that otherwise might not be addressed. New opportunities may be created that can be addressed in later phases of the dam removal and river restoration.

Case example A
The removal of three dams along a 3-mile stretch of the Baraboo River in Sauk County, Wisconsin, provided the impetus to expand an existing river walk in the community of Baraboo. The three were Oak Street Dam (14 feet high, 270 feet long), Waterworks Dam (14 feet high, 220 feet long), and Linen Mill Dam (11 feet high, 160 feet long). Shortly after the second dam removal, more than 50 people attended a planning session that included brainstorming for ideas on expanding the river walk; installing fishing and boating access points, interpretive signage, gazebos, and benches; and pursuing the revitalization of historic riverfront buildings that had deteriorated over time.

Case example B
Rindge Dam (100 feet high) on the Malibu River near Malibu, California, originally was considered for removal to return passage of endangered steelhead trout to the upper watershed. Since that time, improved sediment transport for replenishment of beach sand has come to be viewed as a significant potential benefit, which would enable the sustained use of popular public beaches.

6. Permitting

■ Lesson 1

Become familiar with the permit procedures and regulatory requirements of the local, state, and federal agencies with jurisdiction over a project, and identify permits and agency approvals needed early in the project. Do not underestimate the cost and time required to obtain permits and approvals. Pre-application meetings can be useful tools.

■ Lesson 2

Consult and work cooperatively with regulatory agencies; help them figure out how a dam removal meets regulatory requirements, so that they can help design a removal that will meet regulatory needs. Take agency personnel along when doing the initial site reconnaissance.

Case example A
During the breaching of Old Berkshire Mill Dam (15 feet high, 120 feet long) on the East Branch of the Housatonic River in Dalton, Massachusetts, the permitting costs were twice as much as the cost of removal. The project was subject to a requirement for a mandatory environmental impact report. Although 11 separate permits were needed, regulatory agencies expedited their issuance, enabling the project proponent to meet the removal schedule.

Case example B
The state of New Hampshire has developed a single application for permitting a dam removal project. The need for this approach was determined during the removal planning process for McGoldrick Dam (6 feet high, 150 feet long) on the Ashuelot River in Hinsdale, New Hampshire. The single application increases the efficiency and effectiveness of planning and permitting, from the perspectives of both dam owners and regulatory agencies.

Case example C

Grist Mill Dam (14 feet high, 75 feet long) on the Soudabscook Stream in Hampden, Maine, was a hydroelectric dam with an 8-acre impoundment. The decision to remove it was made by the dam owner to reduce liability and restore anadromous fish passage. Numerous federal and state permitting and licensing agencies were asked to meet on site to discuss how to expedite the permitting process based on the expected positive environmental effects. All natural resources personnel who were invited, as well as the news media, attended the meeting. All agency personnel concurred that it was in the best interests of all concerned to expedite permits/reviews and commence with the removal as soon as possible. Many personal and best professional judgments were made in the cooperative effort, which significantly reduced the project cost and restoration time frame.

Case example D

The Massachusetts Environmental Policy Act unit solicits and considers the input of the River Restore Triage Team (an interdisciplinary group of engineers, fishery biologists, and wetlands ecologists) in determining the appropriate level of review for a dam removal project in the state. A pre-application site visit to Mill Pond Dam (9 feet high, 320 feet long, 10-foot spillway to be removed), on Third Herring Brook in Norwell, led the team to recommend that the proponent seek either a waiver from a mandatory environmental impact report (EIR) requirement or a single-stage EIR (as opposed to the usual draft and final versions). This recommendation recognized the scale and setting of the dam and the scope of interests affected.

■ Lesson 3

Perform appropriate levels of studies and data gathering activities to facilitate discussions with permitting agencies. Regular communication with the permitting agencies can help ensure that adequate information is provided.

■ Lesson 4

Notify and consult with the state historic preservation office early in the process regarding the potential impact of a dam removal on historic resources. Understand the processes that may apply to the removal. Plan sufficient time to complete all the necessary consultations and regulatory processes. If the project involves federal permitting or funding, then it must be carried out in accordance with the National Historic Preservation Act.

Case example A

The removal of McGoldrick Dam (6 feet high, 150 feet long) on the Ashuelot River in Hinsdale, New Hampshire, was delayed for a year when it was discovered that the State Historic Preservation Office had not been properly informed of the dam removal project, and historical review requirements were deemed necessary. This office is now notified at the beginning of all dam removal planning processes.

Case example B

The Massachusetts Historical Commission was represented on the Interagency Dam Decommissioning Task Force that provided regulatory oversight for the breach of Old Berkshire Mill Dam (15 feet high, 120 feet long) on the East Branch of the Housatonic River in Dalton, Massachusetts. At the Task Force's suggestion, archeological/historical reconnaissance was scheduled to occur when the impoundment was dewatered to stabilize an upstream waterline prior to the dam breach. During this reconnaissance, a remnant timber crib dam was discovered beneath the impounded sediment. The project proponent responded quickly to commission requirements to document the structure properly, with no delays in receiving federal permits or meeting scheduled deadlines.

■ Lesson 5

Write permit applications to provide for contingencies for unanticipated temporal, spatial, and technical aspects and to accommodate change orders. Projects situated in a naturally dynamic environment such as a river are likely to present unexpected circumstances that are best addressed promptly to avert cost increases and threats to lives or environmentally sensitive habitats.

Case example A

To facilitate the removal of dams in an inexpensive and timely manner, Pennsylvania has developed a restoration waiver procedure, in lieu of a permit. There are no fees associated with the waiver, which generally is issued within three to four months of submission of the design plans for removal of a dam. The Department of Environmental Protection advertises the project in the *Pennsylvania Bulletin* and conducts an environmental assessment as part of the waiver approval process. The waiver procedure allows the completion of any approved restoration work within the former impoundment, thus providing flexibility to address unforeseen complications without obtaining additional permits.

Case example B

During the removal of Union City Dam (7 feet high, 190 feet long) on the Naugatuck River in Waterbury, Connecticut, difficulties arose in connection with the erosion of a streamside bank. These difficulties might have been avoided if the permit application had been written with an expanded area of potential impact, inclusive of any areas upstream where work might have been required because of the dynamic nature of the channel's post-removal flow capacity.

Appendices

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Additional Resources

1. Web Pages for Dam Removal Clearinghouse

- Academy of Natural Sciences, http://www.acnatsci.org/research/pcer/manatawny.html
- American Rivers' Rivers Unplugged Program, http://www.amrivers.org/damremoval
- Association of State Dam Safety Officials, http://www.damsafety.org
- Friends of the Earth's River Restoration Program, http://www.foe.org/foenw/rivers/main.html
- Friends of the River's River Reborn Program, http://www.friendsoftheriver.org/riversreborn/main3.html
- International Rivers Network's River Revival Program, http://www.irn.org/revival/decom/
- Massachusetts Department of Fisheries, Wildlife, and Environmental Law Enforcement, River Restore Program, http://www.state.ma.us/dfwele/RIVER/rivRestore.htm
- National Performance of Dams Program Stanford University, http://www.npdp.stanford.edu
- New Hampshire Department of Environmental Services, http://www.des.state.nh.us/dam.htm
- Pennsylvania Department of Environmental Protection, Division of Dam Safety, http://www.dep.state.pa.us
- Pennsylvania Fish & Boat Commission, http://www.fish.state.pa.us
- River Alliance of Wisconsin's Small Dams Program, http://www.wisconsinrivers.org/SmallDams/prog_dams.html
- River Recovery – Restoring Rivers through Dam Decommissioning, http://www.recovery.bcit.ca/index.html
- Trout Unlimited's Small Dams Campaign, http://www.tu.org/small_dams/
- United States Society on Dams, http://www.ussdams.org
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Trout Unlimited. Case studies. http://www.tu.org/small_dams/removal/3a-removal.html. Features Kennebec River, Muddy Run and Lititz Run, Eighteen Mile Creek, Naugatuck River, Colburn Creek, and Onion River.

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Selected Publications of the Aspen Institute's Program on Energy, the Environment, and the Economy

Energy Supply and Infrastructure

In 2001, in the wake of a year of energy price volatility, serious electricity supply and price problems in California, and new proposals for energy legislation, the 25th annual Energy Policy Forum examined factors affecting energy supply and infrastructure. Former Energy and Defense Secretary James R. Schlesinger chaired the Forum, which included sessions on natural gas supply, the California electricity crisis, the future of electricity restructuring elsewhere, and domestic and world oil markets. Rapporteur, Paul Runci. 2001. 57 pages, ISBN#0-89843-328-2, $8 per copy.

U.S. Policy and the Global Environment: Memos to the President

Prior to the 2000 election the Aspen Institute convened a distinguished group of science, business, and environment leaders as a hypothetical committee to advise the new President on global environmental policy. Experts prepared this set of policy memos to tell the President, concisely and in understandable language, "what he should know" and "what he should do" about climate change, biodiversity, population, oceans, water, food and agriculture, and other problems. A thematic summary of the group's conclusions, written by co-chairs Donald Kennedy of Stanford University and Roger Sant of the AES Corporation, communicates the urgency of the challenges, the complexity of the inter-related issues, and the optimism necessary to tackle them. Editors, Donald Kennedy and John A. Riggs. 2000. 220 pages, ISBN#0-89843-303-7, $18 per copy.

The Mexico-US Border Environment and Economy: A Call to Action to Make the Mexico-US Border Region a Model of Bi-National Cooperation for Sustainability

Co-sponsored by the Aspen Institute Program on Energy, the Environment and the Economy, and the Leadership for Environment and Development (LEAD), Mexico, participants in the Mexico-U.S. Border Dialogue convened in Aspen in October 1999. In this report, available in English or Spanish, the group calls on then-Presidents Zedillo and Clinton as well as the 2000 presidential candidates in both Mexico and the U.S. to take major bi-national action necessary to ensure the environmental and economic health of the border region. 2000. 159 pages, ISBN# 0-89843-287-3, $10 per copy.

Market, Technology, and Policy Drivers: The Future Structure of the Electricity Industry

Rapid developments in legislative and regulatory ground rules, the growth of e-commerce, improvements in supply and demand technologies, and the changing expectations of investors are buffeting traditional utilities and creating opportunities for those who can anticipate the direction of change. This report of the 24th annual Energy Policy Forum, chaired by John H. Gibbons and William W. Hogan, considered some of the key factors causing these developments. Rapporteur, Elizabeth L. Malone. 2000. 36 pages, ISBN#0-89843-300-2, $12 per copy.

A Call to Action to Build a Performance-Based Environmental Management System

The outcome of a dialogue among participants from small businesses, corporations, federal and state governments, and environmental and other non-governmental organizations. In September 1999, the group met to assess the progress of environmental performance in the U.S., to leverage the outcomes of prior Aspen Institute collaborations as well as other activities that had occurred in the previous five years regarding environmental performance, and to recommend systemic improvements. 2000. 24 pages, ISBN# 0-89843-280-4, $8 per copy.

Nuclear Waste Disposal: Exploring Paths toward a Permanent Repository

During 1999 the Aspen Institute conducted three meetings among stakeholders with differing views on the disposal of high level nuclear waste. The focus was on the environmental and non-proliferation implications of the upcoming Presidential decision on the Yucca Mountain repository. This report is a staff summary of the process and the initial results, defining the issues addressed and identifying broad areas where stakeholders agree or disagree on approaches and solutions. 2000. 21 pages, photocopied, $5 per copy.

The Stewardship Path to Sustainable Natural Systems

Recommendations of a diverse group of participants from the private, public, and NGO sectors who, in a series of eight dialogues over a two-year period, sought improved approaches to managing natural systems in the U.S. The group built on their collective expertise to shape and describe a vision and principles on which to found an agenda for change including stewardship approaches to prevention, mitigation and restoration. 1999. 62 pages, ISBN# 0-89843-265-0, $8 per copy.

With All Deliberate Speed: Electricity Restructuring in Asia

The 1999 Pacific Rim Energy Workshop was held in Kanagawa, Japan, in November, 1999. The Asia-Pacific Energy Research Centre (APERC), the energy research arm of the Asia Pacific Economic Council (APEC) was the co-sponsor and host. Representatives of 17 countries or economies discussed electricity restructuring and fuels trade in the region. This report of the meeting concludes that the theoretical and observed benefits of deregulation are quite powerful, but there are concerns about the impacts of making the transition from national monopoly systems to deregulated or privatized systems. Moderator and rapporteur, Loren Cox. 1999. 23 pages, ISBN#0-89843-278-2, $8 per copy.

Fuel Choice, Supply and Reliability in the 21st Century

In response to continuing interest in the rapidly restructuring utility industries and to the low prices and merger activities in the oil industry, the 1999 Energy Policy Forum, co-chaired by former Energy and Defense Secretary James R. Schlesinger and Edison International CEO John E. Bryson, examined how these trends might play out in coming years. Rapporteur, Elizabeth L. Malone. 1999. 51 pages, ISBN# 0-89843-275-8, $8 per copy.

After Kyoto: Are There Rational Pathways to a Sustainable Global Energy System?

The 1998 Energy Policy Forum was chaired by AES Corporation and World Wildlife Fund Chairman Roger W. Sant. It addressed a number of major energy questions and challenges surrounding the Kyoto Protocol and the broader issue of how to achieve a sustainable global energy system. Although participants disagreed on the adequacy of the scientific basis for strong early actions to reduce greenhouse gases and on the wisdom of the Kyoto Protocol, there was widespread agreement on the need to take a long-term approach, to accelerate research and development in low-carbon and non-carbon fuels and technologies, to remove barriers to technological innovation, and to depoliticize the climate change debate. Rapporteur, Paul Runci. 1998. 51 pages, ISBN# 0-89843-251-0, $8 per copy.

Uncovering Value: Integrating Environmental and Financial Performance

This report is the product of a series of six dialogues over thirteen months. The participants, from academia, corporations, governments, not-for-profit groups, and the financial community, focused on the emergence of a potentially powerful trend developing in the business and financial world. By learning to "value the environment," companies and financial institutions are uncovering another competitive edge. As communication of the business value of environmental considerations improves in quality and quantity, market forces will increasingly drive environmental progress and environmental opportunities will more directly drive strategic business planning. 1998. 37 pages, ISBN# 0-89843-254-5, $8 per copy.

Powering Asia: Is Gas the Answer

The report of the 14th annual Pacific Rim Energy Workshop, which met in Brunei in November, 1997, directed attention to continued strong prospects for growth in electric demand, and thus an increased need for major additions to generation capacity. In particular, the meeting focused on the potential role of natural gas/LNG in the fuel mix for new generation capacity in the region. Moderator and rapporteur, Loren Cox. 1998. 23 pages, ISBN# 0-89843-231-6, $8 per copy.

Utility Restructuring in Central and Eastern Europe

This report examines the market-oriented reforms of the electric power industries in central and eastern Europe and the Commonwealth of Independent States, related utility cooperation and business strategies, and conditions of integrating these electricity systems into the emerging European electricity markets. It is based on the dialogue at the second Central and Eastern European Energy Workshop, co-chaired by Dr. Klaus Brendow and Professor Adam Gula, held in Krakow and Lopuszna, Poland in May, 1997. 1997. 58 pages, ISBN# 0-89843-215-4, $8 per copy

The Alternative Path: A Cleaner, Cheaper Way to Protect and Enhance the Environment

This report of a three-year dialogue among business, environmental, community, and government leaders outlines an alternative environmental management system based on a simple quid pro quo: more flexible regulation and lower compliance costs in return for superior environmental performance and full stakeholder involvement. 1996. 43 pages, ISBN# 0-89843-225-9, $8 per copy.

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