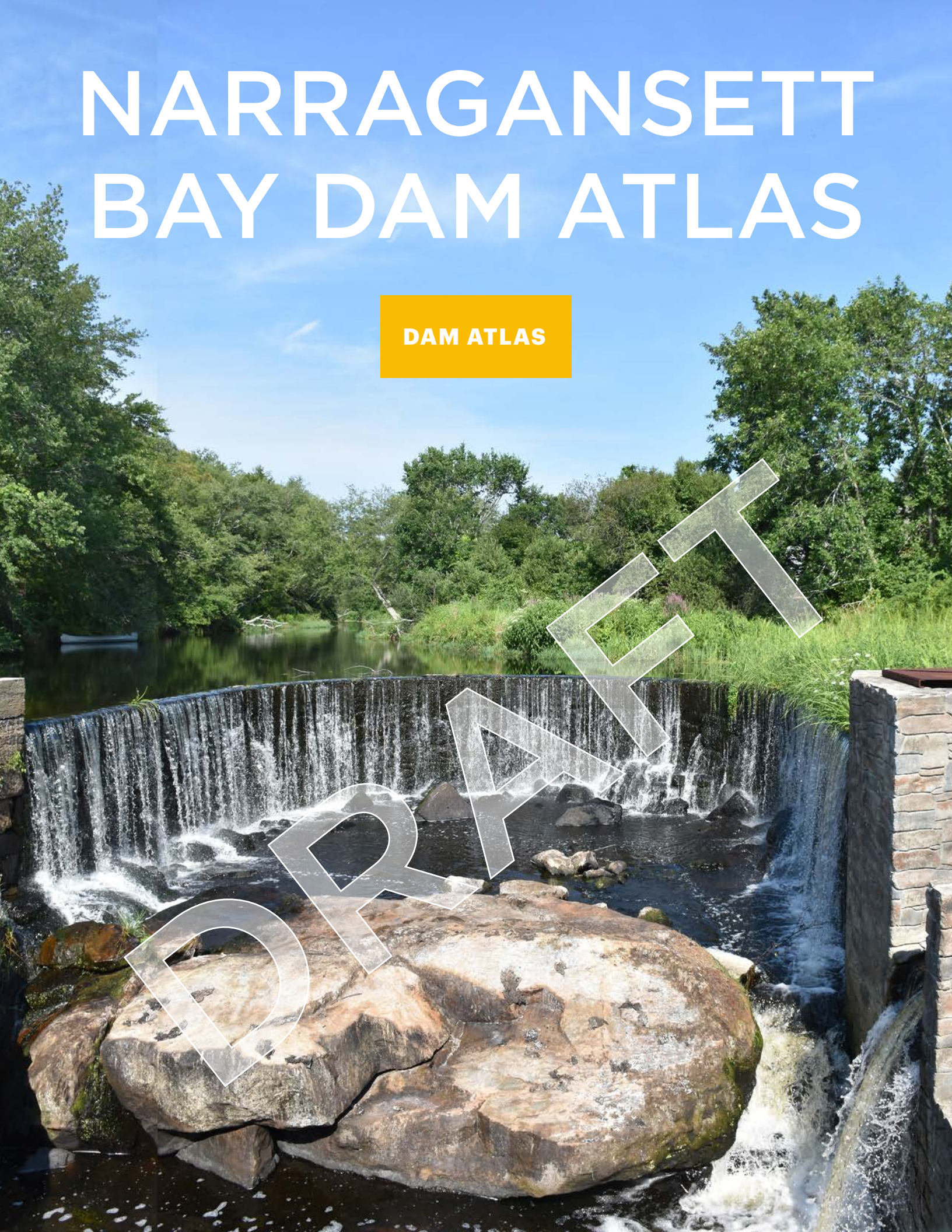
NARRAGANSETT BAY DAM ATLAS

DAM ATLAS



NARRAGANSETT BAY DAM ATLAS

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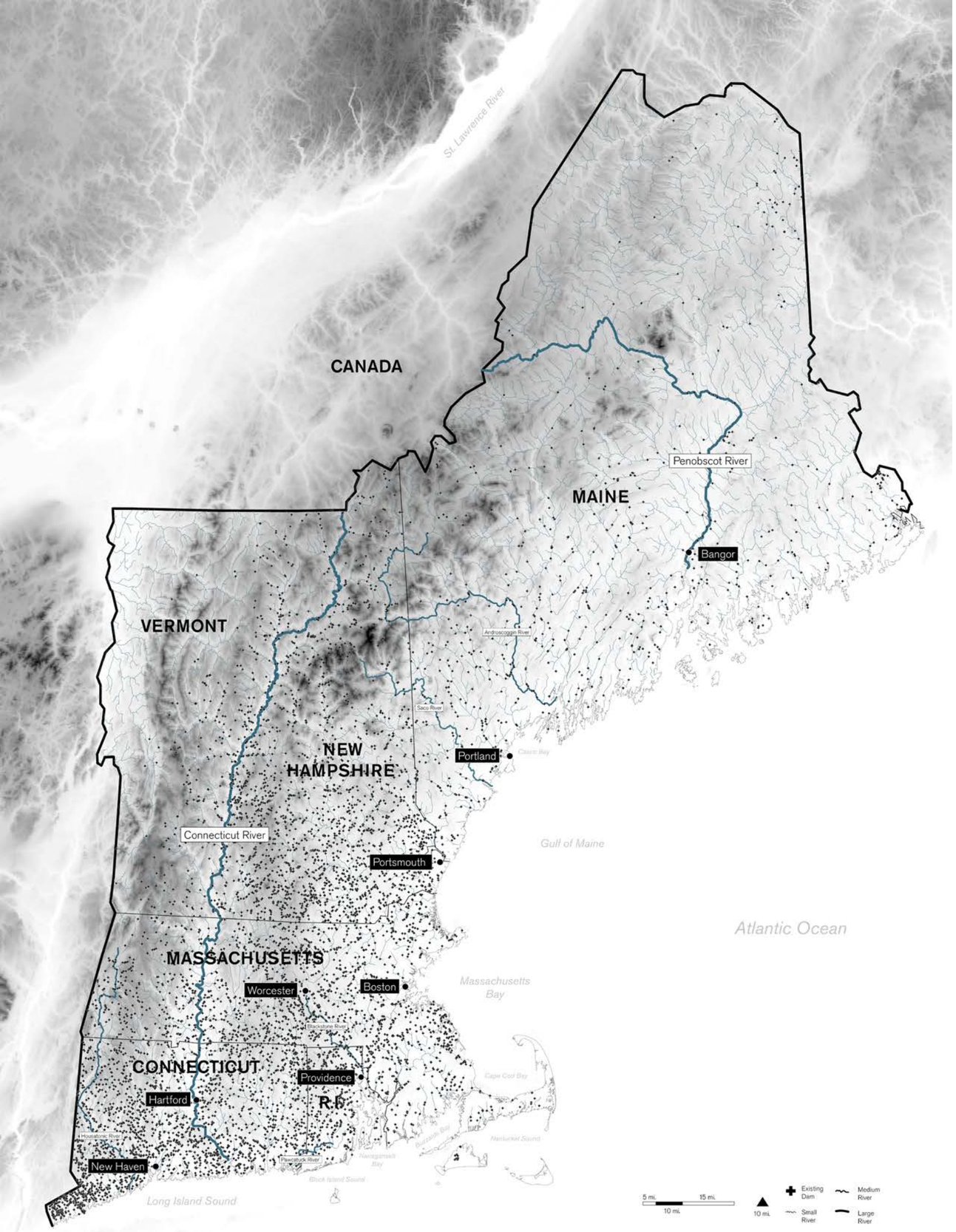
COMMONPLACE
Landscape and Planning

CONTENTS



There are over fourteen thousand dams in New England. The majority are small "legacy dams," only five to twenty feet tall, built over one hundred years ago to power early colonial grist mills and later industrial textile mills. Dams have shaped complex landscapes; they are a symbol of economic prosperity and cultural identity as well as a potential source of clean energy and recreation. However, many dams within the region no longer serve their original purposes and are coming to the end of their life cycles. In its 2021 Infrastructure Report Card, the American Society of Civil Engineers gave the nation's dams a 'D' grade, indicating the lack of maintenance and poor condition of many of the dams. Aging infrastructure, shifting climate regimes, and large storm events have heightened these concerns, as an increasing number of dams are at risk of breeching and threatening downstream communities. In addition to addressing these safety concerns, future decisions about these dams have the potential to improve habitat connectivity for endangered and threatened migratory fish such as salmon, herring, shad, and eels, and to improve water quality and restore the flow of sediments and nutrients that support critical freshwater and coastal habitats.

While it may make sense to remove legacy dams from an ecological, economic, or safety perspective, some dams and their associated impoundments, have become a significant part of individual and collective sense of place in rural New England communities[1]. Dams and impoundments are landmarks within an otherwise unstructured forested landscape; they are places where people grew up fishing with their grandparents, landscapes people drive or walk by every day, and features that have led to higher property values. In some cases, the dams are on the town seal in recognition of the village's colonial and industrial history. To many, these dams are seen as a symbol of cultural and regional identity.

As many of these dams are coming to the end of their life cycle and will either need to be repaired or removed in the coming decades, communities will need to come together to make decisions about the future of these dams. These decisions are complex and will need to consider ecological, social, safety and

economic trade-offs. In making these decisions, the public and community leaders will benefit from a trusted and unbiased source of information on the ecological and social considerations associated with dams.

This document is intended for both community members as well as practitioners that are working with communities to make a decision about the future of a dam. While there are many great resources and publications for proponents of dam removal[2], this document proposes a slightly different approach. Rather than advocating solely for removal, the goal of the methods and approach shared in this document is to bring a community into an open conversation to think creatively about the future of a dam. While this may seem counterintuitive if your role is to advocate for dam removal, engaging communities in an open but structured discussion about the future of a dam has the potential to lead to better environmental outcomes and a community that has more ownership, connection and sense of stewardship over their river. In addition, this approach has the potential to address what are often perceived as unequal power dynamics between dam removal proponents and the local community that has lead to projects stalling or failing in the past[3].

Our methods bring together design workshops with a method of environmental decision making called Structured Decision Making[4] with the specific goal of improving the way stakeholders and community members are brought into the decision making process around dams. Structured Decision Making is founded on the idea that good decisions are grounded in an in-depth understanding of both values (what is important) and consequences (what is likely to happen if an alternative is implemented). It is based on the assumption that there are not "right decisions" so aims to help inform and make decisions transparent rather than prescribe a preferred solution.

The document is made up of three main sections- The first part, "*Understanding Dams" i*ntroduces key ecological, social, infrastructural and economic factors that are important to consider for the management of dams at the individual and watershed scale. The second part, "*Case Studies",* looks at various alternatives for the future of a dam and presents a series of case studies of projects throughout the region. The last section, "*Making Decisions*", shares methods, ideas and tools for how to engage in conversations about the future of a dam. In addition to this document, these materials, along with an interactive GIS map, are being shared open-source on the website- www.damatlas.org.

The study area for this Dam Atlas encompasses the Narragansett Bay Watershed and the coastal watersheds of Rhode Island. Within this study area, we have mapped and analyzed 1,034 documented dams. Approximately 53% of the dams are within the state of Rhode Island, 44% are in Massachusetts and 3% are in Connecticut. Each dam within the watershed is unique; they vary in size, age, flow, material, and use; they differ in the ecological impact they have on the watershed; and they each have a distinct relationship to the surrounding communities.

The maps in the document were produced using GIS. State databases provided the locations of dams in the study area in addition to other data about the dams. However, as is apparent in the maps on the following pages, the different state databases have different data available. For example, the ownership of the dam was not available for many of the Rhode Island dams and the age of the dam was not available for many of the Massachusetts dams. One of the goals of this document and the website is to encourage the inventorying and sharing of data about dams. In addition to the dam datasets, we used GIS data available on state and national websites to do additional analysis of the dams. A full report of the methods we used can be found in the journal article, *Guiding Decisions on the Future of Dams: A GIS Database Characterizing Ecological and Social Considerations of Dam Decisions in Southern New England.*

While this Dam Atlas is focused on dams in the Narragansett Bay and coastal watersheds of Rhode Island, the metrics calculated in the GIS analysis can be applied to other watersheds and the decision making tools are not regionally specific. By sharing our methods and the open source decision support toolkit, the aim is to help support practitioners and communities that are looking for ideas, methods, and techniques for having discussions about the future of a dam. We encourage others to use, test, modify, evolve, and share these methods. Ultimately, the goal is that this work can contribute to a "library of approaches" that are openly shared to build knowledge and techniques to support collaborative environmental decision making around dams.

REFERENCES and ADDITIONAL RESOURCES

1. See, for example, arguments made by the group aiming to save the Natick Dam, https://www.savenatickdam.org/

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3. *Fox, C. A., F. J. Magilligan, and C. S. Sneddon. 2016. "You kill the dam, you are killing a part of me": dam removal and the environmental politics of river restoration. Geoforum 70:93–104.*

4. Our methods were adapted from Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T.L., & Ohlson, D.W. 2012. *Structured Decision Making: A Practical Guide to Environmental Management Choices.* Wiley-Blackwell, Chichester, U.K.

DAMS IN NARRAGANSETT BAY AND COASTAL WATERSHEDS

BOSTON

WORCESTER

MASSACHUSETTS

CONNECTICUT

PROVIDENCE

CAPE COD BAY

RHODE ISLAND SOUND

Breached Saundersville Dam on the Blackstone River. Many dams within the watershed are over 100 years old.

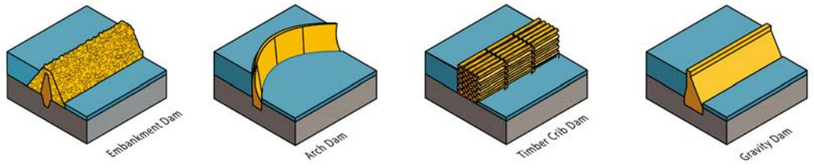
SECTION 01

UNDERSTANDING DAMS

DAM TYPES, USE and OWNERSHIP

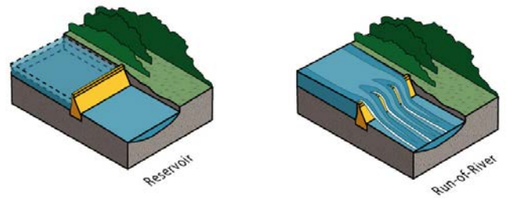
Dam Types

Depending on the size, age, and use of a dam, a range of construction materials and methods may have been used in the original construction. Some common materials used to construct dams include earth, concrete, and masonry. Embankment dams are made of compacted earth ("earthfill") or rock ("rockfill"). Concrete and masonry dams are categorized into gravity or arch dams. Gravity dams hold back water by using only the weight of the material. Arch dams are thin in cross section and the force of the impoundment water is borne by the abutments on the side of the dam. Some historic dams within Narragansett Bay and the Coastal watersheds were originally timber crib dams that were constructed of heavy timbers stacked like a log house and filled in with earth or rubble. Most of the timber crib dams were later rebuilt with concrete and stone. Many older dams are composed of a combination of materials as repairs were made to the structure over the years.



Embankment dam, Gravity dam, Arch dam, Timber crib dam

Dams operate in a range of ways depending on their intended purpose. Two common types of dams are run-of-the-river dams and detention or storage dams. Run-of-river dams have low water storage capacity and little impact to the water flowing over a dam. Thus, run-of-river dams have minimal fluctuation in water levels --the amount of water that flows over the dam is essentially equivalent to the amount that would be present without the dam. Many of the dams in Narragansett Bay and coastal watersheds are considered run-of-river dams. Detention or storage dams typically have large impoundments that store water. When constructed, they often served a specific purpose, such as water supply, irrigation, and hydroelectric power. Flood control dams are a form of detention dam with the capacity to fill up during flood conditions.



Run-of-river-dam, Detention or storage dam

Dam Ownership

Unlike the large federally-owned dams in the Western United States, the majority of dams in New England were constructed by private individuals and companies to power mills and many are still privately owned. Within the Narragansett Bay and coastal watersheds, records from state regulatory authorities show that of the dams whose owners are known, 42% of dams are privately owned, 0.5% are federally owned and 37% are owned by states and municipalities. When a property with a dam is sold, the ownership and responsibility for the dam is transferred to the new owner. While some landowners may appreciate having a dam on their property, it is a liability. Dam owners are tasked with the responsibility of the safe operation of the dam and may be liable for the consequences of any accidents or failures of the dam. Furthermore, dam owners must incur the costs of regular maintenance and repairs, as well as the acquisition of any necessary licenses or inspections. Within Narragansett Bay and the coastal watersheds, there are over 55% of dams whose owner is unknown to the state regulatory authorities. Since many of these dams are over a century old, ownership information may have been lost or forgotten over the years. These "orphan" dams provide a unique challenge for regulating authorities, as many of these dams are in need of repair and the responsible party is not clearly defined.

Even though the majority of dams are privately owned, dams are a public issue. Dams impact the health of rivers, which are a public common resource, and if not properly maintained, they can pose a significant threat to downstream communities. Although the dam owner is ultimately the decision-maker and is responsible for costs associated with the dam, the cost of repairs or removal often far exceeds the financial ability of most private owners - sometimes amounting to hundreds of thousands of dollars. There are no other examples in the United States of such widespread infrastructure being privately owned.

Dam Use

The majority of dams in the Narragansett Bay and coastal watersheds were built for small-scale, localized production of hydropower but are now functionally obsolete. Many dams have been adapted to serve other functions, including recreation, small-scale hydroelectric power generation, and road, rail, or utility river-crossings. Within Narragansett Bay and the coastal watersheds, the majority of the population rely on surface water reservoirs to meet their water consumption needs. The Scituate Reservoir provides drinking water to over 60% of Rhode Islanders and the Assawompset Pond Complex provides water for much of southeastern Massachusetts, including New Bedford and Taunton. Because they are critical utilities, it is important that these dams and reservoirs are properly maintained to support such functions.

Within the Narragansett Bay and coastal watersheds, 10 dams currently serve as a source of hydropower (7 in RI and 3 in MA). In Rhode Island, the seven commercial hydropower plants can produce 6.7 MW which is less than 0.3 percent of the state's energy needs[1]. Local electric utilities and the general public are increasingly interested in exploring carbon-free domestic energy sources. Some have advocated that the legacy dam infrastructure in the region could be transformed to provide local distributed energy production. However, given the topography, river flow rate, dam size, and available technology, there are limits to the amount of electricity that dams within the Narragansett Bay and the coastal watershed can generate. For example, a hydropower facility that was proposed on a 20 foot tall dam on the Pawtuxet river would have provided 0.3 MW of power[3], while a 70-acre solar power plant proposed for a landfill in East Providence would provide 3.7 MW of power[4]. However, it is possible that new hydropower technology[5] will be more efficient and make distributed micro-hydro (generating 5 kW to 100 kW of electricity) or pico-hydro (less than 5kW) power a possibility, but seasonal low flows will continue to be a challenge and constrain year round outputs.

The type, ownership, and use of a dam determine how decisions are made about its future.

REFERENCES and ADDITIONAL RESOURCES

1. STATE OF RHODE ISLAND, Office of Energy Resources https://energy ri.gov/renewable-energy/hydro/learn-about-hydropower

2. See, for example, New Enland Hydropower Company. https://www.nehydropower.com/

3. Kuffner, Alex. 2013 Developer seeks to use ancient technology to draw energy from Pawtuxet River. Providence Journal.

4. Forbes Street Solar Project I. https://www.cme-energy.com/content/forbes-street-solar-project-i

5. See, for example proposals by Turbulent. https://www.turbulent.be/

DAM OWNERSHIP

- National
- Private
- State
- Local/Municipal
- Unknown

BOSTON

WORCESTER

MASSACHUSETTS

PROVIDENCE

CONNECTICUT

CAPE COD BAY

RHODE ISLAND
SOUND

WATER SUPPLY

Dams with reserviors used for municial water supply

BOSTON

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PROVIDENCE

CAPE COD BAY

RHODE ISLAND SOUND

HYDROELECTRIC DAMS

Dams used to genearte hydroelectric power

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RHODE ISLAND SOUND

HAZARD RISK + CLIMATE CHANGE

The majority of the dams within the Narragansett Bay and coastal watersheds were built over a century ago and are coming to the end of their life cycle. Many dams have not been properly maintained or repaired over the years and would cause significant damage if they were to breach. Federal and state governments classify dams based on the potential impact of dam failure to downstream communities, infrastructure, and structures. Hazard risk does not consider the structural integrity of the dam -- it just focuses on downstream consequences of failure.

There are 3 hazard rankings commonly used by Federal and State agencies:

- **High Hazard Dams:** A dam where failure or misoperation would result in a probable loss of human life to communities downstream of the dam.
- **Significant Hazard Dams:** A dam where failure or misoperation would result in no probable loss of human life but can cause major economic loss, disruption of lifeline facilities or impact other concerns detrimental to the public's health, safety or welfare.
- **Low Hazard Dam:** A dam where failure or misoperation would result in no probable loss of human life and low economic losses.

In both Massachusetts and Rhode Island, regulated dams include dams classified as significant or high hazard as well as low hazard dams that are six feet or more in height, or that have a storage capacity of fifteen acre-feet (note: an acre-foot is the volume of water of an area approximately 200 ft by 200 ft flooded to a depth of 1 foot). Dams less than 6 feet are unregulated.

With the exception of hydropower dams that are regulated by the Federal Energy Regulatory Commission (FERC), there is no national standard for inspecting dams. The Department of Conservation and Recreation Office of Dam Safety[1] regulates dams in Massachusetts and the Rhode Island Department of Environmental Management (RIDEM)[2] monitors regulated dams in Rhode Island. Within both states, an engineer must inspect and report results every two years for High Hazard Potential dams and every five years for Significant Hazard Potential dams. Within Massachusetts, Low Hazard Potential dams need to be inspected every ten years and in Rhode Island, Low Hazard Dams are required to be inspected every five years.

While the dam hazard ranking communicates the potential impact of dam failure on downstream communities, it does not consider the condition of the dam. When dam inspections are conducted, the condition of the embankment, spillway and low level outlet are ranked good, fair, poor or unsafe. Following the visual inspection, a dam inspection report is prepared, identifying specific deficiencies and, when warranted, recommending corrective measures. In Rhode Island, as of 2019, 54 high and significant hazard dams were identified as unsafe or potentially unsafe and received notice from RIDEM[3]. By the end of 2019, safety issues at 5 of these dams had been addressed. Thirty-one additional high and significant hazard dams in RI were identified as unsafe or potentially unsafe but owners are unknown[4]. Within the portion of the Narragansett Bay Watershed that is in Massachusetts, and that have available hazard data, there are 52 high-hazard dams. At this time, we do not know how many of the high-hazard dams in the Massachusetts portion of the study area are classified as being in poor or unsafe condition.

In addition to inspections, both states expect all dams classified as high and significant hazard to have an Emergency Action Plan (EAP). An EAP is a formal document that identifies potential emergency conditions at a dam and specifies pre-planned actions to be followed during an emergency to minimize loss of life and property damage. The EAP includes an analysis of downstream areas that would be flooded in the event of a dam failure, as well as mechanisms for alerting local emergency agencies and downstream residents if a dam failure is imminent. As of 2019, 31% of high and significant hazard dams in Rhode Island had approved EAP's on record[5]. At this time, we do not know how many of the high and significant hazard dams in the Massachusetts portion of the study area have approved EAP's on record.

CLIMATE CHANGE

In addition to the risk associated with the age and lack of maintenance of the dams, there is a growing risk of failure due to extreme weather events. These historic dams were built at a time when severe weather was a rarity, not the norm it is becoming today. In addition, many were built when there were fewer established communities living in the flood zones downstream of dams.

Climate change has altered many aspects of our lives, requiring reconsideration of our long-established national infrastructures, including dams. With the exception of the small number of dams that were constructed specifically for flood control, most dams in the Narragansett Bay and coastal watersheds do not provide flood control benefits. The risk posed by aging dam infrastructure is exacerbated by increasing annual precipitation along with increasing numbers of extreme precipitation events that can lead to flooding upstream of a dam and potential extreme and sudden flooding downstream if a dam fails. For example, the 2010 flood in Rhode Island inundated the state with more than 16.34 inches of rain falling during the month of March -- the highest monthly precipitation on record. Many dams could not handle the excess flow and several dams within the region failed or were close to failing[6]. Fortunately, these breaches did not cause loss of life. Similar dam failures around the country, including the failure of the Edenville and Sanford dams in Michigan in 2020, have led to millions of dollars in damages, and thousands of people whose homes were flooded[7].

Dam failure can be catastrophic -- leading to loss of life, property and infrastructure. Dam failure is most frequently caused by water flowing overtop of the structure; foundation defects such as slope instability and settlement; and piping, resulting in internal erosion caused by seepage. Other causes may include structural failure of materials, settlement and resulting cracking, and poor maintenance.

Given the age of dams within the region, the increase in large storm events, and the potential risk of a dam failure on downstream communities, there is a need to ensure that local agencies have the resources needed to conduct regular inspections. In addition, while it is important that dams have an Emergency Action Plan on file to know how to react if a dam is failing, it is equally important for States to have adequate funding or other approaches that enable proactive preventative measures to address high and significant hazard dams that are in poor condition.

Record Flooding on the Pawtuxet River, March 31, 2010;
Photo Source: National Weather Service Northeast River Forecast Center

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1. MASS Department of Conservation & Recreation. https://www.mass.gov/service-details/dam-safety-inspection-requirements

2. https://dem.ri.gov/environmental-protection-bureau/compliance-and-inspection/compliance-programs/dam-safety

3. Department of Environmental Management: Office of Compliance and Inspection State Of Rhode Island. 2018. Annual Report To The Governor On The Activities Of The Dam Safety Program.

4. Ibid.

5. Ibid

6. Department of Environmental Management: Office of Compliance and Inspection State Of Rhode Island. 2010. Annual Report To The Governor On The Activities Of The Dam Safety Program.

7. Einhorn, Erin. 2020. Thousands fled for their lives when two Michigan dams collapsed. More disasters are coming, experts say. NBC NEWS.

DAM HAZARD RISK RANKING

Low Risk
Significant Risk
High Risk

BOSTON
WORCESTER
MASSACHUSETTS
PROVIDENCE
CONNECTICUT
CAPE COD BAY
RHODE ISLAND SOUND

DAM HEIGHT

- >51′
- 31′ - 50′
- 21′ - 30′
- 11′ - 20′
- <10′
- No Data

BOSTON

WORCESTER

MASSACHUSETTS

PROVIDENCE

CONNECTICUT

CAPE COD BAY

RHODE ISLAND
SOUND

AGE OF DAM

- pre 1875
- 1875-1885
- 1886-1937
- 1937-1993
- No Data

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CONNECTICUT

PROVIDENCE

CAPE COD BAY

RHODE ISLAND
SOUND

INDIGENOUS AND COLONIAL HISTORY

The Narragansett Bay and coastal watersheds are the traditional homelands of the Narragansett, Wampanoag, and Nipmuc nations. Discussions surrounding the history of dams and rivers in New England often focus on the dominant colonial and industrial histories of the region. However, prior to the colonial settlement of New England, Indigenous nations had their own distinct relationship to the region's rivers. All the tribes of the region relied heavily on rivers for transportation, fishing, and subsistence. Rivers were, and for many continue, to be considered living entities and an important aspect of cultural identity, spiritual livelihoods and lifeways of indigenous communities.

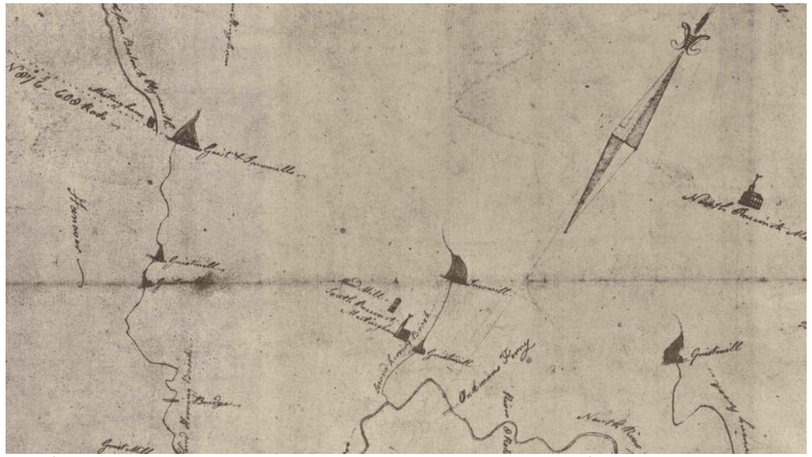
Indigenous Nations of the Narragansett Bay and coastal watersheds

When European colonists first arrived, they found an abundance of migratory fish throughout New England's rivers. Indigenous communities had long depended on the migration of these fish which typically coincided with early spring when other food sources were scarce. However, shortly after arrival, the colonists started constructing dams to provide power to mills which blocked these migration routes to the ocean. The impact of dams on fish populations was soon evident to indigenous communities who were cut off from a major food source. This only worsened over time, and by the mid-19th century, many migratory fish, such as shad, eel and river herring, could no longer be found in abundance within the watersheds of RI and the coastal ponds. In addition to the impact of dams on traditional food sources, dams flooded farmland and destroyed gravesites along with other ceremonial and spiritual areas along the rivers.

Rivers are still a crucial part of life for Indigenous communities who live in the region. For some, dams and the diminished migratory fish runs continue to symbolize the injustices of colonization and its impact on indigenous cultures, spiritual connection, and respect between people and the rivers within the region.

COLONIAL HISTORY

Dams played an important role in the colonial and industrial history of the United States. Early Colonial settlement of New England was oriented around the region's rivers. European colonists brought the knowledge and technology to convert energy from the region's rocky rivers into power for the early colonial gristmill and sawmills. The construction of Slater Mill Dam on the Blackstone River in 1793 to power the nation's first textile mill changed the scale and impact of hydropower technology within the region. Slater Mill's success inspired other local entrepreneurs, prompting the rapid increase of hydro-powered mill construction and leading to widespread changes to the New England landscape. However, the advent of steam power during the Industrial Revolution allowed factories to reduce their reliance on rivers and hydropower. This led to the shift of production out of New England, leaving dams as post-industrial relics throughout the landscape.



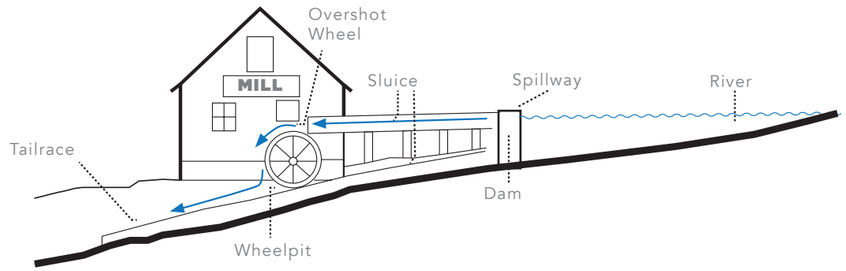
Map of area surrounding Scituate, Massachusetts, circa 1795. Map shows the density of early gristmills on streams.

As thousands of dams reach the end of their life cycles, communities around the country must make decisions about the future of their aging dam infrastructure. When making a decision about a dam, there is often the need to balance ecological restoration and public safety with the desire to preserve local history and the unique cultural landscapes of New England[1]. Some dams, including Slater Mill Dam among others, are officially listed on the National Register of Historic Places[2]. This federal register documents properties that are "significant in American history and worthy of preservation." Section 106 of the National Historic Preservation Act (NHPA) requires federal agencies to follow a review and consultation process to consider the effects of their undertakings on historic properties. As part of this process, a range of alternatives are explored that can help avoid, minimize and mitigate the impact to a historic property.

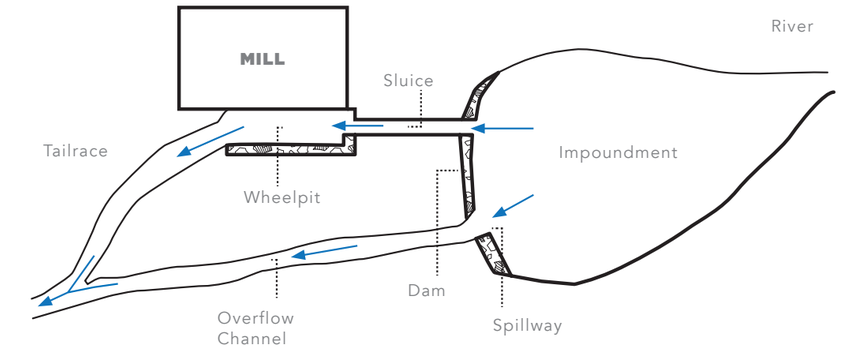
Some dams are not listed on the National Register of Historical Places but hold significance for local communities as cultural landscapes and are part of the local sense of place. According to the World Heritage Convention, cultural landscapes represent the "combined works of nature and of man. They are illustrative of the evolution of human society and settlement over time." Dams, associated mill ponds, and old mill structures make up the unique cultural landscape of New England that tell the story of how landscapes and colonial settlement are intricately connected in this region.

In some cases, the historic significance of a dam may lead to a historic dam structure being repaired and maintained. However, for other sites, there may be an opportunity to use design to mark the location of the dam and recognize the multiple histories of the dam and river without preserving the physical dam structure. Refer to the "Case Studies" page to explore some of the alternatives that can be used to mark, interpret, and adapt historic dam structures to help maintain the sense of place even if the dam structure is removed.

SECTION



PLAN



There are several types of mill designs, but the most common type of energy production in New England was the overshot and undershot water wheel. The water was diverted from the river or an upstream pond into a sluice which brought the water to the water wheel.

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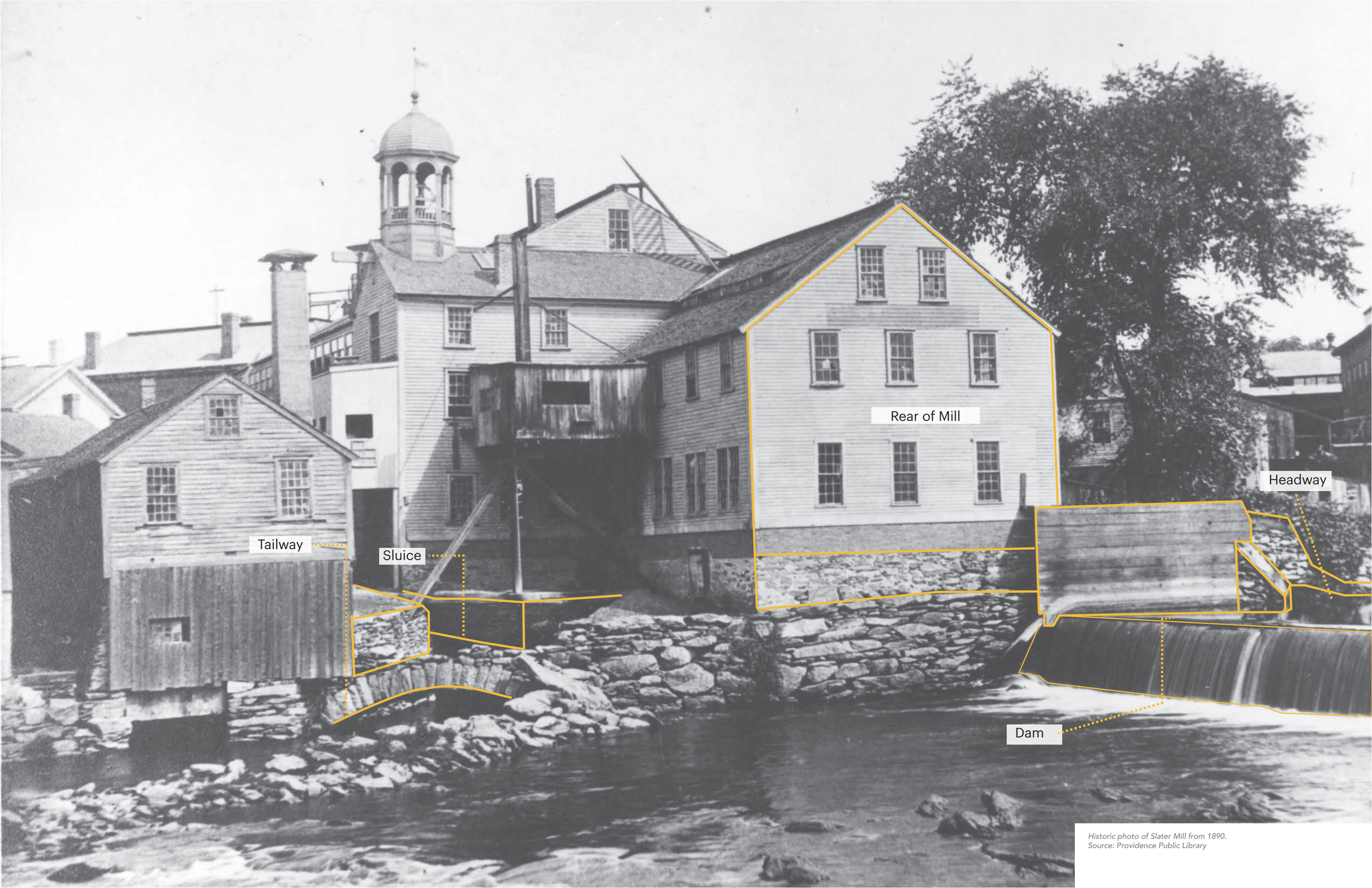


Historic photo of Slater Mill from 1890.
Source: Providence Public Library

DAMS WITHIN HISTORIC DISTRICTS

Dams within Historic District

Dams not in Historic District

BOSTON

WORCESTER

MASSACHUSETTS

CONNECTICUT

PROVIDENCE

CAPE COD BAY

RHODE ISLAND SOUND

SENSE OF PLACE + RECREATION

Sense of place indicates our emotional connection or attachment to specific places or landscapes. Sense of place often develops over time through personal experience and encompasses a variety of qualities. Social, cultural, ecological, aesthetic, or historical associations all have the ability to create a special relationship between people and their environment. Because it largely develops from experience and perception, sense of place differs for each individual. While one person might have positive memories associated with a specific location, another might experience this same place negatively. Regardless of perception, attachment to a place plays an important part in one's mental health. It is not unusual for this type of emotional connection to become intertwined with one's own personal and cultural identity.

Community sentiment around a dam may vary based on the location, structure, history, and the use of the dam and impoundment[1]. A dam may have been the foundation of a community, used to provide power for a mill by one generation, and a tourist attraction for the next - becoming an important part of the community identity, sense of place, and pride. In some cases, a community's attachment may be to the impoundment rather than to the dam itself. It may be a cherished community swimming hole or a place where generations have grown up fishing. In some cases, the aesthetics of the dam are valued by the community -- the view of the waterfall, the sound of falling water, a visual landmark within the forest. And for others, the dam may represent the colonization of the river and the appropriation of the land from Indigenous communities.

Depending on whether a community's attachment is to the dam, the impoundment, or the free-flowing river, various future scenarios may be considered. For example, a nature-like fishway can preserve a impoundment while significantly improving fish passage, however the dam structure will no longer be visible. If space exists around the dam, a bypass channel can preserve the view of the dam while also significantly improving fish passage and habitat connectivity. In addition, there may be ways to use design to maintain a sense of place and the aesthetics of the dam if the dam is removed[2].

Aesthetics of a dam, Horseshoe Falls. Photo by Emily Vogler

Since all dams and all communities are unique, it is important for local communities to discuss what is significant to them. The Decision Support Tools can provide guidance on helping communities discuss their local dam to explore what aspects of the dam and surrounding landscape are important to them.

RECREATION

One of the primary ways that people currently interact and develop a connection to the region's rivers is through recreation. Within the Narragansett Bay and coastal watersheds, waterways provide an important opportunity for recreation. In addition to the 256 miles of coastline in Narragansett Bay, there are over 3,000 miles of rivers and streams in the watershed that provide freshwater boating, swimming and fishing opportunities.

Flowing River Recreation- Rivers within the region are a popular recreational destination for kayaks and canoes. Whether day trips or overnight trips, smooth water or rapids, paddlers flock to rivers in the warm months of the year. However, the high number of dams in the watershed create an obstacle and hazard for paddlers traveling downstream along a river. Paddlers have to be knowledgeable about the location of dams and the location of portages (locations where boats need to be carried around a dam). In some places, the portage includes challenging and lengthy traverses across roads and up steep embankments. There is also a significant risk that paddlers unaware of a dam's location can go over the dam, capsize and potentially drown. The presence and frequency of dams on rivers can prevent paddlers from feeling safe exploring the region's rivers. In addition to paddling, some of the region's free flowing rivers are commonly used for fly-fishing.

Impoundment Recreation- Flat water behind a dam provides a different set of recreational opportunities. Impoundments are often used by communities for boating, swimming and fishing. In addition to canoes and kayaks, impoundments are sometimes accessible to motorized boats. Out of the 801 impoundments in the watershed, 68 (or 8.5%) are stocked with fresh water fish. Additionally, the flat water of impoundments make them popular swimming places for people of all ages. The recreational opportunities on a impoundment will vary based on size and access. Some have boat ramps and docks while others have restricted access due to them being for water supply.

When making a decision about the future of a dam, there is a trade-off between prioritizing flowing river recreation vs recreation on flat water of a impoundment. See the "Scenarios Page" to explore some of the alternatives that can be used to preserve a impoundment while improving habitat connectivity and fish passage.

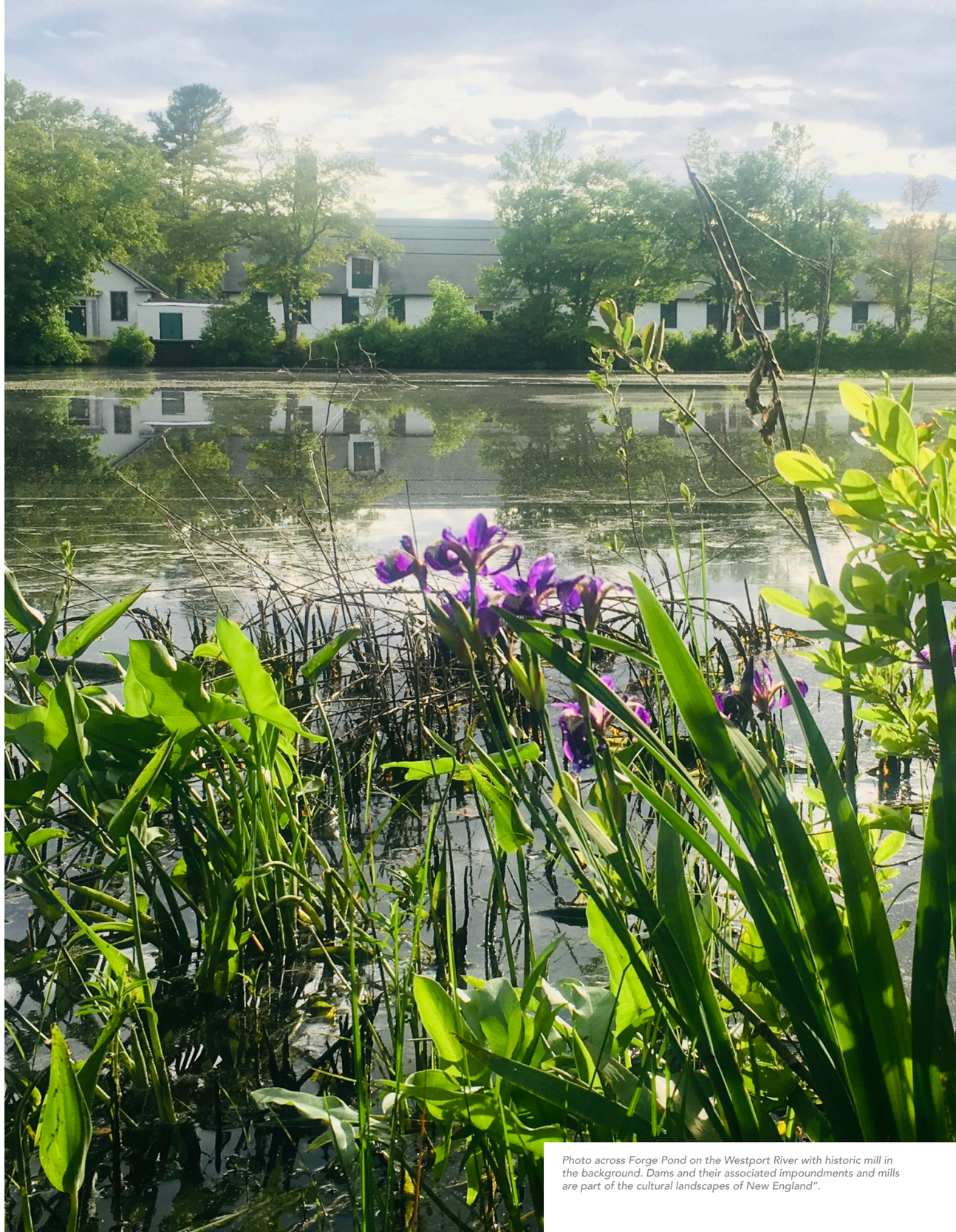


Photo across Forge Pond on the Westport River with historic mill in the background. Dams and their associated impoundments and mills are part of the cultural landscapes of New England".

REFERENCES and ADDITIONAL RESOURCES

1. See, for example, McClain, Serena, Lindloff, Stephanie, Baer, Katherine. *Dam Removal and Historic Preservation: Reconciling Dueling Objectives.* American Rivers *and the National Park Service. 2008.*

2. See the "Case Studies" chapter to explore some of these alternatives.

DEVELOPMENT AROUND DAM

- 0% - ¼% land developed
- ¼% - ½% land developed
- ½% - ¾% land developed
- ¾% - 1% land developed

BOSTON
WORCESTER
MASSACHUSETTS
PROVIDENCE
CONNECTICUT
CAPE COD BAY
RHODE ISLAND SOUND

DAM VISIBILITY

Visible from road
Not visible
No Data

BOSTON
WORCESTER
MASSACHUSETTS
CONNECTICUT
PROVIDENCE
CAPE COD BAY
RHODE ISLAND
SOUND

IMPOUNDMENT AREA IN ACRES

BOSTON

WORCESTER

MASSACHUSETTS

PROVIDENCE

CONNECTICUT

CAPE COD BAY

RHODE ISLAND SOUND

IMPOUNDMENTS STOCKED WITH FISH

Stocked with fish
Not Stocked with fish
No Data

BOSTON
WORCESTER
MASSACHUSETTS
PROVIDENCE
CONNECTICUT
CAPE COD BAY
RHODE ISLAND SOUND

FISHING AND BOATING ACCESS

Fishing and boating access
No Access
No Data

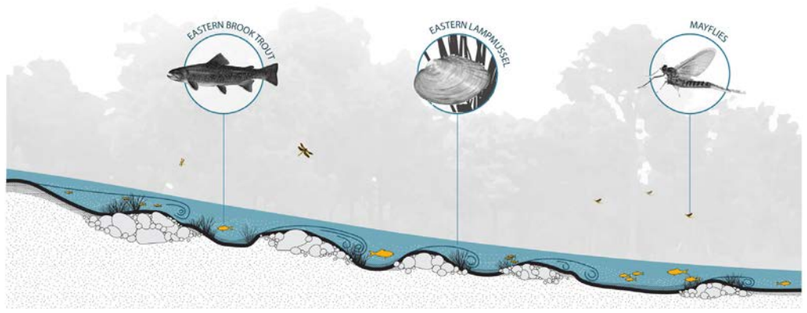
BOSTON
WORCESTER
MASSACHUSETTS
PROVIDENCE
CONNECTICUT
CAPE COD BAY
RHODE ISLAND SOUND

FISH PASSAGE + ECOSYSTEM IMPACTS

River systems are dramatically altered by the construction of a dam, which often has a lasting impact on interspecies relationships and overall habitat connectivity. More than just flowing water, rivers transport fish, sediment, and aquatic organisms between the headwaters (the smallest parts of river and stream networks) to the mouth (where the rivers discharge into coastal waters), sustaining healthy ecosystems along the way. Dams disrupt the system by acting as barriers that disconnect upstream and downstream river lengths, effectively weakening multiple ecosystems[1].

RIVER FLOW AND ECOSYSTEM DYNAMICS

Before European settlement, beaver dams and ponds were common in the smaller streams of the Narragansett Bay Watershed. However, these beaver dams did not generate the extent of changes associated with current dams in the watershed; beaver dams are relatively small, highly porous (leaky) and often seasonal or temporary. In contrast to beaver dams, dams constructed for industry and power along the rivers in the Narragansett Bay and coastal watersheds were permanent and impervious, creating a large-scale shift in the flow and ecology of rivers. Dams effectively transform portions of a river ecosystem into a lake ecosystem (or impoundment). While different aquatic and terrestrial species thrive in these distinct habitats, both rivers and

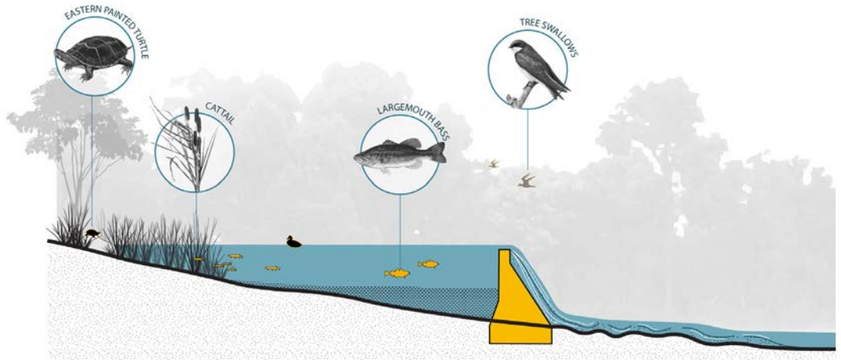


Diagrammatic Section of free flowing river

impoundments can provide critical wetland habitat. These wetlands may serve as travel corridors; nesting, feeding, resting, nursery and brood-rearing sites; drinking water sources and escape cover; and provide seasonal breeding, migration and overwintering habitat for wildlife[2].

Free-flowing reaches of rivers and streams transport wood, rocks, and other natural debris downstream where they accumulate to create characteristic riffles (shallow rocky areas), pools, and meanders. These habitat features act as shelter for prey species and help to support coldwater fish species such as Brook Trout, Fallfish, Blacknose Dace, and Longnose Dace. There is also a unique macroinvertebrate fauna of mayflies, stoneflies, caddisflies, midges, craneflies, blackflies, dragonflies and damselflies, crayfish, and mollusks. In Rhode Island, due to habitat loss, dams, water pollution, and climate change, Eastern brook trout are listed as a Species of Greatest Conservation Need.

When dams are constructed, the river habitat above the dam is transformed into a lake habitat that supports warm-water species such as large and smallmouth bass, bluegill, and chain pickerel. Within these impoundments, wetlands often emerge along the shoreline or in shallow areas, providing



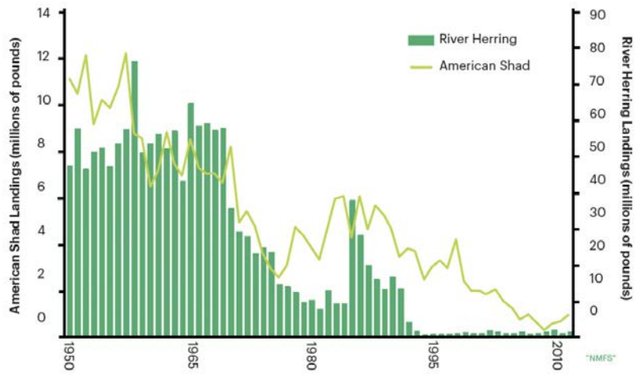
Diagrammatic Section of free flowing river

spawning and nursery habitat for a number of fish species. In addition, turtles, amphibians, and fish feed on the abundant invertebrate species that are found among aquatic plants. In some cases, rare and endangered species can be found in the novel lake ecosystems created by the impoundment. The presence of these species requires careful consideration to ensure that the selected alternative does not have a negative impact on the endangered species.

When a river is damed, the river below the dam no longer receives input of wood, rocks, debris and sediment to create critical habitat features, and begins to behave more like a chute with reduced habitat diversity. Dams may also reduce genetic diversity within an ecosystem by separating resident fish populations and wildlife from their natural habitat and range. When free-flowing systems are dammed, there may be an influx of non-native species, which shifts predator-prey dynamics. While dams often have a negative impact on habitat connectivity and species diversity, there are some cases in which dams have prevented the spread of invasive species or disease from one fish population to another by blocking passage.

MIGRATORY FISH PASSAGE

Dams disrupt the migration and spawning of fish, which travel through waterways at different stages in their lives. Anadromous fish such as salmon, American shad, and river herring live in the ocean and travel back to fresh water every spring to spawn (reproduce). Using the earth's magnetic field as a guide, they return to the exact location where they were born. Once they find their specific river, they use odor to locate their home stream. If unable to reach this stream, rather than spawn in a new location, some will continue searching until they have depleted all of their energy and die in the process. American eel are catadromous--they spawn in the Atlantic ocean and the young migrate into the river networks to feed and mature--often remaining for 5 to 40 years in freshwater ecosystems before returning to the ocean to reproduce. The



National Commercial Landings of Herring and Shad

Alewife
Alosa pseudoharengus

Length: Up to 15"
Weight: 8-10 oz.
Migratory Run: Mid-March to Mid-June
Passage Needs: 5' channel width, 2.25' pool depth, 10' channel length
Spawning Temperature: 57°

The Alewife migrates to freshwater streams where it spawns in large rivers, small streams, and ponds, including barrier beach ponds. Spawning substrates include gravel, sand, detritus, and submerged vegetation with sluggish water flows.

American Shad
Alosa sapidissima

Length: Up to 30"
Weight: 6-12 lbs.
Migratory Run: Early-Mid May
Passage Needs: 20' channel width, 4' pool depth, 30' channel length
Spawning Temperature: 50W°

This keystone species migrates to fresh water when temperature reaches 50˚F. Spawns in broad flats of 1-6m deep water. Eggs do best in gravel and rubble substrates. Females lay 650,000 eggs. Juvenile migrate back to ocean in Fall.

American Eel
Anguilla rostrata

Length: Females average 2' to 3'. Males half the size
Weight: 8.9 lbs
Migratory Run: Spring - Summer
Passage Needs: 6' channel width, 2' pool depth, 10' channel length
Spawning Temperature:

Eels are catadromous, meaning they live in freshwater rivers and spawn in the ocean. In October, sexually mature eels swim out of the Bay to the Sargasso Sea in the mid atlantic where they spawn and die. The eel larvae drift in the ocean for 9-12 months and then enter the bay where adults remain in freshwater rivers and streams for the majority of their lives.

Blueback Herring
Alosa aestivalis

Length: Up to 16"
Weight: 8-10 oz.
Migratory Run: Early-Mid May
Passage Needs: 5' channel width, 2' pool depth, 10' channel length
Spawning Temperature: 57°

Blueback herring have similar habitat requirements to the Alewife, but spawn in swiftflowing, deeper stretches of rivers and streams with an associated hard substrate and in slower-flowing tributaries and flooded low-lying areas adjacent to main streams. Spawn 3-4 weeks after Alewife.

Atlantic Salmon
Salmo salar

Length: 28" to 30"
Weight: 8 to 12 lbs
Migratory Run: Late Fall
Passage Needs: 20' channel width, 3.75' pool depth, 40' channel length
Spawning Temperature: 45-50°

Atlantic Salmon lay their eggs in the river bed. Juveniles need clean, well-oxygenated water and cobble sized substrate free of sediment. Historically, Atlantic salmon were present in Narragansett Bay; however, recent attempts to restore salmon to southern New England waters have been unsuccessful.

migration of fish and eels is not only critical for the survival of the species, but it also contributes to the whole ecosystem as the fish recycle nutrients along the way.

Historically, the river systems of Narragansett Bay and the coastal ponds, which drain into the Narragansett Bay and Block Island Sound, supported healthy migration of River Herring, Atlantic Salmon, shad and American eels, allowing them to feed and reproduce. However, after the proliferation of dams, these species declined dramatically[3]. Rhode Island's once lucrative Atlantic salmon fishery collapsed in 1870, and the river herring fishery was significantly depleted by 1930.

Due to the importance of migrating fish species to the coastal rivers of Narragansett Bay, when trying to understand the impact of a dam, it is important to consider the locations of the dam within the watershed. Head of tide dams are the first dams on a river system. If these dams do not allow for fish passage, the whole river system is impassable to migratory fish, greatly diminishing their spawning habitat and ability to reproduce. Dams located on the main stem of river systems are particularly disruptive to fish migration since they cut off huge areas of the upstream watershed. When fish are stopped or delayed by a dam, even if the dam allows for some fish passage, they become easy prey and may experience significant population decline while predator species flourish.

In cases where dams have been removed along rivers in New England, some species of migratory fish quickly return, sometimes to rivers where they have not been seen for over 200 years. In areas where dam removal is not possible, alternative fishways may be an option to improve fish passage. See the case studies for more information about the various dam alternatives to improve fish passage. A full ecological assessment is needed as part of any dam related project to evaluate the current wildlife and wetland habitats and to understand how they will be affected by the scenarios being considered.

Migrating Herring
Source: Jacob Bøtter

REFERENCES and ADDITIONAL RESOURCES

1. For a more in depth discussion of the ecological impact of dams, see: Hart, D.D et al. 2002 .Dam Removal: Challenges and Opportunities for Ecological Research and River Restoration BioScience. 52 (8).

2. Dam Removal and Wetland Regulations. Massachusetts Department of Environmental Protection. 2007

3. Erkan, Dennis. *Strategic Plan For The Restoration Of Anadromous Fish To Rhode Island Streams.* Rhode Island Department of Environmental Management Division of Fish and Wildlife. 2002.

HEAD OF TIDE DAMS

- Dam located at the tidal limit of a water body (head of tide)
- Dams at head of tide with fish passage structures
- Head of tide dams that have been removed
- Dams in watershed not located at head of tide
- Rivers allowing full migratory fish passage
- Rivers upstream of fish ladder allowing partial passage

BOSTON

WORCESTER

MASSACHUSETTS

CONNECTICUT

PROVIDENCE

RHODE ISLAND SOUND

CAPE COD BAY

UPSTREAM MILES OPENED IF DAM IS REMOVED

30+ Miles
16-30 Miles
9 - 15 Miles
2 - 8 Miles
0-2 Miles

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MASSACHUSETTS
PROVIDENCE
CONNECTICUT
CAPE COD BAY
RHODE ISLAND SOUND

COLDWATER FISHERIES

Rivers and Streams with coldwater fish habitat

BOSTON

WORCESTER

MASSACHUSETTS

CONNECTICUT

PROVIDENCE

CAPE COD BAY

RHODE ISLAND SOUND

WATER QUALITY + SEDIMENT

Dams alter the flow of a river, which can change many aspects of water quality[1]. Dams can increase river temperatures by creating stagnant impoundments with large surface areas that absorb the sunlight. Surface conditions may become unsuitable for many cold-water fish species that once thrived in rivers. Warmer waters experience accelerated evaporation and a lower capacity to hold oxygen that can negatively impact fish and aquatic life. Dissolved oxygen levels are also impacted when a dam changes the flow regime from a fast-moving river that gathers oxygen as the water flows downstream to a dammed impoundment with still water. In large, deep impoundments release of cold bottom waters can support a cold water fishery (trout or herring) for several miles downstream of the dam.

Excess nutrients (nitrogen-N and phosphorus-P) can create undesirable conditions in impoundments and coastal waters. These high concentrations of nutrients can trigger the growth of aquatic plants and algae, which is likely to consume oxygen in the water column. At its worst, excess nutrients and low oxygen conditions can cause large scale fish kills within lakes and Narragansett Bay. Some blooms, like those produced by cyanobacteria, or blue-green algae, are especially worrisome as they are toxic to humans and animals.

Fish Kill due to low oxygen conditions in Narragansett Bay

In certain settings, scientists have hypothesized that a small portion of dams -- those with impoundments located within headwater tributaries -- may actually promote natural removal processes or storage of nitrate and improve water quality in downstream estuaries[2]. The riparian wetlands around the dam also may be protecting excess nutrients from entering rivers. Research is underway to determine if nutrient retention may be an unexpected tradeoff for dam removal.

SEDIMENT

Rivers naturally transport sediment downstream; however, when dams are built, most sediments are trapped and settle behind the dam. There are two important concerns regarding sediment including accumulation and toxicity[3].

Accumulation: Unless the impoundment is dredged, sediment will accumulate over time. Generally, there will be more accumulated sediment in watersheds with more urban areas. Sediment accumulation reduces the impoundment water storage capacity, which can lead to flooding during high flow conditions and storms. Additionally, trapped sediment can cover the habitat of bottom-dwelling species. The accumulation of sediment behind a dam can cause the stream below the dam to be sediment starved often resulting in erosion.

Contamination: Since many dams within the Narragansett Bay and Coastal Watershed date back to the Industrial Revolution, a wide variety of pollutant materials, including nutrients, metals, hydrocarbons, and exotic organic compounds may be present in the sediments behind a dam. Dams may prevent contaminated sediment from traveling downstream and further dispersing these pollutants.

Sediment management is an important consideration when looking at scenarios for the future of a dam. Sediment behind a dam - contaminated or not - will often make dam removals more complex and costly. When a dam is removed, sediment may be released downstream, which increases turbidity, impacts downstream wetland habitats, and potentially, releases contaminants. There are three primary sediment management alternatives to consider if the decision is made to remove a dam[4]: Sediment removal and disposal; allowing the sediment to flow downstream and get redistributed by the river; and capping, or in-situ remediation if the sediment is highly contaminated. The decision about how to manage the sediment will depend on a "due diligence" review to consider the current and past upstream land uses as well as contaminant screening if there is any likelihood of contamination.

In addition to depriving rivers of sediment, dams can also diminish sediment supplies in coastal ecosystems[5]. Sediment from the rivers within the watershed help to nourish the beaches and salt marshes in Narragansett Bay. Salt marshes within Narragansett Bay are currently drowning due to sea level rise[6]. Because dams prevent the flow of sediment downstream to the Bay, they effectively reduce the capacity of salt marshes to adapt to rising sea levels.

REFERENCES and ADDITIONAL RESOURCES

1. For a more in depth discussion of the ecological impact of dams, see: Hart, D.D et al. 2002 .Dam Removal: Challenges and Opportunities for Ecological Research and River Restoration BioScience. 52 (8).

2. Gold, Arthur, Kelly Addy, Alisa Morrison, and Marissa Simpson. 2016. "Will Dam Removal Increase Nitrogen Flux to Estuaries?" Water 8 (11): 522. https://doi.org/10.3390/w8110522.

3. *See:* Snyder, N. P., Rubin, D. M., Alpers, C. N., Childs, J. R., Curtis, J. A., Flint, L. E., & Wright, S. A. (2004). Estimating accumulation rates and physical properties of sediment behind a dam: Englebright Lake, Yuba River, northern California. Water Resources Research, 40(11). and Evans, J. E. (2015). Contaminated Sediment and Dam Removals: Problem or Opportunity? Earth and Space Science News. Retrieved from https://eos.org/features/contaminated-sediment-and-dam-removals- problem-or-opportunity-2

4. Massachusetts Department of Environmental Protection. 2007. *Dam Removal and Wetland Regulations.*

5. Crosby, Sarah C., Dov F. Sax, Megan E. Palmer, Harriet S. Booth, Linda A. Deegan, Mark D. Bertness, and Heather M. Leslie. 2016. "Salt Marsh Persistence Is Threatened by Predicted Sea-Level Rise." Estuarine, Coastal and Shelf Science 181 (November): 93–99. https://doi.org/10.1016/j.ecss.2016.08.018.

6. Roman, C.T. (2017). Watershed Counts 2017 Report: Climate Change in Narragansett Bay: Rising Seas and Salt Marshes. Ed. Nicole E. Rohr. University of Rhode Island and Narragansett Bay Estuary Program. R.I. 8 pp.

Managing sediment during the Bradford Dam Removal © Ayla Fox

IMPAIRED WATERWAYS

Impaired for one or more designated uses but does not require the development of a TMDL: TMDL has been completed.

Impaired for one or more designated uses but does not require the development of a TMDL: Impairment is not caused by a pollutant.

Impaired for one or more uses and requiring a TMDL (impairment due to pollutant(s) such as nutrients, metals, pesticides, solids and pathogens).

BOSTON

WORCESTER

MASSACHUSETTS

PROVIDENCE

CONNECTICUT

CAPE COD BAY

RHODE ISLAND
SOUND

COST + FUNDING

Dam removal, repairs and/or modifications can be costly, and because every dam is different there are many factors that can affect the cost and economic impact of a decision. Some economic factors to keep in mind when considering possible future dam scenarios include short-term cost, long-term cost, liability cost, and societal economic impacts.

When examining the cost of various scenarios, the short-term cost of the alternative is often the primary consideration. Short-term costs may span multiple phases, including: Public outreach and feasibility study; designing and permitting; implementation (repair, removal or modification); and post-removal monitoring. The actual cost of implementation will vary depending on the size, location, and condition of the dam.

It is also important to account for the long-term cost of dam maintenance and operation. Repairing or upgrading a dam may be less expensive than removal in the short-term, but the cost of repairing and maintaining a dam will be an ongoing expense.

In addition to the direct economic impact of any modifications to the dam, there may be other societal economic impacts to consider. For example, if a impoundment is a significant tourist attraction and the local economy is built around recreation, it will be important to consider the impact of various scenarios on local revenue. Furthermore, it will be critical to consider potential impacts to surrounding property values.

While many dam modification alternatives (e.g., Nature-like fishway, by-pass channel, etc.) can be more costly than repair or removal, they may allow for a community to find a compromise and balance the trade-offs on an otherwise controversial decision.

FUNDING

Dam projects often require a combination of different funding sources from state and federal agencies, non-profit organizations, cities, towns, and private foundations. In some cases, there may be a greater likelihood of external funding if full removal is chosen, but each case is particular and the economic considerations need to be evaluated alongside other dimensions of the dam decision. Any available grants and loans will be specific to the stated purpose of the dam removal. For example, there may not be grants available for restoration of fish passage, but there could be funds available for watershed restoration, flood mitigation, or coastal and climate resilience.

See the appendix for a list of possible funding sources.

SOCIAL AND ECOLOGICAL METRICS

As part of the Narragansett Bay Dam Atlas, we developed a GIS database to assess the ecological and social dimensions of the dams in the Narragansett Bay Watershed. While there have been other studies that characterize and rank the ecological benefits of dam removal, these studies often focused only on the regional scale and do not consider the social aspects of dams. Such large scale geographical studies are not always relevant to local communities. For example, in the Narragansett Bay watershed, many rivers do not rank highly at a regional scale even though they are considered important for improving fish passage at the local-scale. In addition, by omitting information on the social dimensions of dams, these databases overlook one of the most critical factors that often decides the future of a dam regardless of ecological considerations.

In this study, we modeled the ecological metrics and ranking system after the Nature Conservancy's Northeast Aquatic Connectivity study. There were 13 metrics that consider factors relating to river connectivity and watershed quality (Table x). The metrics were then weighted for the potential benefit of removal for either resident or migratory fish. Weights for migratory fish emphasized river connectivity improvements particularly for the downstream river network. Weights for resident fish emphasized barrier densities, connectivity improvement, and watershed condition. Ecological rank values range from 1 to 1034 (i.e. the number of dams). Low values indicate higher ranks and greater ecological benefit for dam removal or modification.

To better understand and map the social dimensions of a dam, we created a set of social value metrics to estimate the value that the presence of a dam currently provides to the local community. High social value may indicate a stronger community attachment to the dam and/or impoundment and require a more extensive community engagement to explore options that balance the social and ecological dimensions of the decision. The metrics consider the value of dams and their impoundments to history, sense-of-place, recreation, scenery, and property value. We aimed to discern between community attachment to the dam vs. the impoundment and created two separate social metrics (Table x and x).

ECOLOGICAL METRICS

METRIC	DEFINITION	RATIONALE
Upstream Length	Length of river upstream (ignores dams).	Maximum potential habitat if all upstream dams are removed.
Distance to mouth	Distance to river mouth (ignores dams).	Maximum potential habitat if all down-stream dams are removed.
Downstream barrier count	Number of dams downstream to mouth.	Potential for fully connecting downstream habitat to ocean.
Upstream barrier density	Dams/km upstream.	Average length of upstream network opened up per dam removal.
Downstream barrier density	Dams/km downstream.	Average length of downstream network opened up per dam removal.
Area of lakes/ponds	Area of lakes/ponds in the upstream functional network.	Lakes/ponds provide key habitat for some migratory fish (e.g., river herring).
Upstream functional network length	Length of contiguous upstream riv-er.	Additional functional habitat that would be added given the other existing dams.
Downstream functional net-work length	Length of contiguous downstream river.	Additional functional habitat that would be added given the other existing dams
Total functional network length	Sum of upstream and downstream networks.	Total habitat that would be connected given the other existing dams.
Absolute Gain	Smaller of the upstream and down-stream functional network lengths .	Gain in functional habitat from barrier removal.
% impervious cover	% impervious cover in the dam watershed.	Associated with increased nutrient and pollutant loads in run-off.
% agricultural cover	% agricultural cover in the dam watershed.	Associated with increased nutrient loads in run-off.
% natural riparian zone	% natural cover within 50 m of up-stream rivers in the dam watershed.	Natural riparian cover helps remove pollutants from run-off.

Ecological metrics for evaluating benefits of dam removal or modification. All metrics are defined based on the dam or its watershed.

SOCIAL METRICS- DAM

METRIC	DEFINITION	RATIONALE	SCORING
Historic status	Is dam in a historic district and is it visible from a road?	May provide legal protection or sentimental value.	If in historic district: +5 if not visible +10 if visible
Year of construction	Year the dam was built.	Older dams may have more sentimental value.	+3 pts if before 1800 +2 pts if 1800-1900 +1 pt (1900-1950)
Trails	Does a hiking/biking trail pass within 50 m?	Dam may provide a scenic destination to hikers/ bikers.	+1 if any trails present
Construction material	Type of material used for the dam construction.	Dam material can affect aesthetic value.	+1 if dam is either masonry or stone
Visibility	Dam visibility from local road segments > 50 m long and < 50 m from the dam.	May provide sense-of-place to a larger number of residents.	+10 if dam is visible
Developmental setting	Percent of land within 100 m of the dam that is developed.	May provide sense-of-place to a larger number of residents.	+2 pts if 25-49%, +4 pts if 50-74%, +6 pts if ≥75%
Neighboring properties	Buildings < 50 m from river centerline and < 1 km upstream). Omitted if pond is present.	Lowering water level could affect property values and water access.	+10 per building
Hazard class	National Inventory of Dams hazard ranking.	The hazard level posed by a dam can detract from its community attachment.	-2 if medium -5 if high

Social value metrics for evaluating community attachment to the dam. More points are assigned to metrics that we considered associated with greater social attachment.

SOCIAL METRICS- IMPOUNDMENT

METRIC	DEFINITION	RATIONALE	SCORING
Neighboring properties	Buildings < 50 m from pond or river centerline (< 1 km upstream).	Lowering water level could affect property values.	+10 per house
Parks	Is the pond adjacent to a public park? (yes/no)	Impoundment may be a central feature of the park and provide sense-of-place	+20 if present
Hiking/biking	Do biking/hiking trails pass within 50 m? (yes/no)	Pond may provide a scenic destination.	+1 if present
Visibility	Is pond visible from local roads > 50 m long and within 500 m of pond?	May provide broader community with sense-of-place.	+10 if either impoundment is visible
Pond size	Area of impoundment in acres	Larger impoundments may benefit a larger community and provide more recreational opportunities.	+1 if < 1 acre +2 if 1-10 acres +3 if 11-25 acres +4 if 26-100 acres +5 if 101-500 acres +6 if > 500 acres
Road access	Does a local road pass within 10 m?	Provides access to either motorboats or non-motorized boats.	+5 if road present
Motorboat access	Is a boat ramp present?	Provides access to motorized boaters. Lowering of water level may eliminate all opportunity for motorboats.	+5 if boat ramp present
Fishing opportunity	Is the pond stocked with fish?	Pond provides benefit to anglers.	+5 if pond is stocked

Social value metrics for evaluating community attachment to the dam impoundment. More points are assigned to metrics that we considered associated with greater social attachment.

The GIS analysis and assessment of the social and ecological factors provide the ability to compare opportunities and priorities across the watershed and consider where and how to invest resources. Dams that are highly ranked for either migratory or resident fish are priority targets for removal or modifications that allows fish passage. Dams may be good candidates for removal if they have low social value scores and high ecological value for either migratory or resident fish. For example, a dam would probably come up against less resistance to removal if it is located in the middle of the forest than a dam located off of Main street. For dams with high social and ecological value, there are substantial ecological benefits from improving fish passage as well as a strong likelihood of community attachment. These dams would require a more extensive public process that explores of a full range of alternatives including removal, nature-like fishway, bypass channels and technical fishways may address social concerns while still providing some ecological benefits.

The metrics and maps provide a new way for us to understand and visualize the ecological and social dimensions of dams in the watershed. By quantifying the social metrics, we do not intend to suggest that these metrics should limit the mitigation options that are considered, or prohibit ecological restoration actions, for a particular dam. Instead, the social metrics are intended to indicate the need for community engagement and the consideration of alternative options that provide ecological benefit, where possible, but preserve social value where there is community attachment. Our analysis is intended for broader-scale guidance, comparisons, and prioritization of projects at the watershed scale. Projects addressing the future of a specific dam will need an extensive community engagement process to fully understand the social dimensions of place attachment for that dam. Identifying and quantifying the social dimensions of dams provides a way for these factors to be discussed and analyzed alongside the ecological dimensions and included in watershed scale decision-making about priority projects.

The full results of the analysis can be found in the journal article, *Guiding Decisions on the Future of Dams: A GIS Database Characterizing Ecological and Social Considerations of Dam Decisions in Southern New England.* The GIS methods are shared in the paper and can be replicated in other geographic regions.

REFERENCES and ADDITIONAL RESOURCES

Parent,J., Gold, A., Lowder,K. Vogler,E. 2023 *Guiding Decisions on the Future of Dams: A GIS Database Characterizing Ecological and Social Considerations of Dam Decisions in Southern New England*. Forthcoming Publication.

ECOLOGICAL RANK: MIGRATORY FISH

- Dams ranked 1-50
- Dams ranked 51-100
- > 100

Dams that are highly ranked (with 1 being the highest) would have the most ecological benefit if removed or modified to allow fish passage.

BOSTON
WORCESTER
MASSACHUSETTS
CONNECTICUT
PROVIDENCE
RHODE ISLAND SOUND
CAPE COD BAY

ECOLOGICAL RANK: RESIDENT FISH

Dams ranked 1-50

Dams ranked 51-100

> 100

Dams that are highly ranked (with 1 being the highest) would have the most ecological benefit if removed or modified to allow fish passage.

BOSTON

WORCESTER

MASSACHUSETTS

CONNECTICUT

PROVIDENCE

CAPE COD BAY

RHODE ISLAND SOUND

SOCIAL VALUE SCORE-
DAM AND IMPOUNDMENT

- 0 - 2 Social Score
- 3 - 9 Social Score
- 10 - 50 Social Score
- > 50 Social Score

The lower the social score, the less likely there is community attachment to the dam/impoundment and potentially less resistance to dam removal

BOSTON

WORCESTER

MASSACHUSETTS

CONNECTICUT

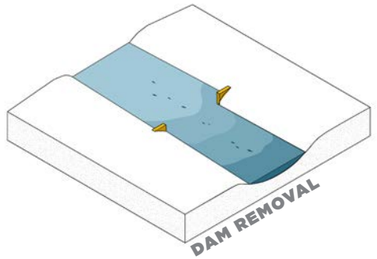
PROVIDENCE

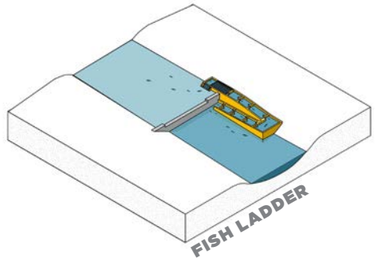
CAPE COD BAY

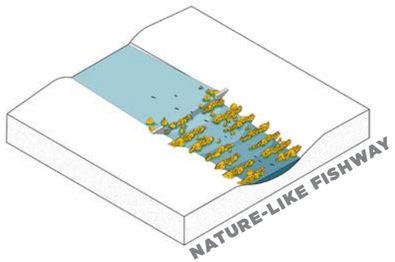
RHODE ISLAND
SOUND

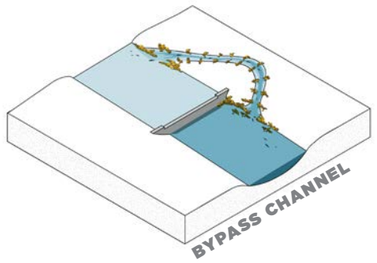
SECTION 02

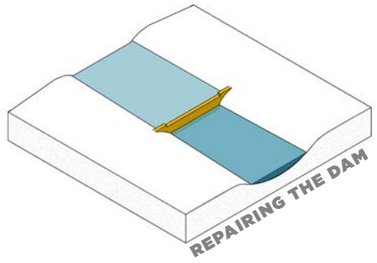
CASE STUDIES











Within the Narragansett Bay and coastal watersheds, there is a need to address aging dams that are in poor condition and in need of repair. Each dam is unique and has different ecological, social, physical and economic factors that need to be considered when exploring solutions. Given that most dams within New England are small and obsolete, there are often a range of alternatives that can achieve multiple objectives. Dam removal is frequently the most cost-effective way to manage aging dams. Removal will restore most natural river functions and ecological connectivity, eliminate future risks of failure, and avoid long term maintenance and repair costs. However, the social, physical and economic aspects of the local community often warrant consideration of alternatives. Conventional fishways or nature-like fishways are often used in combination with either no or partial lowering of the water levels upstream of the dam. Where dams are not removed, repair and long-term maintenance costs and the potential consequences of dam failure to property, infrastructure and livelihoods need to be identified through engineering studies. The future of any particular dam may warrant the exploration of other options that move beyond what is often perceived as just two options of either keeping or removing the dam.

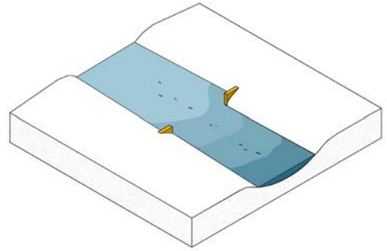
Dams are constructed landscapes that require creative thinking to address the often competing trade-offs of a decision. On the following pages are a description of different strategies that have been used and case studies that describe specific projects where these strategies have been deployed. See the “Decision-Making Tools” section to explore how to engage in conversations about the range of alternatives and to explore how they meet the project objectives.

DAM REMOVAL

Dam removal provides full habitat connectivity and fish passage up and downstream. It eliminates the risk of dam failure and avoids long-term maintenance and repair costs. It represents a “one and done” solution to the many aging dams in the region. Removal also allows canoes and kayaks unobstructed passage downstream without the need for long and sometimes dangerous portages (carrying a boat around the dam).

Dam removal requires careful study and engineering to assure that neighboring infrastructure, such as bridges and roadways are not damaged by changes in the river channel. Studies are also needed to understand the impact of lowering the upstream water elevations on wells, upstream wetlands, recreation and private properties along the impoundment. While dam removal can be expensive up-front, there is no long-term cost or maintenance required once the dam is removed.

DAM REMOVAL



FISH PASSAGE UP AND DOWN STREAM

Low Fish Passage — 1 2 3 4 5 — *High Fish Passage*

UPSTREAM WATER LEVELS

Potential Lowering of Water Levels — 1 2 3 4 5 — *Maintain Existing Upstream Water Levels*

RECREATION ON THE IMPOUNDMENT

Reduced Flat Water Recreational Opportunities — 1 2 3 4 5 — *Maintains Existing Flat Water Recreational Opportunities*

RECREATION ON THE RIVER

Maintains Existing Difficulties to River Recreation — 1 2 3 4 5 — *Improves River Recreation by removing hazards and portages*

VISIBILITY OF DAM

Dam Structure No Longer Visible — 1 2 3 4 5 — *Dam Structure Remains Visible*

WATER QUALITY

Maintain Existing Water Quality — 1 2 3 4 5 — *Improve Water Quality*

RISK OF DAM FAILURE

No Risk of Failure — 1 2 3 4 5 — *Maintain Existing Risk of Failure*

UP-FRONT COST

Less Expensive — 1 2 3 4 5 — *More Expensive*

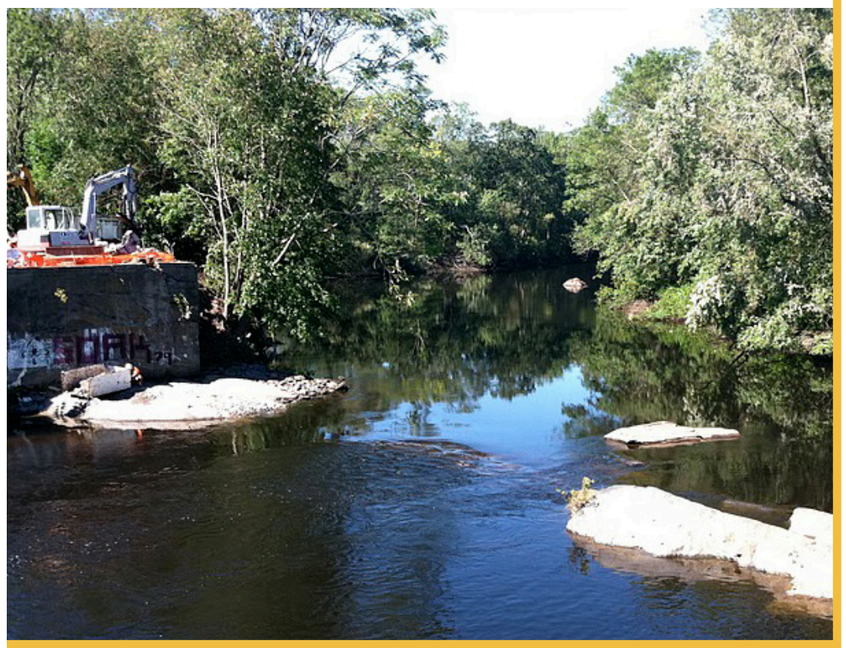
LONG-TERM COST AND MAINTENANCE

Lower Long Term Cost And Maintenance — 1 2 3 4 5 — *Higher Long Term Cost And Maintenance*

PAWTUXET FALLS DAM

PROJECT SUMMARY

In the 19th century, dams constructed along the Pawtuxet River helped to power Rhode Island's textile industry. Years of industrial use, including the release of untreated chemicals from the Ciba-Geigy chemical plant, left the river heavily polluted. Poor water quality led to declines in fish population and river access for the local community. After decades of investments aimed at improving water quality and habitat in the river, the decision was made to remove the Pawtuxet Falls Dam. For hundreds of years, the Pawtuxet Falls Dam blocked migratory fish passage as the first of many dams leading from the Narragansett Bay through the mill towns situated along the river.



LOCATION
Cranston and Warwick, RI

RIVER
Pawtuxet River

YEAR
2011

GOAL
Migratory fish passage

TYPE
Partial removal

COST
Approximately $1,000,000 including permits, engineering, and project management; construction cost of approx. $800,000

PROJECT PARTNERS
Pawtuxet River Authority & Watershed Council (PRA); Narragansett Bay Estuary Program; USDA Natural Resources Conservation Service; RIDEM; RICRMC; The Rhode Island Foundation; USEPA; National Oceanic and Atmospheric Administration; US Fish and Wildlife Service; American Rivers; Save The Bay; RI Saltwater Anglers Association; Friends of the Pawtuxet; Pawtuxet Village Association; City of Cranston; City of Warwick; Restore America's Estuaries; RI Rivers Council; RI Corporate Wetlands Partnership; Rhodes-on-the-Pawtuxet; Hunter's Garage 66.

CHALLENGES:

There were multiple hurdles that needed to be overcome before the dam could be removed. Design issues were complicated as stakeholders wished to minimize changes to the river's morphology. However, bedrock in the area was not stable enough to safely navigate river herring upstream and allow for a full dam removal. The water quality and sediment were degraded by more than a century's worth of upstream discharge of human and industrial waste, including the hazardous waste. Furthermore, at the time, it would have been the largest ecological dam removal undertaken in Rhode Island. Lastly, Pawtuxet Falls Dam was in a highly visible historic location and the dam and waterfall were part of the local landscape and sense of place.

SOLUTIONS:

In 2011, a project led by the Pawtuxet River Authority and Narragansett Bay Estuary Program, along with dozens of partners, used excavators to strategically demolish the concrete spillway. Native wetland plantings were installed along the newly exposed river banks to aid habitat restoration goals. Today, anadromous fish populations like river herring and American shad are once again able to travel upstream to spawn.

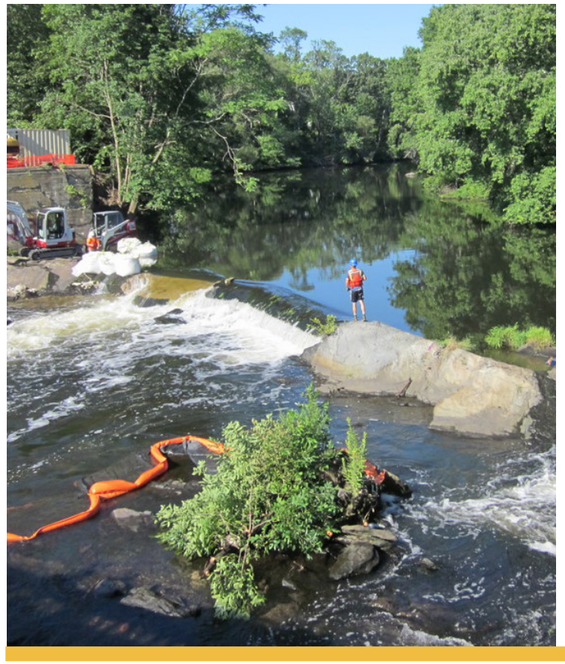
This project employed a process of ongoing public interaction, including advocacy on the part of a local business owner. Eight public meetings were held over four years, during which time, assessments and design plans were completed. During this process, the design was modified due to the bedrock conditions. The final design resulted in a portion of the dam staying in place to divert flow and fish in a way that promotes successful upstream migration.

SUCCESSES:

A NOAA representative reflecting on the process asserted that the biggest hurdle was consensus-building. Ultimately, community consensus was reached, and for the first time in three hundred years, this section of the river was able to flow freely into Narragansett Bay, restoring 7.5 miles of spawning habitat above the dam.

LESSONS LEARNED:

For highly visible dams, the public process is very important to build an understanding of the project trade offs and the varying community interests.



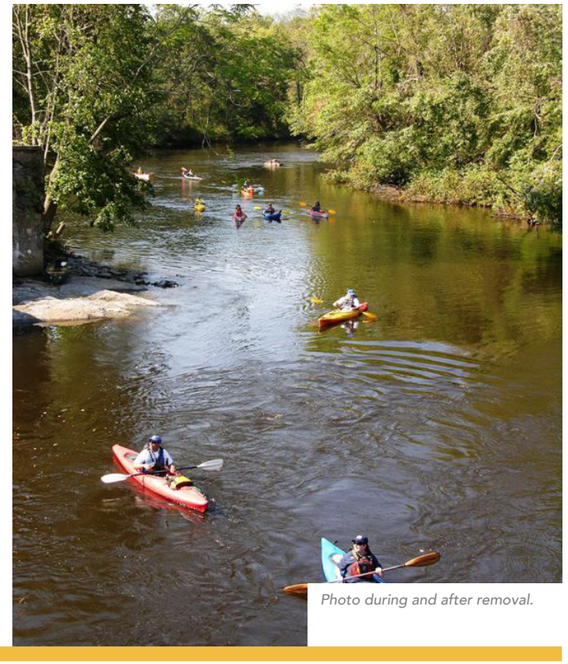


Photo during and after removal.

REFERENCES and ADDITIONAL RESOURCES

NBEP presentation: https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1212&context=fishpassage_conference

Cranston Herald Article: https://cranstononline.com/stories/village-celebrates-dam-removal-opening-pawtuxet-to-migratory-fish,63352

LOWER SHANNOCK FALLS

PROJECT SUMMARY

Lower Shannock Falls Dam, located on the Upper Pawcatuck River between Charlestown and Richmond, was erected in the early 1800's. This site contains historic significance to both the Narragansett Tribe and Anglo-European communities. The Lower Shannock Falls dam removal was part of a comprehensive project that opened fish passage through seven dams along the Pawcatuck River. The dam was removed in 2010 but modifications were made in 2011 to improve flow conditions.

LOCATION
Charlestown/Richmond, RI

RIVER
Pawcatuck River

YEAR
2010

GOAL
Migratory fish passage

TYPE
Complete removal with Historic Signage and Artifacts

COST
$843,470 including: Feasabilty Assesment (~$42,300), Design and Permitting ($187,260), Construction and Oversight ($588,910), Post- Construction Monitoing (~$25,000).

PROJECT PARTNERS
Wood Pawcatuck Watershed Association; Trout Unlimited; United States Fish and Wildlife Service; RI Coastal Resources Management Council; RI Department of Environmental Management; National Oceanic and Atmospheric Administration; Save the Bay; Richmond Conservation Commission; Town of Richmond; USDA Natural Resources Conservation Service; American Rivers; and Narragansett Bay Estuary Program.

CHALLENGES:

Initially, the neighboring community was not in favor of the design and construction that was needed for the dam to be removed. Some residents were worried that the diversion of the river during the construction process may have negative ecological impacts. Others were concerned that the site would not reflect its historical significance to both Anglo-Americans and the Narragansett Tribe . Additionally, others were worried that when the dam was removed, the water would be too turbulent to permit recreational use.

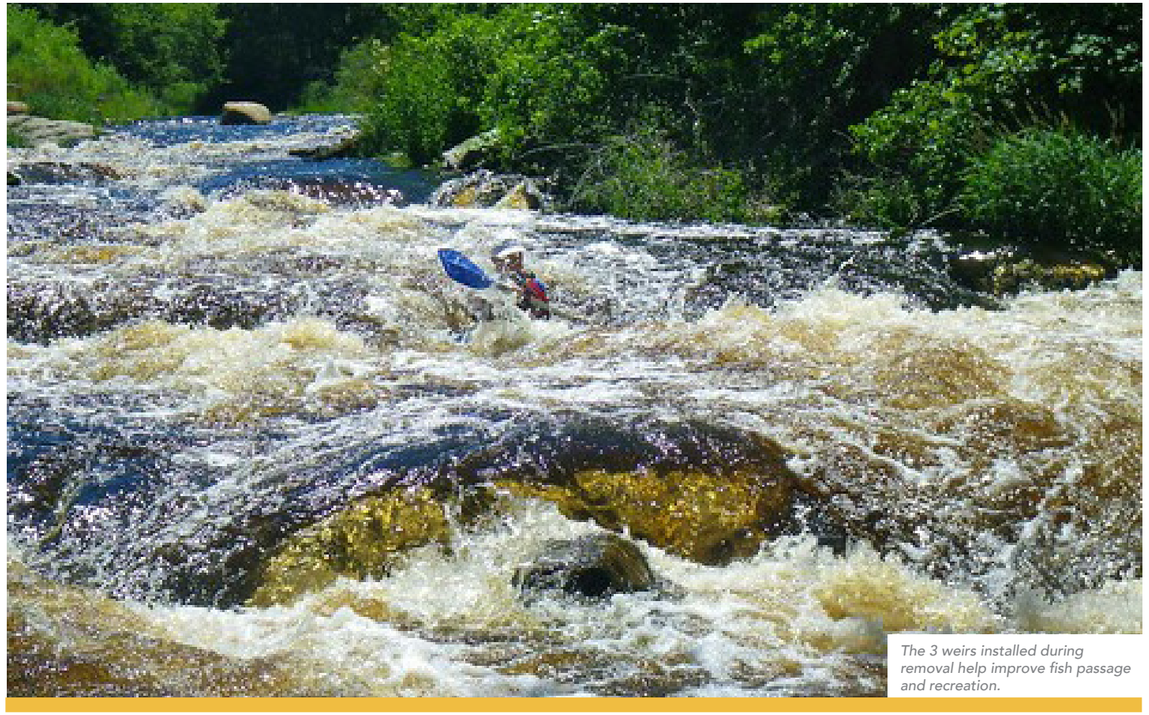
SOLUTIONS:

In 2010, the dam was removed and three weirs were installed to ensure that river flows met the migratory needs of the fish. The Knowles Mill Public Park was developed by the town of Richmond on the river bank below the falls providing trails as well as fishing and boating access downstream of the former dam. The historic smoke stack from the mill was left in place and interpretive signs were installed in the park to document the historic and cultural importance of the area.

SUCCESSES + LESSONS LEARNED:

Throughout the project, the project team consulted with the local community and the Narragansett Tribe. This collaboration allowed for the historical preservation concerns of the community to be addressed while allowing for the dam to be removed. By creating a public park surrounding the old dam site, public access to the river was enhanced. The history of the site is communicated through the preservation of ruins as well as signage in the park that displays historic photos.

The project benefited from a team experienced in fishery biology, hydrology/ hydraulics, sediment transport, and water management. Completing the weirs in "dry" conditions helped achieve elevations and other design features required for fish passage. Testing river flows during and following construction allowed site-specific modifications that would help fish in their migration up and down the river.



The 3 weirs installed during removal help improve fish passage and recreation.

REFERENCES and ADDITIONAL RESOURCES

NOAA's presentation: "Advancing Anadromous Fish Passage Efficiency Lower Shannock Falls Dam Removal Pawcatuck River, Rhode Island" https://www.estuaries.org/pdf/2010conference/tuesday16/galleon3/session3/turek.pdf

WHITE ROCK DAM

PROJECT SUMMARY

For over 200 years, there have been dams at the mouth of the Pawcatuck watershed. In 1938, these historic dams were replaced by the White Rock Dam. It spanned 108 feet across the Pawcatuck River and stood six feet high. The dam blocked most fish passage from the Atlantic Ocean into the Pawcatuck River. Although a raceway was available to migrating fish, it only passed fish under perfect stream conditions; studies showed that only 15 percent of fish were able to battle through the strong currents in the narrow channel. Flooding was another significant concern. Major flooding in 2010 damaged the structure, causing it to become a safety hazard.

LOCATION
Westerly, Rhode Island and Stonington, Connecticut

RIVER
Pawcatuck River

GOAL
Migratory fish passage; Flood abatement; Recreation enhancement

TYPE
Complete Removal

COST
$794,000

PROJECT PARTNERS
The Nature Conservancy; United States Fish and Wildlife Service; RI Coastal Resources Management Council; RI Department of Environmental Management; National Oceanic and Atmospheric Administration; the Wood-Pawcatuck Watershed Association; and Save the Bay.

add caption to picture on the left. Is this post removal? Looking up or down stream? Is the a per removal photos that can be added to help

CHALLENGES:

White Rock Dam was privately owned and adjacent to three other properties. It spanned across the Connecticut and Rhode Island border. One of the greatest challenges was that the dam was under the jurisdiction of two states.

SOLUTIONS:

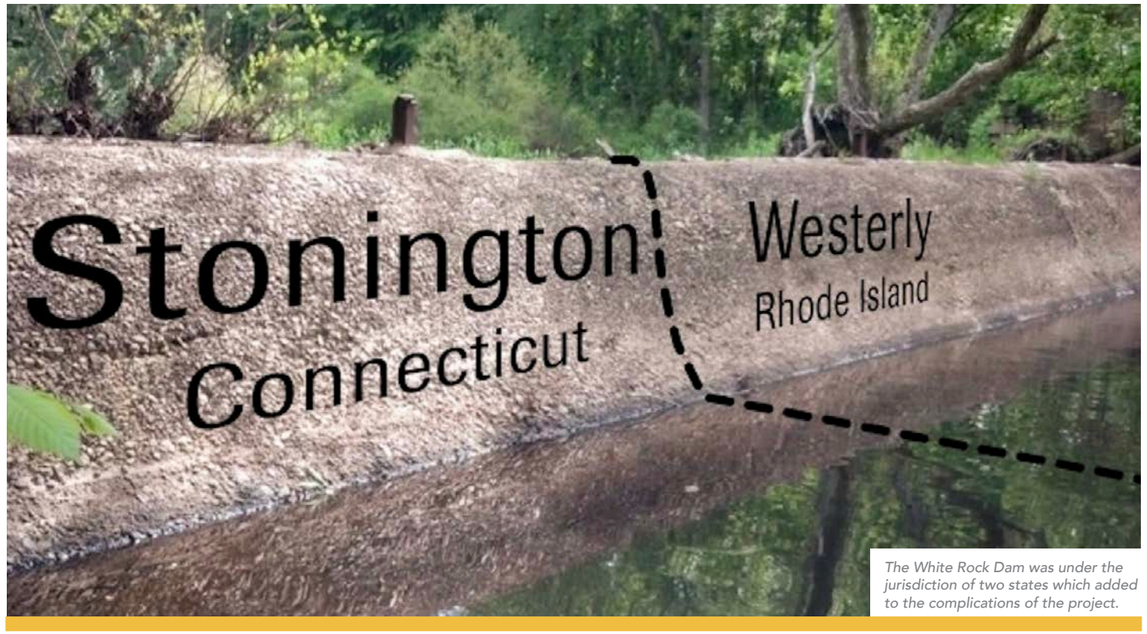
The removal of the White Rock Dam required stakeholder and decision-maker integration across both states. The owner of the dam, who would be liable for damages if the dam were to fail, allowed the removal of the dam. There was no significant push back from the owners of the other adjacent properties. Working across state boundaries provided significant permitting challenges, but coordination between government agencies and environmental organizations in both states allowed the process to move forward. Two separate filings -- an 800-page application in Connecticut and a 650-page application in Rhode Island -- resulted in approval of the dam removal permits.

SUCCESSES:

Removal of the dam eliminated a hazardous structure, which minimized possible flooding downstream while allowing diadromous fish species to regain passage to and from the ocean. The White Rock Dam was the first dam blocking migratory flow from the Narragansett Bay through the Pawcatuck River. The removal of the dam spurred subsequent projects upstream.

LESSONS LEARNED:

Cooperation with other agencies is necessary especially when working across state boundaries: Sally Harold, from the Connecticut chapter of The Nature Conservancy, stated, "A lot of it means we have twice as much work to do. We have two agencies to work with, but it also means we can double‑dip fisheries biologists from both sides, from both agencies, and there's been great cooperation between agencies and other project partners from both sides of the river."



The White Rock Dam was under the jurisdiction of two states which added to the complications of the project.

REFERENCES and ADDITIONAL RESOURCES

FUSS and O'NEILL: https://www.fando.com/project/white-rock-dam-removal/

https://www.ctpublic.org/environment/2015-09-08/dem-begins-white-rock-dam-removal-along-pawcatuck-river

MILL RIVER DAMS

PROJECT SUMMARY

Mill River, a 4-mile long tributary of the Taunton River, historically provided habitat and spawning grounds for migratory and resident fish, such as river herring, yellow perch, chain pickerel, American eel, and trout. The river was an active fishing location for native peoples for centuries until their forced removal from the area. At that point, colonists constructed a series of dams, which provided water and power to settlers, but cut off major fish runs. As a result of these obstructions and pollution from upstream manufacturing, a Massachusetts state report declared the river "dead" in terms of alewife population in 1921. In 2005, the decaying Mill River Dams were thrust into the national spotlight when Whittenton Dam nearly failed, forcing thousands of local residents to evacuate their homes and costing the city close to $1.5 million. Failure of the dam was narrowly avoided in this case, but community and regulatory attention turned toward finding solutions as dam failure may have led to major loss of life and property in downtown Taunton.

LOCATION
Mill River, Massachusetts

RIVER
Mill River

YEAR
Hopewell Mills 2012;
Whittenton 2013;
West Britannia 2018

GOAL
Reduce flooding risk, Migratory fish passage, Recreation and habitat enhancement

TYPE
Complete Removal of two dams; Reconstruction of one dam

COST
$1,574,000 (estimated total)
West Brittania Dam removal: $354,420
Whittenton Dam removal: $650,435
Morey's Bridge Dam (dam reconstruction, fish ladder/ eel ramp installation): $4.3 million (includes cost of bridge replacement)

PROJECT PARTNERS
The Nature Conservancy, NOAA, American Rivers, the Coastal America Foundation, the National Oceanic and Atmospheric Administration, the Massachusetts Division of Ecological Restoration, U.S. Fish & Wildlife Service, the Massachusetts Division of Marine Fisheries, Southeastern Regional Planning and Economic Development District, Save the Bay, USDA-Natural Resources Conservation Service, MA Department of Mental Health, MA Department of Transportation, Mass Audubon, Taunton River Watershed Alliance, Corporate Wetlands Restoration Program, Acuity Management and other dam owners.\

CHALLENGES:

Because multiple dams (West Brittania, Whittenton, and Morey's Bridge) were involved in this project, each had its own set of challenges.

SOLUTIONS:

In response to the near dam failure, risk posed to the surrounding communities, and an effort to reconnect the area to the Wild and Scenic Taunton River, three dams were removed over a series of years(Hopewell Mills in 2012, Whittenton in 2013, West Britannia in 2018). Morey's Bridge Dam was left in place, but a fish ladder and eel ramp was installed in 2012 as part of a bridge restoration project through the Department of Transportation.

SUCCESSES:

With a release of natural sediment held back by the dams, the river has begun to restore its natural channel, with increased biodiversity, and recreational access from the Narragansett Bay to the headwaters of the Mill River. The dam removals and reconstruction restored fish passage to 30 miles of habitat in the Taunton Watershed. River herring and sea lamprey have been reported in the area for the first time in 200 years. The project has also improved recreational access and reduced flooding threat to local communities--and has spurred secondary projects like the Weir Village Riverfront Park, which provides a waterfront walkway, boat ramp, and fishing pier.

LESSONS LEARNED:

The near-failure of the Whittendon Dam highlighted the dangers of neglected historic dams. Repairing the Whittenton Dam alone would have cost an estimated $1.9 million. The cost of removing the dams, restoring the river, and reducing dangerous hazards was far less costly and provided more beneficial outcomes for local residents and habitats along this stretch of the Mill River.

The Mill River Dams are a good example of the benefit of taking a "river approach" to addressing dams to improve habitat connectivity. Rather than only repairing or removing the failing Whittenton Dam, the team used the crisis as a catalyst to address multiple decaying dams along the Mill River and as a result were able to improve habitat connectivity along 30 miles of the river.

Vegetation growing in along the restored river edge and paddling the river without obstructions.

REFERENCES and ADDITIONAL RESOURCES

Nature Conservancy: https://www.nature.org/en-us/about-us/where-we-work/united-states/massachusetts/stories-in-massachusetts/mill-river-restoration/

MASS DER: https://www.mass.gov/service-details/mill-river-restoration#:~:text=The%20Hopewell%20Mills%20Dam,constructed%20at%20Morey's%20Bridge%20Dam.

DAM REMOVAL-
PRIORITIZING PUBLIC ACCESS

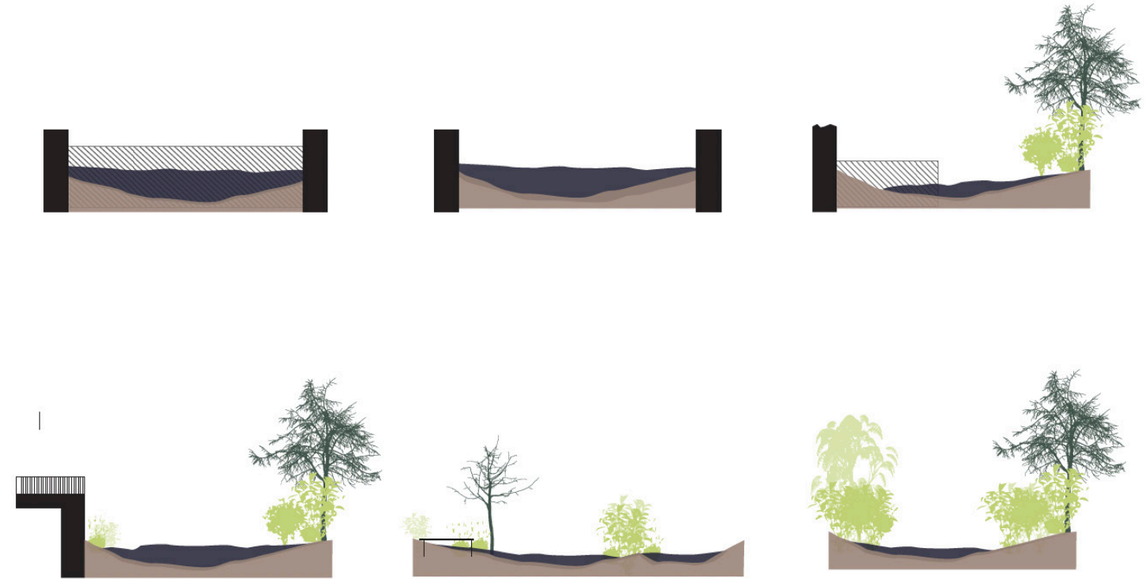
When dams are being considered for removal that are owned by state or local governments, there may be the possibility that removal can provide new public spaces adjacent to the river. These public spaces can provide public access to the river such as new walking trails, boat ramps, or fishing docks and help create or maintain a sense of place even if the landscape is changing. Landscape architects on the project team can work with the community to envision and design the future of public access to the surrounding landscape.

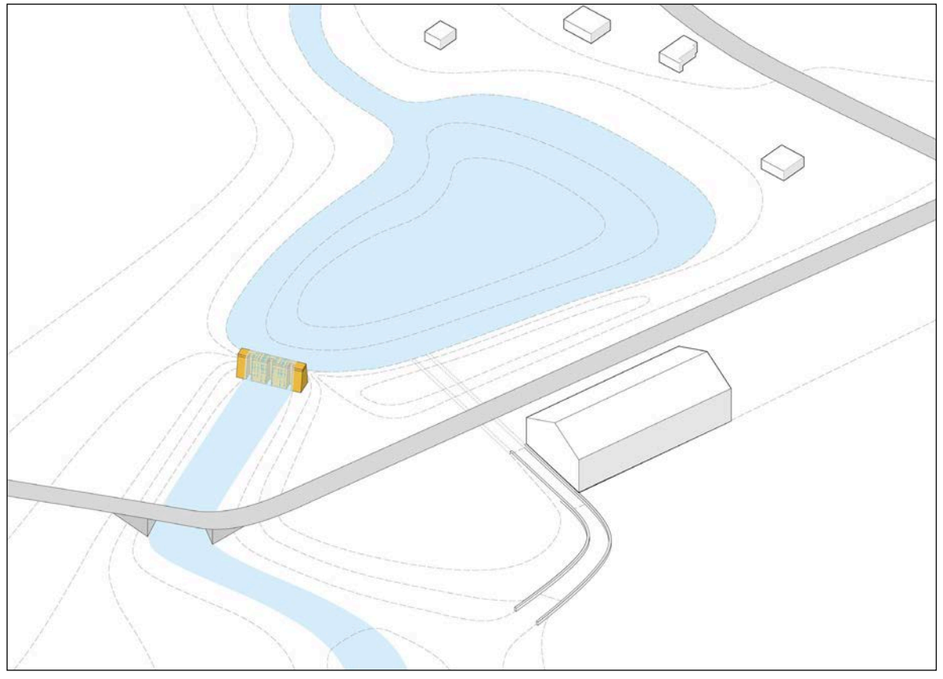
On some sites that are being considered for removal, the dam may be perceived as an important part of the local landscape and cultural history. There are design strategies that can help maintain a sense of place and/or preserve portions of the historic structures while restoring a free-flowing river.

Some examples include:

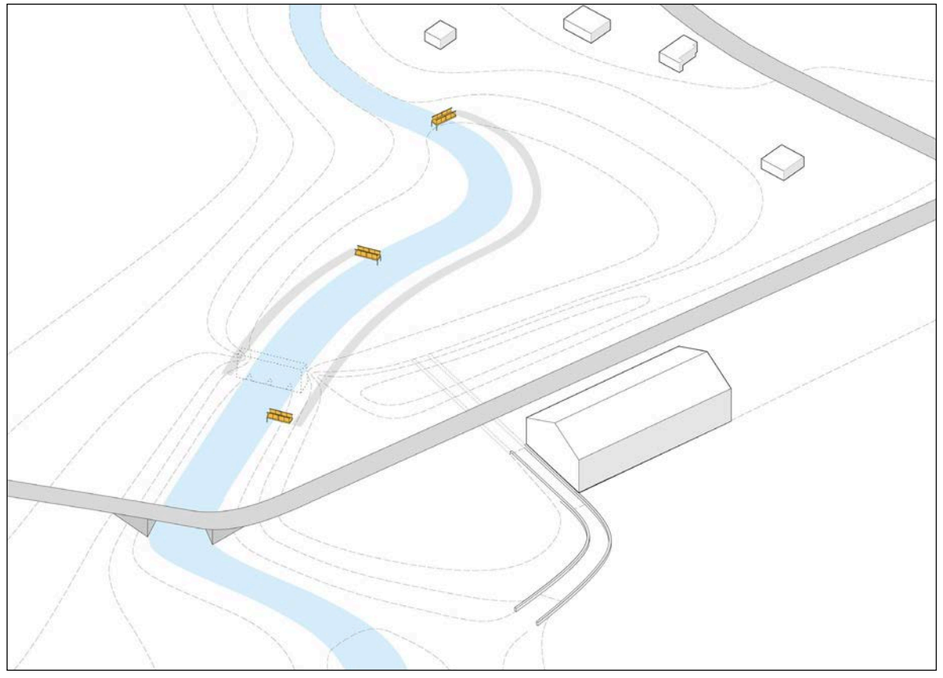
- A portion of the dam structure can be preserved on either side of the river channel to mark the historic location of the dam.
- The location of the dam can be marked with a piece of public art that can tell the history of the dam and site.
- The river can be diverted around the dam, but the structure can be preserved.
- Water features can be added that maintain the acoustic and aesthetics of the waterfall
- The area that was the impoundment can be maintained as a wet meadow to ensure views across the historic impoundment are maintained
- A trail at the historic elevation of the impoundment can be installed to mark its historic location
- Other features can be added that maintain the aesthetics of the dam and public access can be provided in the area surrounding the dam.

On the following pages, speculative ideas for how to design a site post removal are shared through a series of diagrams. In addition, there are a series of case studies where public access was a key aspect of the design.

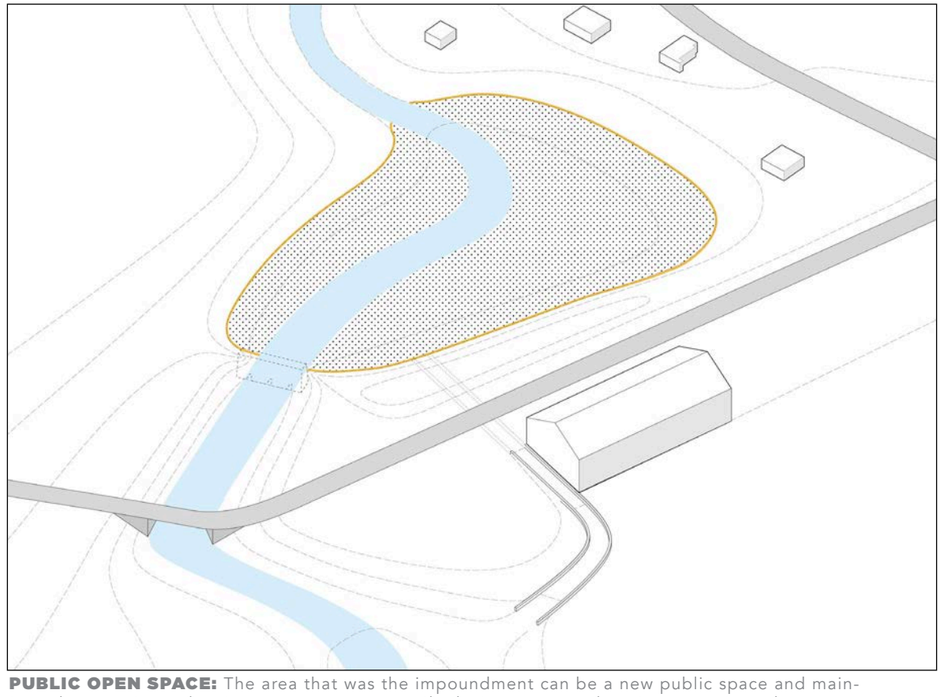




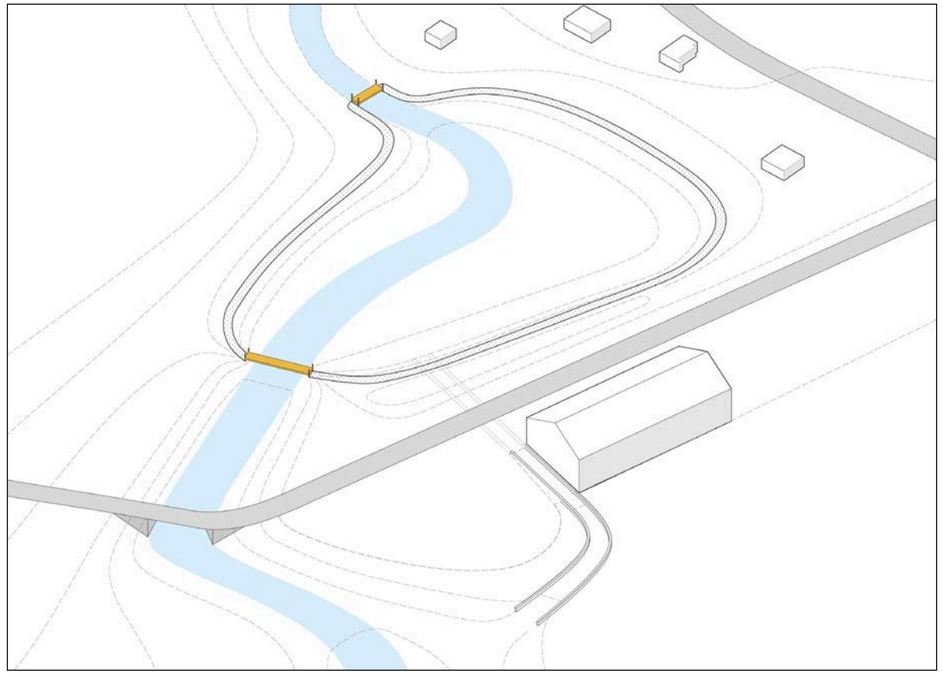
EXISTING CONDITIONS: Diagram of Existing Conditions- Dam and impoundment.



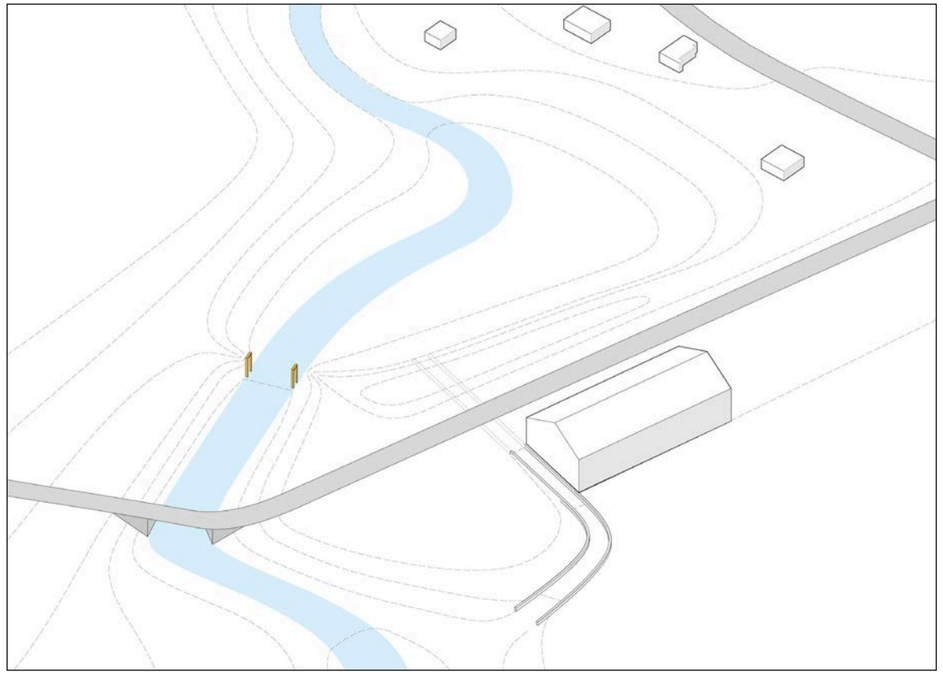
FISHING ACCESS: Fishing docks or rocks can be installed along river to improve fishing access and improve recreation.



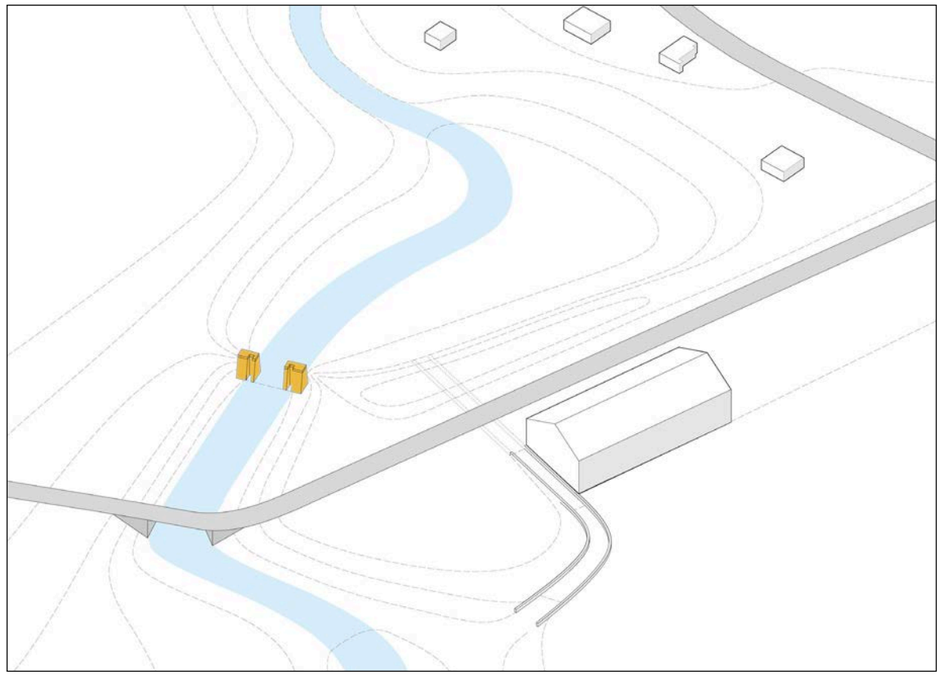
PUBLIC OPEN SPACE: The area that was the impoundment can be a new public space and maintained as a wet meadow to ensure views across the historic impoundment are maintained.



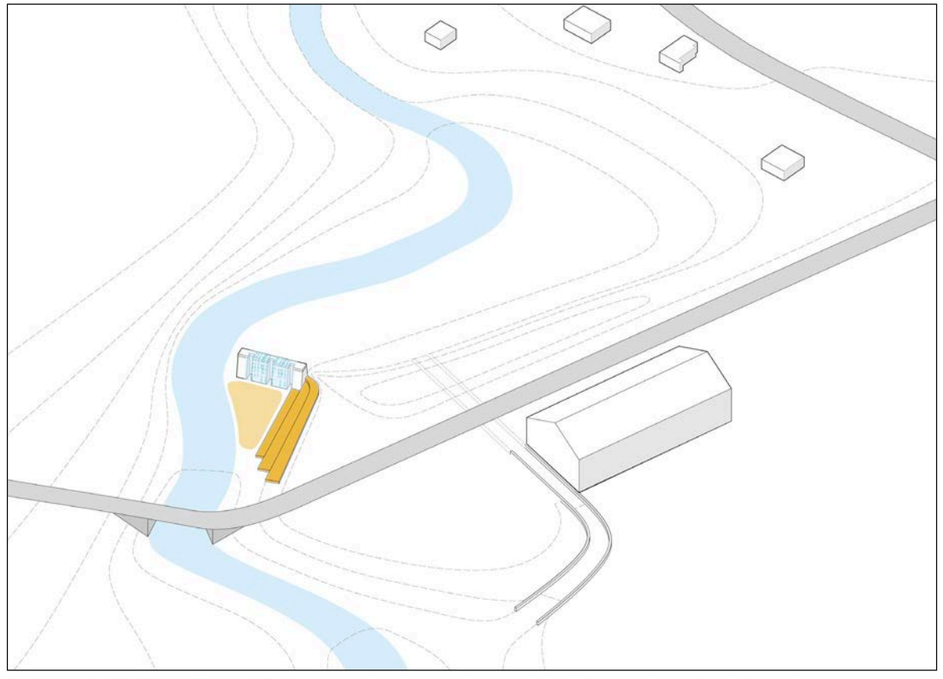
PATHS: Path can mark the location of the historic impoundment or provide trails to acccess the floodplain.



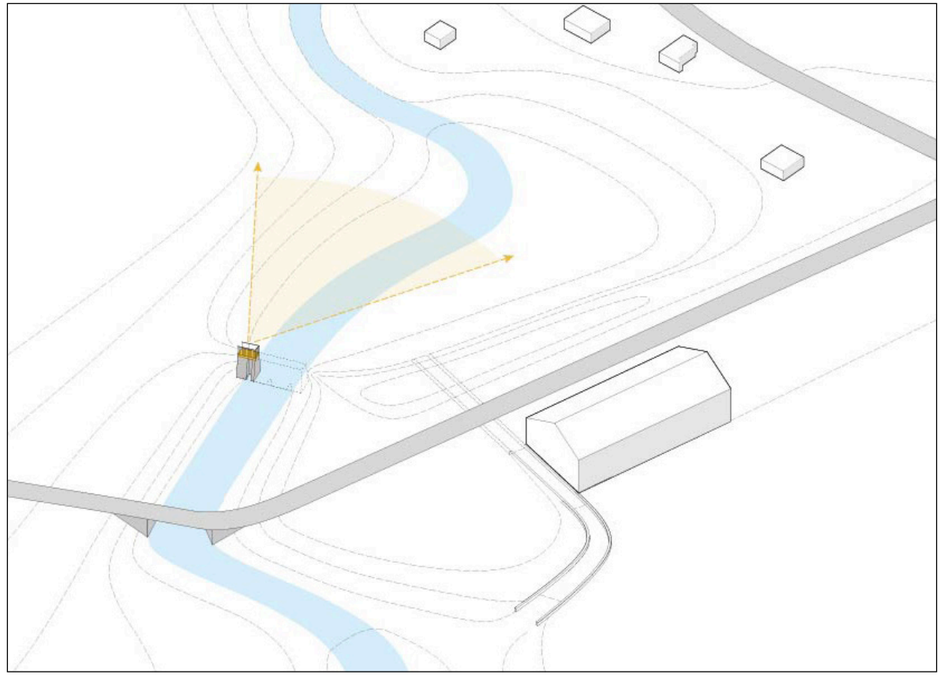
PUBLIC ART: Public Art sculptures can be installed to mark the historic location of the dam.



HISTORIC STRUCTURE: A portion of the dam can remain to mark the historic location and honor the history of the dam.



PUBLIC GATHERING SPACE: River can be diverted around the historic dam. A public gathering space can be constructed adjacent to the historic structure and a water feature installed to maintain the aesthetics of the waterfall.



OVERLOOK: An overlook can be constructed on top of the historic dam structure to provide views of the river.

Rendering showing the possibility of installing public art to mark the location of a removed dam.

CASE STUDIES - REMOVAL

KENT DAM AND WATERFALL

PROJECT SUMMARY

Although outside of the Narragansett Bay watershed, the Kent Dam case study is a useful example of a project that provided habitat connectivity, improved water quality, and historic preservation of a dam structure. The Cuyahoga River in Kent, Ohio has been a vital resource for people of the river valley since approximately 9,000 BC--acting as a travel corridor, water supply, and hunting and fishing grounds. The arch-shaped Kent Dam was constructed in 1836 to power various mills in the rapidly-industrializing Kent area. Because it is the oldest masonry dam in Ohio and the second oldest arch-shaped dam attached to a canal lock in the US, it has become an iconic feature of the city. However, after falling into disuse in the early 20th century, it caused dam pool stagnation, obstructed fish passage, and led to other water quality issues. The nation's attention was drawn to the Cuyahoga River in 1970, when industrial and sewage waste caused the river to catch fire. This event, along with others across the country, spurred the adoption of the Clean Water Act, which was passed in 1972 in an effort to "restore the chemical, physical and biological integrity of the nation's waters."

LOCATION
Kent, Ohio

RIVER
Cuyahoga River

YEAR
2005

GOAL
Improved water quality, Historic preservation, Migratory fish passage, Aquatic habitat

TYPE
Partial removal with historic preservation

COST
$5,013,150

PROJECT PARTNERS
The Ohio EPA; Kent Dam Advisory Committee; The City of Kent.

FUNDING SOURCES
The City of Kent
Ohio EPA WRRSP Grants
Clean Ohio Fund Grant
Ohio Department of Natural Resources Grant
Ohio EPA Section 319 Grant

CHALLENGES:

The stretch of the Cuyahoga River that ran through the defunct Kent Dam was cited for noncompliance with the Clean Water Act by the Ohio EPA for exceeding pollutant concentrations. The EPA informed the City of Kent that they must pursue a modification-removal of the dam or face more stringent permitting limits at the City's Water Reclamation Facility. Because this permitting would be costly to Kent taxpayers and have little benefit to the quality of the river, the City of Kent began the processes of review and public engagement necessary to remove the dam with historic preservation.

SOLUTIONS:

Due to the potential conflict between historical preservationists and environmental advocates, the city created a 19-member Kent Dam Advisory Committee (KDAC). Their goal was to examine feasibility and decision-making pathways by studying factors like applicable laws and regulations, water quality issues, historical significance, and fish migration routes. After several meetings, the KDAC proposed a solution: the removal of a concrete wall that had been placed across the old lock area. This removal would allow water to flow around the arch dam, which would improve water quality and allow fish passage while maintaining the historic arch structure. Tannery Park was constructed surrounding the historic arch dam and a pump circulates water so water continues to flow over the front of the dam.

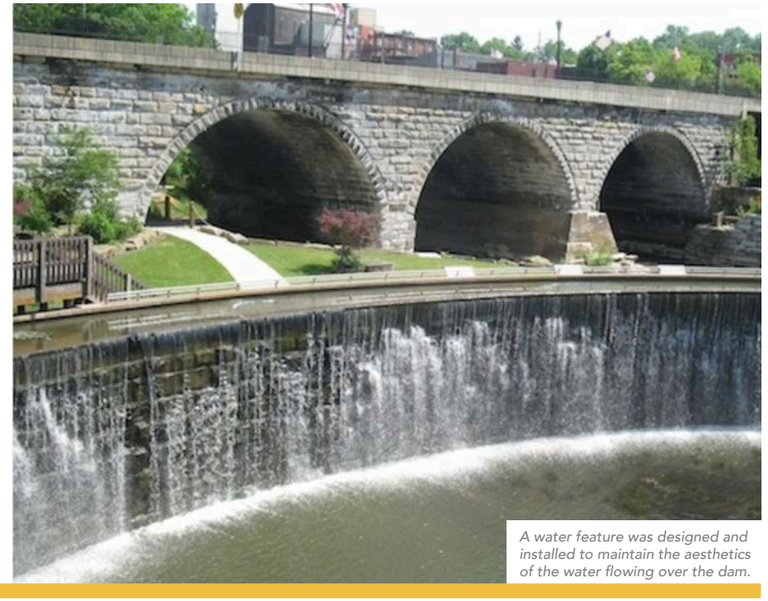
SUCCESSES:

By removing part of the dam to create a by-pass channel around the arch dam structure, the health of the river was restored without jeopardizing the historical aspect of the dam or interfering with the city's identity. Since the partial removal of the dam, once-stagnant pools that emitted a foul odor are now flowing and allows for migratory fish passage. Dissolved oxygen levels at Kent Dam have improved. Also, the adjacent Tannery Park was expanded to allow increased public access to the historic landmark.

LESSONS LEARNED:

By creating an advisory committee dedicated to research and resolution, the project team was able to reach a solution that met the needs of the environment as well as the citizens of Kent. Because so much national attention was focused on the project, early involvement spurred the Clean Water Act, strategies of engagement, analysis, and implementation; it even helped to inform similar projects across the country.

The Kent Dam is also a good example of a project that was able to achieve the dual goals of habitat connectivity and historic preservation. By creating a public park at the dam site, the history of the site and sense of place was able to be preserved and possibly enhanced. In addition, by adding a water feature to the arch dam artifact, the aesthetic and acoustic experience of being near a waterfall was preserved.



A water feature was designed and installed to maintain the aesthetics of the water flowing over the dam.

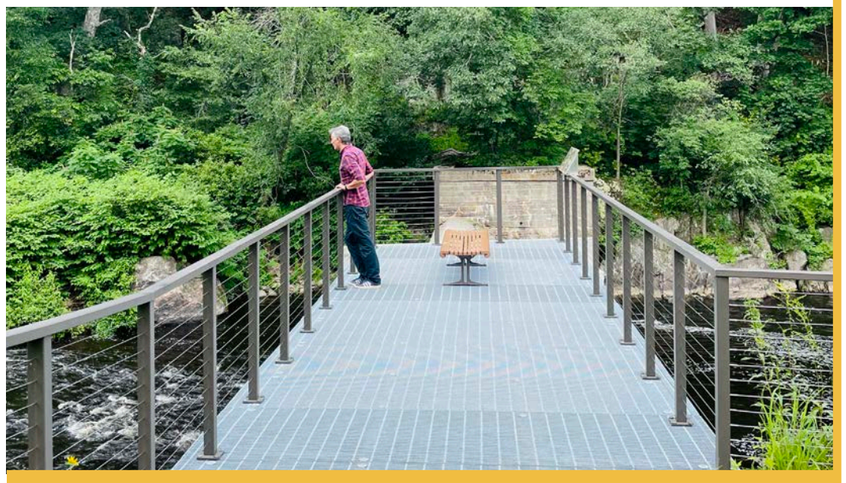
REFERENCES and ADDITIONAL RESOURCES

City of Kent: https://www.kentohio.org/409/Dam-Restoration-Project

HEAD TIDE DAM

PROJECT SUMMARY

Although outside of the Narragansett Bay watershed, the High Tide Dam in Alna provides a case study of a partial removal of a dam. The project consisted of the removal of 26 feet of the west side of the dam, the construction of an overlook in its place, construction of a retaining wall at the foundation of an old mill, and the addition of a path to the river. The modification of the Alna dam is the second project in a series of three projects aiming to improve fish passage in the Sheepscot River, improve public safety and access, and honor the history at the individual sites. The first of the three projects, completed in 2018, was the removal of the Coopers Mills Dam in Whitefield upstream of the Head Tide Dam. The third project, at Branch Pond Mill Dam in the town of China, Maine, will stabilize the dam and install a fishway. Together the project aims to improve fish passage on the Sheepscot River which is home to the southernmost genetically unique wild populations of Atlantic salmon remaining as well as 11 other species of migratory species.



LOCATION
Alna, Maine

RIVER
Sheepscot River

YEAR
2019

GOAL
Improve fish passage, enhance public safety and access, and honor the history of individual sites.

TYPE
Partial Removal

COST
$515,000.

PROJECT PARTNERS
Town of Alna, Atlantic Salmon Federation (ASF), The Nature Conservancy, Midcoast Conservancy, National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service, Maine Department of Marine Resources, Maine Department of Environmental Protection, and the National Fish and Wildlife Foundation.

FUNDING SOURCES
NOAA Community Habitat Restoration Program, US Fish and Wildlife Service, Enbridge Corporation, The Nature Conservancy, Elmina B. Sewall Foundation, Davis Conservation Foundation, Patagonia, Farnsworth Foundation, Trout and Salmon Foundation and others.

CHALLENGES:

The Head Tide Dam was constructed over 250 years ago to power a series of mills in Alna. The Jewett family donated the dam to the town in 1964. One of the main challenges in the project was deciding whether work could proceed due to a covenant in the deed stating the dam could never be destroyed.

SOLUTIONS:

To address the concerns about the legal deed covenant, the decision was made to partially remove the western portion of the dam. The partial dam removal and construction of the overlook platform – which maintained "one contiguous line from shore to shore" – was deemed acceptable by Alna selectmen and legal counsel as complying with the legal deed covenant. In addition, the partial removal maintained a portion of the historic structure as a landmark for the community.

Public access was an important aspect of the redesign of the site. Over the western portion of the river where the dam was removed, an elevated ADA accessible viewing platform was constructed. The viewing platform provided a space for informational signage and a lookout onto the river. By using a grate rather than concrete for the elevated walkway, the project team hoped that it wouldn't deter shad which can be sensitive to passing under concrete. The final design maintained and strengthened recreational opportunities at the site. By maintaining part of the dam, a swimming hole that has been a popular destination for generations was preserved. In addition, the pedestrian path down to the river provided access to the river and a safe place to put in and take out kayaks and canoes.

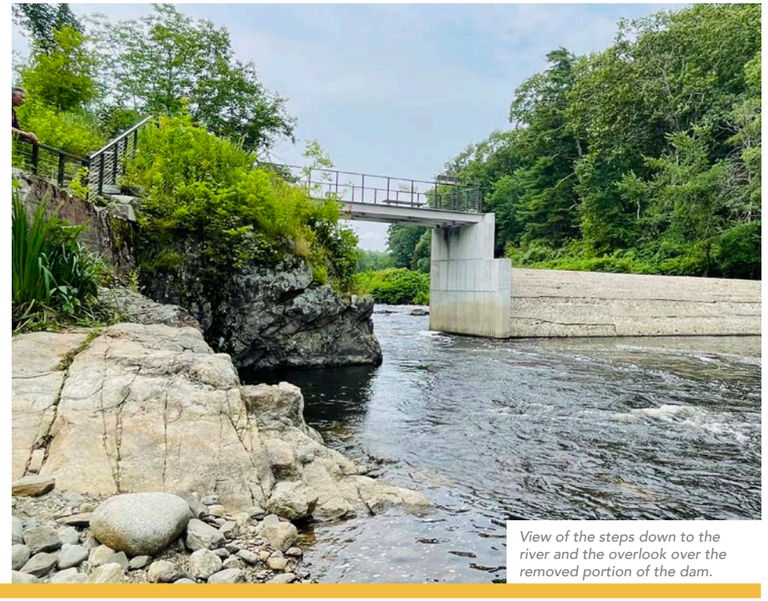
SUCCESSES:

The partial removal of the Head Tide Dam is a good example of the ability to think and work creatively to address legal limitations on a project. It also was successful in providing habitat connectivity as well as preserving the historic dam structure that was important to the community.

LESSONS LEARNED:

The partial removal of the Head Tide Dam dam resulted from a strong team that worked on the project. The restoration team did not go into the community with a preconceived idea of what needed to happen but rather worked with the community to decide how to improve fish passage and river connectivity.

Just because there are legal challenges or deed restrictions on a dam, doesn't mean that modifications can not be made to a dam. This project highlights the opportunity to think creatively to work through legal challenges and deed restrictions.



View of the steps down to the river and the overlook over the removed portion of the dam.

REFERENCES and ADDITIONAL RESOURCES

https://atlanticsalmonrestoration.org/projects/magic-on-the-river

https://lcnme.com/currentnews/work-starts-at-head-tide-dam-in-alna/

https://lcnme.com/currentnews/head-tide-dam-project-a-gift-thats-going-to-outlive-us-all/

FISH LADDERS

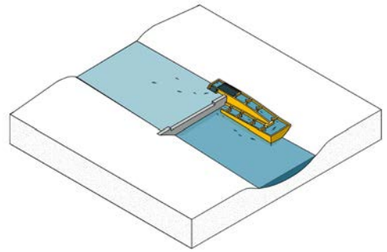
A conventional fishway, commonly nicknamed “fish ladder,” is a structure that is built alongside an existing dam that is intended to provide a corridor for aquatic species to swim up and over the dam barrier, then back down. Conventional fishways may be an option where there is a desire to provide some fish passage without removing the dam. Selecting the most appropriate fishway for a given project will depend upon the slope, budget, flow conditions, and target species.

Those unfamiliar with fish ladders may be surprised at the complexities and challenges that must be overcome for these to function well with a variety of species (e.g., river herring, shad, eels) and life stages (juvenile vs. adult). Fish vary dramatically in their swimming speed, stamina and leaping ability. The slope, turbulence, placement of resting areas and other design features are essential elements. Unfortunately, a “one-size-fits- all” approach with fishways rarely works. In addition, fish seek particular velocities and pathways through a river channel as they move upstream. If the entrance placement and water flow out of a fish ladder does not match preferred conditions, migrating fish will not use the ladder and can mass in huge numbers at the base of a dam – negating the entire fish ladder. The design of fish ladders that will accommodate multiple fish species and life stages is not yet a mature science and many fish ladders require costly alterations after construction.

If a dam has received a letter of deficiency, the dam would need to be repaired prior to constructing the fishway. In addition to this upfront cost, this scenario requires long-term maintenance of the dam and the fishway. Conventional fishways vary in cost, aesthetics, and performance depending on the design and dam structure. They are not inexpensive and frequently cost upwards of half a million dollars.

There are 3 general types of conventional fishways found within Narragansett Bay Watershed: Denil fishway, Alaskan steeppass fishway and Weir and Pool fishways.

TECHNICAL FISH LADDERS



FISH PASSAGE UP AND DOWN STREAM

Low Fish Passage — 1 2 3 4 5 — *High Fish Passage*

UPSTREAM WATER LEVELS

Potential Lowering of Water Levels — 1 2 3 4 5 — *Maintain Existing Upstream Water Levels*

RECREATION ON THE IMPOUNDMENT

Reduced Flat Water Recreational Opportunities — 1 2 3 4 5 — *Maintains Existing Flat Water Recreational Opportunities*

RECREATION ON THE RIVER

Maintains Existing Difficulties to River Recreation — 1 2 3 4 5 — *Improves River Recreation by removing hazards and portages*

VISIBILITY OF DAM

Dam Structure No Longer Visible — 1 2 3 4 5 — *Dam Structure Remains Visible*

WATER QUALITY

Maintain Existing Water Quality — 1 2 3 4 5 — *Improve Water Quality*

RISK OF DAM FAILURE

No Risk of Failure — 1 2 3 4 5 — *Maintain Existing Risk of Failure*

UP-FRONT COST

Less Expensive — 1 2 3 4 5 — *More Expensive*

LONG-TERM COST AND MAINTENANCE

Lower Long Term Cost And Maintenance — 1 2 3 4 5 — *Higher Long Term Cost And Maintenance*

HORSESHOE FALLS DAM

PROJECT SUMMARY

Located in Shannock Village on the Upper Pawcatuck River, the Horseshoe Falls Dam was built around 1759. The last working mill burned down in 1856, but the dam remained and repairs were made over the years. Rich in both cultural and historical value and located in a well-populated area, the dam was not a good candidate for complete or even partial removal, as the site is well known and appreciated for its aesthetic value. In 2010, the community and the local stakeholders decided to build a Denil fishway and eel passage structure. The Horseshoe Falls fish ladder installation was part of a comprehensive project that opened fish passage through seven dams along the Pawcatuck River.

LOCATION
Charlestown/Richmond, RI

RIVER
Pawcatuck River

YEAR
2010

GOAL
Migratory fish passage + historic preservation

TYPE
Denil Fishway

COST
$628,469

PROJECT PARTNERS
Wood Pawcatuck Watershed Association; Kenyon Industries, Inc; Town of Charleston; Trout Unlimited; United States Fish and Wildlife Service; RI Coastal Resources Management Council; RI Department of Environmental Management; National Oceanic and Atmospheric Administration; Save the Bay; Richmond Conservation Commission; Town of Charlestown; USDA Natural Resources Conservation Service; American Rivers; Fuss and O'Neill; and Narragansett Bay Estuary Program.

CHALLENGES:

Removal of the dam was challenged as the Horseshoe Falls Dam was a local landmark widely appreciated for its scenic beauty. It is the only horseshoe-shaped falls in Rhode Island. Many perceive Horseshoe Falls Dam as an historically significant part of the state's industrial heritage.

SOLUTIONS:

Due to the dam's scenic beauty and historical importance, the restoration project required sustained outreach to ensure all stakeholders were heard and all interests were met. An elaborate state of the art Denil fishway was designed to allow alewife and eel passage. To ensure the fishway did not look out of place, engineers shaped the exterior of the fishway to match the stones of the original mill foundation on the opposite bank.

SUCCESSES:

This project was able to meet the dual objectives of improving fish passage and the preservation of the historic arch dam structure.

LESSONS LEARNED:

The Horseshoe Falls Dam fishway project demonstrates that there is room for flexibility in discussions between dam removal and historic preservation. Creative alternatives can achieve project goals like fish passage without compromising the aesthetic of a cherished landmark.

The fishway at Horseshoe falls was designed to match the stonework of the historic mill foundation.

REFERENCES and ADDITIONAL RESOURCES

Wood Pawcatuck Watershed Association's presentation:
http://www.wpwa.org/documents/WPWA%20Horseshoe%20Presentation.pdf

MANTON MILL POND DAM

PROJECT SUMMARY

The Woonasquatucket River has been designated an "American Heritage River" by the U.S. Environmental Protection Agency (EPA) for its legacy of use for food and energy before and during the Industrial Revolution. Since the 1990's, the Woonasquatucket River Watershed Council has been working to restore the health of the river and provide access and recreation opportunities for the surrounding community. This work has included the restoration of dams within the river as well as upgrades to a Greenway network that runs adjacent to the river. The fishway installed at Manton Mill Pond Dam is the fifth in a series of dam removal and fish passage projects along the lowest stretch of the Woonasquatucket River.

LOCATION
Providence, Rhode Island

RIVER
Woonasquatucket River

YEAR
2016

GOAL
Migratory fish passage, Public art, Education

TYPE
Denil Fishway

COST
$492,000

PROJECT PARTNERS
Woonasquatucket River Watershed Council (WRWC), Rhode Island Department of Environmental Management (DEM), Rhode Island Coastal Resources Management Council (CRMC), EA Engineering, U.S. Department of Agriculture (USDA), Preferred Equipment Resource.

CHALLENGES:

The dam is a concrete run-of-river dam. Located downstream of the Centredale Manor Superfund site in North Providence, the Manton Mill dam accumulated toxic sediment (dioxins) from chemical production that took place from the 1940s-1970s. Because these pollutants are persistent, dam removal could pose danger to communities and habitats downstream. Therefore, the decision was made to add a fish ladder rather than remove the dam.

SOLUTIONS:

Before construction of the fishway could begin, areas of toxic, dioxin-impacted sediment were removed from the site. The fishway was designed with S-shaped concrete walls with a series of pools and weirs that allow for upstream migration.

SUCCESSES:

Completed in 2016, the new fishway was designed to allow up to 40,000 herring to migrate upstream each year. The S-shaped fishway allows other project goals to be met as well; public art pieces were incorporated into its concrete surface and it is an ideal location to observe the spring fish migration. Local schools have begun to use the new fishway as an educational tool--bringing students to the Woonasquatucket to teach them about habitat restoration.

LESSONS LEARNED:

Because dams within New England were typically constructed to support industrial activities, toxic sediment accumulation behind a dam is a common concern. In order to mitigate the potential impact of dam removal releasing toxic sediments downstream, it is often necessary to keep the dam when contaminated sediments are present.

The S-shape structure provided the elevation change needed between the pond and river below dam.

REFERENCES and ADDITIONAL RESOURCES

Woonasquatucket River Watershed Council: https://wrwc.org/wp/what-we-do/restoration/fish-passages/

GILBERT STEWART DAM

PROJECT SUMMARY

Gilbert Stuart Stream is the largest freshwater tributary to the Narrow River, which empties into the Narragansett Bay. For over a century, a small dam located at the historic home of artist Gilbert Stuart has impeded the passage of migratory river herring, who travel up the Narrow River via Gilbert Stuart Stream and into Carrs Pond to spawn. In the 1960's, Rhode Island's Division of Fish and Wildlife installed an Alaskan steeppass fish ladder that allowed thousands of migrating river herring to pass to Carrs Pond.

LOCATION
North Kingstown, RI

RIVER
Gilbert Stuart Stream / Narrow River

YEAR
1960's (fish ladder),
2021 (picket weir)

GOAL
Migratory fish passage

TYPE
Alaskan steeppass fishway

PROJECT PARTNERS
Gilbert Stuart Birthplace & Museum, Rhode Island Division of Fish and Wildlife (1960's fish ladder) The Nature Conservancy, the RI Department of Environmental Management (DEM), Horace and Ella Kimball Foundation, Narragansett Improvement and Preservation Foundation, Rhode Island Saltwater Anglers (picket weir).

CHALLENGES:

Although the 1960's fish ladder allowed herring to pass to Carrs Pond above the dam, a junction that led to a mill race frequently attracted and confused the fish, forcing them to choose the wrong path. If the herring turned into the mill run instead of the fishway, they were prone to becoming trapped and ultimately dying.

SOLUTIONS:

The Gilbert Stuart Museum was able to maintain the character of the historic dam by implementing a barrier that would allow water, but not fish, to pass through the mill run. The blocking structure, known as a picket weir, resembles a picket fence and is aesthetically consistent with the historic character of the surrounding property. This picket weir is a novel alternative to the Department of Environmental Management's practice of using temporary plastic fencing, which can be visually distracting and prone to failure during high flow.

SUCCESSES:

In recent years, between 30,000 and 100,000 herring may be seen migrating up the Gilbert Stuart fish ladder. The Gilbert Stuart Birthplace & Museum hosts an annual spring fair, where visitors are encouraged to watch the herring run from trails and bridges, as well as via an underwater camera stream. The Shady Lea Mill dam, situated above Carrs Pond on the Mattatuxet River, was designated as a "high hazard" and was removed in 2018. This subsequent project opened an additional ½ mile of river to the herring, eels, and trout.

The Alaska steeppass is a prefabricated, modular style of Denil fish ladder.

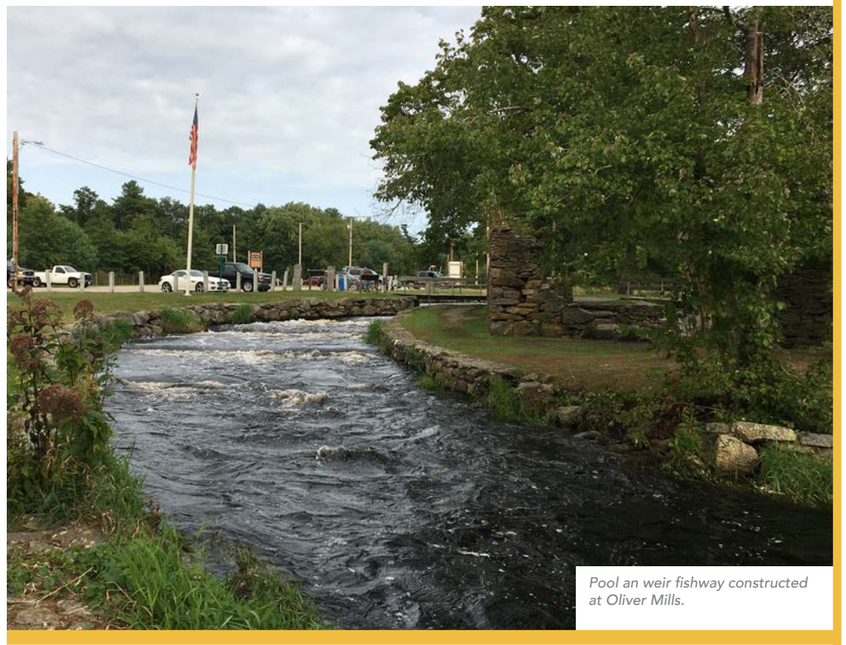
REFERENCES and ADDITIONAL RESOURCES

Narrow River Preservation Association: https://narrowriver.org/river-herring/

OLIVER MILLS (MUTTOCK) DAM

PROJECT SUMMARY

The Nemasket River supports the largest and longest herring run in Massachusetts. The herring make the yearly 40-mile journey from Mount Hope Bay through the Taunton and Nemasket River to the Assawompset Pond Complex to spawn. Members of the Wampanoag Tribe built weirs to catch migrating herring each spring in a village at Muttock (now Oliver Mills area). In 1734, the weirs were replaced by a dam, which was used to power iron works, grist, and saw mills serving the colony of Middleborough until it was abandoned in the 1870s. Throughout this period, the site remained an active fish run, with highly organized yearly efforts to catch and distribute the passing herring, which were cooked and distributed at the nearby community herring house. The Oliver Mills dam is the first of three dams on the Nemasket River between the undammed Wild and Scenic Taunton river and the valuable spawning grounds of the Assawompset Pond Complex.



Pool an weir fishway constructed at Oliver Mills.

LOCATION
Middleborough, MA

RIVER
Nemasket River

YEAR
1982

GOAL
Migratory fish passage

TYPE
Pool and Weir Fishway

COST
Unknown

PROJECT PARTNERS
Massachusetts Division of Marine Fisheries.

CHALLENGES:

The mill and dam remained in a state of abandonment until the 1960's, when Oliver Mill Park was opened surrounding the dam and historic industrial ruins. Herring populations in the Nemasket River declined dramatically during this time, with a mysterious die-off event in 1965. Low water levels and invasive plants exacerbated the issue and prompted proposals to reestablish fish passage on the river.

SOLUTIONS:

The fishways at Oliver Mill were initiated by an effort to restore the ecological and cultural heritage of the Nemasket River. During the 1960's and 1970's the site was partially restored for recreation, fish passage, and to preserve the industrial archeological site. During this time, two stone fish ways were installed. In 1982, the Massachusetts Division of Marine Fisheries built a new stone and concrete notched weir-pool fishway. In 1996 the Middleborough-Lakeville Herring Fishery Commission was created to administer and enforce herring harvest regulations, maintain and enhance herring habitat, and public education on the herring run.

SUCCESSES + LESSONS LEARNED:

The Nemasket River is relatively short (11.2 miles) with only 3 dams between the ocean and the 1,721 acres of prime spawning grounds of the Assawompset Ponds. Taking a whole river approach, fishways have been constructed at all three dams, allowing fish passage into the ponds. In 2013, almost one million herring were able to pass through the fishway at Oliver Mill to spawn in Assawompset Pond!

The communities of Middleborough and Lakeville have been shaped by the abundance of herring in the Nemasket River. In addition to the ecological value of the annual hearing run, it is also an important social and cultural event. Community support to preserve the yearly fish run helped to spur the restoration of the river and the fish migration. Since 2013, local and state Cultural Councils and the Middleborough Tourism Committee have hosted the Annual Herring Run festival to bring the community together to celebrate the fishrun. These celebrations help to reinforce the relationship between the community and the herring, ensuring the herring remain an important part of the local identity and helping to spur continued stewardship and involvement in preserving and improving the annual fish runs.

This case study is also an example of how a fishway can be integrated into a public park to achieve multiple objectives. With the creation of the Oliver Mill Park, the project was able to achieve the shared goals of improving fish passage, providing recreation, and preserving history. The fishways are integrated into the design of the park allowing the fishruns to be highly visible. Oliver Mill park provides paths for visitors to see the historic stone mill ruins and bridges that cross the multiple river channels and allow visitors to see the herring run below. In 2000, Oliver Mill Park was listed on the National Register of Historic Places as the Muttock Historic and Archeological District.

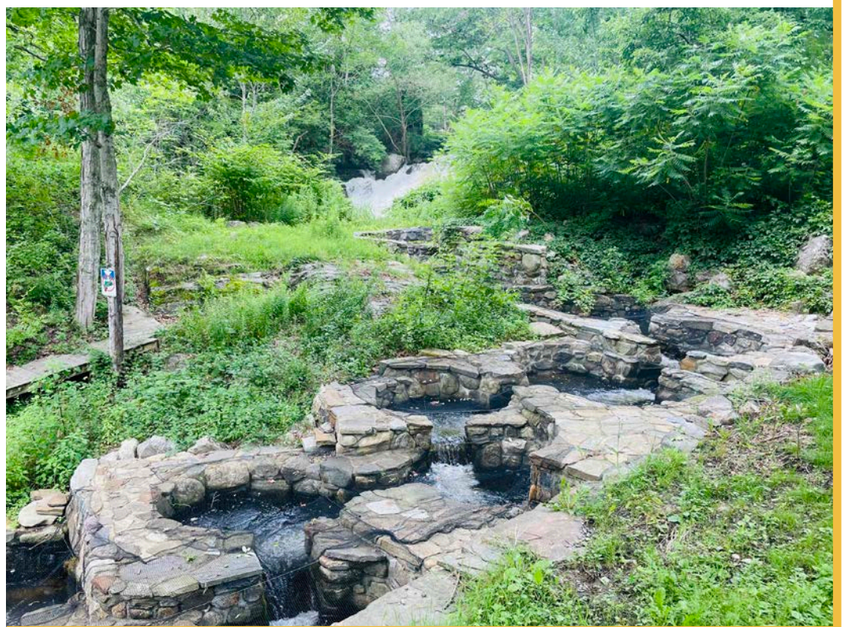
The fishway at Oliver Mills is integrated into the design of a public park.

REFERENCES and ADDITIONAL RESOURCES

DAMARISCOTTA MILLS

PROJECT SUMMARY

Although outside of the Narragansett Bay watershed, the Damariscotta Mills provides a unique case study of a fish ladder. In Algonquian, the name Damariscotta means "place of an abundance of alewives."However, in 1729, a double sawmill was constructed at the falls between fresh water Damariscotta lake and the tidal headwaters of the Damariscotta river. The dams blocked the annual alewife migration. In 1741, the legislature called for fish passage at Damariscotta mills, but it wasn't until 1807 that the towns built the new "stream" to bypass the dam. In 2007, after two centuries of use, a restoration project was initiated by a strong community group working with the Towns of Nobleboro and Newcastle and the Nobleboro Historical Society to restore the deteriorating fish ladders.



LOCATION
Nobleboro, Maine

RIVER
Damariscotta River

YEAR
Originally constructed in 1807 and then restored and rebuilt and restored between 2007-2017

GOAL
Fish passage

TYPE
Pool and Weir Fishway

COST
Restoration cost over $1,000,000

PROJECT PARTNERS
Towns of Nobleboro and Newcastle, the Nobleboro Historical Society, US Fish and Wildlife Service, Maine Department of Marine Resources, and the involvement of many community members.

CHALLENGES:

The original fish ladder was a series of small pools connected by short passages that raised over 42 feet from the bay to the impoundment. The fish ladder worked well for about 180 years but its stonework and the underlying concrete deteriorated as ice dislodged stones and blocked the path for the fish. By the 1990s, the fish ladder was in very poor condition, and fish count plummeted to less than 200,000.

SOLUTIONS:

With strong community organizing, and fundraising, the reconstruction of the fish ladder began in 2007. The redesign and reconstruction of the fish ladder is similar to that of the original, consisting of a series of 69 ascending pools connected by weirs, or short waterfall passageways that each rise 8-10 inches. The reconstruction took over 10 years and could only take place from November - April to avoid spawning season. In April every year, the construction team had to stop so the ladder could be used for the spring migration. The renovated ladder winds 1,500 feet up the hill and was reconstructed using the original stones and designed to weave around mature trees that shade the pools.

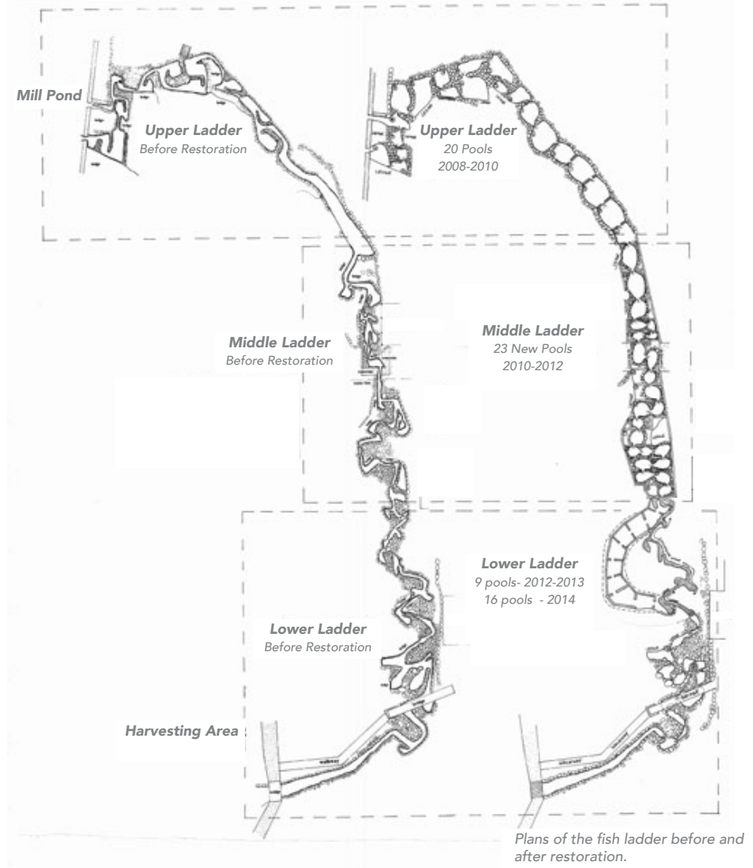
The lower pools are publicly accessible and include a boardwalk and signage. The upper portions snake through residential backyards before reaching the lake.

At the lower end of the pools, a set of "dippers" and troughs, allow for the towns to harvest alewife. The harvested alewives are used primarily as lobster bait however a few bushels are smoked and sold for human consumption. All funds received for harvested alewives are spent to maintain and restore the fish ladder and harvesting area.

SUCCESSES:

Following the restoration, more than one million alewives pass up the fish ladder to spawn each spring making the Damariscotta river one of Maine's oldest and most productive alewife fisheries.

Community support has been key to the restoration of the fish ladders. An annual Herring festival took place from 2007 until the pandemic and helped raise funds and support for the restoration. Currently the community group is raising funds to replace the boardwalk and foot bridges . Volunteers are present at the Fish Ladder on May weekends to welcome visitors, and sell tee shirts caps and other Fish Ladder. In addition, fundraising takes place at community events such as a silent auctions, an annual "Alewife run" and concerts.



Plans of the fish ladder before and after restoration.

REFERENCES and ADDITIONAL RESOURCES

https://damariscottamills.org/

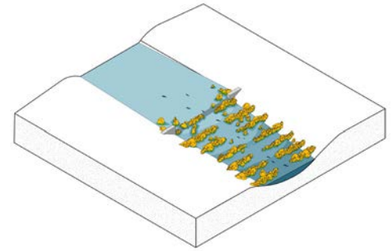
https://www.atlasobscura.com/articles/fish-ladder-maine-lobster-industry

NATURE-LIKE FISHWAYS RIVER WIDE

A nature-like fishway resembles a natural river with a series of pools and riffles. It consists of a wide, low-gradient channel that is constructed with rocks and boulders that are gradually terraced to make up the height difference between the below-dam and above-dam elevation. Boulders in the channel create multiple pathways that vary in length and velocity to allow multiple fish species to swim upstream. Because nature-like fishways are wide and gradual channels, they also provide improved fish habitat connectivity up and downstream. Nature-like fishways may be suitable for low height obstructions, where upstream water level control is not essential, and if there is a need or desire to preserve the upstream impoundment due to recreation, well water, contaminants or habitat. Nature-like fishways vary in cost, aesthetics, and performance depending on the design and dam structure

River-Wide Nature Like Fishways - In this scenario, the river downstream of the dam is gradually raised to the elevation of the dam across the whole river channel through a series of rock/pools. Because the fishway spans the whole width of the river channel, the dam is no longer visible. In this scenario, there needs to be sufficient space downstream to build up the channel gradually to the height of the dam. Frequently, the dam is partially lowered to reduce the elevation the downstream channel has to be raised. In addition to full width nature-like fishways, there is an option for partial width fishways that only extend across a portion of the river width.

NATURE-LIKE FISHWAY



FISH PASSAGE UP AND DOWN STREAM

Low Fish Passage — 1 2 3 4 5 — *High Fish Passage*

UPSTREAM WATER LEVELS

Potential Lowering of Water Levels — 1 2 3 4 5 — *Maintain Existing Upstream Water Levels*

RECREATION ON THE IMPOUNDMENT

Reduced Flat Water Recreational Opportunities — 1 2 3 4 5 — *Maintains Existing Flat Water Recreational Opportunities*

RECREATION ON THE RIVER

Maintains Existing Difficulties to River Recreation — 1 2 3 4 5 — *Improves River Recreation by removing hazards and portages*

VISIBILITY OF DAM

Dam Structure No Longer Visible — 1 2 3 4 5 — *Dam Structure Remains Visible*

WATER QUALITY

Maintain Existing Water Quality — 1 2 3 4 5 — *Improve Water Quality*

RISK OF DAM FAILURE

No Risk of Failure — 1 2 3 4 5 — *Maintain Existing Risk of Failure*

UP-FRONT COST

Less Expensive — 1 2 3 4 5 — *More Expensive*

LONG-TERM COST AND MAINTENANCE

Lower Long Term Cost And Maintenance — 1 2 3 4 5 — *Higher Long Term Cost And Maintenance*

CASE STUDIES - NATURE-LIKE FISHWAYS
RIVER WIDE

KENYON MILL DAM

PROJECT SUMMARY

Located on the Upper Pawcatuck River in Rhode Island, Kenyon Mill was built around 1772. The privately-owned mill houses and Kenyon Industries, a fabric producer housed in the historic mill building, once used the impoundment created by the dam to retain water for possible fire suppression. By 2010, the dam had fallen into disrepair and had a partial breach at the end of its spillway. This work was part of a comprehensive project that opened fish passage through seven dams along the Pawcatuck River.

LOCATION
Richmond, Rhode Island

RIVER
Pawcatuck River

YEAR
2013

GOAL
Migratory fish passage

TYPE
River Wide Nature Like Fishway

COST
$1,124,322

PROJECT PARTNERS
Wood Pawcatuck Watershed Association; Kenyon Industries, Inc.; Town of Richmond; Trout Unlimited; United States Fish and Wildlife Service; RI Coastal Resources Management Council; RI Department of Environmental Management; National Oceanic and Atmospheric Administration; Save the Bay; Richmond Conservation Commission; USDA Natural Resources Conservation Service; American Rivers; and Narragansett Bay Estuary Program.

CHALLENGES:
The neighboring community did not support full dam removal due to concerns about the impacts of lowered water levels on residential wells upstream. In addition, Kenyon Mills owned the dam and was willing to have it removed, but needed the impoundment for fire suppression.

SOLUTIONS:
Construction crews implemented a partial dam removal and installed a rock ramp, or nature-like fishway spanning the full width of the river channel. The dam height was lowered and a rock ramp was constructed to create the riffles and flow necessary to sustain fish passage with a gradual incline in elevation.

SUCCESSES:
Creating a nature-like fishway provided fish passage while allowing for the impoundment to remain upstream, providing water for fire suppression and ensuring that the upstream wells would not lose drinking water. In addition, during low flow, the rock ramps provide diverse habitat along the river's edge.

The Kenyon Mills Nature Like Fishway created pockets of wetland habitat between the weirs.

REFERENCES and ADDITIONAL RESOURCES

Wood Pawcatuck Watershed Association's presentation: http://www.wpwa.org/documents/KenyonPublicPresentation%20(3).pdf

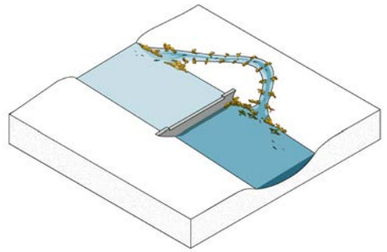
Turek, J., A. Haro, and B. Towler (2016). Federal Interagency Nature-like Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes. Interagency Technical Memorandum.

NATURE-LIKE FISHWAYS BYPASS CHANNEL

A nature-like fishway resembles a natural river with a series of pools and riffles. It consists of a wide, low-gradient channel that is constructed with rocks and boulders that are gradually terraced to make up the height difference between the below-dam and above-dam elevation. Boulders in the channel create multiple pathways that vary in length and velocity to allow multiple fish species to swim upstream. Because nature-like fishways are wide and gradual channels, they also provide improved fish habitat connectivity up and downstream. Nature-like fishways may be suitable for low height obstructions, where upstream water level control is not essential, and if there is a need or desire to preserve the upstream impoundment due to recreation, well water, contaminants or habitat. Nature-like fishways vary in cost, aesthetics, and performance depending on the design and dam structure

Bypass Nature-Like Fishways - In this scenario, a new channel is constructed to bypass the dam and connect the river upstream of the dam to the river downstream of the dam. This alternative requires that there is land adjacent to the dam where a channel can be excavated and graded using the rock/pool strategy. It is a good alternative to consider if the dam is a historic structure or there is the desire to protect views of the dam structure itself. If a dam has received a letter of deficiency, the dam would need to be repaired prior to constructing a by-pass channel. In addition to this upfront cost, this alternative requires long-term maintenance.

BYPASS CHANNEL



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UP-FRONT COST

Less Expensive — 1 2 3 4 5 — *More Expensive*

LONG-TERM COST AND MAINTENANCE

Lower Long Term Cost And Maintenance — 1 2 3 4 5 — *Higher Long Term Cost And Maintenance*

HOWLAND DAM BYPASS CHANNEL

PROJECT SUMMARY

Although outside of the Narragansett Bay watershed, the Howland Dam case study is a good example of a nature-like bypass channel. The Penobscot River Restoration Project was a decades-long effort to restore migratory fish passage while maintaining hydropower within Maine's largest watershed. In order to reconnect the Lower Piscataquis River to the Upper Penobscot River, various dams needed to be altered or removed to accommodate passage. In 2012, the Great Works dam was removed at the head of tide, followed by the 2013 removal of the Veazie Dam, and 2014 installation of a fish lift at Milford Dam. The Howland Dam would become the final obstacle in the effort to reconnect the two rivers.

LOCATION
Howland, Maine

RIVER
Piscataquis River

YEAR
2016

GOAL
Migratory fish passage, Maintain hydropower

TYPE
Bypass- Nature Like Fishway

COST
~$4.8 million

PROJECT PARTNERS
Penobscot River Restoration Trust, Penobscot Indian Nation, Atlantic Salmon Federation, The Nature Conservancy, American Rivers, Natural Resources Council of Maine, Maine Audubon, Maine Department of Marine Resources, Maine Department of Inland Fisheries and Wildlife, Maine Department of Environmental Protection, U.S. Fish and Wildlife SErvice, National Marine Fisheries Service, Kleinschmidt, Inter-Fluve.

FUNDING SOURCES
50/50 by government grants and private donations

CHALLENGES:

Because the Howland, Great Works, and Veazie Dams once generated hydroelectric power, production would need to be shifted elsewhere. The river also experienced dramatic variations in flow, necessitating careful monitoring of volume and velocity to prevent flooding.

SOLUTIONS:

The project team ensured that hydroelectric energy production could continue by strategically decommissioning the existing facilities and implementing system upgrades at six other sites. These upgrades resulted in as much hydropower production as before the dam removals. A nature-like bypass channel was designed to resemble a natural stream, reflecting ideal conditions for migratory species. In order to re-grade the sloped site into a channel, bedrock was blasted and strategically placed throughout the stream bed to create roughness and water perturbation critical to the health of migrating fish.

SUCCESSES:

This project was the first large-scale natural fish passage channel of its kind, allowing for a restored Salmon run up the Penobscot River. Its complex construction accommodates a wide range of flow volumes and velocities. Overall, the Penobscot River Restoration Project restored nearly 2,000 miles of historic river habitat.

The Nature-Like bypass channel allowed fish passage and continued recreation on the impoundment.

REFERENCES and ADDITIONAL RESOURCES

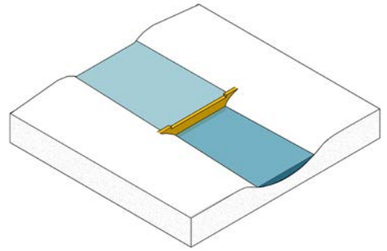
PENOBSCOT RIVER RESTORATION TRUST: https://www.nrcm.org/wp-content/uploads/2016/06/Howlandbypassfacts.pdf

REPAIRING THE DAM

For social, economic, and/or environmental reasons, keeping and repairing a dam is sometimes the option selected for a dam and its community. Some reasons a dam may be preserved include: the presence of contaminated sediment behind a dam; the dam is listed on the national registry of historic places; rare or endangered species are found in the upstream impoundment; and there are multiple dams downstream that block fish passage. Depending on the location of the dam within the watershed and the importance of fish passage, repairs to the dam can be combined with other fish passage structures. For example, if a dam is located in the headwaters (upstream) where anadromous fish passage is not a priority and where the cost of providing fish passage is very expensive, the decision may be made to just repair the dam. However, if the dam is located close to where the river meets the ocean and providing fish passage is a priority but removal is not possible, the dam may be repaired and a fish passage structure may be added. If the decision is made to keep a dam, structural deficiencies must be addressed through repairs and future inspection and maintenance needs to be factored into cost estimates.

With dam repair, the structure of the dam would remain and the existing surrounding ecology would be unaffected. However, unless fish passage structures are added, there would be no fish passage or habitat connectivity above this dam. And while this may be one of the least expensive alternatives in the short term, this alternative requires long-term maintenance so cost over time needs to be considered.

REPAIRING THE DAM



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SECTION 03

MAKING DECISIONS

There are a range of reasons why there may be a need to make a decision about the future of a dam. It may have received a letter of deficiency and be in need of repair. Members of the community may be wanting to restore fish passage to the river. Or maybe there are concerns about water quality as a result of the dam.

Depending on the dam, the community and the decision, every process will look different. Many decisions around dams can take a long time and require patience. While there maybe a desire to move fast to make a decision, it is important that the decision is not rushed to ensure that everyone has a chance to participate.

In this section, we present a method that was developed by a team of researchers from the Rhode Island School of Design working with colleagues on the National Science Foundation funded Future of Dams team. The methods that were developed bring together elements of design charrettes with Structured Decision Making (SDM).

Although many dams in New England are privately owned, they have a significant impact on a public resource- the river. Rivers are a commons- a resources whose benefit is to be shared by the surrounding communities. The underlying goal is to work towards environmental democracies - where communities participate in the decisions about shared resources- and through this process to build a community of stewards who feel connected to their local landscapes, and feel a responsibility to help care for these resources.

These materials are made open source in the hope of improving the way communities are brought into the decision making process and improve the ability of communities to work together to find creative solutions to addressing the competing demands of rivers and dams. There are many ways to engage communities in conversations about dams and our goal with this document is to encourage the sharing of methods. Others are encouraged others to use, test and adapt these methods and to share their methods and experiences.

DECISION MAKING PROCESS

Decisions about aging dams in New England can be contentious with community members coming out on both sides of the debate. While it may make sense to remove legacy dams from an ecological, economic or safety perspective, over 50 dams that were identified for potential removal have been stalled or delayed due to community opposition[1]. In some cases this resistance is based on the perceived threat to the "cherished local landscape", in other cases there may be different interpretations of which "nature" to preserve or restore, and in many cases it was the process whereby the community was brought into discussions about the future of the dam that made the discussion more divisive and controversial. Researchers have found that when outsiders from agencies or non-profits are involved in the decision making, there was a sense that the process ignored the opinions and rights of community-based stewardship of local resources. In some circumstances, there has been the perception by local communities that agencies come in with the resources and desire to remove the dam irrespective of what the local communities' desires. Power dynamics have been identified as one of the key factors that undermine community engaged restoration efforts[2].

The most common form of public engagement around dams is in Town Hall style meetings or public hearings. These are open public meetings intended to allow for both information sharing as well as to provide the opportunity for the public to express their position about a dam decision. In some cases, the meetings are run by an outside neutral trained facilitator however, in many cases they are often organized and facilitated by local government officials, conservation commissions, or environmental organizations that are looking into dam removal options. Depending on the level of community interest or apathy about a dam decision, the meetings can be dominated by strong voices on either side of the dam removal debate. In some cases, the microphone can be dominated by people who feel comfortable talking in front of large groups and are very vocal about their position. This approach doesn't allow for a back and forth exchange amongst participants and often leads to the more moderate participants not contributing which could help balance the discussion.

In addition to these existing methods, there are an increasingly wide range of decision support tools that are being developed to help stakeholders make decisions about the future of the dams. However, in most cases, these decision support tools are aimed at decision makers (town officials, federal and state agencies, etc.), but not the general public. In addition, while they may help support prioritization based on scientific facts, they often fail to provide a significant way to incorporate social values that are often important to community members, such as history, sense of place, and aesthetics.

EXPLORING NEW METHODS

One of the best ways to incorporate social dimensions into river restoration projects is through direct community participation throughout the restoration planning process. Some of the values of community engaged restoration projects include: providing insight into local social, ethical and political values; providing opportunities for social learning; and leading to broader acceptance, legitimacy and support of the planning process and final decision. Although there is growing agreement on the importance of engaging citizens in the planning of restoration projects, it is unclear how best this should happen and what form it should take. Our work aims to contribute to this discourse by providing a unique perspective from landscape architecture, a profession that has also been working to create meaningful opportunities for communities to participate in design decisions. By bringing together methods from Structured Decision Making (SDM) and design charrettes, we developed a trans-disciplinary approach to community engagement around dams.

A range of strategies emerged from our process that may be helpful for future projects that aim to engage communities in dialogue about the future of a dam. These include:

RESPECTING LOCAL PEOPLE'S VALUES AND PERSPECTIVES

Similar to many current environmental challenges, the ultimate decision about the future of a dam is often based on moral, ethical or value-based factors, and while scientific information can help inform the decision it does not provide the solution or the answer. In some cases, dam projects have stalled or failed due to project proponents over-reliance on science as the only credible or relevant source of knowledge which led to a disregard for the social considerations that are often the issues that matter to residents. Listening, acknowledging, honoring, and being willing to factor in community and individual values into the decision making process are key to community engaged processes. One of our aims with developing these methods was to ensure that the community members felt comfortable sharing their values and perspectives. While values may not be able to be quantified in the same way as scientific objectives, the objectives are listed alongside one another and can equally be factored in when evaluating the impact of the alternatives.

NEUTRAL FACILITATORS + STRUCTURED DIALOGUE

In order to create a space for dialogue, sharing, and learning, it is important that the facilitators be neutral. Having a neutral third party to help mediate between the restoration team and the local community can help to address some of the unequal power dynamics that have led to dam projects stalling or failing in the past. Our goal in designing this workshop was to develop a process that did not go into a community with a set agenda, but that brought the community into the creative process of exploring alternatives.

The facilitated small group discussions help ensure that all community members participate, have a chance to voice their opinions, listen to different viewpoints, ask questions, and participate in a civil exchange with fellow community members. This structure can help participants build an understanding of each other's perspective and open the space for negotiation.

HELPING PARTICIPANTS SHIFT FROM POSITION TO INTERESTS

Position are something that participants have decided upon whereas interests are what caused them to make that decision. In dam decision making, some examples of positions would be to remove the dam or keep the dam and examples of interest would be improve fish passage or maintain sense of place. Unlike positions that lock people into a single outcome, when a problem is defined in terms of interests it is more likely to find a solution which satisfies both parties' interests. Therefore, the goal of our workshops is to get the participants to focus and communicate about their interests, rather than their positions.

EXPLORATION OF A RANGE OF ALTERNATIVES TO MOVE PAST BINARY POSITIONS

Unlike large dams, where there are often very few options beyond removing or keeping a dam, with small dams, there are often a range of alternatives that can achieve multiple objectives. Although dam modification alternatives may be more costly than removing the dam and require long term maintenance and repairs, exploring a range of alternatives during the workshop allows for the conversation to move beyond what is often perceived as the binary option of either keeping or removing the dam to find a space of negotiation. The goal of our process was to explore the aesthetic, ecological and historical implications of a range of alternatives and to encourage participants to think about creative solutions to addressing the issues and trade-offs.

FOSTERING LEARNING BY MAKING INFORMATION ACCESSIBLE AND VISUAL

One of the key tenets of a successful decision making process is a knowledgeable group of participants. When working with the general public, there is the need to translate complex technical ideas into language and decision-relevant information that can allow people without technical expertise to meaningfully consider technical information. For this reason, we encourage the use of visualizations to help facilitate dialogue and develop mutual understanding amongst the group. The visual tools can help foster insights not accessible through other, often more quantitative approaches to communicating information.

TRANSPARENT EVALUATION OF ALTERNATIVES BASED ON OBJECTIVES

The Structured Decision Making process allows for the transparent evaluation of alternatives based on how well each alternative meets the project objectives. For individual participants, each objective may hold a different weight or level of importance, which will impact their final decision or ranking of preferred alternatives. By laying out the objectives and alternatives clearly in the decision matrix, it allows for a visible way for these subjective values to be openly discussed and ranked.

REFERENCES and ADDITIONAL RESOURCES

1. Fox, C. A., F. J. Magilligan, and C. S. Sneddon. 2016. "You kill the dam, you are killing a part of me": dam removal and the environmental politics of river restoration. Geoforum 70:93–104.

2. Johnson, S. and Graber, B.E. 2002. Enlisting the Social Sciences in Decisions about Dam Removal. Bioscience 52 (8), 731–738.

3. Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T.L., & Ohlson, D.W. 2012. *Structured Decision Making: A Practical Guide to Environmental Management Choices.* Wiley-Blackwell, Chichester, U.K.

STRUCTURED DECISION MAKING

Structured Decision Making provides a structured and collaborative approach to decision making that is able to incorporate both values and facts into the decision making process. Traditional steps in the SDM framework include problem framing, determining objectives, identifying alternatives, estimating consequences, evaluating trade-offs, and deciding and taking actions . SDM is based on the idea that there are not "right decisions" so aims to help inform and make decisions transparent rather than prescribe a preferred solution. It seeks to provide a structured way for participants to talk and to learn together about both the facts and values that will inform the final decision.

STEPS IN PROCESS	UNDERLYING QUESTION	EXAMPLE in the context of dam decisions
1. Problem Framing	What is the context for (scope and bounds of) the decision?	• Single Dam • Whole River approach
2. Determining Objectives	What objectives and performance measures will be used to identify and evaluate the alternatives?	• Improve Fish Passage • Increase Recreational Opportunities • Reduce Flooding
3. Identifying Alternatives	What are the alternative actions or strategies under consideration?	• Do Nothing • Remove Dam • Nature-Like Fishway • Technical Fishway • By-pass Channel
4. Estimating Consequences	What are the expected consequences of these actions or strategies?	• 50% improved fish passage • 80 summer days when the river would be passable by canoe
5. Evaluating Trade-offs	What are the key trade-offs among consequences?	• Trade-off between fish passage and Hydropower
6. Deciding And Taking Actions.	How can the decision be implemented in a way that promotes learning over time and provides opportunities to revise management actions based on what is learned?	• Citizen science • Ongoing stewardship

TABLE 1: Steps in the Structured decision making framework (Modified from Gregory et al. 2012)

Although there are steps outlined in this document, Structured Decision Making is an iterative process - meaning that it may not be linear. During the decision making process, new data or issues may become apparent that require going back and adjusting the project objectives or reconsidering new alternatives. In addition, it may be beneficial to start with a scoping round and use the process to get an initial idea of which objectives and alternatives may be worth pursuing, then at a later time when there are the funds available to do a full feasibility study, additional workshops can help work towards a final decision.

These materials and approach have been adapted from the book, *"Structured Decision Making: A practical Guide to Environmental Management Choices."* It is strongly encouraged that anyone who plans to use the methods outlined in this document consider reading that book as well.

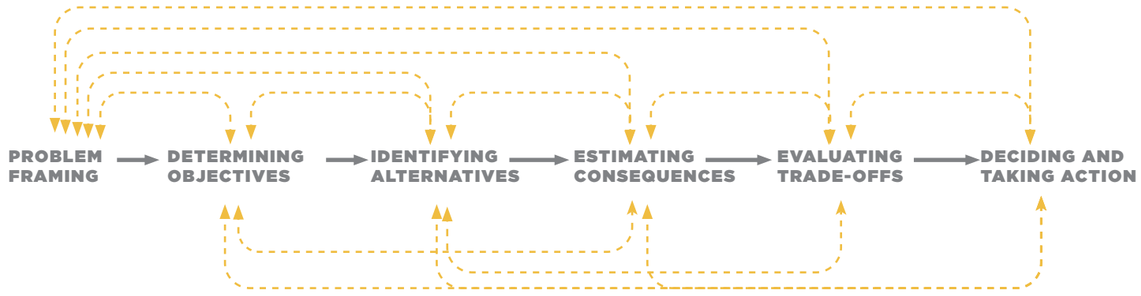


Figure x : Iterative Process

DESIGN CHARRETTES

Design charrettes are an approach commonly used within the architectural design professions to involve community members in the design and planning process. Similar to environmental decision making, design has and continues to struggle with issues of inclusion and power. Design charrettes are intended to help democratize design by bringing the general public into the design process. Coming from the architectural design fields (architecture, landscape architecture, urban planning), charrettes rely on a range of visual and graphic tools that designers often use to ideate, test ideas and communicate to broader audiences. These graphic tools can include maps, rendered views, models, sections, diagrams and plans to communicate the physical consequences of various decisions and show alternatives that can then be debated. Prior to a charrette, the design team develops interactive exercises and materials to help facilitate the public's participation and contribution to the design and envisioning of a site.


Sharpie
Western
South Side access

HYBRID APPROACH

While providing a valuable framework for environmental decision making, SDM is primarily intended for a group of 5-25 stakeholders/decision makers and not the general public. In previous examples of SDM being used to support dam decisions, the participants represented local, state and federal agencies, universities, tribes, non-governmental organizations, utility companies, and the fishery commission, but not the general public. In the book, *Structured Decision Making: A practical Guide to Environmental Management Choices"*, the authors briefly mention the possibility for integrating SDM with public engagement and suggested running 3 parallel processes with an advisory committee, technical working groups, and a public process. However, the authors provide little guidance on how to structure the public process or how the information that is gathered at the public meeting will inform the final decision. In the book, the authors describe these challenges:

> *Although approaches such as SDM might be used to encourage well-structured input from smaller groups, in most cases little methodological rigor is applied to engaging the public. As a result, key sectors of the community are alienated, choose not to participate, or shrink at the prospect of endless meeting at the same time that keenly interested, 'professional citizens' appear at all town-hall meetings and often dominate the entire process. Information open houses barely scratch the surface of engagement and opinion surveys rarely offer substantive insight into key aspects of the decision making process, such as creating responsive alternatives or making defensible trade-offs that characterize wise, long-term resource-management decisions. Yet accountable decision makers-from small city councils to the office of state governors- may not have faith in recommendations if they feel the broader public values are not well represented"*

Our goal in bringing together structured decision making with design charrettes is to address some of these challenges and find meaningful ways to engage a broader public in the decision making process. We find that the benefits of one method helps to address the limitations of the other method. Structured decision making has a clearly defined process for coming to a decision and a systematic ability to evaluate a set of alternatives based on performance measures. However, as described earlier, there is limited guidance on how to engage a broader public audience. Charrettes offer guidance on how to organize and facilitate large public meetings as well as the use of visuals to help participants understand the alternatives. However, charrettes provide little guidance on how to make a final decision. The integrated approach offers a clearly defined process for coming to a decision as well as guidance on working with the public.

It is important to recognize and to communicate to the public about the roll of the community input in the final decision. The SDM process rarely makes decisions but, instead, usually serve in an advisory capacity providing insight to decision makers.

STEPS IN PROCESS	BENEFITS	LIMITS
STRUCTURED DECISION MAKING	• Clearly defined process for coming to a decision • Ability to evaluate alternatives based on performance measures	• Limited guidance on how to engage the public in decision making
CHARRETTES	• Geared toward groups of the general public • Use of visualizations to communicate about complex alternatives • Guidance on facilitation	• Often more open ended design process without clear guidance on how to make a final decision.

TABLE 2: Benefits and limitations to the Structured Decision Making process and Charrettes that lend themselves to a hybrid approach

WHO SHOULD BE INVOLVED?

The reality of who participates in decision making about a dam will vary based on ownership, geographical context, funding and motivation for removal. If a dam is owned by the local, state or federal government, there will be a greater obligation and opportunity to have a full community process. If a dam is owned by a private owner, the extent of the community process will largely depend on the specific context of the dam and decision.

It is suggested that three groups participate in this work. Their involvement can inform one another at various stages of the decision making process:

1. PROJECT TEAM

The project team is made up of the consultants that are helping support the decision. This may include engineers that are doing an Hydrology and Hydraulics study to look into the impact of dam removal on flow or a feasibility study to understand the feasibility and design of alternatives. It also can include local environmental planning agencies that are helping to manage the project. Ecologists may be part of the project team to analyze the impact of various alternatives on migratory fish and wetland habitats. Landscape architects may be part of the project team to study the impact of various alternatives on the recreational, spatial and aesthetic landscape and to help envision how public access can be incorporated into the design of the site if the dam is removed.

It is highly recommended that a neutral facilitator be brought in to help with the community engagement. In order to create a space for dialogue, sharing, and learning, it is important that the facilitators be neutral. This work may be able to be led by the landscape architects or a separate facilitator can be brought in. It is important that the full project team be aware of the methods and approach outlined in this document.

2. STEERING COMMITTEE

The steering committee can be made up of key local stakeholders in the project. This can include representatives from local, state, federal agencies, local tribes, local river advocacy organizations, non profits, and local historical societies. It is important that the steering committee is made up of representatives that can speak to all the major issues about a dam. The steering committee will work closely with the project team to help guide the work and the process and so it is key that all trade offs are being considered within this group.

3. COMMUNITY

The involvement of the community will vary based on the project and how engaged the local community is in the outcome of the dam decision. Inevitably, contentious dam decision will attract a greater number of participants than less contentions decisions. Even if there is very good attendance, as is common in many public processes, the people who attended the meeting are often only a very small subset of the larger population and are primarily people who have leisure time and therefore the results are skewed towards an older, richer and formally educated public. Acknowledging these limitations, it is important that the project team make a concerted effort to develop additional methods to reach out to a broader and more diverse audience. A multi-pronged approach to engagement is important to engage the broader community in conversation about the future of a dam and can include both community workshops, like those discussed in this guide, as well as finding opportunities to go out into the community rather than expecting the community to come to meetings. This can include attending family-oriented community events and festivals, setting up at local grocery stores or attending existing meetings in the community.

MEETING SETUP

Whether you are setting up for public meeting as part of a single exploratory workshop or multiple meetings, it is important to think about how to create the space for a productive conversation.

VENUE:

It is important to choose a neutral venue for the public meetings. A local library, gymnasium, community center may have venues that can be used by the community free of charge.

SIGN UP AND DISTRIBUTION OF PARTICIPANTS

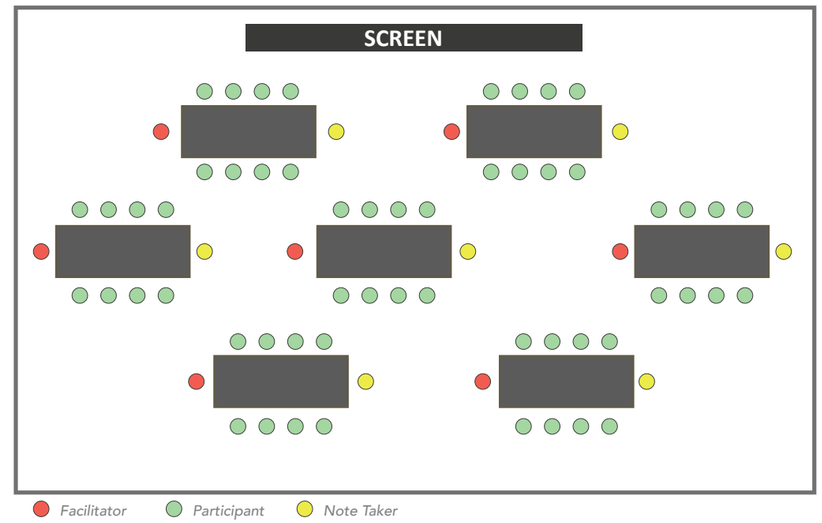
As community members enter the venue, they should sign in. This allows for follow up emails and correspondence especially if there will be multiple meetings as part of the process. After signing up, it is best to randomly divide up the attendees into tables with groups of 5-8 people. By dividing up the groups, it ensures that there is a mix of participants representing different interests at each table rather than grouped together. This is especially important since people may come to the meeting with friends or other people who may share the same view points.

To randomly distribute the participants, you can have color groups- each table can have a piece of construction paper on it and when participants enter, they are randomly given a piece of small piece of construction paper and asked to find the table that corresponds to the color.

GROUP TABLES

The break out tables are an important part of this process because dialogue is a central part of any community engaged process. Small group dialogues allow community members to listen to different viewpoints, ask questions, and participate in a civil exchange with fellow community members. Facilitated small group discussions help ensure that all community members participate and helps participants build an understanding of each other's perspective and open the space for negotiation.

Each table should have a facilitator from the project team and a note taker. The facilitators are responsible for guiding the conversation during the small group discussions, explaining the decision making tools, and answering basic questions about the dam. Since not everyone will hear everyone else's comments- the note takers have an important roll. During the break out discussions, the note takers record participant comments so that the comments can be included in the minutes, discussed by the project team and factored into the decision making.



HOW TO USE THESE TOOLS:

In the following section, a range of tools are shared that have been designed to support various stages of the Structured Decision Making process. Some tools are intended for the project team, others for the steering committee and others for the general public. The level of involvement of the community will largely depend on the nature of the dam and how active the community is or wants to be in the process. In addition to these larger public meetings, it is recommended that prior to any public meeting that the project team meet one-on-one with any adjacent property owners, including business and residents, especially if those properties may be directly impacted by any decision.

It is recommended that at a minimum there are 3 points within the process at which the general public is involved in the decision making process. The first meeting (or series of meetings) can gather input on project objectives, the second meeting (or meetings) gather input on project alternatives, and the third and most significant workshop(s) ask participants to evaluate the alternatives. This process can allow for more meaningful involvement by the public in defining the project objectives and brainstorming possible alternatives.

On the following pages, one possible sequence is shared but the exact structure and interaction between the project team, steering committee and public will vary depending on the specifics of each project. We encourage practitioners and community members to adapt and incorporate any of the tools that are helpful for the process that they are guiding.

1. PROBLEM FRAMING:
What is the context for (scope and bounds of) the decision?

- 1.1 Roll-Playing Board Game
- 1.2 Data Collection/ Reconnaissance
- 1.3 Problem Sketch
- 1.4 Paddle The River

2. DETERMINING OBJECTIVES:
What objectives will be used to identify and evaluate the alternatives?

- 2.1 Brainstorming Objectives
- 2.2 Objective Cards
- 2.3 Developing Performance Measures

3. IDENTIFYING ALTERNATIVES:
What are the alternative actions or strategies under consideration?

- 3.1 Case Studies
- 3.2 Brainstorming Alternatives
- 3.3 Site Visit

4. ESTIMATING CONSEQUENCES:
What are the expected consequences of these actions or strategies?

- 4.1 Feasibility Studies
- 4.2 Visualizing the Alternatives

5. EVALUATING TRADE-OFFS:
What are the key trade-offs among consequences?

- 5.1 Decision Matrix

6. DECIDING AND TAKING ACTION:
How can the decision and implementation promote learning and stewardship?

- 6.1 Final Report
- 6.2 Permitting
- 6.3 Implementation
- 6.4 Stewardship

PROBLEM FRAMING + DETERMINING OBJECTIVES

Project Team:
- Research into the river system
- Modeling of existing conditions
- Review existing studies

→ **1st Steering Committee Meeting:**
- Discuss the framing of the project
- Outline and discuss the process
- Identify objectives/and performance measures
- Determine what additional technical expertise might be needed

→ **1st Public Meeting:**
Intro Presentation:
- What is known about the river and dam
- Explain the public engagement process + timeline
- Introduce Project team and Steering Committee

Small group discussion:
- Discuss initial set of project objectives

Wrap-Up

IDENTIFYING ALTERNATIVES

Project Team:
- Reflect on public meeting
- Gather data on existing conditions
- Site Surveys field work, etc

→ **2nd Steering Committee Meeting:**
- Reflect on public meeting
- Choose case studies and alternatives to present at second public meeting.

→ **2nd Public Meeting:**
Intro Presentation:
Case Study Presentation:
- Present Case studies of alternatives

Small group discussion:
- Consequence Cards
- Review Case Studies
- Brainstorm other possible alternatives

Wrap-Up

ESTIMATING CONSEQUENCES + EVALUATING TRADE-OFFS

3rd Steering Committee Meeting:
- Reflect on public meeting
- Finalize list of alternatives

→ **Project Team:**
- Reflect on public meeting
- Model the alternatives
- Feasibility studies (H&H study, ecological studies, etc)
- Estimate impacts + Costs

→ **3rd Public Meeting:**
Intro Presentation:
Matrix Presentation:
- Present the methods used to estimate consequences and the results

Small group discussion:
- Consequence Cards
- Review Matrix
- Evaluate and rank project alternatives based on consequence matrix

Wrap-Up

DECIDING AND TAKING ACTION

4th Steering Committee Meeting:
- Reflect on public meeting
- Finalize preferred alternatives

→ **Project Team:**
- Write final report
- Send report to Steering Committee for review

→ **Final Report and Presentation:**
- Present to decision makers and public about process and determine next steps

A Diagram of one possible way that the steps in the Structured Decision Making process can align with a broader public engagement process.

SAMPLE AGENDA FOR 1st PUBLIC MEETING:

INTRODUCTION PRESENTATION:

- **Introductions**- Introduce project team and steering committee
- **Background to the Project**- information about the watershed, river, dam, why the dam is being discussed.
- **Project Timeline** - what will be the timeline of work for the project and specific points the public will be involved in the process
- **Overview of Approach**- Describe the approach that is being taken for decision making around the dam and how the public input will be factored into the final decision

BREAK OUT GROUPS:

(2.2) **Objective Cards Exercise (Printed Objective Cards)**
  - Ask people to introduce themselves by selecting or writing-in 5 objective cards in response to the question: What Do You Think Are The 5 Most Important Project Objectives?
- **Post-it Exercise**- ask the group to respond to the following questions:
  - What do we want to make sure to protect in this process?
  - What are some of the key issues that you want to make sure are addressed in this planning process?
  - When you imagine a healthy resilient river, what does that look like to you?
  - How can the community be good stewards of the river?

WRAP-UP

- **Debrief**- The facilitator or members of the group can share highlights from their break out group discussions.
- **Review Next Steps** - Revisit timeline and opportunities for the public to be involved.

(1.4) Paddle of River- If the project team is able to organize a paddle of the river, announce it at the first public meeting

SAMPLE AGENDA FOR 2nd PUBLIC MEETING:

INTRODUCTION PRESENTATION (20 min):

- **Introductions**- Introduce project team and steering committee
- **Background to the Project**- information about the watershed, river, dam, why the dam is being discussed.
- **Project Timeline** - what will be the timeline of work for the project and specific points the public will be involved in the process
- **Overview of Approach**- Describe the approach that is being taken for decision making around the dam and how the public input will be factored into the final decision
- **Review Objectives**- Review project objectives and how the information from the first public meeting was incorporated into the project objectives.

ALTERNATIVES PRESENTATION (20 min):

(3.1) Introduce case studies

BREAK OUT GROUPS (1 hour):

(2.2) Objective Cards Exercise (Printed Objective Cards)
- Ask people to introduce themselves by selecting or writing-in 5 objective cards in response to the question: What Do You Think Are The 5 Most Important Project Objectives? Are there any objectives that are missing?

(3.1) Case Studies (Printed Case Study Cards)
- Ask the participants to take time to review the case study cards.
- Are there any questions about the case studies?
- What aspects of each case study are relevant to the dam being discussed?

(3.2) Brainstorming:
- Given what was learned from the case studies, ask the group to consider which alternatives might be good for the dam being discussed?
- With the printed plans and photos of the site, ask participants to sketch on trace any ideas of other alternatives that may be worth considering for the project.

WRAP-UP (20 min):

- **Debrief**- The facilitator or members of the group can share highlights from their break out group discussions.
- **Review Next Steps** - Revisit timeline and opportunities for the public to be involved.

SAMPLE AGENDA FOR 3rd PUBLIC MEETING:

INTRODUCTION PRESENTATION (20 min):

- **Introductions**- Introduce project team and steering committee
- **Background to the Project**- information about the watershed, river, dam, why the dam is being discussed.
- **Project Timeline** - what will be the timeline of work for the project and specific points the public will be involved in the process
- **Overview of Approach**- Describe the approach that is being taken for decision making around the dam and how the public input will be factored into the final decision
- **Review Objectives**- Review project objectives and how the information from the first and second public meeting was incorporated into the project objectives and alternatives.

MATRIX PRESENTATION (20 min):

- **Present the Matrix** - Review the methods used to estimate consequences and the results as they are represented in the Matrix

BREAK OUT GROUPS (1 hour):

(2.2) Objective Cards Exercise (Printed Objective Cards)
- Ask people to introduce themselves by selecting or writing-in 5 objective cards in response to the question: What Do You Think Are The 5 Most Important Project Objectives? Are there any objectives that are missing?

(5.1) Matrix (Printed Matrix for each participant)
- Ask the participants to take time to review the Matrix.
- Ask if there are any questions about the Matrix.
- Ask the participants to use the sticky dots to indicate the alternatives they endorse, accept or oppose
- Have participants share with the group their reasoning for their selection
- Optional second round of ranking following the discussion

WRAP-UP (20 min):

- **Debrief**- The facilitator or members of the group can share highlights from their break out group discussions.
- **Review Next Steps** - Revisit timeline and opportunities for the public to be involved.

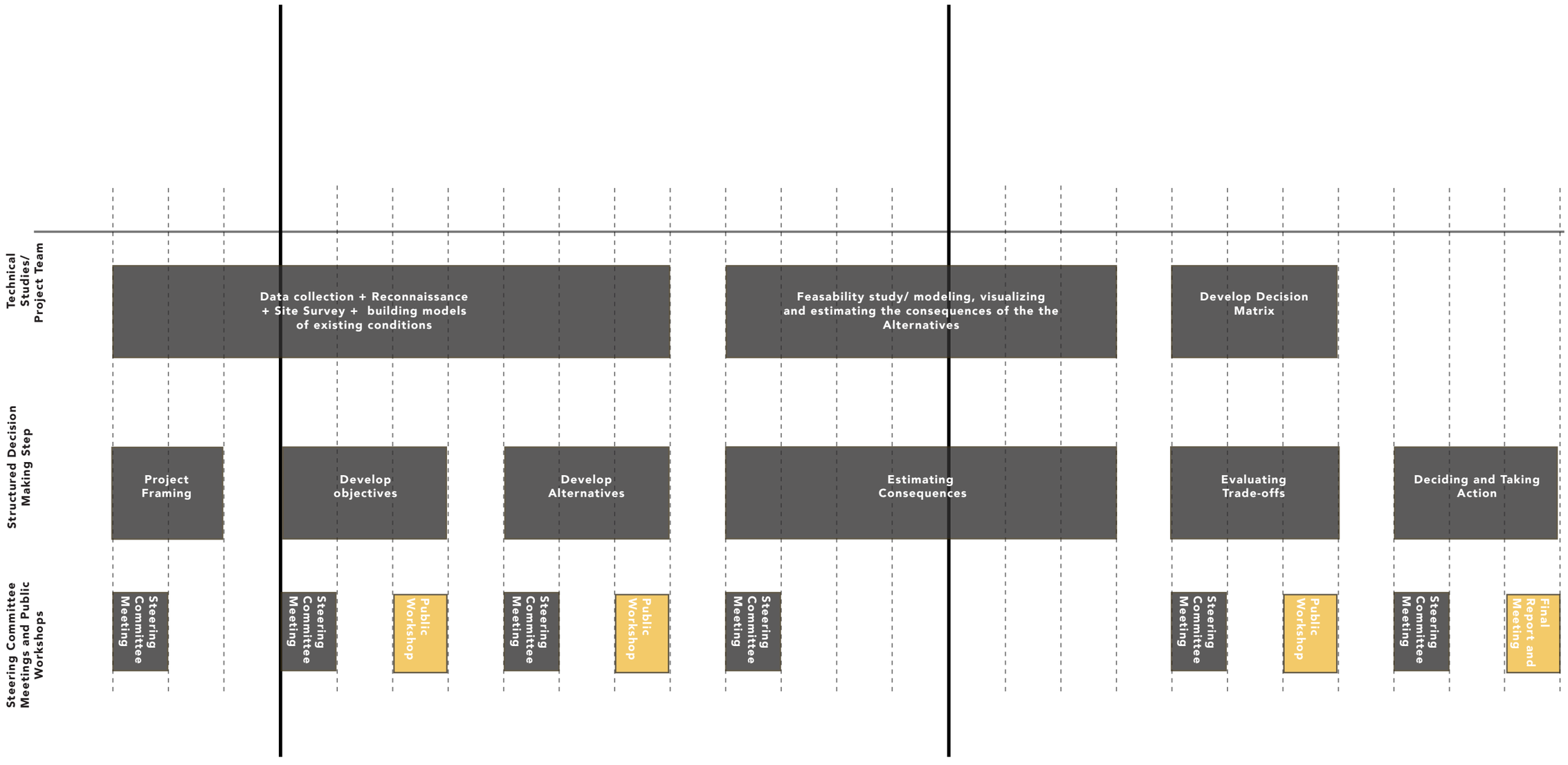


FIGURE x: Example of Project Timeline

1

PROBLEM FRAMING

One of the first steps in any decision making process is to determine how to frame or structure the problem, the decision context, and the scope of the work. This initial stage will likely take place with the project team and the steering committee during one of the initial project meetings.

Below are some questions that may be helpful to clarify early on:

- What is the decision to be made?
- Does it make sense to look at a single dam, a segment of the river, or a whole river approach?
- What is the potential relationship of this decision to other decisions?
- Who will make the final decision? Is it a single individual or a group?
- When and how will the decision makers be engaged in the process?
- How will public input be factored into the final decision?
- What is the timeline within which the decision needs to be made?
- What deliverable will be needed from the decision process?

ROLE PLAYING GAME

WHO:
Steering Committee

TIME:
3 hours

PURPOSE:
Roll playing can be a valuable way for people to understand an issues from another persons perspective.

MATERIALS:
Board game

OVERVIEW

The steering committee should include people representing the full range of concerns about a decision. Given that many dam decisions are multi-year projects, it is important to take time at the beginning of the process for the steering committee to get to know one another as the group starts to frame the problem. During this process it is good to also find ways for individuals within the group to understand the decision from other members of the groups perspectives.

One technique that is increasingly being used in diverse environmental public policy and natural resource management contexts is Role Playing. According to Song et al. (2021), "role playing simulation provides a forum to engage participants in a hypothetical, yet realistic policy decision making scenario in which they reconsider the usual way of making decisions and explore innovative solutions". Participants typically "assume a role different from their own, which is intended to interrupt behavior patterns, relieve anxieties related to concerns about revealing one's strategy, and provide insights into other stakeholders' perspectives, interests, and constraints" (Song et al. 2021; Crampton and Manwaring, 2014; Rumore et al., 2016).

We developed a Role Playing scenario that aims to help members of the steering committee understand each other's perspectives and interests and also introduce them to the decision support tools.

PROBLEM FRAMING	DETERMINING OBJECTIVES	IDENTIFYING ALTERNATIVES	ESTIMATING CONSEQUENCES	EVALUATING TRADE-OFFS	DECIDING AND TAKING ACTION
Project Team	Project Team	Project Team	Project Team	Project Team	Project Team
Steering Committee	Steering Committee	Steering Committee	Steering Committee	Steering Committee	Steering Committee
General Public	General Public	General Public	General Public	General Public	General Public

HOW TO PLAY:

To begin with set up a series of tables with 5-10 participants at each table as well as a "neutral" facilitator. Each participant at the table receives a character card.

STEP 1: OVERVIEW + AGENDA

Main Organizer: Read through the scenario and review the agenda for the workshop.

STEP 2: GROUP INTRODUCTIONS + OBJECTIVE CARDS

Facilitators: place cards in a row in the center of the table.

Ask participants to identify 5 cards that represent their interests and concerns about the dam and rank them in order from left to right with left being highest priority and right being lowest priority. There will be blank cards as well- if participants do not feel like their interests are represented on the existing card deck, encourage them to write in on blank cards.

Facilitators ask participants to use the cards as a way of introducing themselves and sharing with the group their interests and concerns about the Sabin Town Dam.

STEP 3: CASE STUDIES + ALTERNATIVES + MATRIX

Present case studies, alternatives that are being considered for the Sabin Town dam and introduce the Matrix.

STEP 4: GROUP DISCUSSION OF ALTERNATIVES

Facilitators : Put the case studies out in the middle of the table.
Ask participants what aspects of the case studies seem relevant to the Sabin Town dam. Encourage participants to pick up the case study sheet when they speak about it.
Ask the participants to consider if there are alternatives that they think should be considered that are currently not included?
Ask participants if there are any questions about the various alternatives?


SABIN TOWN DAM

SCENARIO

The Sabin Town Dam is a 12' foot tall granite dam that was constructed in 1880 to power a local gristmill. Over the years, the small New England town of Sabin was established around the dam. Although the dam no longer serves a purpose, it is an important part of the town's identity and sense of place. There is a waterfall that flows over the front face of the dam that is visible from Main Street. A park surrounding the dam provides walking trails and a view of the dam. The dam creates a small impoundment that historically provided summer swimming, boating, and bird watching. However the past couple years there have been harmful algae blooms on the impoundment which has made the pond unusable for recreation and potentially dangerous to humans and wildlife.

This dam is the second dam on the river. The head-of-tide dam (the first dam on the river) was just removed, triggering the need to address fish passage at the Sabin Town Dam. There are no fish passage structures at the dam and the dam is blocking migratory fish from reaching critical spawning habitat upstream. The dam recently received a Letter of Deficiency because the structure is old and hasn't been maintained. It is a high hazard dam and if it were to fail it would pose a significant threat to downstream houses, schools and roads. In addition, during large storm events the dam holds back water and causes flooding upstream of the dam. There is a federal grant available for removal of the dam to improve fish passage, water quality and reduce flooding but it can only be used for removal. Any other modifications would most likely have to be paid for by a bond and the cost would be passed onto taxpayers.

The Town of Sabin owns the dam and the town manager and selectboard know that the issues with the dam need to be addressed. The town was recently approached by an environmental non-profit organization that will help support the application and permitting to go after the federal funds to remove the dam. They know that this will be a controversial and potentially "hot topic" in the town. Prior to moving forward with a grant application for removal, the town manager and selectboard are wanting to get a sense of the community's sentiments around the dam. They are running an "exploratory" workshop to begin the conversation to discuss the future of the dam.

STEP 5: EVALUATING ALTERNATIVES + RANKING MATRIX

Facilitators : Hand out Matrix to each participant. Put a stack of green, yellow and red dots in the middle of the table
Ask participants to review the alternatives, review the matrix and rank the alternatives on the matrix.
Ask participants if there are any questions about the Matrix?

Ask participants to use stickers at the bottom of the matrix to indicate the following:
GREEN = Preferred option = enthusiastic support –"this is a great solution"
YELLOW = Acceptable option = "Maybe it is not the best solution but it is one I could support.
RED = Oppose = no support "I cannot support this solution"
All participants must use one green and one yellow sticker
Go around in the circle and ask participants to share their ranking and why they support or oppose the different alternatives.
As people are presenting, the facilitator compiles the ranking.
Once everyone has gone around and shared their ranking, the facilitator asks if anyone wants to change their rankings. If so- record it on the sheet.

STEP 6: REPORT OUT

Report on the results of the final matrix. What are some of the major issues (tensions) that came up in the group?

REFERENCES and ADDITIONAL RESOURCES

Song, Cuihong, Natallia Leuchanka Diessner, Catherine M. Ashcraft, and Weiwei Mo. 2021. "Can Science-Informed, Consensus-Based Stakeholder Negotiations Achieve Optimal Dam Decision Outcomes?" Environmental Development 37 (March): 100602. https://doi.org/10.1016/j.envdev.2020.100602.

1.2

MAKING DECISION - PROBLEM FRAMING

DATA COLLECTION

WHO:
Project Team with support of Steering Committee

TIME:
May take weeks to gather all the relevant data and make it into a clear presentation.

PURPOSE:
Compile everything that is know about the dam

MATERIALS:
Historic documents, studies, planning documents, town records, etc.

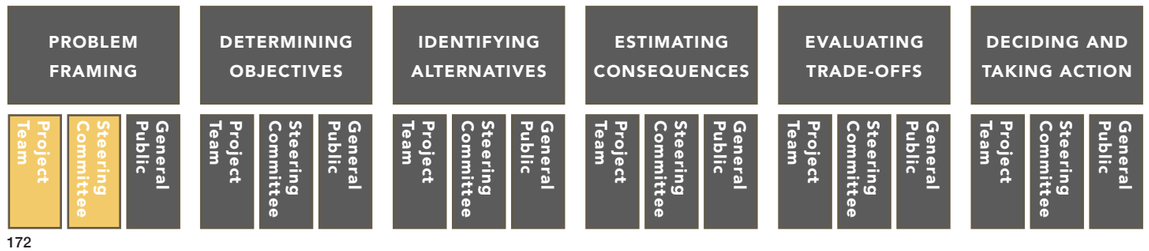
OVERVIEW

One of the initial steps for the project team is to collect and synthesize all available existing data on the dam, the river, and the surrounding landscape. These could include archival records of local, state, and federal agencies for existing maps and plans, past dam inspection reports, FEMA flood mapping, air photos, historic maps and photographs, fisheries data, planning department reports, and utilities mapping. The initial reconnaissance phase is intended to determine the overall breadth of the project and the likely project challenges. The materials are best compiled into a presentation or document that can be shared with the public and steering committee and kept for future reference.

Dam and Land Ownership: Determine the date of construction and history of repairs and modifications of the dam through research and consultation with a civil engineer, expert consultants and historical engineering drawings. If the dam owner is not the project proponent, determine the dam owner and, if necessary, a point of contact for the dam owner. It may also be helpful early on to do a preliminarily assessment of land ownership around the impoundment and the dam structure.

Dam Uses: Determine if the dam and impoundment are currently serving any purpose that will necessitate replacement of the use. Most dams in Massachusetts no longer serve the purpose for which they were designed, but many do provide important functions. Dams that provide water supply, hydropower, flood control, road, rail, or other utility crossing, are much less viable dam removal projects than those structures that do not provide these services. In some cases, these purposes can be replaced by other means.

Infrastructure: Identify any potential infrastructure that could be impacted by dam removal. For example, if bridges cross any portion of the impoundment or downstream of the dam, an assessment will need to be made of potential scour during the feasibility study. In some places, water and sewer pipes or telecommunication cables cross through dams or through the impoundment and alternatives will need to be assessed for protecting or moving them. Some dams are attached to mill buildings or retaining walls, requiring a stability assessment during the feasibility phase.



Rare Species: Determine if the dam, impoundment, or adjacent land are in priority or estimated habitat for state listed species, based on maps published by the Natural Heritage & Endangered Species Program. If these habitats are present, projects can only proceed through close consultation with state and federal biologists.

Sediment Quality
Preliminarily assess the potential for contaminants trapped behind the dam by considering current and past upstream land uses such as industrial activity and road density. Information on water and sediment quality in the river may also be available from past environmental studies. Analyzing a sediment sample may even be useful at this reconnaissance phase, to understand the breadth of the project if other assessments are insufficient to determine the probability of contamination. The sample should be taken from the fine-grained portion of the impounded sediment and analyzed at a lab for heavy metals and organic constituents. Sediment screening standards are available from the Department of Environmental Protection. The need for contaminant cleanup can significantly increase project complexity and cost.

Community Concerns
Preliminarily assess potential community interests and concerns. Is the impoundment currently used for recreation? Is there an opportunity for a park or canoe access following dam removal? Is the dam structure an important historic resource for the site, neighborhood, or town? Have other parties expressed an interest in contributing to the long-term maintenance and liability of the dam structure?

Funding Possibilities
Determine potential "hooks" for funding possibilities. Foundations and agencies that provide grants for river restoration and dam removal have different interests. Some provide funds for projects that help anadromous fish such as herring or salmon or for other sport fish such as trout. Others will provide funds for private landowners working to improve habitat on their land. Based on these "hooks" some projects can be almost entirely funded by outside sources, while others will receive very little outside funding. With overall project costs typically in the hundred thousands, this is a critical first step.

Site Survey: As part of this process of early data collection, it is recommended that a professional site survey is done. The site survey will create a scaled topographic base map showing existing conditions to provide information necessary to assess engineering conditions and deficiencies, hydraulics and sediment management. In order to completely survey the site, the surveying team must get in the water! The surveying should include:

1. Topographic plans and cross section drawings of the river and adjacent land, cultural (the dam, roadways, buildings, utilities, etc.) and geographic features in the impoundment, downstream and upstream,

2.. A survey of the deepest part of the stream through the impoundment, downstream, and upstream (longitudinal profile),

3. A survey of the impoundment bottom and the depth of soft sediment throughout the impoundment (bathymetry and depth to refusal),

4. A delineation and survey of the resource areas that will be affected as required in the Wetlands Protection Act and Army Corps of Engineers regulations, including: Land Under Water, Bordering Vegetated Wetland, Riverfront Area, Mean Annual High Water Line (or Ordinary High Water Line), and Bordering Land Subject to Flooding.

REFERENCES and ADDITIONAL RESOURCES

Executive Office of Energy and Environmental Affairs (2007). *DAM REMOVAL in MASSACHUSETTS: A Basic Guide for Project Proponents.*

Historical Topographic Maps available here: https://www.usgs.gov/faqs/how-do-i-find-download-or-order-topographic-maps

1.3

MAKING DECISION - PROBLEM FRAMING

PROBLEM SKETCH

WHO:
Project Team and Steering Committee

TIME:
2-5 hours

PURPOSE:
Build understanding of key elements of the decision and get group familiar with SDM process.

MATERIALS:
Printed blank SKETCH decision matrix and a chalkboard or flip chart and writing materials.

OVERVIEW

During this early problem framing, it may be helpful to do a quick problem sketch with the group. The problem sketch walks quickly through the first steps of the SDM process- framing the decision, identifying preliminary objectives, and identifying a range of possible alternatives. This problem sketch immediately helps everyone understand the SDM process, helps build a shared understanding of the key elements of the decision, and may help clarify what studies or data will be needed to evaluate the alternatives.

During this problem sketch, the group can develop a draft of a preliminary consequence table that links objectives, performance measures and alternatives. This process can provide insight early on into key information gaps, potential trade-offs and uncertainties. This will help the team determine what additional expertise, studies, or consultation may be needed to help evaluate the alternatives.

It is important to remember at this stage that Structured Decision Making and the creation of the consequence table is an iterative process. The goal of this early problem sketch is just to get a better sense of the decision and to test the possible objectives and alternatives. The consequence table will change and evolve as the public is engaged and the decision is better understood- objectives or alternatives may be added or removed and the language used to describe them can be refined further down the process.

PRE-WORKSHOP PREPARATION:

Ensure that the room you are working in has a large chalk board , blackboard, projector, or other way to draw the consequence table. It is best that it is visible to the whole group as you are filling it in. You may also print out the draft consequence table to the right so that each participant has one to take notes and brainstorm with.

SETTING UP THE EXERCISE:

Start to get the group brainstorming about the problem by asking them what matters most to them with regard to issue or decision. This can help begin to establish the objectives that can be filled in on the left hand side of the table.

During the process, do not let the group get too caught up in the wording of the objectives- that will come later. At this stage the goal is to get the main factors that will be impartation to understand.

Once the group has completed the Sketch consequence table, ask them to look over it- If it was filled in, would it summarize all the essential information to make a decision?

SKETCH Consequence Table	Performance Measure	SCENARIO 1	SCENARIO 2	SCENARIO 3
OBJECTIVE 1				
OBJECTIVE 2				
OBJECTIVE 3				
OBJECTIVE 4				
OBJECTIVE 5				
OBJECTIVE 6				
OBJECTIVE 7				
OBJECTIVE 8				
OBJECTIVE 9				
OBJECTIVE 10				

REFERENCES and ADDITIONAL RESOURCES

Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T.L., & Ohlson, D.W. 2012. *Structured Decision Making: A Practical Guide to Environmental Management Choices*. Wiley-Blackwell, Chichester, U.K.

See exercises:
2.1 for guidance on brainstorming objectives
2.3 for guidance on brainstorming performance measures
3.2 for guidance on brainstorming alternatives.

1.4

MAKING DECISION - PROBLEM FRAMING

PADDLE THE RIVER!

WHO:
Steering Committee and General Public

TIME:
3-5 hours

PURPOSE:
Familiarize the Project Team, Steering Committee and public with the river and the dam site

MATERIALS:
Canoes/kayaks, maps, life jackets, insurance, water, snacks

OVERVIEW

Early on in the process, it is helpful to get the steering committee, the project team and members of the public out on the river. Sometimes when talking about a river or a dam in a meeting, it is easy to forget the physical realities. By getting out on boats and exploring the river both upstream and downstream of a dam, everyone can gain a better understanding of the dam within its context and get clarity on some of the key issues are on the river. Being on the water, is the best way to get to know a river. Participants can observe the wildlife and plants, and experience the recreational opportunities first hand.

PROBLEM FRAMING	DETERMINING OBJECTIVES	IDENTIFYING ALTERNATIVES	ESTIMATING CONSEQUENCES	EVALUATING TRADE-OFFS	DECIDING AND TAKING ACTION
Project Team	Project Team	Project Team	Project Team	Project Team	Project Team
Steering Committee	Steering Committee	Steering Committee	Steering Committee	Steering Committee	Steering Committee
General Public	General Public	General Public	General Public	General Public	General Public

PREPARATION:

Determine a route for the group that is reasonable given the time and the skill level of the group. Ideally you will want to put the boats in above the dam or series of dams that is under discussion and paddle downstream. If canoes are available they are ideal since there can be an experienced paddler in the stern and two inexperienced people in the front.

Take all necessary safety precautions to ensure the group is safe or hire a kayak/canoe rental company that can help with safety and logistics. Require all paddlers to wear life jackets.

DAY OF PADDLE

Prior to getting in the boats, use an aerial and/or topographic map to orient the group to the area that will be explored. The maps should be brought on the trip and depending on the length of the paddle, they can be taken out multiple times to help the group make the connection between what they are seeing on the ground in the landscape and what is on the map.

Ideally, there should be someone on the paddle that can discuss the ecological conditions that are observed on the paddle including plant and animal species, invasive species, flow conditions, etc. From the water, the participants may be able to observe the adjacent upstream properties that might be affected by dam removal. They can observe any recreation on the impoundments and experience portaging the dam.

REFERENCES and ADDITIONAL RESOURCES

To Access Topographic Maps: https://www.usgs.gov/faqs/how-do-i-find-download-or-order-topographic-maps

For information on insurance contact the American Canoe Association Insurance: https://americancanoe.org/insurance/for-event-organizers/

2

DETERMINING OBJECTIVES

Project objectives represent the social, ecological, and economic attributes that are important to the public and decision makers. The objectives will be used to evaluate and understand the consequences of the alternatives. The wording of the objectives often includes the thing that matters as well as a verb that indicates the desired direction of change. Defining objectives can take important but ambiguously defined things that matter and define them for the purpose of the specific decision. Different individuals and groups will attach different importance to different objectives. Some examples of common objectives with decision making around dams include- Increase fish populations, improve water quality, maintain views of the historic dam structure, minimize negative impact on hydro power production, reduce costs.

In the classic negotiation book Getting to Yes (2007), Fisher and Ury discuss the role of positions and interests in the negotiation process. They explain "Your position is something you have decided upon. Your interests are what caused you to so decide."Unlike positions that lock people into a single outcome, when a problem is defined in terms of interests it is often possible to find a solution which satisfies both parties' interests. One of the goals of a objectives is to get the participants to focus on interests, rather than their positions.

Performance measures are specific metrics for each objective that helps compare and report on how well an alternative performed with regard to project objective. No objectives should be eliminated because they are hard to measure. While scientific and economic considerations may be easier to describe and quantify (ex. water temperature, cost), social and cultural concerns that are more qualitative (sense of place, aesthetics) are equality important to include in the decision making process.

2.1

MAKING DECISION - DETERMINING OBJECTIVES

BRAINSTORMING OBJECTIVES

WHO:
Steering Committee

TIME:
2-5 hours

PURPOSE:
Clarify project objectives

MATERIALS:
Paper for individual steering committee members + flip chart or blackboard for taking notes.

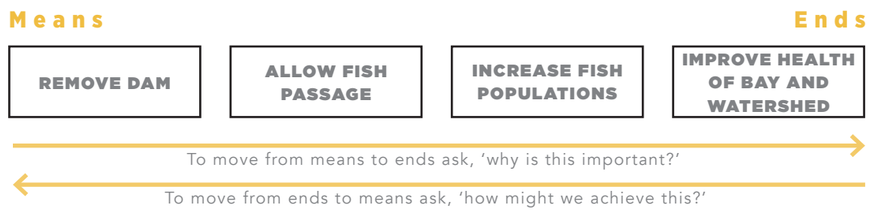
OVERVIEW

Good objectives help decision makers focus on what matters and what will be needed to evaluate the alternatives. The process of developing the objectivities can help build an understanding of shared values and build common ground early in the process.

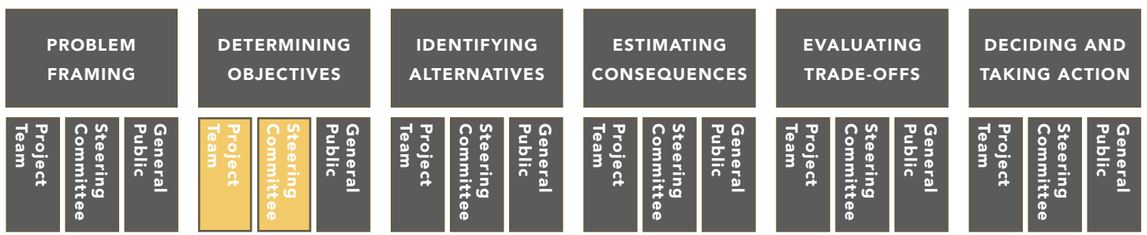
During this activity, the goal is to create a list of objectives that capture all the things that matter in evaluating the proposed alternatives, are concise and easily understandable, are influenced/impacted by the alternatives under consideration and are independent from one another.

During this phase, it is also important to start separating out the means (actions we can take to influence outcomes) from the ends (the outcomes we really care about). A fundamental objective is an end that you are trying to achieve and a means objectives is a way of achieving the fundamental (ends) objective. To move from means to ends you can ask " why is that important"?
At this stage you can also separate out process objectives (how the decision is made) and strategic objectives (an individual or organization own strategic priorities or direction.

Just because an objective may be hard to measure does not mean it is a bad objective. At this point all things that might influence the decision about alternatives should be included- figuring out how to measure or account for it will come in a later activity.



A simple means-ends diagram adapted from Gregory et al.



BRAINSTORMING:

Start by asking everyone the following questions (write the questions on the flip chart or have a slide that is projected with the question).

1. What are we trying to achieve by making this decision?
2. What are the specific issues or concerns you'd like to see addressed?
3. What are the specific issues or concerns that others might like to see addressed through this process?

Ask members of the steering committee to take 5-10 minutes to write down their own ideas independently on a piece of paper before starting to refine them as a group. If people have attached to supporting (or opposing) a specific solution, ask thewm to list out what is so good (or so bad) about the solution.

SHARING:

Once the steering committee members have completed their list, the group will need to start structuring the issues and concerns into a clear set of objectives. Start by asking the participants to share their notes. Depending on the size of the group- it might make sense to ask everyone to start by sharing 3-4 objectives and go around the circle. Following the first round you can ask if anyone has any additional objectives to add. As the participants share their objectives, write them on a flip chart or blackboard. It might be helpful to divide the responses into general categories (ex. ecological, social/ cultural, infrastructural, economic).

FUNDAMENTAL OBJECTIVES

The goal at this stage in the process is to extract the fundamental objective from the means objectives. One of the best ways to do this is by asking "why is that important?" A fundamental objective is an objective for which the answer to "why is that important?" is, simply, "because it is". As participants are listing out their objectives -it might be helpful to ask them to clarify why it is important in order to help get to the fundamental objective. It might also be helpful to sketch out a means-ends network. If people are listing out process and/or strategic objectives, consider making a list adjacent to the fundamental objectives so those considerations can be recorded and understood in relationship to the fundamental objectives.

HIERARCHICIZING:

Once the group has agreed on some fundamental objectives, you can begin to develop an objective hierarchy that identifies sub-components or sub-objectives. Below is an example of possible objectives and sub objectives for a dam project:

TESTING:

Once an initial list of project objectives have been developed, it is good to test them to see if they are useful and sufficient for evaluating the alternatives. Creating another iteration of the consequence table is a great way to do this. As a group, look at the sketch consequence table and imagining it filled in with data. Ask the group to consider whether the list represents the issues that are most important and if there is anything missing.

EXAMPLE OF HIERARCHICIZED LIST

MAXIMIZE ANADRAMOUS FISH POPULATIONS
- Improve fish passage
- Enhance habitat

MAXIMIZE ECOLOGICAL HEALTH OF RIVER
- Improve water quality
- Reduce spread of contaminated sediment downstream
- Reduce spread of invasive aquatic species

MINIMIZE NEGATIVE IMPACT ON SENSE OF PLACE
- Maintain views of the dam
- Reduce impact on historical landscape
- Honoring indigenous connection to river and migrating fish

MAXIMIZE PUBLIC SAFETY
- Minimize the risk of infrastructure failure
- Minimize risk of paddlers portaging dams
- Reduce flooding

MAXIMIZE RECREATION
- Maximize flat water recreation on impoundments
- Maximize river recreation
- Maximize access points

MINIMIZE ECONOMIC COSTS
- Minimize construction costs
- Minimize maintenance costs

REFERENCES and ADDITIONAL RESOURCES

Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T.L., & Ohlson, D.W. 2012. Structured Decision Making: A Practical Guide to Environmental Management Choices. Wiley-Blackwell, Chichester, U.K.

2.2

MAKING DECISION - DETERMINING OBJECTIVES

OBJECTIVE CARDS

WHO:
General Public

TIME:
3-5 hours

PURPOSE:
Clarify project objectives and help people focus on interests not positions.

MATERIALS:
Trade-off cards

OVERVIEW

The deck of "Trade-Off Cards", are 6"x4" physical cards that on one side have written out the objective and on the other side have a diagram and text that further explained the issue.

Many people come into a public meeting about a dam with a clear position (ex. keep or remove the dam). One of the goals of the trade-off cards is to help shift the conversation away from a focus on positions to a conversation about the underlying interests (ex. improve fish passage, preserve the history of the town, etc.). This shift Is key because while positions lock participants into advocating for a single alternative, many of the underlying interests that they care about could be achieved through multiple alternatives.

Using the trade-off cards early on in the public process can allow people to start by building a common ground. For example, many participants may agree that having a healthy river is important. This agreement then can allow for participants to collectively discuss and consider options that could help to achieve their shared goals later on in the process.

This process allows for the public to agree on what matters and will need to be assessed in order to effectively compare alternatives. By doing it in a public setting it also ensures that all considerations (both ecological and social) are being factored into the final decision. One of the goals of this process is to engage the public in determining the project objectives.

THE OBJECTIVE:

1. Allow participants to introduce themselves in a structured way that encouraged dialogue.
2. Help participants clarify the issues that they felt most strongly about.
3. By choosing 5 cards it helps participants move beyond a focus on single issue.
4. Encourage participants to shift from thinking about their position (keep or remove the dam) to thinking about their interests (improve fish passage, preserve sense of place, etc.).
5. Communicate to the participants that both scientific facts and social values are being considered in the discussion about the future of the dam.

PRE-WORKSHOP PREPARATION:

First you need to determine what the objectives are for the project. This should come from discussions with the steering committee. It can also be informed by research into the history of the dam and any previous community involvement. While you should try to represent all the issues, there will also be blank cards that the community members can fill in which will help determine if any objectives are missing.

Once you have a sense of the key objectives for the project, print out the trade off cards from the card deck that are most relevant. In addition, print enough extra blank cards so that community members can add additional project objectives.

SETTING UP THE EXERCISE:

Following an introduction presentation that outlines the decision context and the goal of the workshop, place trade-off cards face down in a row in the center of the table.

Ask participants to select 5 cards that represent their interests and concerns about the dam and to place them in front of themselves in ranked order from left to right with left being highest priority and right being lowest priority. Facilitators ask participants to use the cards as a way of sharing with the group the issues and concerns they have regarding the project.

It is suggested that enough cards are printed so that everyone can take 5 cards. However, if printing costs are a concern, you can ask community members to look at the cards and make a list of their top 5 choices on a sheet of paper. When it is an individuals turn, you can ask the participant to pick up their top 5 cards during their turn and return them to the middle of the table when their turn is over.

Go around the whole table until everyone has had a time to introduce themselves and go over their cards.

REFERENCES and ADDITIONAL RESOURCES


Fish Alteration
Upstream Habitat
Long-Term Gain

2.3

MAKING DECISION - DETERMINING OBJECTIVES

DEVELOPING PERFORMANCE MEASURES

WHO:
Steering Committee

TIME:
2-5 hours

PURPOSE:
Clarify performance measures

MATERIALS:
Paper for individual steering committee members + flip chart or blackboard for taking notes.

OVERVIEW

Once an initial draft of the objectives has been developed, performance measures can be identified that can help compare the impact of the alternatives on the objectives. The goal is to choose performance measures that highlight differences in the effects of management alternatives on different objectives. The identification of potential performance measures will lead to the practical need to collect data or build models. If it is impossible to collect the data or develop the models within the temporal, financial or personnel constraints of the project, other performance measures will need to be chosen.

Desired Characteristics of Performance Measures:

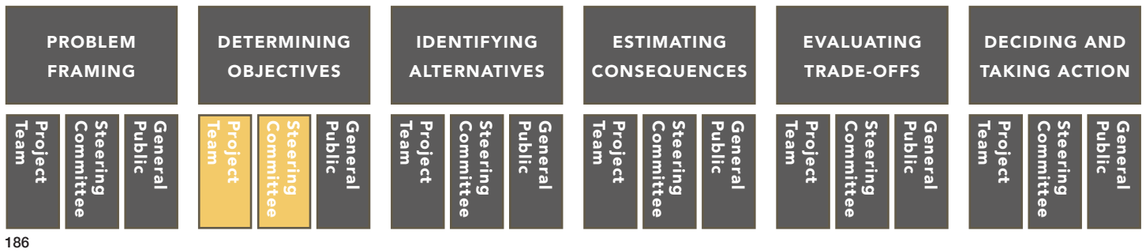
- **Unambiguous -** Clear relationship to fundamental objectives
- **Direct -** Clearly related to the consequences of interest
- **Comprehensive -** Cover full range of possible outcomes
- **Operational** - Suitable information available
- **Understandable -** Readily understood and easily communicated

Three Types of Attributes

Natural: Natural criteria directly measure the attribute itself . Some obvious examples are dollars (for financial or economic impacts) or hectares (for habitat). It is best to use natural criteria wherever possible.

Constructed: Constructed scales use a sliding or relative scale that is constructed for the decision. Constructed scales can be practical solutions to handling difficult or complex indicators however there is ambiguity surrounding exactly what is meant by a score and can be interpreted differently by different decision makers requires interpretation.

Proxy: A proxy is a natural attribute that is highly correlated with the objective, but does not directly measure it. A common example of this is the use of habitat area as a proxy for the degree of welfare of an endangered species. Only use proxies when natural and constructed criteria are not available. Proxies can hide non-linear relationships; mask uncertainty; and obscure value judgments



SETTING UP THE EXERCISE:

Display the draft list of objectives so the whole group can clearly see them. This can be a flip chart, a projector or a blackboard. Make sure there is enough room below each so that you can take notes on possible performance measures.

BRAINSTORMING:

Start by going through the objectives one by one and asking the steering committee for each objective:

- *What specific information would you like to see to be able to evaluate the impact of these alternatives?*

As the committee members provide responses, list out all the possible answers for each objective on the board, flip chart or slide.

Before moving on to the next objective, ask the steering committee to consider the possible sources of data or models that would be needed:

- *For each of these possible performance measures, what are possible sources of information for estimating the measure?*

Open a discussion to evaluate and select the most useful measure for each objective. Sometimes time and financial constraints will prohibit the selection of the most ideal performance measures. Also, there may need to be adjustments later on in the process if it is determined that the most useful data or model will not be available. As like all aspects of the SDM process, this will be an iterative process.

REFERENCES and ADDITIONAL RESOURCES

Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T.L., & Ohlson, D.W. 2012. Structured Decision Making: A Practical Guide to Environmental Management Choices. Wiley-Blackwell, Chichester, U.K.

3

IDENTIFYING ALTERNATIVES

Within the Narragansett Bay and coastal watersheds, there is a need to address aging dams that are in poor condition and in need of repair. Each dam is unique and has different ecological, social, physical and economic factors that need to be considered when exploring solutions. Given that most dams within New England are small, there are often a range of alternatives that can achieve multiple objectives. Dam removal is frequently the most cost-effective way to manage aging dams. Removal will restore most natural river functions and ecological connectivity, eliminate future risks of failure, and avoid long term maintenance and repair costs. However, the social, physical and economic aspects of the local community often warrant consideration of alternatives. Conventional fishways or nature-like fishways are often used in combination with either no or partial lowering of the water levels upstream of the dam. Where dams are not removed, repair and long-term maintenance costs and the potential consequences of dam failure to property, infrastructure and livelihoods need to be identified through engineering studies. The future of any particular dam may warrant the exploration of other options that move beyond what is often perceived as just two options of either keeping or removing the dam.

CASE STUDIES

WHO:
Steering Committee and/or General Public

TIME:
1 hour

PURPOSE:
Review case studies of other similar projects to help understand possible alternatives

MATERIALS:
Case Study Cards

OVERVIEW

Each dam is unique and the specific ecological, social, physical and economic factors need to be considered when exploring future scenarios. Unlike large dams, where there are often very few options beyond removal to achieve multiple project objectives, with small dams, there are often a range of alternatives that can achieve multiple objectives. While dam removal may be the best way to restore river functions and ecological connectivity, the social, physical and economic aspects of the local community may benefit from considering a range of alternatives. While typical design charrettes tend to be more open ended, with dams, there are common sets of known alternatives. Public processes around dams benefit from exploring and evaluating the known alternatives while also leaving open the space for creative problem solving if there are new alternatives that can be introduced that are unique to the site.

Case studies allow for the steering committee and general public to learn about how other communities have found solutions to address their aging dam infrastructure. Case studies allow the group to gain familiarity with the common alternatives and use this as a starting point for discussions about possible alternatives for the project at hand. It also can help the group imagine what is possible and reduce fears of the unknown future conditions- for example, seeing photos of projects where the dam has been removed can help the group imagine what that future condition might look like. Case studies can also provide an understanding of the support that is needed to move projects forward and the regulatory and funding opportunities and constraints of a project.

PRE-WORKSHOP PREPARATION:

The meeting organizers should choose case studies that are appropriate to the scale, type and context of the dam being discussed. There are downloadable PDF's of case studies included in this resource as well as a Microsoft Word and Google Doc template that can be used to create new case studies. If the case studies that are

Prior to the workshop, these case studies should be printed so that every table has at least one of each case study. If you do many workshops- consider printing on card stock paper so that they can be used at multiple workshops.

THE EXERCISE:

During the presentation, the facilitator can present the case studies. Using before and after photos is a great way for people to understand the impact of the alternative.

Following the presentation, at each table, ask the participants to take time to review the case study cards.

Following the review of the case studies, ask participants to respond to the following questions:

- Are there any questions about the case studies?
- What aspects of each case study seems relevant to the decision at hand?
- Given what we learned from the case studies, what might be appropriate alternatives to consider for this project?

REFERENCES and ADDITIONAL RESOURCES

3.2

MAKING DECISION - IDENTIFYING ALTERNATIVES

BRAINSTORMING ALTERNATIVES

WHO:
Steering Committee

TIME:
2-5 Hours

PURPOSE:
Brainstorm alternatives

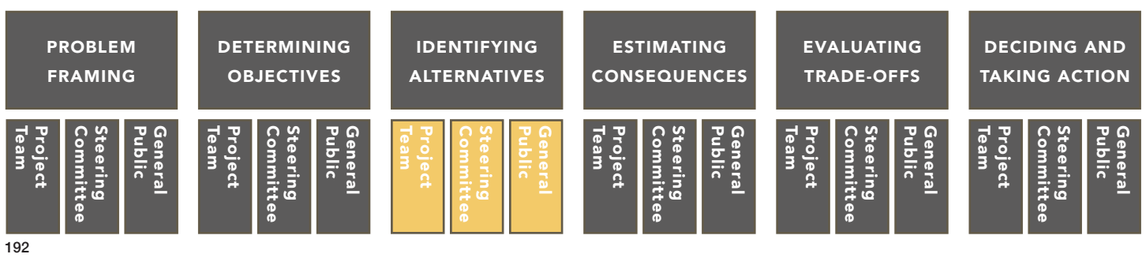
MATERIALS:
Aerial and topographic survey printed at the same scale, photographs

OVERVIEW

Each dam is unique and the specific ecological, social, physical and economic factors need to be considered when exploring future scenarios. Unlike large dams, where there are often very few options beyond removal to achieve multiple project objectives, with small dams, there are often a range of alternatives that can achieve multiple objectives. While dam removal may be the best way to restore river functions and ecological connectivity, the social, physical and economic aspects of the local community may benefit from considering a range of alternatives. While typical design charrettes tend to be more open ended, with dams, there are common sets of known alternatives. Public processes around dams benefit from exploring and evaluating the known alternatives while also leaving open the space for creative problem solving if there are new alternatives that can be introduced that are unique to the site.

Community sentiment around a dam may vary based on the location, structure, history, and the use of the dam and impoundment. Depending on whether the community attachment is to the dam or to the impoundment, various future scenarios may be considered. For example, a nature-like fishway can preserve a impoundment while significantly improving fish passage, however the dam structure will no longer be visible. If space exists around the dam, a bypass channel can preserve the view of the dam while also significantly improving fish passage and habitat connectivity. In addition, there may be ways to use design to maintain a sense of place and the aesthetics of the dam even if the dam is removed. There are now good case studies that exist for many of these alternatives that can be shared with community members to help them understand and visualize the different alternatives.

Although dam modification alternatives may be more costly than removing the dam and require long term maintenance and repairs, exploring a range of alternatives during the workshop allows for the conversation to move beyond what is often perceived as the binary option of either keeping or removing the dam. The goal of the process is to explore the aesthetic, ecological and historical implications of a range of alternatives and to encourage participants to think about creative solutions to addressing the issues and trade-offs. Community members often appreciate this type of creative thinking that clearly shows the project team trying to address community concerns and find solutions that address the multiple project objectives.



SETTING UP THE EXERCISE:

Depending on the size of the steering committee group, it may be helpful to divide the group up into smaller groups of 5 that can comfortably sit around a table. At each table, have aerial images of the dam site, topographic surveys, measurements and photographs of the site. It may be helpful to have the areal and topographic surveys printed at multiple scales- one that is very zoomed into the dam sites and surrounding landscape, one that includes the larger reach of river upstream and downstream of the dam, and one that is of the larger regional context. All aerial and topographic maps should have a graphic scale. Each table should also have trace paper, scales and pens and markers. These tools can help with the brainstorming process and to quickly test ideas.

BRAINSTORMING:

In this exercise, you will work with the steering committee to start brainstorming possible alternatives for the site. While the group may think that the only options are to keep or remove the dam, the goal of this brainstorming activity is to help the group think creatively and explore a wide range of possible future scenarios that can help address the project objectives.

Begin by asking everyone to start writing down ideas for alternatives individually. Once everyone has had a chance to brainstorm- you can go around the group and have them individually share their ideas with the group. This helps to avoid group-think and improves creativity. As people are describing an alternative, if it is spatial, ask them to sketch the ideas out on the trace paper or you can do it for them as they are describing it and ask them to correct it.

It might be helpful to start brainstorming alternatives for the individual objectives. For each objective, ask how could it be best supported or achieved? What alternatives look desirable from the perspective of that objective alone? To get the group started, you can ask:

- "if you were considering only the objective of x, what alternatives might you consider?"

This should be a creative process of exploring the widest ranging possibilities. At this point the goal is to get the group to explore the "what if" possibilities. List alternatives first, evaluate them later. Critiquing them as they are offered hinders creativity.

Challenge constraints. Some are real but some are only assumed. Try out alternatives that assume the constraint is not there. If the alternative looks great, start questioning the assumed constraint. Remove implicit assumptions about what will be economically or politically feasible …

Ask yourself what others would think. If you presented this alternative to others, what concerns might they have? What alternatives can you think of to address these concerns?

CHARACTERISTICS OF "GOOD" ALTERNATIVES

Value-Focused- Explicitly designed to address the fundamental values or ends of the decision – the "things that matter" or "felt needs", as defined by the objectives and the evaluation criteria;

Technically Sound - meaning that in developing alternatives for achieving the objectives, the project team has drawn on the best available information about cause and effect relationships and has designed creative and diverse alternatives based on sound analysis;

Clearly and Consistently Defined- Alternatives are defined to a sufficient and consistent level of detail using logically consistent assumptions, and that a base case against which all alternatives can be compared has been clearly established;

Small in number and high in quality- Poor alternatives have been eliminated and those remaining have been iteratively refined to incorporate new ideas and joint gains;

Comprehensive and mutually exclusive- Individual elements or components of a strategy are combined into complete packages, and that the packages are directly comparable;

Able to expose fundamental trade-offs- Emphasize rather than hide difficult but unavoidable value-based trade-offs and present real choices for decision makers;

REFERENCES and ADDITIONAL RESOURCES

Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T.L., & Ohlson, D.W. 2012. Structured Decision Making: A Practical Guide to Environmental Management Choices. Wiley-Blackwell, Chichester, U.K.

SITE VISIT

WHO:
Project Team and Steering Committee

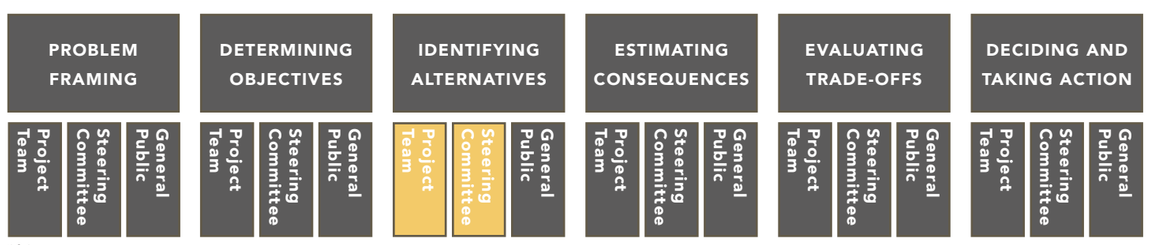
TIME:
2-5 Hours

PURPOSE:
Gain familiarity with the site and help brainstorm possible alternatives

MATERIALS:
Aerial and topographic survey printed at the same scale

OVERVIEW

While discussing and developing a list of possible alternatives, it can be helpful to do a site visit with the project team and the steering committee to help ground the discussions of alternatives in the specific site context and realities. Each of the alternatives have specific site constraints that will need to be factored in to know whether they are viable alternatives to consider. For example, understanding the downstream conditions will influence whether a river wide nature-like fish ladder would be possible; Seeing the amount of space surrounding the dam and any adjacent buildings or infrastructure (bridges, utilities, etc) may help the group understand whether a by-pass channel or removal would be a viable alternatives; understanding which part of the dam structure is visible from adjacent roads may lead to ideas of how to preserve parts of the dam while removing others to improve habitat connectivity. It is important to think creatively at this stage and visiting the site can help the group brainstorm other ways to balance the various physical constraints and opportunities of a site.



Either prior to the brainstorming alternatives activity or after an initial list of alternatives have been developed, it can be helpful to visit the site with the steering committee. This can help everyone visualize the different possible alternatives on the site and realize if any were not considered that should be added to the list.

Bringing scaled aerial and topographic maps out to the field can help people connect what they are seeing in the field with the plan which can also help with future efforts to discuss the site conditions.

With the group, walk around the dam and the areas upstream and downstream of the dam site. If there is any missing data about the dam this may be a chance to gather data as well. Understanding height, slope, adjacent infrastructure can help the group explore the possibility of other alternatives such as bypass channels, nature like fishways and removal and think through what additional data would be needed to determine if those would be viable alternatives.

If the dam is in a populated area, walk around the adjacent streets as well. This can help build an understanding of how the dam is part of the built fabric of the community and if it might impact the sense of place. Is the dam visible from the surrounding roads, is the sound audible, are there houses or businesses adjacent to the structure?

REFERENCES and ADDITIONAL RESOURCES

To Access Topographic Maps: https://www.usgs.gov/faqs/how-do-i-find-download-or-order-topographic-maps

4

ESTIMATING CONSEQUENCES

Once the objectives and alternatives have been identified and agreed upon, the next step is to estimate the consequences of the alternatives with respect to the evaluation criteria using available knowledge and predictive tools. This step is primarily an analytical task, usually undertaken by scientists, engineers, economists and specialists in traditional ecological knowledge. Some of these specialists may be part of the project team but others may be consultants from outside of the project team. For Example- a fish biologist might be needed to estimate anything related to anonymous fish populations. Engineers may be needed to do an Hydrology and hydraulics analysis to understand the impact on flooding. Landscape architects may be helpful to visualize the aesthetic impact of the alternatives and how if might affect sense of place.

The information that is gathered during this step should be relevant to the decision and should incorporate best practices in term of bias avoidance, treatment of uncertainty, and documentation.

Once the data has been collected, it will be critical to think about how this information is communicated to the steering committee and general public. When working with the general public, there is often the need to translate complex technical ideas into language and decision-relevant information that can allow people without technical expertise to meaningfully consider technical information. For this reason, we suggest the use of visualizations and well designed graphics to develop mutual understanding amongst the group and help facilitate dialogue. These visual tools can help foster insights not accessible through other, often more quantitative approaches to communicating information.

4.1

MAKING DECISION - ESTIMATING CONSEQUENCES

FEASIBILITY STUDIES

WHO:
Project team

TIME:
Weeks

PURPOSE:
To gather information that will help estimate consequences of the alternatives on the objectives.

MATERIALS:
Engineering and design software and programs.

OVERVIEW

The feasibility study provides concept-level plans and quantitative information on environmental and engineering feasibility necessary to make final decisions on the project approach. The feasibility study typically includes analyses necessary to understand the impact of alternatives on the structure, protecting infrastructure, restoring in-stream and riparian habitat, and managing sediment. While feasibility studies will often only include the analysis of removal, we strongly recommend looking at the feasibility of a range of alternatives at this stage. While every case is site-specific, below are some general items that are frequently included in the feasibility study scope of work:

Conceptual Drawings.

Develop concept-level drawings of design alternatives for repairing, replacing, or removing structures and restoring the site.

HYDROLOGIC AND HYDRAULIC MODELING

Hydrologic and hydraulic modeling is a tool commonly used for engineering analysis and to evaluate the benefits of proposed alternatives. Hydrology represents the quantity of water (runoff) generated from a specific area or watershed. Hydraulics deals with the physical properties of water, such as calculating the depth of flow in a pipe or open channel. A combined hydrologic/hydraulic model can help evaluate the impacts of various scenarios on water flow and flooding.

SEDIMENT MANAGEMENT PLAN

Quantitatively assess sediment quality and quantity. Develop a conceptual plan to manage sediment movement. Fundamental to this analysis is determining what portion of the sediment will transport downstream as a result of different management approaches. The consulting team must know how to complete this type of analysis and it is integral in the decision of who to hire for the work.

PRELIMINARY STRUCTURE REMOVAL PLAN

The final approach for removing or modifying the structure will be completed during the engineering design, but several issues should be considered during the feasibility phase as they can have a significant effect on the scope of the design. These include:
1. Assess the condition of the dam structure to determine safety concerns, potential demolition approaches, and whether there are usable gates or removable boards that can be used during the dam removal,
2. Assess access to the site and staging areas for construction equipment,
3. Assess site limitations, such as utilities or topographic constraints, and
4. Assess locations suitable for the disposal of dam rubble, as well as sediment removed from the site, if necessary.

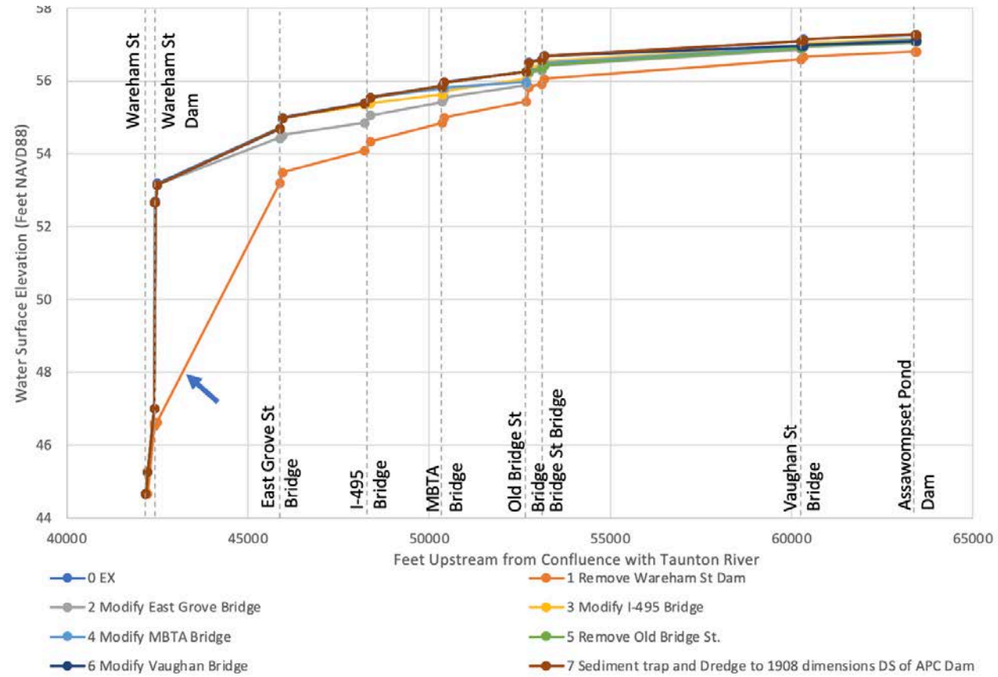
COST ESTIMATES

Develop cost estimates to bring the recommended approach to completion, including costs of final design, permitting, construction and construction oversight. At this point in the process until the engineering design has been finalized, the cost estimate will be considered a 'probable cost' based on the consulting team's best judgment and past experience.

RIPARIAN RESTORATION PLAN:

Assess alternatives for the structure and habitat within the stream channel and on exposed land in the former impoundment. This may include assessing whether the site will provide fish passage and should provide alternatives for habitat improvements.

FISHERIES Consult Division of Marine Fisheries when the dam removal involves an anadromous or catadromous fish run. Additionally, consult Mass Wildlife (Division of Fisheries and Wildlife) when the dam removal involves a cold water fisheries resource or waterfowl breeding or feeding habitat; and in the Merrimack and Connecticut watersheds, when dam removal involves anadromous or catadromous fish runs.



Results of H&H Model conducted by Horsley Witten Group for the Upper Nemasket River Enhancement Plan

PROBLEM FRAMING	DETERMINING OBJECTIVES	IDENTIFYING ALTERNATIVES	ESTIMATING CONSEQUENCES	EVALUATING TRADE-OFFS	DECIDING AND TAKING ACTION
Project Team	Project Team	Project Team	**Project Team**	Project Team	Project Team
Steering Committee	Steering Committee	Steering Committee	Steering Committee	Steering Committee	Steering Committee
General Public	General Public	General Public	General Public	General Public	General Public

REFERENCES and ADDITIONAL RESOURCES

https://civiltechinc.com/the-benefits-of-hydrologic-hydraulic-modeling-a-case-study/

Executive Office of Energy and Environmental Affairs (2007). *DAM REMOVAL in MASSACHUSETTS: A Basic Guide for Project Proponents.*

VISUALIZING THE ALTERNATIVES

WHO:
Project team

TIME:
Weeks

PURPOSE:
Help visualize the alternatives to understand the impact to the surrounding landscape

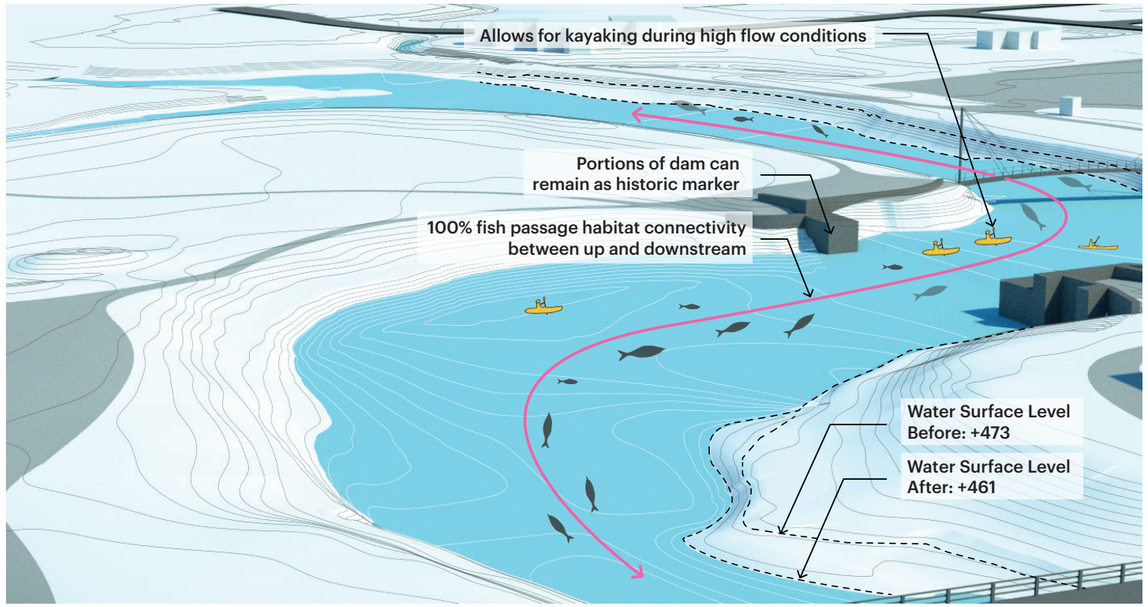
MATERIALS:
Graphics programs such as Photoshop and 3-D modeling program such as Auto CAD and RHINO

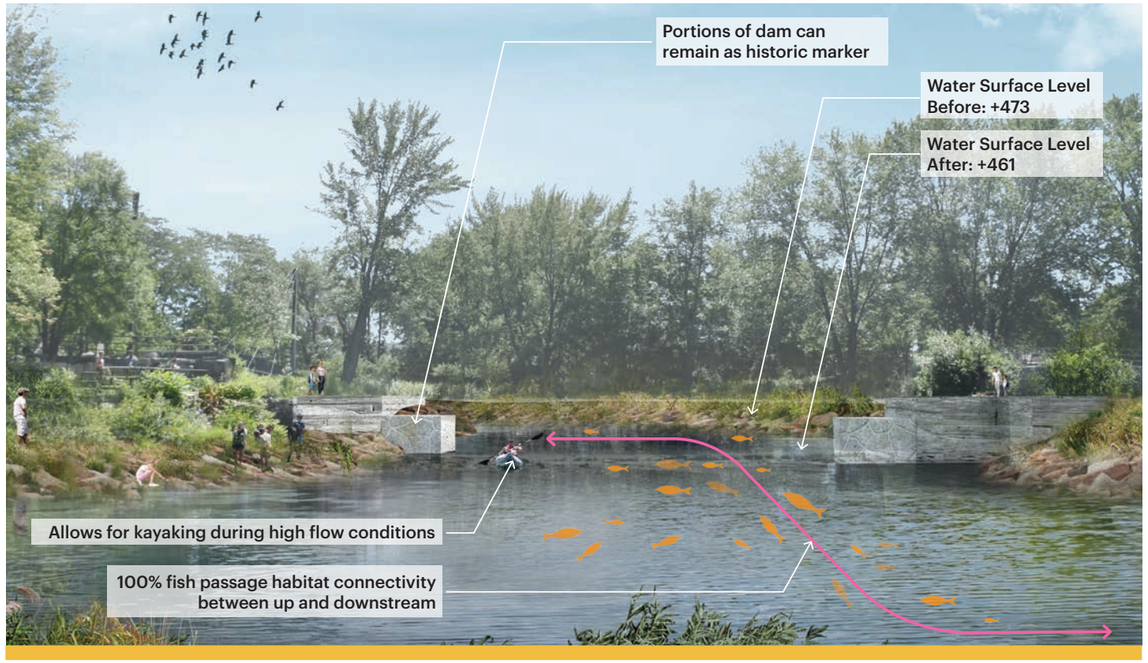
OVERVIEW

One of the consequences of the alternatives will be the visual, aesthetic and physical impact of the alternative on the dam site and upstream and downstream conditions. For sites that have a high visibility and social value, this may be a very important factor whereas for other sites that are not visible, it may be inconsequential. Visualizations can help the group and the general public be able to imagine and understand the physical changes that are being proposed.

Different types of visualizations can be used depending on what needs to be communicated. Eye level renderings, such as the lower image on the right, can give a sense of the aesthetic and visual changes to the dam structure. Birds eye views, such as the upper image to the right can give a sense of the larger upstream and downstream impacts. Since these visualizations will be used to help make decisions, it is important that the information communicated in them is accurate. Therefore there may need to be close communication between the engineering team and whomever is making the visualizations to ensure that water levels and other potential topographic, structural, hydrological, and vegetation impacts are being communicated as accurately as possible.

In the images on the right, the existing conditions and various alternatives were first modeled in the computer program Rhinoceros. That allowed for an accurate representation of topographic conditions and the modeling of water level changes. For the lower image, the view of the model was then brought into the computer program Photoshop to merge it with an existing photo. Annotation was then added on top of the images to call out the specific changes to the site conditions.





REFERENCES and ADDITIONAL RESOURCES

5

EVALUATING TRADE-OFFS

The SDM process allows for the transparent evaluation of alternatives based on how well each alternative meets the project objectives. For individual participants, each objective may hold a different weight or level of importance, which will impact their final decision or ranking of preferred alternatives. By laying out the objectives and alternatives clearly in the decision matrix, it allows for a visible way for these subjective values to be openly discussed and ranked. The consequence matrix can help stakeholders' focus on their interests and identify the various alternatives that can meet those interests rather than just focusing on the position. Given the complexity of many dam decisions and the number of competing objectives, the consequence matrix can make the decision visual which can help people keep track of the impact of the alternatives on the project objectives. Without this ability to organize and keep track of information, people can revert to their original positions or default to physiological shortcuts.

5.1

MAKING DECISION - EVALUATING TRADE-OFFS

DECISION MATRIX

WHO:
Steering Committee + General Public

TIME:
2-5 Hours

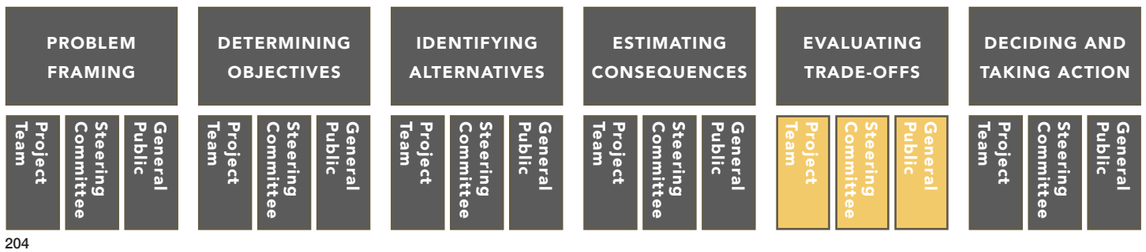
PURPOSE:
Gain understanding of how the alternatives meet the project objectives and indicate preferences

MATERIALS:
Printed Matrix, Red, green, and yellow stickers

OVERVIEW

A consequence table is a summary matrix illustrating the performance of each alternative on each objective. It concisely summarizes estimates of the predicted consequences of the alternatives, relative to the objectives and criteria. It exposes key trade-offs among objectives across the alternatives under consideration.

The Structured Decision Making process allows for the transparent evaluation of alternatives based on how well each alternative meets the project objectives. For individual participants, each objective may hold a different weight or level of importance, which will impact their final decision or ranking of preferred alternatives. By laying out the objectives and alternatives clearly in the decision matrix, it allows for a visible way for these subjective values to be openly discussed and ranked. The consequence matrix was a new tool for the participants, but proved to be effective in aiding stakeholders' understanding of their options and how their priorities shifted. It also allows for the participants to focus on their interests and identify the various alternatives that can meet those interests rather than just focusing on the position. Given the complexity of many dam decisions and the number of competing objectives, the consequence matrix can make the decision visual which can help people keep track of the impact of the alternatives on the project objectives. Without this ability to organize and keep track of information, people can revert to their original positions or default to the physiological shortcuts mentioned previously.



PRE-WORKSHOP PREPARATION:

Prior to the workshop, the organizers will need to make a decision matrix. To make the matrix, the alternatives should be listed along the top of the sheet and along the left side list out the trade-offs. Inside of the matrix, the impact of the alternative on the trade-off should be included. Depending on where the group is in the process the matrix can be filled in with general impacts or with more specific quantifiable impacts. To make the matrix table more visually accessible, an icon or text can be used to indicate the impact of the alternative on the attribute.

SETTING UP THE EXERCISE:

Ask participants to review the alternatives

RANKING:

Review the matrix and rank the alternatives on the matrix.
Give participants red, green, and yellow stickers and ask them to use the stickers at the bottom of the matrix to indicate the following:
GREEN = Preferred option = enthusiastic support –"this is a great solution"
YELLOW = Acceptable option = "Maybe it is not the best solution but it is one I could support.
RED = Oppose = no support "I cannot support this solution"

Participants are required to use at least one green and at least one yellow sticker. The yellow "acceptable alternative" sticker is intended to help participants find a space of negotiation.

Go around in the circle and ask participants to discuss their ranking and say the main reasons they support or the main reason they are against the different alternatives. As people are presenting, the note taker compiles the ranking in a master sheet indicating the number in prefe red, acceptable and oppositional votes for each alternative.

OPTIONAL: RE-RANKING

The goal of the 2nd round of ranking is to provide a chance for the participants to reflect on their choices after the discussion and to allow for participants to adjust their preferences based on the discussion.

After the first round, ask participants to re-rank the alternatives (everyone has to use one green, one red and 2 yellow, and one optional color)

Facilitators ask everyone to share their final ranking.

AS people are presenting, the facilitator compiles the ranking in a master sheet indicating the number in preferred, acceptable and oppositional votes for each alternative.

REFERENCES and ADDITIONAL RESOURCES

Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T.L., & Ohlson, D.W. 2012. Structured Decision Making: A Practical Guide to Environmental Management Choices. Wiley-Blackwell, Chichester, U.K.

		Keep and Repair Dam	Denil Fish Ladder	Nature Like Fishway	ByPass Channel	Remove Dam
ECOLOGICAL TRADE-OFFS	**Fish Passage up and downstream**	0% Passage	30%-50% Passage	60%-70% Passage	30%-50% Passage	100% Passage
	Conservation of upstream wetlands	Upstream Wetlands Conserved	Upstream Wetlands Conserved	Upstream Wetlands Conserved	Upstream Wetlands Conserved	Potential Loss of Wetlands
CULTURAL AND AESTHETIC TRADE-OFFS	**Recreational Opportunities on the impoundment**	Recreation Maintained	Recreation Maintained	Recreation Maintained	Recreation Maintained	No recreation on impoundment
	Visibility of Historic Dam	Dam visible	Dam visible	Dam no longer visible	Dam visible	Dam no longer visible
	Impact to existing park	Remove vegetation from berm	Remove vegetation from berm + Denil fish ladder	Remove vegetation from berm + downstream channel elevated	Remove vegetation from berm + new bypass channel construction	Keep vegetation on berm + dam removed + water elevation lowered
ECONOMIC TRADE-OFFS	**Up-Front costs**	$	$$	$$	$$$	$$
	Long-Term costs and maintenance	$	$$	$$	$$$	0
	Likelihood of external funds to offset upfront cost	**NOT LIKELY**	**LESS LIKELY**	**LESS LIKELY**	**LESS LIKELY**	**MORE LIKELY**
	GREEN = Preferred YELLOW = Acceptable RED = Oppose You must use at least one green and one yellow sticker					

Example of a Matrix Used for an Exploratory Workshop

RIVER ALTERNATIVES SUMMARY TABLE			**No Action Alternative**	**Sediment Trap**	**Remove Wareham St Dam**	**Full River Restoration** Remove Wareham St Dam Naturalized channel Widen 3 bridges
ECOLOGICAL OBJECTIVES	**Fish Passage up and downstream**		**NO CHANGE**	**MINOR IMPROVEMENT**	**IMPROVED**	**GREATLY IMPROVED**
	Improve Water quality + Habitat		— Disolved Oxygen — Water Temperature — Sediment Transport	— Disolved Oxygen — Water Temperature ↓ Sediment Transport	↑ Disolved Oxygen ↓ Water Temperature ↓ Sediment Transport	↑ Disolved Oxygen ↓ Water Temperature ↓ Sediment Transport
	Improve low-flow aquatic connectivity	Points along river where challenging for Herring to pass	**7** potential low points	**7** potential low points	**5** potential low points	**4** potential low points
INFRASTRUCTURAL AND OPERATIONAL OBJECTIVES	**Minimize flood damage to infrastructure and property downstream of APC.**	Flooded Area (100 Year storm)	**723** Acres	**723** Acres NO Reduction	**680** Acres 6% Reduction	**653** Acres 10% Reduction
		Impacted buildings	**27** Buildings	**27** Buildings	**23** Buildings	**19** Buildings
	Reduce ongoing maintenance by working with river morphology		**Works against river morphology**	**Works against river morphology. Requires ongoing maintenance**	**Works with river morphology**	**Works with river morphology**
	Permitting		**N/A**	**VERY CHALLENGING**	**CHALLENGING**	**CHALLENGING**
RECREATIONAL OBJECTIVES	**Maximize quality and quantity of recreation on the river**	Boating Opportunities Expanding fishery habitat diversity	**FLAT WATER RIVER RECREATION** Maintains Existing "flat water" recreation on river + ease of round trips	**FLAT WATER RIVER RECREATION** Maintains Existing "flat water" recreation on river + ease of round trips	**FREE FLOWING RIVER RECREATION** No portage at Wareham st and fewer low flow areas	**FREE FLOWING RIVER RECREATION** No portage at Wareham st and fewer low flow areas
ECONOMIC OBJECTIVES		Cost	**N/A**	**$**	**$$**	**$$$**
		Availability of Funding	**N/A**	**UNLIKELY**	**LIKELY**	**LIKELY**
	GREEN = Preferred YELLOW = Acceptable RED = Oppose You must use at least one green and one yellow sticker					

Example of a Matrix Used for the Upper Nemasket River Enhancement Plan with data from Horsley Witten Group Hydrology and Hydraulics Study


AIR DAM
LEVEE
FISHWAY
NOT LIKELY
LESS LIKELY
MORE LIKELY

6

DECIDING AND TAKING ACTION

While the Structured Decision Making process does not "make a decision", it helps to communicate to decision makers about the trade-offs of different alternatives and the preferences of the steering committee and the community. The ultimate goal of the process is to be able to move forward with a decision about the future of a dam. For contentious projects, there will most likely not be consensus on which alternative to move forward with, but the process should help clarify preferences and areas of agreement and disagreement. One of the goals of having 3 levels of support for an alternative (endorse, accept, and oppose) is to hopefully find alternatives that while they may not be preferred by all parties, can be accepted by all parties.

6.1

MAKING DECISION - DECIDING AND TAKING ACTION

FINAL REPORT

WHO:
Steering Committee +
General Public

TIME:

PURPOSE:

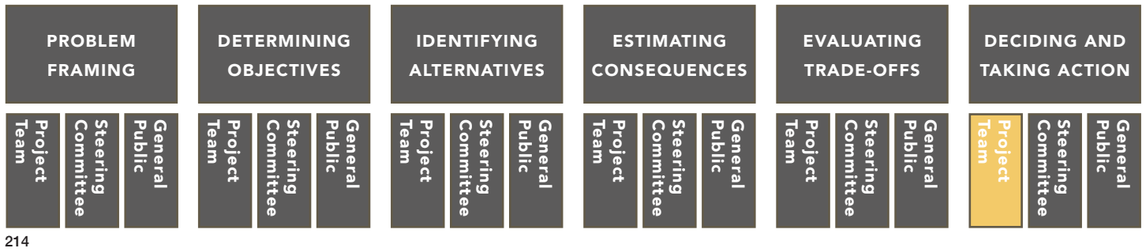
MATERIALS:

OVERVIEW

Once the trade-offs have been evaluated, there is a need to summarize the process and the outcome of the process. This summary is best compiled into a final report that is made publicly available. The summary can include the full engineering feasibility study as well as a summary of the community engagement process.

Within the report the support for the various alternatives and areas of agreement and disagreement can be summarized.

Following this phase of a project, an alternative should be decided to move forward with.



REFERENCES and ADDITIONAL RESOURCES

6.2

PERMITTING

WHO:
Steering Committee +
General Public

TIME:

PURPOSE:

MATERIALS:

OVERVIEW

Local, state, and federal agencies have authority over dams, including dam removal, and ecological restoration. Depending on the nature of the dam and the site-specific conditions, multiple permit applications may be required to remove a dam. Timing for each permit varies and some permits, once the application is submitted, can take up to 90 days for the agency to review. The more thoroughly prepared the feasibility analysis and permit application, the less time it takes to receive approval. Note that in some cases, regulators may require additional information during the permitting review process. It is advisable when submitting information for environmental review to send it by certified mail, return receipt requested, so that you know when it was received and by when to expect a response based on that agency's regulatory timeline for review and response.

Costs to prepare permits can vary widely depending on project complexity. If the work is entirely completed by consultants (including completing paperwork, filing forms, and attending hearings, meetings, and site visits) permitting can cost between a few thousand and a hundred thousand dollars depending on site-specific permit requirements. Many of the filings and hearings can be completed by the proponent at significant cost savings if so inclined. Most permit applications require payment of fees, although some of these fees can be waived if the applicant is a municipality or state agency.

Some general recommendations:
- Consult with and work cooperatively with regulatory agencies.
- Invite agency personnel to the site prior to beginning the permitting process.
- Maintain communication with permitting agencies and respond completely and accurately to their questions or comments.
- Plan sufficient time to complete all the necessary consultations and regulatory processes.

REFERENCES and ADDITIONAL RESOURCES

PERMITTING- RHODE ISLAND

WHO:
Steering Committee + General Public

TIME:

PURPOSE:

MATERIALS:

OVERVIEW

The Rhode Island dam removal permitting process is represented in this section. Please note, however, as there are so few licensed hydropower dams in Rhode Island, FERC requirements, although briefly discussed, are not integrated into the outlined process.

When is a permit necessary?

Almost always. In adherence to the federal Clean Water Act as well Rhode Island laws and regulations, most dam removals will require completion of an extensive permitting process. Exceptions to this process would be extremely rare; instances might include the removal of a very small dam or removal of a previously breached dam. In such rare instances, a Request for a Preliminary Determination is submitted to RIDEM who must determine if the removal will result in significant changes to the functions and values of the wetland. If there will be no changes, a permit will not need to be issued; if there are changes, but those changes are insignificant, a permit could be issued with conditions. However, if it is determined by RIDEM that the functions and values of the wetland will be likely be affected, the full permitting process will need to be undertaken.

Who issues the permits?

In Rhode Island, project permits will be issued by either the Rhode Island Department of Environmental Management (RIDEM) or Rhode Island Coastal Resources Management Council (RICRMC) and the United States Army Corps of Engineers (USACE). Furthermore, before federal permits can be issued, or if federal financial support or technical assistance is utilized, additional agencies consultations are often required. Additionally, projects will need to abide by local ordinances and as well as a variety of federal regulations. Therefore, acquiring permits requires interaction with multiple agencies across local, state, and federal scales. Because of this complexity, it is beneficial when undertaking a project to involve permitting agencies as early as possible.

What federal agency must issue a permit?

The USACE must issue a Section 404 permit, but before doing so the state (RIDEM) must grant or waive a water quality certification pursuant to Section 401 of the CWA, 33 U.S.C. 1341 which ensuring that the proposed activity will not violate Rhode Island water quality standards. If the project is planned in the coastal zone, or has the potential to affect the coastal zone, the state (RICRMC) must issue a certificate pursuant to the Coastal Zone Management Act, 16 U.S.C. 1451 et seq which ensures that the proposed dam project is consistent with the Rhode island's approved coastal zone management program.

What RI agency issues the certificate?

In Rhode Island, dams lie under either the jurisdiction of the RIDEM or RICRMC. The agency that has jurisdiction is determined by whether the dam lies in a coastal zone. When determining who has jurisdiction, consider the following questions.

- Does the dam lie within tidal waters or within two hundred (200) feet inland from any coastal feature (coastal features are: coastal beaches; dunes; barrier islands; coastal wetlands; cliffs, bluffs, and banks; rocky shores; and manmade shoreline?)
- Will the dam removal or alteration effect activities which occur within watersheds of poorly flushed estuaries?
- Does the dam effect power-generating plants; petroleum storage facilities; chemical or petroleum processing; minerals extraction; sewage treatment and disposal plants; solid waste disposal facilities; and, desalination plants?

If you answered yes to any of the above questions, the project should be under the jurisdiction of RICRMC with the exception of wetlands historically used for agriculture (even if the wetland resides within CRMC boundaries.)

If you answered no to all questions or the lands have been used historically for agriculture, then the dam should be under RIDEM jurisdiction. In general, DEM holds jurisdiction for all freshwater wetlands outside CRMC boundaries and identified activities. If the situation remains unclear. For example, the wetlands impacted by the dam lie on both sides of the jurisdictional boundary the determination shall be made on a case-by-case basis in response to a written request from an applicant to CRMC, and be based on the following: the extent and location of the freshwater wetland or wetlands, the area and proximity of potential land disturbance, and the guidelines set forth in any applicable watershed plan." It is unlikely, but possible that both agencies will maintain jurisdiction over the project.

Is there permitting assistance available?

As the permitting process can be difficult to navigate, it may prove beneficial to seek out resources that will provide guidance for application processes. It may be helpful to:

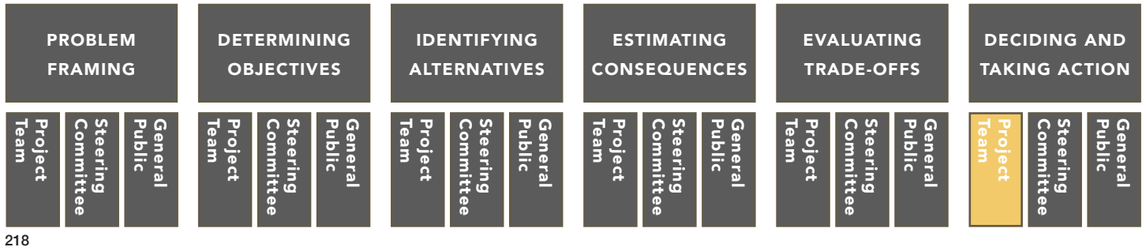
- **For removals in RICRMC jurisdiction**

o Pre-application meetings are available with CRMC professional staff. A pre-application meeting form must be completed and turned into CRMC.
o Preliminary Determination reports (formal and written narratives) are also available and provide a discussion of the merits of a proposed project according to the CRMC management program.

- **For removals in RIDEM jurisdiction**

o Contact RIDEM Office of Customer Technical Assistance RIDEM which has preapplication assistance available.
o Review previously submitted applications for previous dam removal projects (Wenceck). RIDEM maintains files of permit requests. Appointments to review files are made through the Office of Customer and Technical Assistance at RI DEM. Appointment request forms are available on-line at http://www.dem.ri.gov/ .

o Schedule a meeting with the RIDEM Watershed Quality and Wetland Restoration Team whose purpose of is to create an effective partnership between project proponents and regulators; help ensure that projects are successful and meet regulatory requirements; and streamline the DEM permitting process. This team should be able to help you answer what permit will be needed (usually an Application to Alter a Freshwater Wetland), how to get started, who to talk to, and the requirements for the application.



REFERENCES and ADDITIONAL RESOURCES

www.crmc.ri.gov/applicationforms/PreAppMeeting.pdf

http://www.dem.ri.gov/ .

DAM REMOVAL: STARTING THE PERMITTING PROCESS IN RHODE ISLAND

Who do I notify? What permits do I need?
(Preapplication assistance is available. Applications can't be submitted until 60 % of design drawings are completed)

USACE: Contact meeting with New England Branch of Army Corps of Engineers to determine if application for Individual Permit or Programmatic General Permit (PGP) 1 or 2 will be submitted. (See Appendix A of Department of the Army PGP State of RI) If under CRMC jurisdiction, coordinate application process with USACE. If RIDEM jurisdiction, RIDEM will coordinate.

OR

Individual permit:
- 30-day public comment period is required

PGP 1 or 2

CRMC jurisdiction?

Yes → Coordinate directly with USACE: submit required materials as requested; usually drawings, Significant Findings of wetland impact

No → RIDEM will coordinate- no further info submitted to USACE

Determine State Jurisdiction: Coastal?

Yes → Contact **CRMC** Submit pre-application form; set up meeting with staff assigned to the town/city where dam resides. Determine what type of Council Assent is required. Category A or B?

OR

Category B
- A 30 day public notice is required for this permit and a possible public hearing

Category A

No → Contact **RIDEM** Office of Customer Technical Assistance for preapplication assistance. Determine if permit is necessary. (Will there be significant changes to wetland?)

Yes → RIDEM Application to Alter A Freshwater Wetland must be submitted. (60 percent of drawings must be complete before submission.)
- A 45 day public notice is required
- Public hearing may be required
- If water level will decrease by 6", adjacent landowners must be notified of intent and solicited for comment as part of public notice.

No → Request for Preliminary Determination. Significant Changes?

No → No permit needed. Owner can proceed.

Yes → (to RIDEM Application to Alter A Freshwater Wetland)

Contact RIDEM Office of Water Resources Water Quality Certification (WQC) Program for requirements for a WQC application. (Generally required even in CRMC jurisdiction).
- 30 day public notice is required for this permit and a possible public hearing.

Local Governance: Obtain Local excavation permits from building/zoning or planning department

RIDEM Office of Dam Safety. Inform them of status of meetings/permits. Although there are no guidelines for dam removal in RI, this office will help in determining if further action is necessary dependent upon whether the dam is being substantially altered ore removed.

Rhode Island Historic Preservation and Heritage Commission: Contact to determine if the project could affect historic properties at the site. (If the project is being undertaken by a federal agency, must comply with Section 106 of the National Historic Preservation Act of 1966 (NHPA)

6.2

MAKING DECISION - DECIDING AND TAKING ACTION

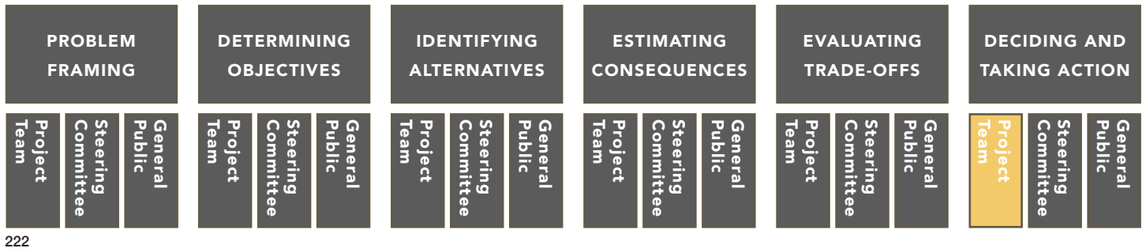
PERMITTING- MASSACHUSETTS

WHO:
Steering Committee +
General Public

TIME:

PURPOSE:

MATERIALS:



REFERENCES and ADDITIONAL RESOURCES

Executive Office of Energy and Environmental Affairs (2007). *DAM REMOVAL in MASSACHUSETTS: A Basic Guide for Project Proponents.*

IMPLEMENTATION

WHO:
Steering Committee + General Public

TIME:

PURPOSE:

MATERIALS:

OVERVIEW

Following the feasibility studies, selection of a preferred alternative, initial permitting meeting and filings, a final engineering design will be necessary. The final engineering design plans and specifications should be completed in sufficient detail that a contractor can take the plans and complete the work. The designer should also be present on-site during construction to oversee the process. Just as with the feasibility study, the design team must be interdisciplinary to appropriately design all aspects of the project (see discussion in the feasibility study section on selecting effective consultants). The design typically includes a set of drawings (the design plan), a set of detailed specifications, and a technical memorandum describing the analysis and approach.

Engineering Design Plan:

The design drawings should show both dam removal or modification and stream restoration plans. Plan sheets typically include base maps and drawings of:

- Existing site conditions
- Staging and access
- Removal plan
- Dewatering plan (sometimes completed by the contractor)
- Delineations of resource areas and resource protection treatments
- Proposed plan view
- Proposed cross sections
- Proposed longitudinal profile
- Erosion and sediment control treatments
- Infrastructure replacement/protection
- Habitat feature schematics

Project Specifications:

The project specifications detail the construction work that will be completed. Typically specifications detail:

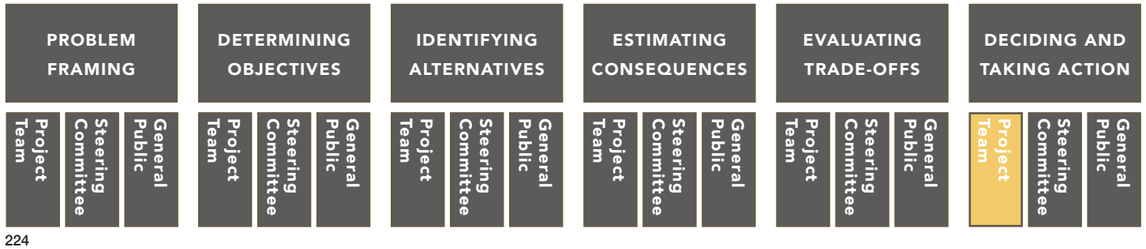
- Construction equipment needs
- Material specifications and quantities
- Project sequencing
- Staging area treatment
- Site access
- Dewatering
- Other site-specific details such as planting plans, traffic control, resource and infrastructure protection,
  etc.

Both the design plan and specifications need to be stamped by a licensed Professional Engineer.

Technical Memorandum:

The technical memorandum describes the analysis that goes into the design and details the rationale behind the project approach. If a technical memorandum is completed during the feasibility, this document may be nearly identical with revisions that were completed in the final design.

Cost Estimate: The design team should develop an itemized cost estimate based on the design and specifications. At this stage, the cost estimate is considered an Engineer's Opinion of Probable Cost based on the project specifications, until contractors bid on the project.



REFERENCES and ADDITIONAL RESOURCES

Executive Office of Energy and Environmental Affairs (2007). *DAM REMOVAL in MASSACHUSETTS: A Basic Guide for Project Proponents.*

STEWARDSHIP

WHO:
Steering Committee + General Public

TIME:
Long-Term

PURPOSE:
Build a community of stewards for a river

MATERIALS:
NA

OVERVIEW

Rivers and oceans are some of the last remaining resources that are still held in common by the people. These are some of the most ecologically dynamic and diverse landscapes, and they will be the most likely to experience the impacts of climate change. We all depend on rivers for drinking water, flood control, recreation, and sustenance and the more-than-human-species depend on the rivers as habitat and migratory corridors.

One of the goals of the decision making process outlined in this document is that it helps build a community and social practices that help care for the river. The community involvement that is initiated through the decision making around the dam can continue and evolve into other forms of community stewardship of the river over time. There may be opportunities for community members to participate in community restoration projects, or help advocate for the river, or just spend time paddling the river which ensures that there are "eyes on the river." If there is not an existing watershed management plan for the river or access plan, the discussion of a dam can help initiate larger discussions about the health of the river and how communities can "turn back" to the rivers and support the human and more than human communities that surround them.

REFERENCES and ADDITIONAL RESOURCES

Fish Passage Parade and Gathering on the Blackstone River. May 2023. Source: Andy Moran

CONCLUSION

Given that there are over 14,000 dams in New England, many coming to the end of their life cycle, that means that there are up to 14,000 dam decisions that may need to be made in the coming years. These decisions will be critical to protect downstream communities, build resilience to climate change, and to improve the health and function of the region's rivers. Our goal with this work is to develop a method that allows for a structured way to engage communities in the decision making process surrounding a dam and to reduce the number of projects that are stalled or delayed due to community resistance. The materials presented in this document are being made available for free to download open source on the web (www.damatlas.org). By sharing our methods and the open source toolkit, our hope is that others will use, test, modify, and evolve these methods. While we recognize that all dams and all communities are unique, our hope is that our methods can contribute to a "library of approaches" that are openly shared to build knowledge and techniques. We hope this collaborative approach is extended to communities as we support them in a collaborative decision making process that strengthens the health of rivers and their human and more-than-human communities.

APPENDIX 01

REFERENCES

REFERENCES

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APPENDIX 02

FACILITATOR SUPPORT

FACILITATING GROUP DISCUSSIONS*

FACILITATION GOALS

- Create an environment for effective communication (the achievement of mutual understanding)
- Keep discussion focused
- Keep people engaged.
- Advance and deepen discussion.
- Provide opportunity for all voices to be heard.
- Create environment of trust and support so disagreement and understanding can surface.
- Leave participants challenged and willing to engage in follow-up conversations.

PREPARATION

Decide who should facilitate the discussion. Consider who knows the topic, can assume an "objective" role, will be accepted by the group and has group experience. Consider what you know about the topic, whether your views are known to participants, and whether that makes your role as a facilitator too difficult.

Know yourself before you begin as a facilitator.

- What are my personal beliefs, values and stereotypes about the issue?
- Can I assume an objective role in the discussion?
- How do I establish trust and openness among the group?
- How do I show respect for the opinions of others?
- How do I tactfully mediate conflict?
- How do I keep discussion flowing smoothly?
- How do I encourage the participation of everyone and avoid domination by a few?
- How do I deal with someone showing disrespect for another?
- What should I do when I don't know how to respond to a comment or question?
- Will I feel comfortable facilitating a group discussion on this issue?

Identify the goals of the session. What are you trying to accomplish?

**Adapted from Stanford University: How to Effectively Facilitate Group Discussions by Ann Porteus, Nanci Howe, and Tommy Woon. https://www.coursehero.com/file/55580661/Facilitating-Group-Discussionsdocx/*

Schedule tentative time blocks, so that the introduction and key points will be covered before the end of the discussion.

Plan for any materials or help you will need. Will you need a writing surface such as a blackboard, or newsprint and marker pens. If it is an event where you will be writing down information, ideas, choose someone else to be the recorder. Hint: It is very hard to facilitate a discussion and be the one doing the recording.

STARTING OFF

Introduce the purpose of the discussion and ensure that the participants have the same understanding.

Explain the organization and structure (including the time line) of the discussion, when it will end, and whether or not there are formal follow-up plans.

Explain your role as facilitator - a person whose role it is to remain neutral or objective, to keep the discussion focused and energized and to create an environment for all to have a chance to participate. This does not mean that you are neutral and have no opinions, but as a facilitator you need to play an objective role.
Set the appropriate tone. Show your comfort with the topic so that others feel comfortable. Create a safe and open environment so that the participants will feel comfortable and share their views openly and honestly.

> "I (we) am (are) here to help us have a good discussion about .... We are here to learn from one another, to get a sense about how we think and feel about ....,. Our job as facilitators is to help us have a good discussion where all views can be voiced in a safe and respectful environment. That doesn't mean that there won't be disagreement and some tension about important issues. We hope that you will say what is on your mind. To create a safe and respectful atmosphere we ask that all of us follow a few groundrules."

Establish groundrules for the discussion so that the participants feel the environment is safe to speak about their ideas and feelings. Groundrules should be explicit. Groundrules may not fit everyone because we have different cultural backgrounds. Ask the group if these rules make sense and if everyone can honor them. The following are some suggestions (add your own):

- We ask that you speak from your own perspective; personal "I" statements are useful ways for keeping your view points personalized, and keep you from generalizing about what others think or feel
- We ask that you respect the viewpoints of others--that you listen respectfully and attentively, and that you withhold judgment about other's views. Our goal here is not to persuade each other of our ideas, but to get ideas out on the table so people can make their own decision.
- To show your respect for others in the room, we ask that you stay focused on the discussion and avoid side conversations. We ask that you make a conscious effort to listen actively to hear what is being said.
- We expect that everyone here will try to make this experience a good one; that we are all responsible for how this discussion goes.
- We ask that you be willing to voice disagreements, but we ask that if you disagree with someone's idea that you criticize the idea, not the person. With sensitive issues, people make take things personally. Please try to be sensitive to each other's needs and concerns. Try to speak up if you feel hurt in anyway. Avoid derogatory or sarcastic comments at the expense of others.
- We ask that you don't interrupt each other.
- All questions are good ones. We encourage you to ask questions of each other no matter how simplistic you might think they are. Chances are there are others who have the same question. The goal of the discussion is to learn and explore.
- We ask that you limit your exchanges with one person to no more than 3 exchanges. If it goes beyond three then others need the chance to express their opinion.
- We ask that you don't make assumptions about what others think or mean. Remember that others will not always attach the same meanings to words that you do or perceive the world the same way you do.

GETTING THE DISCUSSION STARTED

Open questions requiring more than a "yes" or "no" response (as opposed to closed questions which lead to a one word response) generate discussion and stimulate thinking. (Keywords: "how", "why", "what", "what if", "tell us about")

"How do you feel about the points made in the presentation?"
"What in your experience has led you to the view that you just expressed?"

Group oriented questions encourage group participation and tend to stimulate everyone's thinking. (Keywords: "who", "anyone")

"Would anyone be willing to share their reactions to the program?"
"Does anyone have any ideas about how we should start this discussion?"
"Does anyone have an issue or concern that they would like to raise to get us started?"

"What experiences have any of you had with this issue?"

Individual oriented questions encourage individual response (but may put people on the spot) and can tap known resources of a "expert" in the group:

"Tom, what do you think about the issues raised in the article?"
"Allison, how do you feel about what is happening in the dorm now, on the topic of X?"
" Eric, you have done a lot of reading in this area, how do you see the issue?"
Factual questions seek information. (Keywords: "what", "which", "how much")
"What are some of the major pros and cons from your perspective?"
"What statements did you actually hear made during the presentation that made you upset?"
"Who on campus is best suited to talk further about this issue?"

DURING THE DISCUSSION

Checking Yourself

Remain neutral (objective and open). This does not mean that you don't have opinions, but facilitators usually do not offer their own views; they help group members share theirs. Your role is to facilitate the group's discussion. If you have valuable ideas or opinions that are essential to what is being discussed, put your facilitator role aside and ask someone else to act as facilitator while you give your input

"How do some of the rest of you feel about that?"
"That may be your experience, but others may see things differently. Do any of you have a counter example or opinion.?"
"I have an opinion I would like to share, so I am taking my facilitator hat off for a comment."

Stay off the soapbox. Successful facilitators listen rather than talk. Watch for danger signals:

Talking too much
Feeling the need to address all questions
Talking more than your co-facilitator(s)
Seeing the group interacting more with you rather than with each other
Engaging in dialogue with individual members of the group

Avoid being put in the position of the "expert". Some may look to you to provide the answers to challenging questions or situations. Refrain from immediately providing "your answer" to the issue at hand. Turn the situation back to the questioner or ask the question of the whole group. If you are stuck or lost, admit it honestly to the group; someone is almost always likely to come to your rescue.

" How would you handle that?"

Stay aware of your own "hot buttons". Know where you stand on the issues, where your own prejudices/biases lie and where you are in your own personal discovery. If you feel you won't shut down discussion you could own up to them at the very beginning of the discussion and say that although you have deep feelings about the issue, you are

committed to creating an environment where all feelings can be heard and respected.

Acknowledge contributions, validate people's ideas, and give credit where credit is due.

"Thanks for saying that Linda. No one had mentioned that before."
"Thanks for that helpful contribution. It is not easy to share such a personal experience. That was very courageous."
"Dave, I appreciate your offering a different view."
"You made a strong general statement, Mary. Is that what you think (or feel)?"
"Could you restate your point using 'I' instead of 'we' or 'you' or 'people think'?

Keep the focus on ideas not individuals. Some ways to do this are:

- Ask the group to brainstorm ideas - Ask the group to identify pros and cons of a position rather than having individuals explain or defend a position
- Divide the group in half, being sure each half includes representatives of different viewpoints and ask each group to develop one side of the argument
- Go around the circle asking everyone to say something about the topic and indicate in what ways they agree with previous speakers. Then ask a recorder to summarize the primary feelings expressed by the group
- Create small groups, each with a reporter who will bring ideas of the small group back to the whole group
- Redirect people who make personal comments about others.

Try to keep the discussion concrete rather than abstract. People tend to talk abstractly especially when dealing with uncomfortable topics. Suggesting that people share real experiences can be effective.

"Can you give an example of what you are talking about from your own experience?"

Keep the focus on the subject without restraining free expression of ideas.

"You have made an interesting point, but how would you say that relates to X (the topic under discussion)?"
"It seems that we have started another topic without finishing the first. Should we return to the issue we were discussing before going on?"

Get participants to "own" their comments rather than speaking in generalizations about what others think.

Synthesize statements as a way of keeping track and bringing focus on where the discussion is going/has gone.

"Some of the main points I have heard are..."
"What were some of the main themes here tonight?"
"Can someone give a brief distillation of the discussion that we just had?"

Be patient with silences. Don't jump to fill in silence. Silence can be an important time for some and may spur others to talk.

Know and emphasize the importance of pause time. Encourage each person to be aware of their own pause time before jumping in. As a facilitator don't jump in too quickly.

Read non-verbal cues. Are a few people dominating the discussion? Are there many interruptions? Observe who is participating and who is not? Are people looking bored? Angry? Impatient? What is the level of energy in the discussion?

"People seem a little restless, why don't we take a break."
"It looks as if people are uncomfortable with what we have just been discussing."
"The energy of this discussion seems low, should we wind this up for now?"

Pose disagreement constructively. If there is disagreement and the discussion is stuck, have the participants agree to disagree and move on to another subject.

"Can we explore each of the viewpoints as a group and try to understand them rather than having one or to persons defend each view."
"It's clear that there is not agreement on this issue which is perfectly fine. Can we all agree not to be in agreement on this and move on to consider another facet of this issue.."

Minimize attacks. Protect individuals and their ideas from attack by other members of the group.

"Let's remember our groundrule about not attacking each other."

Minimize disruptions such as inappropriate humor, people walking in and out, private/ side conversations, etc.

Confront other problem behaviors that interfere with the progress of the discussion. (See Troubleshooting below)

"It is really hard to focus on what is being said here. There are so many side conversations."

ENCOURAGING PARTICIPATION

Create (and recreate) a safe and trusting environment. Monitor excessive talkers (see Troubleshooting below) and prompt the quieter members. - Consider breaking up into smaller groups or pairs(dyads) or trios for mini-discussions as a way to involve the quieter people

"We hope that you will say what is on your mind. What we say here today is for the group and will not go beyond the group."

Set and reinforce a pattern for participants to talk to each other, not to you. Keep reminding the group that this is conversation/questioning focuses on you.

Notice silences. Who is talking a lot, who is not talking? Is there any pattern?

"The men in the group have been pretty quiet. We'd be interested in what you think."

"I have noticed that some of you have not said what you think. I hope you will find a way to let us hear from you at some point" (be careful of this kind of statement; it may put people on the spot)."
" I have noticed that some of you haven't said anything. Please feel free to jump in at any point."
"John, you made some good points; let's hear from someone else."

Acknowledge the feelings of people in the group.

"Sam, I can see how upset you are. What would you like to hear from the group?"
"I bet you are not the only one here who has that reaction. Has anyone else ever felt the same way?"

Ask individuals and the group how to respond to expressions of emotions.

"It seems to me that the discussion has brought up painful feelings for several people. What shall we do at this point? Would you like to talk about feelings that have been expressed? do you want to keep going? Shall we take a break?"
"This seems to be where a lot of discussions on this issue break down--how can we keep going and get past this point?"
"When I see people angry it is hard for me to listen because I am worried about people getting (emotionally/physically) hurt. Could we just take a minute here to breathe, and make sure we can talk about this respectfully"

Reaffirm that the group is trying to deal with emotionally difficult issues.

"People are expressing many different and deep emotions here which may feel hard and uncomfortable, but that is the reason we are all here, to try to come to grips with emotionally difficult issues."
"It's not easy to share such a deeply held beliefs"

ADVANCING AND DEEPENING THE DISCUSSION

Invite amplification of new points. Encourage the contributors to explain the background behind their ideas/opinions. Help "fact spouters" get more personal.

"What is your opinion, given the facts as you have said them?"
"When I here those facts, it makes me feel like.....?"
"These are interesting facts; would you like to share how you feel about them?."

Encourage people to take risks

Take some risks yourself, including admitting your mistakes
Take a risk yourself and be vulnerable by sharing a personal experience or risky feeling

Ask open-ended questions. (What?, How?, Why?)

Ask follow-up and/or probing questions (if others don't).

"Can you say a little more about that?"
"What do you mean by that?" "Can you give us an example?"
"How did you come to this view?."
"What convinced you of your opinion?"

Paraphrase (or getting others to paraphrase) what people say; paraphrasing can help legitimize people's views, and is especially useful in legitimizing an unpopular or risky opinion/idea.

"As I understand what you are saying, ..."
"Let me see if I understand what you are saying, ..."
Clarify, without interpreting.
"Can you clarify that last comment, I am not sure that I understood what you were saying."
"Can I try to clarify what I think you just said."
"Can you restate that in a different way?"
"What do you mean by that?"

Call attention to alternative viewpoints. Beware of "group think" Sometimes a group will discuss a topic without awareness of a different approach to the same problem.

TROUBLESHOOTING DURING THE DISCUSSION

No one responds.

Ask for any comments
Suggest an answer and ask for agreement or disagreement

Someone who doesn't take the discussion seriously or gives silly comments.

Find something in their answer that is close to a serious answer and in a serious tone repeat it to the group.
Ask them if they can think of another answer
Compliment them when they give a serious answer
"I think most people are here because they think the topic is a valuable one. Does anyone feel differently about this?"

People monopolize the discussion.

Say, "I'd like to hear what the rest of the group has to say."
Ask another person a question just as soon as they pause.
Ask for agreement or disagreement from others.
Explain that you appreciate their comments, but it is important for everyone to have a chance to talk.
Establish ground rules at the beginning (or mid-stream) that one of the goals is to provide everyone an opportunity to share.

Someone keeps changing the subject or goes on tangents.

Say, "That is very interesting but how do you feel about .....?"
Refocus their attention by saying "I know you are enjoying sharing your

experience with each other, but there are some issues I would like to share with you now."
Say, "In order to accomplish our goal today, we really need to move on. Perhaps we can go back to this topic later."

People keep interrupting.
"Could we remember just to have one person talk at a time and let people finish their statements."
"Okay..first Sarah, then Randy, then Marie."
"Jim, you have got a lot of god point, but it is important to let Renee finish, and then I know that Tom is dying to say something as well."

Hostile or belligerent group members
Keep your cool. Try to incorporate negative comments in a positive way. "That's an (interesting, unique, different) way to look at this situation. I appreciate your contributing that different point of view."
If it continues, try to meet with the person at a break and confront them on their behavior. If it is really disruptive, tell them that if they choose to stay, you would like their cooperation.

Someone puts another person down.
Remind the group that there are no wrong answers. Everyone has the right to his/her opinion.

The group gets stuck (lacks sufficient information to go on)
Refer to resources.
Suggest the need for further information if you or someone else in the discussion does not know the answer.

Inappropriate humor
Don't let inappropriate humor go by.
" I realize that you may not have intended it, but this is a pretty sensitive topic, and that kind of humor makes a lot of people very uncomfortable."
"I don't find that remark very funny personally. Were you aware that some people might find that remark offensive?"

You are running out of time.
Don't panic or start rushing. Get as far as you can. - Prioritize questions/points. Try to address the important ones

Someone challenges your role as group leader.
Don't become defensive. Let the group air their dissatisfactions. Express your feelings after they have cooled off. Discuss solutions with the group.

People keep addressing their questions to you.
Redirect the question to the group
If no one in the group has a response, defer the question by having someone in the group come back with pertinent information at a later time.

Conflict occurs
Don't take sides
Remind people of the areas of agreement - Ask people in conflict to agree to restate what they heard before they state their arguments.
Remind people that they are not there to judge others or to persuade others of their views, but to further mutual understanding.
Summarize the conflict and ask for ideas from the whole group as to how to proceed.
Acknowledge the disagreement and agree to move on. Tell the group that conflict is a healthy part of group dynamics, and can enhance learning.
Acknowledge each persons concerns and needs.

Inability to move to another topic because people are overly engaged in a lively discussion
Try to be flexible about time. If something good is happening, assess the value of leaving that discussion in favor of completing an agenda. Get the group to help make this decision.
Give a two-minute warning or some other transition time to prepare the group to change direction.
Acknowledge at the beginning of the session that time will be a factor and that some issues may not be discussed.
Acknowledge the difficulty of leaving a good discussion and get the group to decide how to proceed, or set up another time to finish the agenda.

Something inappropriate is stated, i.e., something offensive, misinformation
Legitimize dissenting opinions/ideas. Don't let misinformation stand. It implies that you agree with it. Ask for other opinions/ideas ("Are there other views?" "Does everyone agree?"
Agree to disagree to give people space to object without destroying the discussion.

WRAPPING UP

Keep to the committed ending time, unless you ask the group if they would like to continue for a specified period of time. (Remember, ending a little too soon is better than discussing a topic to death. Ending on a high note will encourage the discussion to continue at a later time.) Indicate that you will stay around for a while if anyone else wishes to continue the discussion.

Summarize (or have a participant summarize) the major thrust of the discussion.
The major points of agreement and disagreement, if appropriate.
Issues that were discussed but not resolved
Where action has been agreed on, the decision should be stated and the next steps and person responsible should be identified.
What additional information is needed

Comment on (or have the group comment on) how the discussion went

- How do participants feel about their own participation? - What was good about the discussion and what could have been better?
- Did people feel free to express their opinions?
- Do they have suggestions for better facilitation?

Thank everyone for the discussion...for their honest participation, etc.

POST DISCUSSION REVIEW

After the discussion is over, take a few minutes with the project team to reflect on the content and process of the discussion; a few written notes for future reference might be helpful. Consider:

- How well did the group stay focused on the topic? What contributed to this?
- How did the structure and timing contribute to the discussion? What changes, if any, would you make?
- How involved were individuals in the discussion? Were there any individuals noticeably silent, angry or upset?

Seek feedback from others (other staff members present or participants). You will learn much from seeking feedback from others, especially from your co-facilitator or other staff members. Ask what you did that went well (what you did to keep the discussion moving, motivate others to take risks and set the appropriate tone., etc.) and what improvements they would recommend.

APPENDIX 03

FUNDING SOURCES

POTENTIAL FUNDING SOURCES*

Open Rivers Initiative (NOAA)
http://conservationconference.noaa.gov/case/open_river.html
http://www.fedgrants.gov/Applicants/DOC/NOAA/GMC/NMFS-HCPO-2006-2000405/Grant.html
NOAA oversees a competitive grant program focused on community-driven, small dam and river barrier removals in coastal states to help repair vital riverine ecosystems, to benefit communities, and to enhance populations of key trust species. Funding range: $50,000-$250,000.

Gulf of Maine Council/ NOAA Partnership Habitat Restoration Grants
http://restoration.gulfofmaine.org/
The Gulf of Maine Council for the Marine Environment partners with NOAA to fund marine and anadromous fish habitat restoration projects around the Gulf of Maine. Typical Funding Range: $25,000- $75,000.

NOAA Community-Based Habitat Restoration Project Grants
http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners_funding/callforprojects.html
The program invites the public to submit proposals for available funding to implement grass-roots habitat restoration projects that will benefit living marine resources, including diadromous fish, under the NOAA Community-based Restoration Program. Funding range: $50,000-$200,000, October deadline. Funded Silk Mill dam removal in Becket.

NOAA/Ocean Trust/National Fisheries Institute
http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners/otnfi.html
NOAA partners with Ocean Trust to fund habitat restoration projects that enhance living marine resources around the coastal U.S. The applicant must be an individual, association or company in the fish and seafood industry. Funding range: $5,000-$20,000.

** From Massachusetts Executive Office of Energy and Environmental Affairs. DAM REMOVAL in MASSACHUSETTS A Basic Guide for Project Proponents. 2007*

The Nature Conservancy/NOAA Habitat Restoration Partnership
http://nature.org/initiatives/marine/strategies/art9023.html
NOAA partners with The Nature Conservancy (TNC) to fund marine and anadromous fish habitat restoration projects around the coastal U.S. The applicant must be a TNC local chapter. Organizations that have project ideas should contact their local TNC chapter to discuss forming a partnership to apply for project funds under this request for proposals. Funding Range: $25,000-$85,000.

Trout Unlimited/NOAA Partnership
http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners/troutunlimited.html
Provides matching grants that require 1:1 match from a non-federal source or sources. Typical awards are from $10,000 to $100,000, and can cover any aspect of a habitat restoration project, including construction, engineering, planning, or outreach. There is no formal application process. Project must be sponsored by a TU chapter or State Council, or by TU staff.

American Rivers/NOAA Community-Based Restoration
http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners/americanrivers.html
NOAA partners with American Rivers to fund voluntary dam removal and fish passage projects. Funding range: $5,000-$25,000. Funded Robbins Dam removal in Plymouth/ Wareham.

FishAmerica Foundation/NOAA
http://www.fishamerica.org/faf/projects/noaa.html
FishAmerica, in partnership with the NOAA Restoration Center provides funding for on-the-ground, community-based projects to restore habitat for marine and diadromous fish in the United States. Funding Range: $5,000-$50,000. Funded Billington Street dam removal in Plymouth

National Fish Passage Program (U.S. Fish and Wildlife Service)

http://www.fws.gov/fisheries/FWSMA/FishPassage/fpprgs/GetInvolved.htm
The U.S. Fish and Wildlife Service's National Fish Passage Program is a non-regulatory program that provides funding and technical assistance toward removing or bypassing barriers to fish movement. Contact: Region 5 – Northeast Dave Perkins 413/253-8405, David_Perkins@fws.gov

U.S. Fish and Wildlife Service Partners
http://www.fws.gov/partners/
The U.S. Fish and Wildlife Service's Partners for Fish and Wildlife program offers technical and financial assistance to private (non-federal) landowners to voluntarily restore wetlands and other fish and wildlife habitats on their land. Restoration projects include reestablishing fish passage for migratory fish by removing barriers (dams) to movement. Funded Silk Mill dam removal in Becket

National Fish Habitat Initiative Brook Trout Habitat Restoration Program
www.fishhabitat.org
NFHI is a nationwide strategy that harnesses the energies, expertise and existing partnerships of state and federal agencies and conservation organizations. The goal is to focus national attention and resources on common priorities to improve aquatic habitat health.

General Matching Grant Program (National Fish and Wildlife Foundation)
http://www.nfwf.org/guidelines.cfm
The National Fish and Wildlife Foundation operates a conservation grants program that awards matching grants to projects that: address priority actions promoting fish and wildlife conservation and the habitats on which they depend; work proactively to involve other conservation and community interests; leverage available funding; and evaluate project outcomes. Funding Range: $10,000-$150,000. Funded Billington Street dam removal in Plymouth, and Silk Mill dam removal in Becket

Conservation Law Foundation/ NOAA Partnership
http://www.clf.org/programs/cases.asp?id=531
CLF launched this program to distribute funds for estuary restoration projects to communities in the Gulf of Maine. Typical Funding levels between $10,000.00 – 50,000.00

Wildlife Habitat Improvement Program (Natural Resources Conservation Service)
http://www.nrcs.usda.gov/programs/whip/
Funding awarded to projects that work to establish and improve fish and wildlife habitat. Contact local USDA Service Center for more information. Funded Billington Street dam removal in Plymouth

Corporate Wetlands Restoration Partnership (CWRP)
http://www.coastalamerica.gov/text/cwrp.html
CWRP leverages the collective resources, skills and processes of the private and public sectors through dam removal and river projects such as fill removal, channel clearing and enlarging, fish passage construction, and replanting. Funding pending Ballou dam removal in Becket.

U.S. Army Corps of Engineers
http://www.nae.usace.army.mil/pservices/206.htm
Aquatic Ecosystem Restoration – Section 206, Water Resources Development Act of 1996. Funds from this program can be utilized to remove lowhead dams as a way to improve water quality and fish and wildlife habitat. This funding source is listed under the Continuing Authorities Program.

Wildlife Restoration Act (Pittman-Robertson Act) Dept. of Interior-Fish and Wildlife Service
http://federalasst.fws.gov/wr/fawr.html
The purpose of this Act was to provide funding for the selection, restoration, rehabilitation and improvement of wildlife habitat, wildlife management research, and the distribution of information produced by the projects. Contact: The Division of Federal Assistance, FederalAid@fws.gov

National Trust for Historic Preservation Northeast Office
Provides several grant programs for maintenance and preservation of significant historic properties in Massachusetts Brent_Leggs@nthp.org

State Sources
Funding for dam removal in Massachusetts is determined on a case by case basis. Interested proponents should consult with the Riverways Program's River Restore.
http://www.mass.gov/dfwele/river/programs/riverrestore/riverrestore.htm

Local Sources
Funding for fish passage and dam removal on municipal owned land may be funded through the Community Preservation Act (CPA). Check with your local planning department or Conservation Commission, or contact the Community Preservation Coalition.
http://www.communitypreservation.org

Private Sources
Some private sources, such as family foundations or corporate foundations, have funded dam removals in other parts of the country and may have an interest in funding habitat restoration projects.

APPENDIX 04

GATHERING DATA: CITIZEN SCIENCE

GATHERING DATA

There are over 1000 dams in the Narragansett Bay watershed and surprisingly little is known about many of them. One of the goals of this document is to help inventory and make an accessible and centralized place to find information about dams in the watershed. In addition to the GIS data analysis that was conducted as part of the Dam Atlas, there is still significant historical research and site based analysis that is needed to build out a complete understanding and cohesive documentation about dams.

To help fill in the missing data, our hope is that local watershed groups can do the research, inventory and documentation to build out this resource. This can be done by local watershed group volunteers and citizen scientists and through the process help to build a better understanding of the condition, concerns and opportunities that may exist for various dam sites. In this section, we include a volunteer manual and questions that can be filled in for each of the dams.

An example of what this may eventually look like is included at the end for the 18 dams on the main stem of the Blackstone River. But ideally eventually every watershed or sub watershed would have data cards similar to those for each of their dams so whenever a question or opportunity comes up, there would be documentation of all the dams in the watershed.

CITIZEN SCIENCE: VOLUNTEER MANUAL

GETTING STARTED

HELLO! Thank you for being willing to help collect data about dams in the Narragansett bay Watershed.

Before you visit the site, it is helpful to familiarize yourself with the dam and the surrounding area. Our goal is to collect as much information about the dam as possible and this will include both site based data and data that is collected from on line research and other resources.

The best way to start your investigation in the dam is to visit the Dam Atlas website and google maps. Through our map, you can search for the dam by the ID number or name provided. On the map, you can click on the dam and find out what is currently known about the dam in the existing dam database. Between the Dam Atlas Map and Google Maps, you may help to orient yourself. You can answer the first few geographic questions on the google form from these maps. Zoom in to the dam location and record the dam name (if provided), impoundment/pond name (if present), stream name, and adjacent paved road name.

Prior to going to the site, you can also do Internet research about the dam- this may help you know what to look for during the site visit. You can find out if the dam has been in the news- if so, download the articles for the archive. You may also find historic data about the dam at the local historical society. They may have historic documents including historic photos, postcards, construction or engineering document, etc. Get digital copies of any materials you can find for the archives.

PREPARING FOR THE SITE VISIT

When you are preparing to visit the site, you can enter the coordinates into a standard map service such as Google or Apple maps to better familiarize yourself with the area and where you may be able to park. Your site may be located in a highly urbanized area with road access and public parking or it could be located in a park or forest where you may need to walk a distance in order to access it. Please dress according to the weather and boots for the terrain. Pay attention to parking signs and be wary of traffic if you park along the road. If there is no immediate place to park, use your best judgment and be sensitive and aware of private property.

SITE VISIT

When you arrive at the site walk around and determine which direction is upstream and downstream. Be sure you are correctly identifying the dam. Oftentimes near roads and bodies of water, you will observe bridges and culverts; however, for this study we are not collecting data about bridges and culverts. A dam can be a small structure but it specifically holds back water and may contain a waterfall, catchment basin, fish ladders, etc. The height of the dam should be measured from the top of the water level from the downstream side. The width of the dam should be determined by facing the structure and measuring across from shore to shore. Make sure to assess the dam from both sides to determine all construction materials. Dams are often composed of more than one material. Masonry is held together by concrete and may be topped with earth to blend seamlessly into the landscape. Refer to the examples of construction materials below.

Take note of your surroundings and be as specific as you can (the more data, the better!). Are you in a park or a heavily developed area? Check for any signs hanging or on a plaque that may provide information about the dam as well as permitted or restricted activity on the water body. For example, signs that restrict swimming, fishing, or boating in the water body. Refer to the Dam Atlas to see if there are any other dams nearby and if you can see them from your site location. On the google form, you can estimate the % of land uses around the dam. Scan along the perimeter of the impoundment/pond and assess the land use. Look out for buildings, roads, and areas of impervious surface within 50m (about half a football field) of the impoundment. If the impoundment/pond is too big to see all the way around, you can look on Google/ Apple maps to get a better idea of the surrounding land use. Your phone map should outline buildings and provide the names of any neighboring parks, forests, farms, or open spaces.

DAM IDENTIFICATION AND LOCATION:

Name of the Dam: _____
Additional Names for the Dam: _____
State ID: _____
Stream/River Name: _____
Location (Coordinates, street address):_____

SITE VISIT QUESTIONS:

These questions will best be answered during the site visit. In some cases, looking at google maps before can help give you an initial sense of the answers and then that information can be confirmed in the field.

Roads: Name of the nearest paved road to the dam? Is the road within 30 feet of the dam?

Visibility: Is the dam visible from the paved road? Is the dam visible from other areas where there are a lot of people?

Sense of Place Is there development around the dam? Does the dam seem to be a significant part of the surrounding community identity? Is there a plaque on or near the dam? If there is a plaque, you may be able to confirm the dam's name (above). If the date built is listed on the plaque include that date below. Please take a picture of the plaque.

Public Access: Is the dam accessible to the public? Are there any indications of recreation on the river?

Construction Method: Try to identify the materials that the dam is constructed from. Often earth, concrete,masonry or rock fill. There can be multiple materials. Please take a picture of the material. Is there a spillway? Do you see a waterfall at the dam?

Fish Passage: Some dams are equipped with ways to allow fish over the dam. Do you see any fishways evident at the site? If so, please identify type if possible. Please take a picture if there is a fish ladder or fishway

Height: Is the height of the dam known? If not, How how tall is the dam from the downstream side (from water level to the top of the dam)? Identify the ranges below. <6 ft, 6-10 ft, 10-20 ft, 20-30 ft, > 30 ft. If you had to estimate one height of the dam, how many feet would you estimate? Please enter one number. Please take a picture with a yardstick for scale.

Width: Approximately, how wide is the dam from shore to shore? < 10 feet, 10-20 feet 0-30 ft, 30-40 ft, > 50 ft. If you had to estimate a width of the dam, how many feet would you select? Note you can use google earth for an estimate or use a laser distance measurer. Please take a enter one number. Please take a picture with a yardstick for scale.

Surrounding dams: Can you see another dam from this dam? If yes, is the other dam upstream or downstream?

Adjacent Structures: Are there structures or infrastructure above or below the dam that could be impacted by changes to the dam?

Condition: What is the general condition of the dam?

Impoundments/upstream conditions:
Name of impoundment: Name of Impoundment or indicate there is no impoundment (Not all dams have impoundments/ponds): _____

Adjacent Structures to impoundment: Are there homes or businesses adjacent to the upstream impoundment or river?

Recreation on impoundment: Please note any recreational activities you see or know about in the impoundment/pond. Examples are swimming, kayaking, canoing, boat ramp, motor boating, sailing,fishing, etc. Are you aware of any parks/open space with hiking or biking trails along the impoundment/pond?

Surrounding Land Use to the impoundment: Look around the pond. Is the land use uniform? Or does it vary around the pond? Try to estimate the % (up to 100%) of the different type of land use around the pond. Suggested land uses are forested, rural, suburban, urban, agricultural,commercial, etc. You do not have to use all these land uses - just the ones are relevant to this pond

Site Visit Notes: Any other things of note that you saw at the dam, pond or nearby area (e.g.,something pretty or ugly)

Photos:

- Photo in front of the dam if possible with a yard stick
- Photo in front of the dam without the yard stick
- Photo from the top looking across the dam
- Photo from the right side of the dam
- Photo from the left side of the dam
- Picture of waterfall if present
- Dam material close-up
- View of Pond
- Date/name plaques
- Fishway
- Signage or other evidence of fishing, boating, or other recreation
- Surrounding land use/development

ADDITIONAL QUESTIONS:

To answer the following questions, you can start by gathering data from the local watershed organization. In addition, a google search about the dam may bring up articles and publications about the dam. The local historical society may have historic documents that reference the dam or historic images.

Age: What year was the dam built? Did it undergo significant repairs and/or reconstruction? If so, what years?

Historical Uses: What service(s) was the dam structure designed (or later altered) to provide, such as mechanical power, hydropower, flood control, water supply, recreation, irrigation, or navigation?

Historical Significance: Is the dam listed on the National Historic Register? Is there any identified historical/cultural significance related to the dam?

Indigenous land: What indigenous tribes lived in the area before colonization?

Hazard Classification: What is the hazard classification of the dam- Low Hazard / Significant Hazard / High Hazard? Is there any record of a Letter of Deficiency being issued for the dam? If so, please save to the dam Google Drive folder.

Dam Condition: Is there any information about the current condition of the dam/ spillway? Has the dam failed in the past? If so, has it been rebuilt? What year?

Owner: Is the ownership of the dam clear? Is the dam owner actively involved in dam management and maintenance?

Current Uses: What service(s) or benefits does the dam structure provide today?

Watershed and land use plans: Are there any published resource management plans for the river or watershed? Are there any published development plans for the community? If so, please save to the dam Google Drive folder.

Sediment: Is there a potential that contaminated sediments have collected behind the dam? Have the sediments upstream of the dam been tested? If so, what did the results of the tests indicate? What historical uses of the river would have caused pollution? What current land uses impact the river?

Decision makers: Who are the decision makers- town officials /unofficial community spokesperson/dam owner? Who has the ultimate decision making authority?

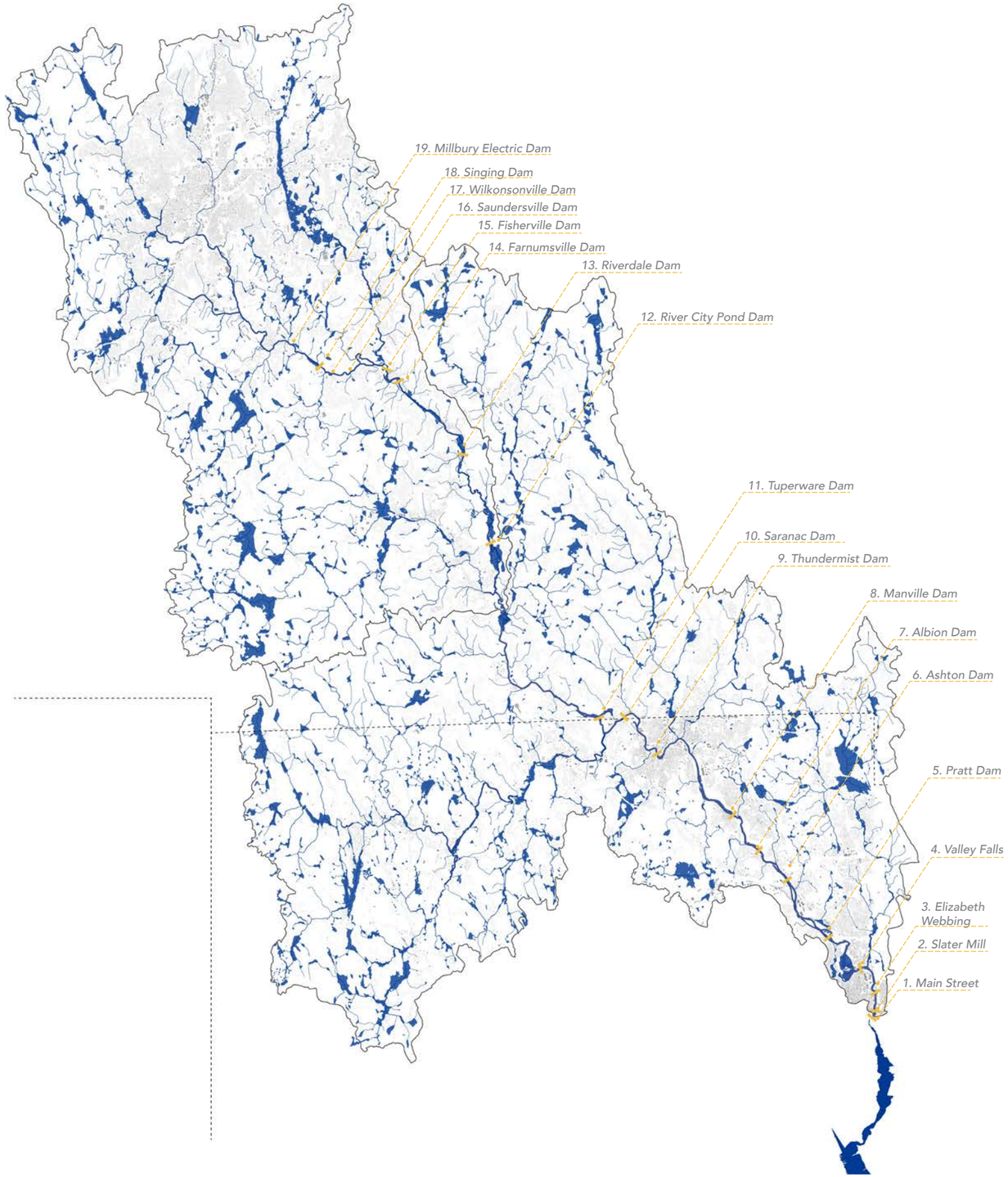
Stakeholders: Who has a stake in the decision about the future of the dam? What community concerns might be expected?

Regulations: What public agency, if any, has regulatory authority?

APPENDIX 05

INDIVIDUAL DAMS

BLACKSTONE RIVER



1. MAIN ST DAM

41°52’35.60”N | 71°22’59.29”W

Year Built: 1896
Height: 15 ft
Owner: Narragansett Electric Company
Purpose: Flood Control, Electricity (6,200,00 kwh per year)
Hazard Level: Not Available
Construction Material: Masonry
Upstream Functional Network: 0.1 miles
Downstream Dam Count: Head of Tide
Fish Passage Modification: None
Pond Area Behind Dam: 0 acres

DESCRIPTION: Commonly known as Pawtucket Falls, The Main Street Dam is located in downtown Pawtucket, Rhode Island. The natural falls were commonly fished for salmon, shad, and alewife by the Algonquins. The falls were later on used for manufacturing during Pawtucket’s development. The existing dam was built in 1896 for the Bridge Mill Power Plant for hydropower. The dam and powerhouse are still in use today.

The Pawtucket Falls mark the end of the Blackstone River and the beginning of the Seekonk River, a tidal river that flows into the Narragansett Bay.

Photo Credit: Lost New England

2. SLATER MILL

41°52’37.73”N | 71°22’56.00”W

Year Built: 1793
Height: 7 ft
Owner: ?
Purpose: Hydropower , Historic Site
Hazard Level: Not Available
Construction Material: Masonry
Upstream Functional Network
Downstream Dam Count: 1
Fish Passage Modification: None
Pond Area Behind Dam: 0 acres

DESCRIPTION: Located in Pawtucket, Rhode Island, the Slater Mill was the first water-powered textile mill built in the United States. The Mill was designed and built by a British immigrant named Samuel Slater and Moses Brown, an industrialist from Providence, Rhode Island. The new technology created for the Slater Mill launched New England’s textile industry. The Slater Mill is now known as the birthplace of the American Industrial Revolution.

The Slater Mill and Dam is now a museum where the textile machines, factory, and dam have been preserved.

3. ELIZABETH WEBBING DAM

41°53’15.17”N | 71°22’48.84”W

Year Built: 1850
Height:18 ft
Owner: RI DEM
Purpose: Hydroelectric Power (4,360,000 kwh per year)
Hazard Level: Not Available
Construction Material: Rockfill
Upstream Functional Network: 0.1 miles
Downstream Dam Count: 2
Fish Passage Modification: None
Pond Area Behind Dam:

DESCRIPTION: Located in Central Falls, Rhode Island, The Elizabeth Webbing Mill was one of six other mills in the Central Falls Mill District. The Mill was once a textiles manufacturer that used the hydropower to operate the looms. After the closing of the mill, the dam was operated by the Roosevelt Hydroelectric Project until 2001. The dam is now owned by the Rhode Island Department of Environmental Management and no longer operates as a hydrolectric project.

4. VALLEY FALLS

41°53’57.93”N | 71°23’23.07”W

Year Built: 1853
Height: 10 ft.
Owner: Blackstone Hydro Associates
Purpose: Hydropower 4,761,00 kwh per year
Hazard Level: Not Available
Construction Material: Granite masonry
Upstream Functional Network:
Downstream Dam Count: 3
Fish Passage Modification: None
Pond Area Behind Dam:

DESCRIPTION: Valley Falls Dam is located between Central Falls and Cumberland, Rhode Island. The Valley Falls Company Mill was built in 1849 for textile production. The hydropower station is located in the old gatehouse for the mill.

The Blackstone Valley National Heritage Corridor transformed the dam and adjacent canals into the Valley Falls Heritage Park.

5. PRATT DAM

41°54’48.86”N | 71°24’31.81”W

Year Built:
Height: 20 ft.
Owner: Town of Cumberland
Purpose: Legacy Dam
Hazard Level: Not Available
Construction Material: Granite Blocks
Upstream Functional Network:
Downstream Dam Count: 4
Fish Passage Modification: Spillway arches are open to river flow so there is unimpeeded connectivity
Pond Area Behind Dam: 0

DESCRIPTION: The Pratt Dam is located in Lincoln, Rhode Island. The stones that make up the canal and the arches seen on the dam and bridge come from a nearby quarry in the Town of Cumberland. The dam was created for flood prevention and provides a crossing on the Blackstone Greenway Biking Trail.

In flooding events, the height of the arches limit the amount of water to pass downstream. The relatively flat water between the Pratt Dam and the Valley Falls Dam create the Lonsdale Marsh, the largest freshwater marsh in Rhode Island.

6. ASHTON

41°56’25.39”N | 71°26’8.91”W

Year Built: 1885
Height: 20 ft.
Owner: Ashton Dam Hydro Watt Associates
Purpose: Hydroelectric Power
Hazard Level: Not Available
Construction Material: Masonry
Upstream Functional Network:
Downstream Dam Count: 5
Fish Passage Modification: None
Pond Area Behind Dam: 0 acres

DESCRIPTION: The Ashton Dam is located in Lincoln, Rhode Island on a remote stretch of the Blackstone River. The Ashton Mill was a textile mill constructed originally for the Smithfield Cotton Company and later bought by the Lonsdale Company in 1840. Because The Ashton Mill is more isolated than many other mills along the Blackstone River, brick homes for the mill workers were built adjacent to the mill. The dam is now operated privately for hydropower.

Photo Credit: Trails & Walk in RI

7. ALBION

41°57’15.10”N | 71°27’12.89”W

Year Built: 1850
Height: 21 ft.
Owner: N/A
Purpose: Recreation, Flood Management
Hazard Level - Not Available
Construction Method: Masonry
Upstream Functional Network:
Downstream Dam Count: 6
Fish Passage Modification: None
Pond Area Behind Dam: 0 acres

DESCRIPTION: Albion Dam is located in a largely wooded stretch of the Blackstone River in Lincoln, Rhode Island. The dam was constructed in 1850 for textile production at Albion Mill. Much like Ashton Mill, because of its location in a relatively remote area, many houses were constructed nearby for the mill workers. The mill and the mill houses have been preserved. Just downstream of the dam is a frequently used boatlaunch for kayaks and canoes.

8. MANVILLE

41°58’17.30”N | 71°28’14.56”W

Year Built: 1860
Owner: Town of Cumberland
Height: 22 ft.
Purpose: Recreation and Flood Control
Hazard Level: Not Available
Construction Method: Masonry
Upstream Functional Network:
Downstream Dam Count: 7
Fish Passage Modification: None
Pond Area Behind Dam: 0 acres

DESCRIPTION: The Manville Dam is located in the town of Cumberland, Rhode Island. The dam was constructed for the Manville Mill, once a grist mill but then later reconstituted as a textile mill. The stone for the dam came from the nearby Cumberland Quarry. The mill was mostly destroyed by a fire in the 1950’s. Both upstream and downstream of the dam are commonly used boat launches for paddlers.

9. THUNDERMIST

41°59’57.96”N | 71°31’4.76”W

Year Built: 1960
Owner: USACE
Height: 24 ft.
Purpose: Flood Control, Hydroelectric
Hazard Level: Not Available
Construction Method: Concrete
Upstream Functional Network:
Downstream Dam Count: 8
Fish Passage Modification: None
Pond Area Behind Dam:

DESCRIPTION: Commonly known as Woonsocket Falls, the Thundermist Dam can be seen from the South Main Street Bridge in downtown Woonsocket, Rhode Island. The original dam was constructed for the Glenmark Mill, a cotton and knitting mill. Due to significant flooding damage in 1955, a new dam was built between July 1956 and April 1960 for $5.4 million. The US Army Corps of Engineers assumed ownership in 2009 of the dam, yet the Thundermist Hydroelectric facility is owned and operated by the city of Woonsocket.

10. SARANAC/BLACKSTONE DAM

42°1’1.07”N | 71°32’17.03”W

Year Built: 1910
Height: 9 ft
Owner: Town of Blackstone
Purpose- Recreation
Hazard Level - Not Available
Construction Material- Rock Fill
Upstream Functional Network-
Downstream Dam Count- 9
Fish Passage Modification- None
Pond Area Behind Dam- 0 acres

DESCRIPTION: The Saranac Dam is located in Blackstone, Massachusetts which is a small town on the border between Massachusetts and Rhode Island. The dam was built by Daniel Simmons in 1856 to power the Waterford Textile Mill. With the construction of the Blackstone Canal in 1828 and the later development of the Providence & Worcester Railroad line and a rail connection to Boston, Blackstone was a critical commercial junction between Massachusetts and Rhode Island. The Blackstone Canal is still preserved in this area, but the Waterford Mill has since been demolished.

11. TUPPERWARE / ROLLING DAM

42°0’55.14”N | 71°33’12.68”W

Year Built: 1904
Height: 12 ft
Owner: Blackstone Hydro Inc.
Purpose: Recreation
Hazard Level: Not Available
Construction Material: Masonry
Upstream Functional Network:
Downstream Dam Count: 10
Fish Passage Modification: None
Pond Area Behind Dam: 0 acres

DESCRIPTION: Tupperware Dam is located in Blackstone, Massachusetts. The dam was orignally constructed for the Tupperware Mill, but is now privately owned by the Blackstone Hydro Inc. and operated for hydropower. The dam’s scenic overflow can be seen from the Blackstone Gorge Park.

12. RICE CITY POND DAM

42°5’53.96”N | 71°37’20.31”W

Year Built: 1880
Height: 21 ft.
Purpose: Fish and Wildlife Pond
Hazard Level: Not Available
Construction Method: Earth
Owner: Dept. of Conservation & Recreation
Upstream Functional Network:
Downstream Dam Count: 11
Fish Passage Modification: None
Pond Area Behind Dam: 0 acres

DESCRIPTION: The Rice City Pond Dam is located on a remote section of the Blackstone River in Uxbridge, Massachusetts. Rice City Pond’s relatively flatwater makes it suitable for fishing and paddling. The wetlands and abundant wildlife can be best seen from the Blackstone River or on the stone arched bridge over the dam.

13. RIVERDALE

42°8’19.98”N | 71°38’23.21”W

Year Built: 1957
Owner: Private
Height: 9.5 ft.
Purpose: Flood Control
Hazard Level: Not Available
Construction Method: Concrete
Upstream Functional Network:
Downstream Dam Count: 12
Fish Passage Modification: None
Pond Area Behind Dam: 0 acres

DESCRIPTION: The Riverdale Dam is located in Northbridge, Massachusetts. The original dam was constructed to power the Riverdale Textile Mill. Since the 1960’s the mill has been reconstituted as a steel mesh producer, notably reinventing and producing lobster traps. The dam is now used for flood control.

14. FARNUMSVILLE

42°10’27.60”N | 71°40’49.06”W

Year Built: 1882
Owner: Private
Height: 13 ft.
Purpose: Flood Control
Hazard Level: Not Available
Construction Method: Earth
Upstream Functional Network: 0.1 miles
Downstream Dam Count: 13
Fish Passage Modification- None
Pond Area Behind Dam: 0 acres

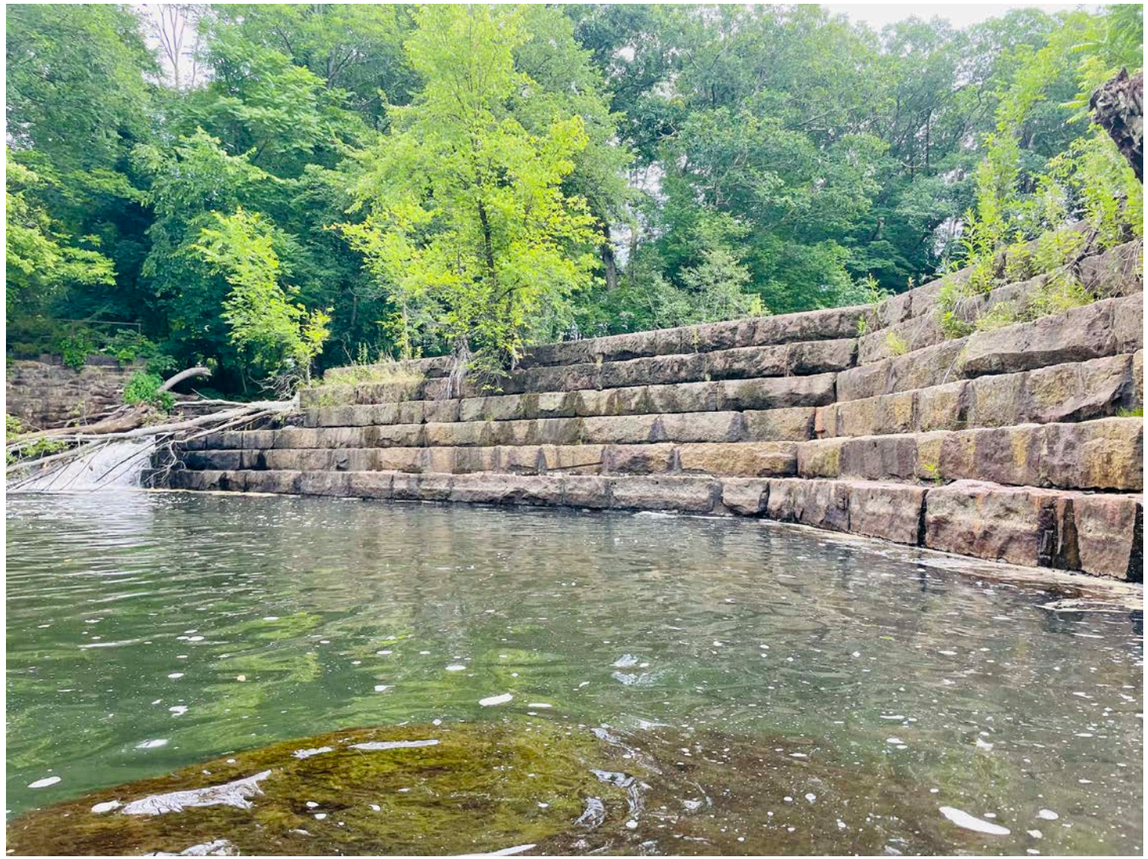
DESCRIPTION: The Farnumsville Dam is located in a historic mill village in Grafton, Massachusetts. The Farnum Cotton Mill was built by John Farnum in 1844 and operated until the 1930’s Great Depression. The mill and the dam are now out of commission.

15. FISHERVILLE POND

42°10’45.03”N | 71°41’19.30”W

Year Built: 1882
Owner: Private
Height: 12 ft.
Purpose: Water Supply
Hazard Level: Not Available
Construction Method: Masonry
Upstream Functional Network-
Downstream Dam Count: 14
Fish Passage Modification- None
Pond Area Behind Dam- 0 acres

DESCRIPTION: Fisherville Pond is located in Grafton, Massachusetts. The pond is commonly used for recreation such as fishing, hiking, and paddling and has become importnat habirat for migratory fish. Multiple studies have uncovered contaminants ranging from metals to hazardous chemicals called polychlorinated biphenyls, or PCBs in the fisherville pond. Fisherville Redevelopment Corp., which controls about 32 acres of land and the pond’s water rights, has spent close to $2 million cleaning up pollutants since it acquired the property in 2004 (link)

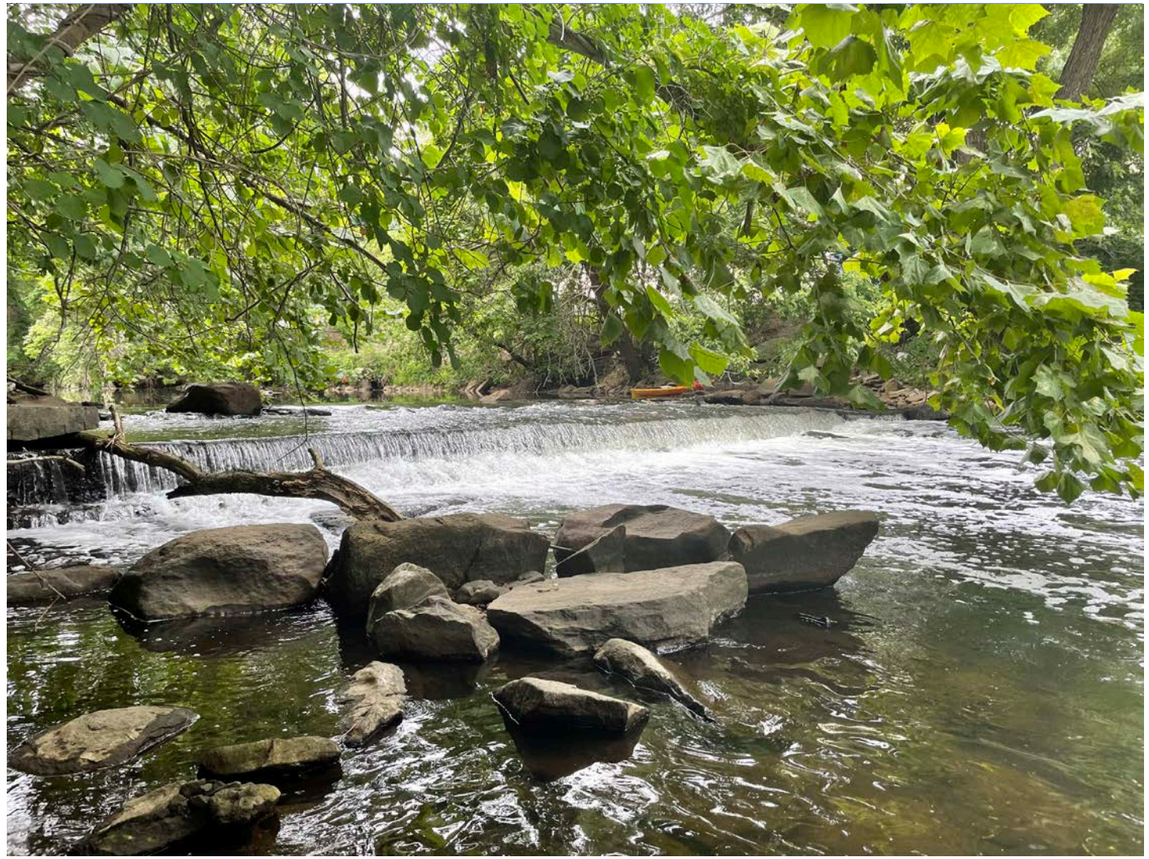


16. SAUNDERSVILLE DAM

N | W

Year Built:
Height:
Owner:
Purpose: Legacy
Hazard Level:
Construction Material: Masonry
Upstream Functional Network:
Downstream Dam Count: 15
Fish Passage Modification: None
Pond Area Behind Dam: 0 acres

DESCRIPTION:



17. WILKONSONVILLE DAM

N | W

Year Built:
Height:
Owner:
Purpose: Legacy
Hazard Level:
Construction Material:
Upstream Functional Network:
Downstream Dam Count: 16
Fish Passage Modification: None
Pond Area Behind Dam: 0 acres

DESCRIPTION:

18. SINGING

42°10’50.89”N | 71°43’48.89”W

Year Built: 1828
Height: 10 ft
Owner: ?
Purpose: Recreation
Hazard Level: Not Available
Construction Material: Granite
Upstream Functional Network:
Downstream Dam Count: 17
Fish Passage Modification: None
Pond Area Behind Dam:

DESCRIPTION: Singing Dam, also known as Pleasant Falls Dam, is located in Sutton, Massachusetts. A grist mill once operated at Singing Dam, but burned down in 1822. A new textile mill was built in 1825 and operated until 1896. The mill building was razed during the 1950’s. The scenic overflow from the remaining dam can be seen from Blackstone Street Bridge.

19. MILLBURY ELECTRIC DAM

N |W

Year Built: 1828
Height: 10 ft
Owner: National Grid
Purpose: Recreation
Hazard Level: Not Available
Construction Material: Granite
Upstream Functional Network:
Downstream Dam Count: 18
Fish Passage Modification: None
Pond Area Behind Dam: 0 acres

DESCRIPTION: The Millbury Electric Dam has been identified for potential removal. A 2007 study by the firm Fuss & O’Neill of West Springfield estimated it could cost $2.2 million to $4.8 million to remove the Millbury Dam due to the cost of dredging and removing sediments loaded with arsenic, metals and other contaminants from the river’s industrial past.

ECOLOGIAL + SOCIAL VALUE: MIGRATORY FISH

Eco Rank- Top 10%
Social Score- Low >10

Eco Rank- Top 10%
Social Score - Moderate 10-49

Eco Rank- Top 10%
Social Score - High >50

BOSTON

WORCESTER

MASSACHUSETTS

CONNECTICUT

PROVIDENCE

CAPE COD BAY

RHODE ISLAND
SOUND

ECOLOGIAL + SOCIAL VALUE: RESIDENT FISH

Eco Rank- Top 10%
Social Score- Low >10

Eco Rank- Top 10%
Social Score - Moderate 10-49

Eco Rank- Top 10%
Social Score - High >50

BOSTON

WORCESTER

MASSACHUSETTS

CONNECTICUT

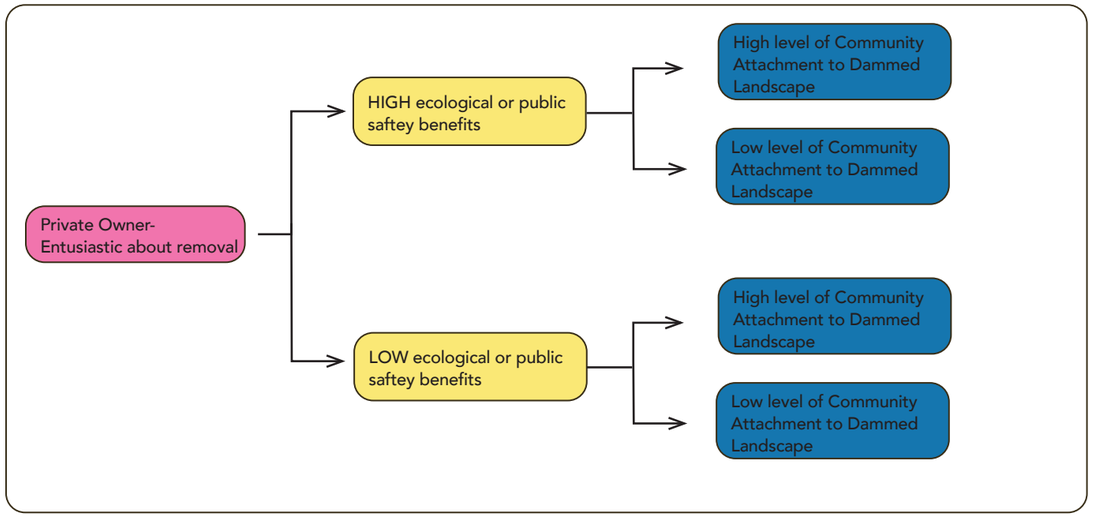
PROVIDENCE

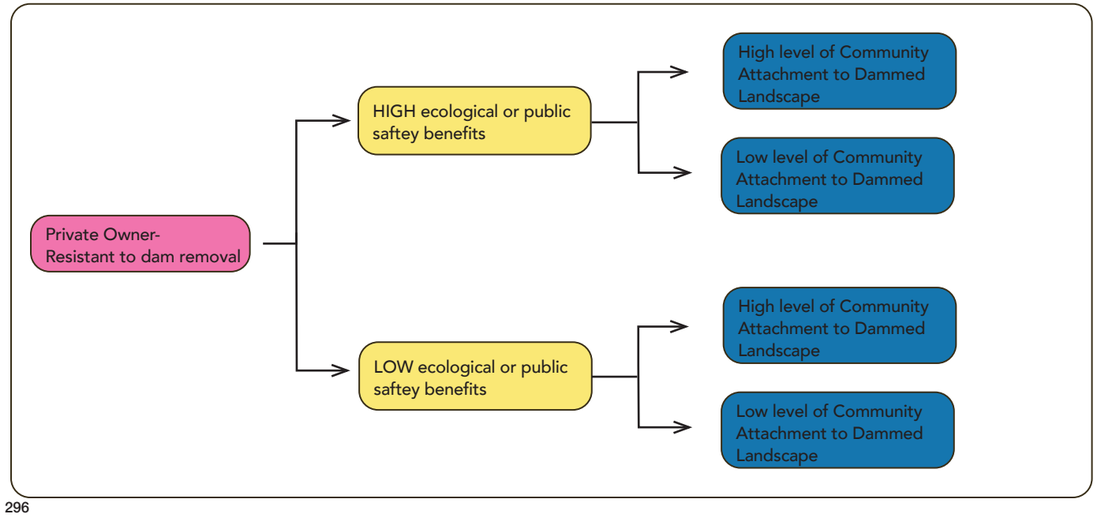
CAPE COD BAY

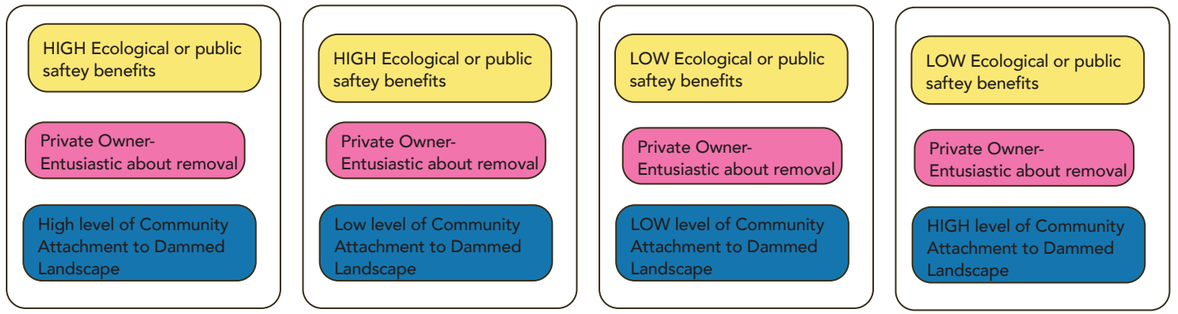
RHODE ISLAND
SOUND

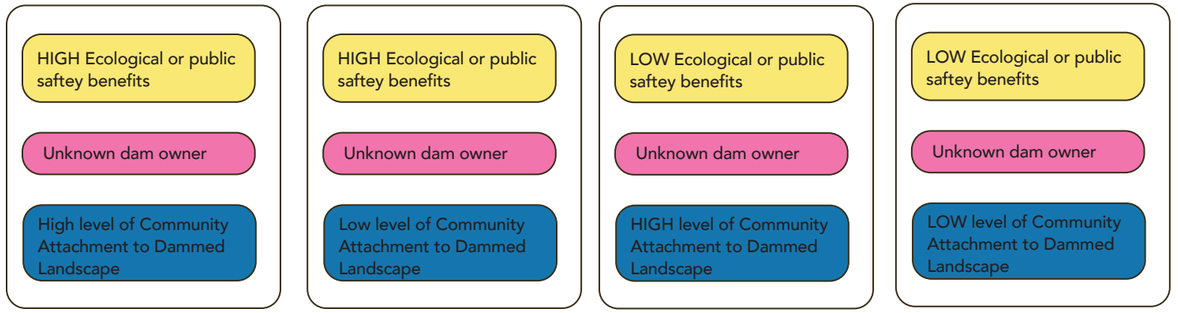
Maybe discuss the 3 types of dam removals - 1) Not getting done: dangerous dams but with no owner; 2) Priority Projects: enthusiastic dam owners, but don't have ecological or public safety benefits to get the support; 3) Landmark/beneficial dam removal without owner interest - tough to crack the case

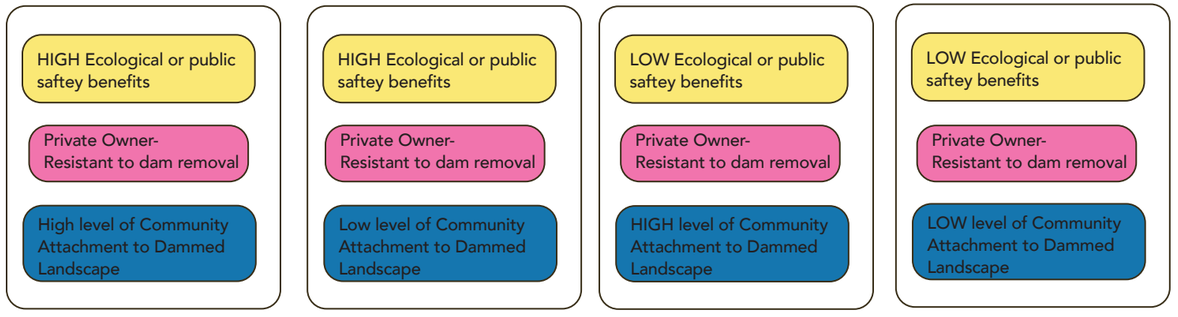
TYPES OF PROJECTS

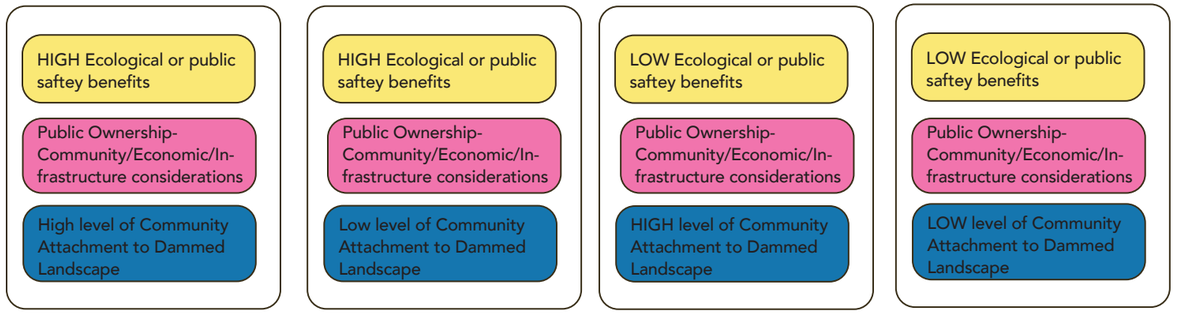












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TYPES OF PROJECTS