What Is Our Water Worth and What Does Our Water Cost?

A review of economic data on water in New Hampshire

Prepared for

New Hampshire Lives on Water: A Public-Private Partnership

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February 2019

Acknowledgments

Funding for this project was provided by the agencies listed below to support this work for New Hampshire Lives on Water, with NH LAKES serving as the fiscal agent. New Hampshire Lives on Water is a public-private partnership composed of for profit and nonprofit organizations and individuals who have a strong interest in the quality, quantity, reliability and future of New Hampshire's water resources and infrastructure.

Funded by contributions from:
Eastman Lakes and Streams Committee
Lake Sunapee Protective Association
Newfound Lake Region Association
NH Charitable Foundation
NH Department of Environmental Services
NH LAKES (Fiscal agent)
Pennichuck Water Service Corporation
Piscataqua Region Estuaries Partnership
Society for the Protection of New Hampshire Forests
Squam Lakes Association
The Nature Conservancy
The Trust for Public Land

This work was guided by input and insight from the New Hampshire Lives on Water Steering Committee, listed below.

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William Arcieri, VHB
John Boisvert, Pennichuck Water
Clark Freise, New Hampshire Department of Environmental Services
John Gilbert, Synchrony Advisors
Marcy Lyman, Public
Barbara Richter, New Hampshire Association of Conservation Commissions
Rachel Rouillard, Piscataqua Region Estuaries Partnership
Paul Susca, New Hampshire Department of Environmental Services
Tom O'Brien, NH LAKES
Mark Zankel, The Nature Conservancy

Infographics were developed with assistance from Molly Shanahan, University of New Hampshire Cooperative Extension. Partial support for Paige McKibben was provided through New Hampshire EPSCoR, and in-kind support was provided by UNH Extension in the form of Mr. Reynold's time, and purchase of modeling software.

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Executive Summary

The goal of this Project was to gather and develop information regarding the worth and cost of water services and resources in New Hampshire in order to better understand the value of water to our state's economy and the real cost of maintaining clean and safe water for drinking, recreation and businesses. We reviewed and summarized over one hundred reports, presentations, fact sheets and other relevant information. We performed an economic analysis on some forms of water-based recreation in New Hampshire, and provide more detailed information on costs and benefits associated with culvert upgrades. We reached out to experts and stakeholders to locate information that is not readily identified through internet searches, and we identified gaps and opportunities for future works.
The results are organized into eight categories: drinking water, stormwater, recreation, ecosystem services, industry and energy, employment, forests and agriculture, and transportation. The primary findings in each section are summarized below and discussed in more detail in the report.

Drinking Water (Quantity, Cost and Public Health)

Value – Public health is the highest value provided by drinking water, but health is also extremely difficult to quantify economically. A recent study by UNH and NHDES estimated an annual willingness to pay of $0.216-0.576 million for the reduced risk of cancer provided by a lowered (5 parts per billion) maximum contaminant level for arsenic (New Hampshire Department of Environmental Services 2018). Indirect value includes jobs provided by the water utility sector (289,000 jobs from 30 water utilities, Quinn et al 2014) and avoided costs to business from service disruptions (up to $5,800 per day per employee for water intensive industries, Value of Water Campaign 2016)
Cost – Drinking water supply rates have increased by 100% in 15 years (NH Department of Environmental Services 2015), but our state's water infrastructure is still severely underfunded, with an estimated 10 year investment of $857 million needed for drinking water services. This cost will increase if substantial investments are needed to protect health through increased treatment for arsenic or emerging anthropogenic contaminants.
Gaps and Opportunities – Specific data on value and cost from New Hampshire businesses could be aggregated to develop local information on value, at least in terms of jobs and other economic outputs, and costs.

Stormwater (Grey & Green Infrastructure)

Value – The value of stormwater treatment is most commonly realized in the form of avoided costs. Stormwater treatment improves surface water quality, and may allow communities to avoid costs associated with required nutrient reductions (up to $100 million in the Exeter Squamscott Watershed; Roseen et al 2015), drinking water treatment (if structural improvements can be avoided; Colgan, Yakovleff, and Merrill 2013).
Cost – The projected cost for meeting New Hampshire's storm water infrastructure needs is approximately $272 million, and does not include costs associated with Municipal Separate Storm Sewer System (MS4) permit compliance (The General Court of New Hampshire 2013).
Gaps and Opportunities – There is an opportunity to better understand the values and costs of stormwater through a New Hampshire focused analysis of a stormwater utility. Better understanding of the co-benefits that result from green infrastructure used for stormwater management would help with community decision making.

Recreation

Value – We estimated the value of several forms of recreation and found that:

- The economic impact of recreational fishing in New Hampshire is approximately $215 million dollars per year.
- The economic impact of visitors who came to swim in New Hampshire's freshwater state parks during the summer of 2017 is approximately $40 million dollars.
- The economic impact of non-New Hampshire registered boaters visiting New Hampshire during the summer of 2017 is estimated at over $100 million dollars.
- New Hampshire's waterfront properties are very valuable to both towns and the state.

Cost – Recreation incurs indirect costs as a result of degraded water quality or habitat. This cost could be quantified though lost property values, or the cost to restore or maintain water quality to support recreation.

Gaps and Opportunities – Future research should focus on a methodology for more specifically collecting information how visitors and residents recreate, what they spend and how they benefit from our water resources. A multi-institution, regularly coordinated survey effort would go a long way to helping to meet this need.

Ecosystem Services – Avoided Cost Studies, Willingness to Pay and Real Estate Values

Value – Ecosystem services can provide value by reducing infrastructure costs (land conservation in Great Bay tributary watersheds could be worth over $40 million in avoided wastewater treatment costs; Berg, Mineau, and Rogers 2016), providing fuel, fibers, climate regulation, erosion control, recreation and habitat (up to $287 million/year in the Sebago Lake, ME watershed; Daigneault and Strong 2018), and by encouraging tourism ($6.8 million in spending and 68 jobs near several central Maine lakes; Donihue, Dissanayake, and O'Keeffe 2015). In Meredith, New Hampshire, on average, waterfront properties are worth twice as much as other properties in the same town (data from this study).

Cost – The cost of maintaining ecosystem services is most commonly in land conservation, or lost opportunity for development. For example, the estimated cost of land conservation needed to reach water quality protection targets in the Sebago Lake watershed is $124 – $230 million.

Gaps and Opportunities – The pilot real estate valuation study presented here could be expanded to additional regions or types of waterbodies. A more comprehensive evaluation should include both the increase in real estate value, and the potential loss in ecosystem value associated with siting residences in close proximity to water.

Industry and Energy

Value – Water is crucial to many industries; Basic chemical manufacturing requires the highest use (2,116,500 gallons per job and 4,700 gallons per $1,000 sales; The Value of Water, 2017), while beverage industries rely on high quality water as a product ingredient. 40% of all freshwater withdrawals in the US were related to energy production - primarily cooling water in generating plants (US Department of Energy 2006).

Cost – Disruptions in service are costly; every day of lost service can cost businesses $230-$5,800 per employee per day.

Gaps and Opportunities – A review of water use and cost in breweries would provide information on the importance of water to a well-liked industry with easily identifiable connections to water.

Employment

Value – Water utilities generate 16 jobs for every $1 million spent in the United States (Quinn et al 2014). The direct and indirect benefit of investing $82 billion per year (as recommended by the American Society of Civil Engineers), would generate and sustain approximately 1.3 million jobs in the country.
Gaps and Opportunities – A survey of utilities and economic analysis (e.g. IMPLAN) would provide more detail on New Hampshire-specific employment opportunities.

Forestry and Agriculture

Value – Forestry, agriculture and commercial fishing generate $2.5 billion in output and support 18,500 jobs nationwide. In 2010 agricultural production added $138 million to the state's economy, and supported 5,050 jobs (Trust for Public Land, 2014).
Cost – Conservation of forest land requires acquisition or easements. Agriculture and timber harvesting may have detrimental effects on water quality if not properly managed.
Gaps and Opportunities – Better understanding the dynamics of managing forests for drinking water provisioning.

Transportation and Culverts

Value – Improved aquatic passage supports New Hampshire's $200 million recreational fishing industry, and reduces the risk of flooding.
Cost – Flooding has caused over $100 million in property damage in the state since 2001, much of it due to major road washouts (Hazards and Vulnerability Research Institute). The estimated life-cycle cost of a stream simulation culvert is less than the cost of installing a corrugated pipe (RBouvier Consulting, LLC 2017).
Gaps and Opportunities – A review of specific culvert failures compared to stream compatibility would present a relatively low cost analysis of the relationship between assessed viability and real failure. There are several locations in New Hampshire where damage from recent severe storms could be assessed.

Introduction and Goals

New Hampshire residents and businesses have been fortunate to be located in a region where water has, historically, been readily available. While this has supported our thriving economic, recreation and personal success, the belief that clean water is plentiful reduces the incentive to proactively protect water resources or infrastructure. However, shifts in population, increased urbanization, aging infrastructure and climate change are among the many factors stressing both water quality and quantity, and public support for actions that avoid and mitigate these stresses is needed. New Hampshire residents overwhelmingly support clean water; most New Hampshire residents are concerned about having clean water for fish and wildlife (92%) and clean drinking water for future generations (91%), while a large majority also say they are willing to pay more to improve the quality of our water resources (Rogers, Berg, and Farrell 2014). Many industries, from beverage suppliers to hydroelectric plants, rely on water as an integral part of their processes.

Water is valuable to us because we drink it and use it for manufacturing, recreation and other needs. But it also provides economic value that can be quantified. Maintaining and operating our water infrastructure such as wastewater treatment systems and drinking water services is an industry that generates $53 billion and 289,000 jobs annually in the United States. The cost of maintaining this infrastructure is high, and funding is rarely sufficient to cover the costs. The funding needs to upgrade and maintain New Hampshire's drinking water infrastructure was estimated at $857 million over 10 years (New Hampshire Section of the American Society of Civil Engineers, 2017).

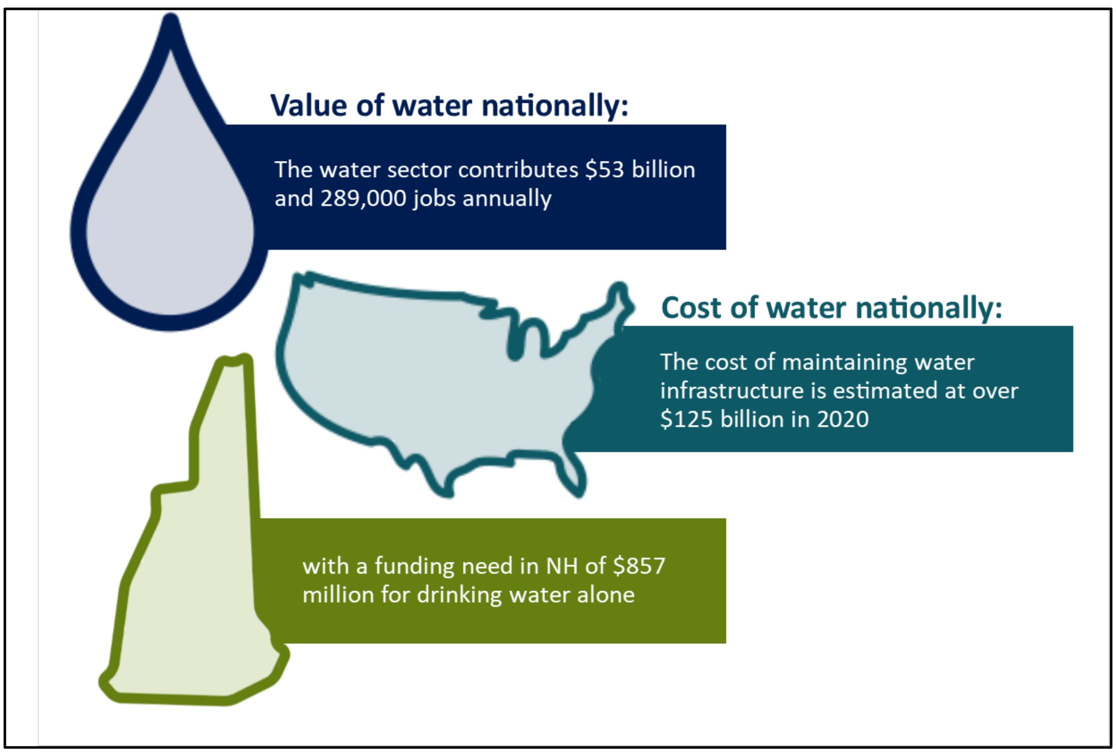


Figure 1. The water utility sector contributes $53 billion and 289,000 jobs annually in the United States, but is often underfunded. The funding need for New Hampshire's drinking water systems is estimated to be $857 million (New Hampshire Section of the American Society of Civil Engineers 2017; Quinn et al. 2014).

New Hampshire Lives on Water: A Public-Private Partnership (NHLOW) is a non-profit entity with a steering committee representing a range of water sectors in New Hampshire. NHLOW has a goal to understand and promote the value of New Hampshire's water resources, and has developed a work plan which identified as a key strategy "educate the public regarding value, cost, and status of water to our quality of life and the New Hampshire economy." However, existing information on the economics of water in New Hampshire is widely scattered, and is difficult to access or interpret. To overcome this barrier NHLOW commissioned this study on the worth and cost of New Hampshire's water resources and infrastructure.

The goal of this Project was to gather and develop information regarding the cost and value of water services and resources in New Hampshire in order to enable all water-related stakeholders to advocate for:

- Increasing and expanding investments in the state's water resources and water infrastructure,
- Enhancing the protection of public health by ensuring adequate supplies of clean and safe drinking water,
- Protecting public safety by ensuring protection from floods,
- Protecting and supporting biodiversity and ecosystem integrity, and
- Supporting and enhancing the economic vitality provided by the state's recreation and tourism industry and other businesses that depend on high-quality water resources and infrastructure.

The project has two components: 1) Compile and synthesize credible data on the economic importance (value and cost) of water and water services in New Hampshire and; 2) provide examples and case studies derived from existing data. A limited amount of new analysis was conducted to estimate the economic value of selected recreation activities, but the primary focus of this report is to identify and collect existing analyses and information on freshwater resources and associated ecosystems. We have included some studies related to watersheds and tributaries in the Great Bay region, but did not conducted a detailed search for resources on coastal waters. This report, and the reference database associated with it, will guide the development of communication materials, additional studies and policy to engage a broad range of stakeholders in New Hampshire to further the purpose outlined above.

Approach

Over 100 documents, presentations, websites, and other information sources were reviewed for this study. We focused on information and analyses generated in or relevant to New Hampshire within the last 10 years. In many cases we found that local information is not available or is outdated. In these areas we broadened the search to include national, regional or less recent data. We also found that there is a significant body of work that is difficult to find through the standard search process, and to identify and collect this data we contacted experts, agencies and stakeholders to request specific types of information. With the exception of the recreation analysis discussed in Section B this report does not generate new data, but we did identify areas where raw data exists to support new analyses. All of the information we collected is compiled in an online database containing about 100 documents, tagged with keywords, with brief summaries associated with each item. Appendix C lists data sources and summaries, grouped into categories as summarized in Figure 2, below. A synthesis of the most relevant information under each of these main categories is provided in this report. Our objective is to provide a brief overview of the information we consider most useful, with some discussion of areas where a small amount of additional work would support the goals listed above.

Keyword	Documents reviewed in each sector
Drinking Water	**20**
Ecosystem Services	**19**
Energy	**6**
Employment	**12**
Infrastructure *Gray Infrastructure* *Green Infrastructure*	**60** *54* *13*
Recreation	**20**
Stormwater	**19**
Surface Water	**23**
New Hampshire	**35**

Figure 2. Over 100 reports, presentations and other documents were reviewed and summarized. Many documents are relevant to multiple sectors. All of the documents, summaries and associated information are available in an electronic database.

Results

Water in New Hampshire

Water reaches across all aspects of New Hampshire's economy, so focusing on the value of water to any single aspect of the economy fails to recognize the interconnected natural and built systems that may all rely on the same resource. For instance, surface water is a component in drinking water, recreation, fishing and many industries, while some of those sectors in turn, may deplete or degrade the water systems they rely on. In this section we summarize existing, relevant information on water resources by sector, recognizing that the sectors interact in many areas.

Overall, we found that while there are numerous reports, papers, and data sets related to water and economics in the United States, there is relatively little data that has been generated specifically in New Hampshire. We also found that there is much more information on the cost of water, particularly infrastructure, than there is on its value or benefit. Our discussion here includes material from regional (New England) or national studies in those cases where we felt that the information was relevant to New Hampshire, even if not generated here. In some cases, these examples may serve as a template for how a similar study could be conducted, and the type of information that could be obtained to fill gaps in our local knowledge.

Drinking Water (Quantity, Cost and Public Health)

Value – *Public health is the highest value provided by drinking water, but health is also extremely difficult to quantify economically. A recent study by UNH and NHDES estimated that public water supply customers with 5-10 ppb of arsenic in their drinking water would together be willing to pay $0.216-0.576 million per year for the reduced risk of cancer provided by a lowered (5 parts per billion) maximum contaminant level (New Hampshire Department of Environmental Services. 2018). Other water supply values include the indirect value of jobs provided by the water utility sector (289,000 jobs from 30 water utilities, Quinn et al 2014) and avoided costs to business from service disruptions (up to $5,800 per day per employee for water intensive industries, Value of Water Campaign, 2016)*

Cost – *Drinking water supply rates have increased by 100% in 15 years (NH Department of Environmental Services, 2015), but our state's water infrastructure is still severely underfunded, with an estimated 10 year investment of $857 million needed for drinking water services. This cost will increase if substantial investments are needed to protect health through increased treatment for arsenic or emerging anthropogenic contaminants.*

Gaps and Opportunities – *Specific data on value and cost from New Hampshire businesses could be aggregated to develop local information on value, at least in terms of jobs and other economic outputs, and costs.*

Drinking water is probably the most highly valued human water use: everyone needs water to drink, and the connections to our health are clear. Recent tragedies, such as lead-contaminated water in Flint, Michigan underscore the vulnerability of the Nation's water supply systems. In New Hampshire longer term threats to our water include naturally present arsenic and radon, as well as human caused contamination from industry, stormwater and other sources. Recent concerns regarding emerging contaminants, particularly per- and polyfluoroalkyl substances (PFAS) in New Hampshire's water will likely require costly infrastructure upgrades and policy changes to mitigate.

The cost to maintain, let alone upgrade, safe drinking water is substantial: A report on water infrastructure resilience estimates that the nation's water infrastructure is underfunded by at least about $400 billion, and that chronic underinvestment, system failures, and service shortfalls are becoming increasingly common in the Nation's infrastructure. (Baylis et al. 2016).

The cost of public water supply service in New Hampshire is increasing, with an average annual cost in 2015 of $473 per household, compared to $218 per household 15 years earlier (New Hampshire Department of Environmental Services 2015). Even with these rate increases our drinking water infrastructure is aging, and would benefit from substantial investment (Pillsbury, Currier, and Susca 2008). In 2016, drought conditions resulted in the failure of hundreds of public and private water systems nationwide, and a joint legislative study released in 2013 found that approximately $857 million is needed in the next 10 years to maintain and upgrade New Hampshire's drinking water infrastructure (The General Court of New Hampshire 2013; New Hampshire Section of the American Society of Civil Engineers 2017). A New England wide study conducted in 2006 found that projected combined (water and wastewater) annual household water costs ranged from a high of $3,592 to a low of $333 (New England Interstate Water Pollution Control Commission 2006).

The value of drinking water is much harder to quantify. A few studies have calculated the economic impact of water borne disease (Corso et al. 2003), but valuation of public health concerns can be controversial, and studies more often focus on employment, materials and other direct costs. A recent study by UNH and the New Hampshire Department of Environmental Services provided an estimate of willingness to pay as a form of value. Based on a survey of NH water customers, residents indicated an annual willingness to pay of $.216 to 1.15 million to reduce their chance of arsenic associated cancers. A 2013 study by the United States Environmental Protection Agency (US EPA) found that the water utility sector nationally generates $53 billion, while an analysis of operating and capital expenditures at 30 urban water utilities nationwide (but none in new Hampshire) identified an annual output of 289,000 jobs and a combined direct and indirect economic impact of $34 billion per year from those businesses alone (United States Environmental Protection Agency 2013; Quinn et al. 2014).

Stormwater (Grey & Green Infrastructure)

Value *– The value of stormwater treatment is most commonly realized in the form of avoided costs. Stormwater treatment improves surface water quality, and may allow communities to avoid costs associated with required nutrient reductions (up to $100 million in the Exeter Squamscott Watershed; Roseen et al 2015), and drinking water treatment (if structural improvements can be avoided; Colgan, Yakovleff, and Merrill 2013).*

Cost *– The projected cost for meeting New Hampshire's storm water infrastructure needs is approximately $272 million, and does not include costs associated with Municipal Separate Storm Sewer System (MS4) permit compliance (The General Court of New Hampshire 2013).*

Gaps and Opportunities *– There is an opportunity to better understand the values and costs of stormwater through a New Hampshire focused analysis of a stormwater utility. Better understanding of the co-benefits that result from green infrastructure used for stormwater management would help with community decision making.*

Stormwater treatment is usually conducted to improve surface water quality and quantity, such as protecting a lake from parking lot or road runoff, or to reduce the risk of flooding from ponded rainwater. Historically, stormwater improvements relied on improved drainage and piping systems (‘grey’ infrastructure) to convey water off-site as quickly as possible. Later, to address both water quality and flow concerns, the detention and gradual release of treated runoff became the norm. More recently, ‘green’ infrastructure or low impact development (LID) approaches emphasize infiltration and the use of natural processes to help prevent damage from runoff.

The projected cost for meeting New Hampshire’s stormwater infrastructure needs is approximately $272 million, and does not include costs associated with Municipal Separate Storm Sewer System (MS4) permit compliance (The General Court of New Hampshire 2013). There is considerable discussion and numerous reports on the relative merits of green vs grey stormwater infrastructure, both in New Hampshire and regionally. Several studies in New Hampshire have evaluated specific benefits associated with implementing green infrastructure stormwater control to address a specific problem: Green infrastructure is sometimes viewed as too costly to implement. *Forging the Link*, a study and training curriculum developed by the UNH Stormwater Center provides examples of costs savings associated with green infrastructure stormwater control at residential and commercial installations nationally and in New Hampshire. Costs savings were obtained by installing LID systems rather than conventional runoff controls at a residential development in Pelham, NH (6% savings) and at a commercial site in Greenland NH (26% savings) (Janeski et al. 2011).

A study in the Exeter-Squamscott River watershed found that communities could potentially save $100 million (over 50 years), by using improved stormwater treatment to offset nitrogen reductions required for the region’s wastewater treatment plants (Roseen et al 2015).

A study in Maine reviewed cost versus benefits of a wide range of green infrastructure, including land conservation, stormwater control and culvert upgrades to protect water quality in Sebago Lake, which supplies drinking water to Portland. They found that the economic benefits of avoiding advanced treatment at a drinking water plant outweighed the upfront costs of the green infrastructure investments (Colgan, Yakovleff, and Merrill 2013).

Recreation

Value – *We estimated the value of several forms of recreation and found that:*

- *The economic impact of recreational fishing in New Hampshire is approximately $215 million dollars per year.*
- *The economic impact of visitors who came to swim in New Hampshire’s freshwater state parks during the summer of 2017 is approximately $40 million dollars.*
- *The economic impact of non-New Hampshire registered boaters visiting New Hampshire during the Summer of 2017 is estimated at over $100 million dollars.*
- *New Hampshire’s waterfront properties are very valuable to both town and state.*

Cost – *Recreation incurs indirect costs as a result of degraded water quality or habitat. This cost could be quantified though lost property values, or the cost to restore or maintain water quality to support recreation.*

Gaps and Opportunities *– Future research should focus on a methodology for more specifically collecting information about how visitors and residents recreate, what they spend and how they benefit from our water resources. A multi-institution, regularly coordinated survey effort would go a long way to helping to meet this need.*

Water based recreation takes many forms; from boating to fishing, or simply walking near a body of water, New Hampshire's residents and visitors enjoy our water resources. The economic benefits accrued from these activities can be measured in several ways. Visitors to a region usually spend money on goods and services such as food, lodging and gas. This income provides tax revenues to the state, and benefits local business, which in turn may hire more workers, or buy more goods. These impacts can be measured directly, through revenues or surveys, or modeled using economic software. Most water-based recreational activities take place on liquid water (snow sports being an exception), and we conducted a limited analysis on the economic value of New Hampshire's freshwater recreation. This analysis is summarized here, and discussed in more detail in Appendix B.

Case Study: Select Estimates of the Values of Freshwater Recreation in New Hampshire

We used IMPLAN (Economic Impact Analysis for Planning), an economic modeling software, to develop estimates for economic outputs associated with selected recreation activities. We combined this with several other recent data sources from surveys and other analysis. The results are summarized below, with more details and methods presented in Appendix B. Our analysis was limited to available New Hampshire-specific data. Generally, visitors to a region spend more and bring economic value into the state, so our analysis focused on visitors to freshwater areas.

Fishing - The Economic Impact of Recreational Fishing in New Hampshire

According to the most recently available data, 228,000 anglers spent 4.37 million days fishing in New Hampshire and spent $208.5 million on trip and equipment related expenditures. The majority of these anglers (over 90%) were fishing in New Hampshire's freshwater. These figures include both residents and nonresidents (2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. US Fish and Wildlife Service and US Census Bureau).

In addition to the spending by visitors and residents, the State also collects revenue in the form of fishing licenses. The State of New Hampshire collected over $6.2 million dollars in fishing license revenue in 2017 (NH Fishing License Sales, 2017. Prepared by Jason M. Smith).

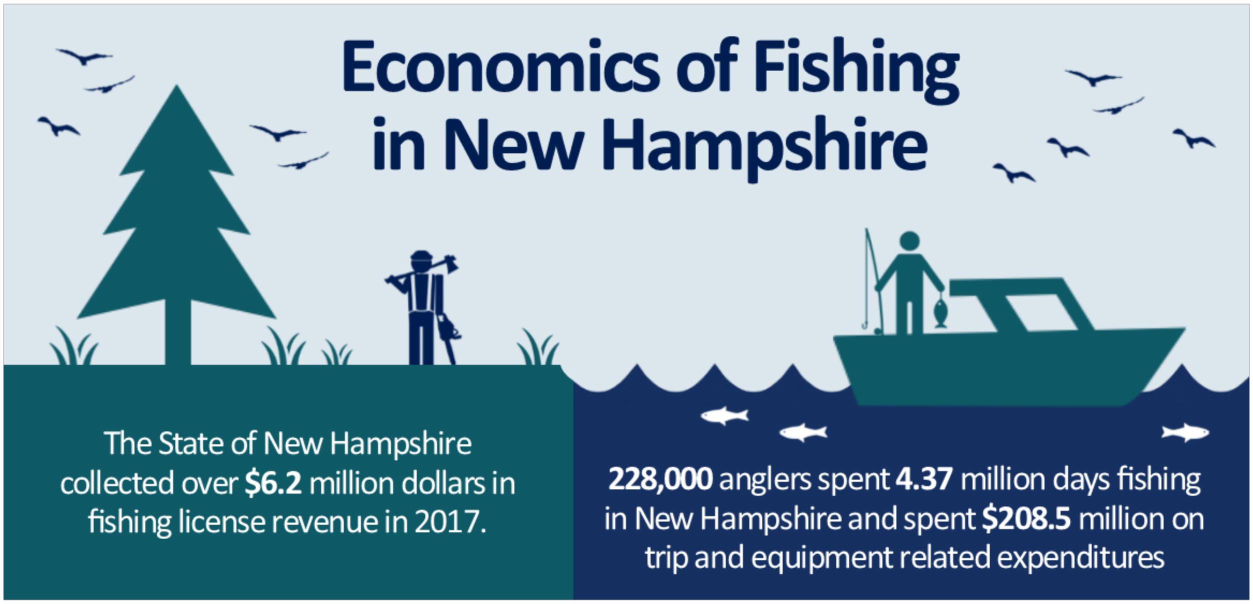


Figure 3. Fishing is a very popular form of water-based recreation and generates over $200 million annually.

Swimming - Economic Impacts of Visitors to New Hampshire's Freshwater State Parks

New Hampshire's state parks provide access to freshwater resources, especially for swimming. We were able to obtain a data set of visitors to freshwater state parks in New Hampshire for June, July, and August 2017 from the New Hampshire Department of Natural and Cultural Resources Division of Parks and Recreation that showed a total of 323,285 cars coming to state parks with freshwater swimming. We estimated the total number of people visiting the parks from out of state from a recent "license plate survey" that showed an average of three people visit per car and that 45% of cars are from out of state. Using IMPLAN, which estimates both direct spending and indirect benefits (such as employment), we calculate that these visitors contribute $41 million dollars to New Hampshire's economy every year. While we do not have spending data on NH resident travel to the parks and thus cannot estimate the economic impact, we can say that with 55% of the cars being from NH, residents value the state parks and their freshwater recreation they provide.

Boating - Economic Impact of Non-New Hampshire Registered Boaters in New Hampshire

19,945 non-New Hampshire boats were registered in the State in 2017 (DMV). We estimated that boats spend 28 days per year on the water, with an average of two people per boat, for an estimated total 1.1 million visitor days. Using published visitor spending profiles, we calculate an economic output of $104 million dollars and 700 jobs. There is no available data on motor boats under 12 feet in length nor is there data available on canoes and kayaks and thus this economic impact is likely conservative.

Non-New Hampshire Recreation Studies

A study conducted in Maine also used IMPLAN to estimate the economic impact of visitors, but included a visitor survey to derive expenditure data. The survey and research methods were designed to explore social and economic dimensions of the area as well as capture information on spending, income, and general knowledge of tourists about the health of the lakes in the watershed. The study estimated an annual impact of $6.8 million in indirect and induced effects of visitor spending (Donihue, Dissanayake, and O'Keeffe 2015).

A 2007 study assessed the group and trip characteristics of paddlers recreating on the Northern Forest Canoe Trail which stretches from Quebec through New Hampshire and Maine. Ninety thousand visitors created $12 million in total economic impacts and supported about 280 jobs., (Pollock and Chase 2007). A similar study in Pennsylvania found that 103,000 paddlers generated $50 million.

Snow sports are an important water-based industry in New Hampshire and in the United States. Approximately 20 million people participate in downhill skiing, snowboarding, and snowmobiling each year, adding an estimated $20.3 billion in economic value to the U.S. economy. Low snow years, which are expected to increase in the future, cost the country's downhill ski industry approximately $1.07 billion in aggregated revenue over high and low snow years over the last decade (Hagenstad, Burakowski, and Hills 2018).

Ecosystem Services – Avoided Cost Studies, Willingness to Pay and Real Estate Values

Value *– Ecosystem services can provide value by reducing infrastructure costs (land conservation in Great Bay tributary watersheds could be worth over $40 million in saved wastewater treatment costs; Berg, Mineau, and Rogers 2016), providing fuel, building materials, climate regulation, erosion control, recreation and habitat (up to $287 million/year in the Sebago Lake, ME watershed; Daigneault and Strong 2018), and by encouraging tourism ($6.8 million in spending and 68 jobs near several central Maine lakes; Donihue, Dissanayake, and O'Keeffe 2015). In Meredith, New Hampshire, on average, waterfront properties are worth twice as much as other properties in the same town (data from this study).*

Cost *– The cost of maintaining ecosystem services is most commonly in land conservation, or lost opportunity for development. For example, the estimated cost of land conservation needed to reach water quality protection targets in the Sebago Lake watershed is $124 – $230 million.*

Gaps and Opportunities *– The pilot real estate valuation study presented here could be expanded to additional regions or types of waterbodies. A more comprehensive evaluation should include both the increase in real estate value, and the potential loss in ecosystem value associated with siting residences or septic systems in close proximity to water, or failing to maintain adequate vegetated buffers.*

Ecosystem services are one of the most difficult aspects of water to quantify, and cover many features of our economy. Ecosystem services are commonly defined as services provided by the natural environment that benefit people. When considering water, common ecosystem services include drinking water supply, recreational opportunity, fish habitat etc. which directly benefit people who live in the region. There are many other services which are also valuable to society, but are often not recognized, or included in economic assessments. Ecosystem services are difficult to quantify directly, and can include avoided costs, improved health, climate and flood regulation, erosion control, wildlife habitat, and others.

Regulating services are functions provided by a water body that regulate or control a potential stressor such as nutrient or thermal pollution. Rivers, lakes, and aquifers regulate some contaminants by either transforming them, or storing and diluting to a lower threshold. A 2016 study in the Great Bay watershed estimated that nitrogen retention and removal associated with land conservation in tributary watersheds could be worth over $40 million in avoided wastewater treatment costs (Berg, Mineau, and Rogers 2016).

Watershed protection for both ground water and drinking water sources is an ecosystem service which is commonly discussed. The link between increased development and poor water quality is well documented. The *value* of watershed protection is less well understood, and depends on the intended water use, type of treatment required and regulatory drivers. The Portland Water District in Maine, for instance, draws from Sebago Lake, which has very high water quality. The District qualifies for a filtration waiver under the US EPA's Surface Water Treatment Rule. A decrease in water quality could result in the loss of the waiver, and a required upgrade to the water treatment system costing approximately $155 million. Investing in watershed conservation to protect water quality would cost about $44 million, resulting in a potential watershed protection value of about $110 million (Talberth et al 2013). There are currently no drinking water plants operating under a filtration waiver in New Hampshire, so this exact scenario is unlikely to occur, but a more recent study (Daigneault and Strong 2018) in the Sebago Lake watershed also estimated a total annual value of ecosystem services other than freshwater protection of $42-287 million per year. These services included provision of fuel, climate regulation, erosion control, recreation and habitat. Another study modeled the direct, indirect and induced effects of spending by tourists in several central Maine lakes. The study estimated the expenditures generated by 705 seasonal and year-round residents of the Watershed to be approximately $6.8 million supported by watershed (Donihue, Dissanayake, and O'Keeffe 2015).

Because water is part of a complex ecosystem, actions that protect or degrade water resources will often have associated economic impacts beyond a single water use, which should be considered in a benefits cost analysis. One way of quantifying the worth of an ecosystem service is through willingness to pay analysis. The amount people would be willing to pay for a service can be used to estimate the value of that service to a community. An analysis in the Exeter-Squamscott River watershed aggregated information from many sources (mostly outside New Hampshire) to estimate that nearby residents would be willing to pay $39 to $54 per household per year for cleaner water in the river and estuary (Bauer and Johnston 2017). Generally, households which are closer to the water are likely to pay more. Another study found that 68% of respondents in the coastal watershed would be willing to pay more for water services to improve the cleanliness of local waters (Rogers, Berg, and Farrell 2014).

Aesthetic and recreational value are other forms of ecosystem service which can be quantified by understanding how much people are willing to pay for them. One way this is demonstrated is through property values; homes located on or near water are often worth more because buyers value the view or the opportunities to swim, fish and use the water. This can be quantified by reviewing property values near water bodies. New Hampshire municipalities derive a substantial portion of their revenues from property taxes, so higher value homes can benefit the community as a whole. We conducted a review of property values in Meredith, New Hampshire, and found that, on average, waterfront properties are worth twice as much as other properties in the same town. A detailed discussion of this analysis is presented in Appendix B.

Case study: The Value of Waterfront property

Meredith is a town of over 6,000 residents located in the heart of the Lakes Region. It is a popular tourist destination with many rental properties and home to a number of waterbodies, including parts of five lakes and three ponds. Waterfront properties make up twenty-five percent of the total properties in Meredith but the value of these properties is about half of the town of Meredith's total residential valuation. More details on this analysis are presented in Appendix B.

Industry and Energy

Value – *Water is crucial to many industries; basic chemical manufacturing has the highest use per dollar of sales (2,116,500 gallons per job and $4,700 gallons per $1,000 sales; The Value of Water, 2017), while beverage industries rely on high quality water as a product ingredient. 40% of all freshwater withdrawals in the US were related to energy production - primarily cooling water in generating plants (US Department of Energy 2006).*

Cost – *Disruptions in service are costly; every day of lost service can cost businesses $230-$5,800 per employee per day.*

Gaps and Opportunities – *A review of water use and cost in breweries would provide information on the importance of water to a well-liked industry with easily identifiable connections to water.*

Industries use water to support production and as a product ingredient (for instance in beverages). Table 1. Lists industries that are highly dependent on water. Service disruptions to these industries cost $230-$5,800 in sales per employee day.

Industry	Gallons /$1000 sales	Gallons /Job
Junior colleges, colleges, universities, and professional schools	4,700	563,600
Other basic organic chemical manufacturing	1,100	2,116,500
Dry-cleaning and laundry services	700	48,300
Car washes	600	33,700
Wineries	400	141,600
Hotels and motels, including casino hotels	400	48,300
Paper mills	300	284,200
Breweries	300	328,000
All other food manufacturing	300	111,300
Plastics material and resin manufacturing	300	505,300
Full-service restaurants	300	14,100
Other aircraft parts and auxiliary equipment manufacturing	300	90,200
Metal coating and nonprecious engraving	300	71,100
Other concrete product manufacturing	300	59,900
Pharmaceutical preparation manufacturing	300	473,200

Source: IMPLAN 2015, USGS 2014.

Table 1. Industries Most Dependent on Water Utilities. Source: The Economic Benefits of Investing in Water Infrastructure, (The Value of Water Campaign 2017).

Energy and water are commonly interconnected; water infrastructure requires energy for pumping, treatment, maintenance and even construction of facilities. Water is used by the energy sector in a variety of ways: kinetic energy in streams is captured to generate electricity, water is used to cool energy generating facilities. In other regions of the country water is a key component of oil extraction. There are very few New Hampshire specific studies on water and energy, but several national studies reviewed the impact of electrical energy generation on water supplies which found that approximately 40% of all freshwater withdrawals in the US were related to energy production (primarily cooling water) (U.S. Department of Energy 2006; Dodder 2014). In 2015, 767 million gallons of surface water per day were withdrawn to support thermoelectric power generation in New Hampshire (USGS, https://waterdata.usgs.gov). Both the withdrawal, and subsequent re-introduction of heated water will impact the receiving water quality. There are approximately 384 thermoelectric plants in New England (Miara et al. 2013), which rely on adequate water supplies to provide energy to residents.

Water is also used to directly generate electricity through hydropower plants. In these facilities the riverine infrastructure (dams, or in few locations turbines) significantly alters the stream in ways that detract from other ecosystem functions such as fish passage, but may enhance recreation and boating opportunities. The Granite State Hydropower Association members own or operate over 60 hydroelectric facilities in New Hampshire, which collectively generate around 50 megawatts ("Granite State Hydropower Association" n.d.). Water and energy are also linked in discussions of green infrastructure as systems that rely on natural processes generally require less energy to operate.

Employment

***Value** – Water utilities generate 16 jobs for every $1 million spent in the United States (Quinn et al 2014). The direct and indirect benefit of investing $82 billion per year (as recommended by the American Society of Civil Engineers), would generate and sustain approximately 1.3 million jobs in the country.*

***Gaps and Opportunities** – A survey of utilities and economic analysis (e.g. IMPLAN) would provide more detail on New Hampshire-specific employment opportunities.*

There are several national studies on labor and employment in the water sector, with most of them focusing on drinking and wastewater infrastructure. An analysis of 30 water utilities, conducted in 2014, found that every $1 million in direct spending by the utilities supported five jobs directly and an additional 11 jobs through indirect and induced spending (Quinn et al. 2014). If extensive investments were made to our water infrastructure (as recommended in numerous reports e.g. (US EPA 2018; Wright-Pierce 2011; New Hampshire Section of the American Society of Civil Engineers 2017), the direct and indirect benefit to jobs is substantial; a national investment of $82 billion per year would result in over $220 billion in total annual economic activity to the country. These investments would generate and sustain approximately 1.3 million jobs (The Value of Water Campaign 2017).

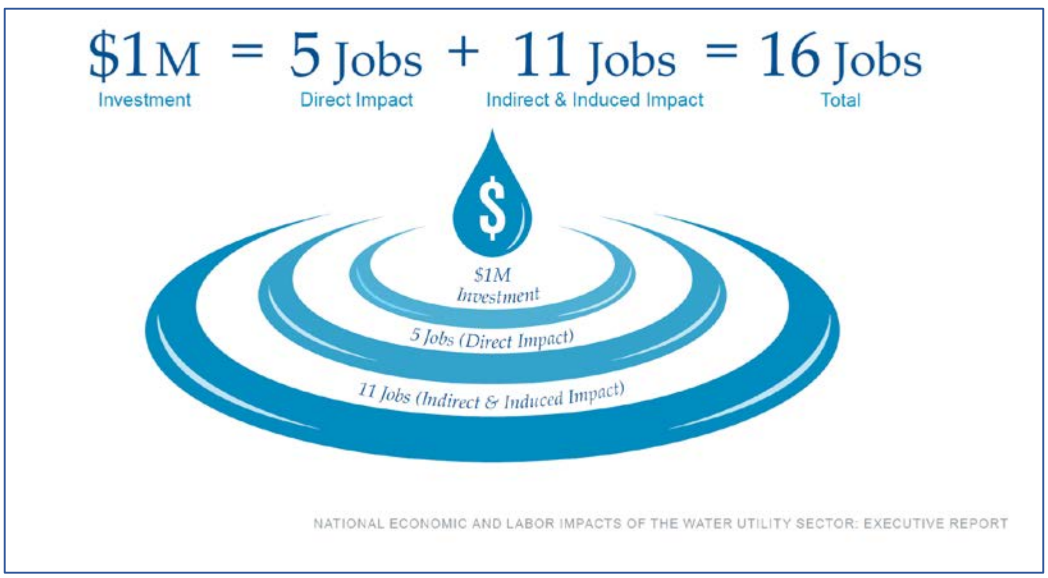


Figure 4. Spending by water utilities generates jobs. From (Quinn et al. 2014)

These analyses are not specific to New Hampshire, but could potentially be updated for our region using the assumptions in the original studies, were local data are available. Employment estimates are included in the IMPLAN model of recreation benefits discussed below, where we find that water-based recreation in state parks alone supports approximately 380 jobs.

Forests, Agriculture, and Commercial Fishing

Value *– Forest, agriculture and commercial fishing generate $2.5 billion in output and support 18,500 jobs. In 2010 agricultural production added $138 million to the state's economy, and supported 5,050 jobs (Trust for Public Land, 2014).*

Cost – *Conservation of forest land requires acquisition or easements. Agriculture and timber harvesting may have detrimental effects on water quality.*

Gaps and Opportunities –*Better understanding the dynamics of managing forests for drinking water provisioning.*

There are 4.67 million acres of productive timberland in New Hampshire. This land supports an active $1.7 billion annual timber harvest and manufacturing economy and also protects water supplies by buffering and filtering rainfall before it enters surface water or aquifers (The Trust for Public Land 2014).

Agriculture is one of the largest uses of water nationwide, representing nearly one third of all withdrawals (United States Environmental Protection Agency 2013), but in New Hampshire, common agricultural practices rarely require extensive irrigation. Some emerging methods of food production, such as hydroponics, may require higher water use in the future, but currently are not a significant draw on our local resources.

Agriculture is also one of the major factors contributing to degraded water quality nationally, but the limited amount of food production in New Hampshire protects us from severe impacts. For example, a study in the Squamscott watershed found that only 2% of the nitrogen in runoff within the watershed was from agriculture, far lower than inputs from urban stormwater or wastewater systems (Roseen et al. 2015).

Transportation and Culverts

Value *– Improved aquatic passage supports New Hampshire's $200 million recreational fishing industry, and reduces the risk of flooding.*

Cost *– Flooding has caused over $100 million in property damage in the state since 2001, much of it due to major road washouts (Hazards and Vulnerability Research Institute). The estimated life-cycle costs of a stream simulation culvert is less than the cost of installing a corrugated pipe (RBouvier 2017).*

Gaps and Opportunities *– A review of specific culvert failures compared to stream compatibility would present a relatively low cost analysis of the relationship between assessed viability and real failure. There are several locations in New Hampshire where damage from recent severe storms could be assessed.*

Transportation and water interact in several ways. Transportation infrastructure – roads, parking lots and other surfaces – prevent infiltration of rainwater and increase runoff (stormwater) that can cause flooding and degrade water quality. In areas where roads cross streams or other water bodies the physical infrastructure alters the hydrology and ecology of the water system. Stormwater is reviewed in more detail under infrastructure, above, and stream crossings are discussed below and in Appendix A.

Water impacts transportation when roads and bridges are damaged or destroyed during floods. Flooding has caused over $100 million in property damage in the state since 2001, much of it due to major road washouts (Hazards and Vulnerability Research Institute). Damage to roads is expected to increase with more heavy rainfall in the future (New Hampshire Department of Transportation 2014).

Water is indirectly consumed by many forms of transportation. A gallon of gasoline requires three to six gallons of water to produce, while ethanol production uses about 10 times as much water (Grace Communications Foundation 2019). Fuel used in New Hampshire is primarily produced elsewhere, so this water use does not directly impact our resources, but it is important to recognize that water, somewhere, was consumed to provide our transportation fuel.

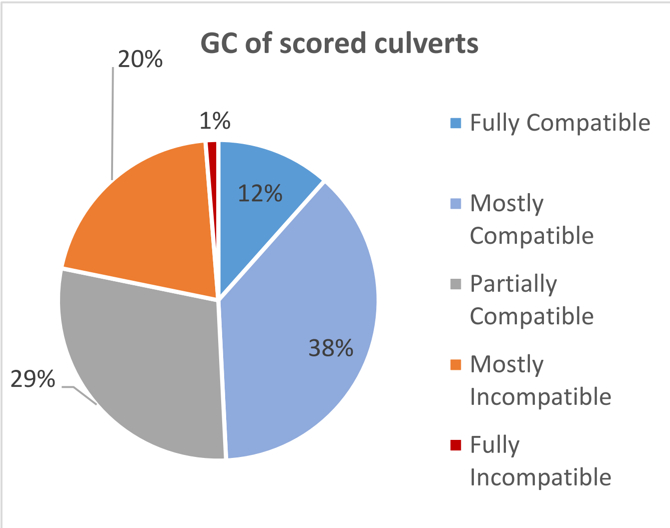
Transportation – Culverts

Stream crossings, or areas where roads cross water, are one of the most common intersections between built infrastructure and water resources. Many stream crossings, in New Hampshire and elsewhere, are simple corrugated metal pipes intended to pass a specific size storm. As more intense rain storms become increasingly frequent, these culverts are no longer adequate to protect either infrastructure or water quality. As part of this project we did a more detailed review of existing information on culverts to determine how much relevant economic information exists, and to identify areas where a small amount of additional information would help support the economic case for upgrading existing culverts around the state. A summary of this study is presented below and a more detailed discussion, including tables of relevant data, are included in Appendix A.

Case Study: Culverts in New Hampshire

Culverts are abundant throughout New Hampshire. They provide essential infrastructure in the form of relatively low cost, reliable means of managing road/stream intersections. However, poorly maintained or undersized culverts may create upstream ponding, flooding or road damage, and block both up- and down-stream movement of aquatic and terrestrial organisms, including fish, turtles, and salamanders, among others. In extreme cases, catastrophic failure of a culvert has resulted in loss of life and millions of dollars in property damage.

Approximately 50% of New Hampshire’s culverts are fully or mostly compatible with river form and processes, but only 16% allow full aquatic organism passage, and 24% of culverts completely block passage by aquatic organisms.



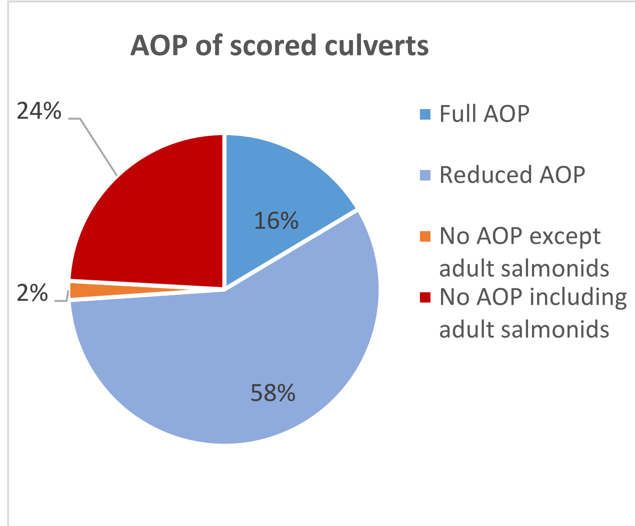


Figure 5: Geomorphic compatibility (GC) and aquatic organism (AOP) passage scores for New Hampshire culverts.

Culvert Installation Costs

Larger, more compatible culverts are more expensive to install, and cost may be a barrier to upgrading or replacing structures. However, when long-term lifespan costs are considered, the cost of upgraded culverts may, in fact, be lower than traditionally sized corrugated pipe installations. A study conducted in Maine, *Are Stream Simulation Culverts Cost-Effective? A Lifetime Cost Comparison,* (RBouvier 2017) estimated the lifetime costs associated with traditional corrugated metal culverts and culverts designed to simulate natural stream flow ("stream simulation" culverts). The study found that in almost all hypothetical scenarios analyzed, stream simulation arch culverts are more cost-effective than traditional culverts in the long run.

Irene: An example from Vermont

In 2011 tropical storm Irene brought over 30 cm of rain to much of New England, exceeding the 100-yr storm flow in rivers across parts of Vermont, Massachusetts, and New Hampshire. Flood damage was particularly extreme in the upper White River Region in VT, where 70 culverts were destroyed or damaged, including one failure that resulted in $1 million in direct damages (Gillespie et al. 2014). A culvert assessment conducted prior to the storm indicated that over 90% of culverts in the region constricted that natural channel. Of the four stream crossings in the region that were considered adequately sized, only one failed, and that was primarily due to large debris. Although this is not a large enough study to present statistical correlation, it supports the effectiveness and sustainability of adequately designed infrastructure.

Stream Ecosystem Cost-Benefits

Over 75% of licensed anglers in New Hampshire support managing selected streams for wild populations (Duda et al. 2016). New Hampshire Fish and Game Department stocks many of these streams with adult fish to support recreational fishing. The economic benefits of improved fish passage can be assessed as both the avoided costs of stocking fish, and the economic benefit of recreational fishing in New Hampshire.

Figure 6. This perched culvert on Slide Brook, NH, blocked passage for all fish species. When the culvert was replaced with an open span in 2010, the number of brook trout upstream of the crossing increased significantly within two months (Magee, 2013, photo: NH Fish and Game).

Data Gap Opportunity

Anecdotal accounts suggest that properly sized culverts, such as those that meet the New Hampshire Stream Crossing Guidelines, are less likely to be damaged as a result of extreme precipitation events. We contacted resource managers and agencies throughout New Hampshire and neighboring states and found no quantitative analyses on the resilience of upgraded culverts, although many of our contacts expressed a desire to have that data. A quantitative assessment of culvert failures compared to assessed GC scores could be conducted in a region, such as the Ammonoosuc watershed, where a regional culvert assessment was completed in 2016. That study found that over half of the culverts in the region did not meet geomorphic compatibility criteria (Lyons and Lawson, 2016). In October 2017, large storms caused severe flooding, road damage and culvert failure in the region. A review of specific culvert failures compared to GC scores would present a relatively low cost analysis of the relationship between assessed viability and real failure.

Conclusions and Recommendations

We identified, summarized and synthesized over 100 relevant sources of information and found information related to all aspects of water in New Hampshire. Generally, published studies either take a broad view of a larger data set, such as stormwater needs throughout the country, or focus in detail on a smaller area. There is a large amount of unpublished information, particularly related to costs, in less accessible records. Municipalities, utilities and state agencies have information on their expenditures and needs that is open to the public, but not aggregated. This information could be leveraged to develop a more focused study on, for instance, water utility costs for industry, but significant time and effort is required to identify, gather, and interpret the data.

An economic analysis of selected aspects water related recreation was conducted. This analysis found that:

- The economic impact of recreational fishing in New Hampshire is approximately $215 million dollars per year.
- The economic impact of visitors who came to swim in New Hampshire's freshwater state parks during the summer of 2017 is approximately $40 million dollars.
- The economic impact of non-New Hampshire registered boaters visiting New Hampshire during the summer of 2017 is estimated at over $100 million dollars.
- New Hampshire's waterfront properties are very valuable to both town and state budgets. For example, in Meredith, New Hampshire, waterfront properties make up 25% of the total properties in the town but they make up over 50% of the town's total assessed property value.

There are several areas where future work would be particularly beneficial:

- We recommend developing and implementing a methodology for more specifically collecting information on visitors to the state and how they benefit from our water resources. A multi-institution, regularly coordinated survey effort would go a long way to helping to meet this need.
- The method for identify additional value attributable to waterfront property could be replicated with assessor's data from in any town with waterfront property.
- There is widespread interest, both in New Hampshire and the New England region, for better examples of avoided cost accrued by maintaining or replacing infrastructure prior to failure. A detailed case study within a region, for instance a survey of failed culverts in the Ammonoosuc watershed, would provide valuable information.
- Additional studies and reports on economics and water resources are generated frequently. Identify and store these in a shared file location as they become available.

We have identified numerous gaps and opportunities that we believe represent achievable and valuable tasks. None are necessarily more important or urgent than others, and should be addressed if/as resources and interests become available. Many of the data gaps identified here are common to other New England States, and in some cases, a regional approach and pooled effort will be beneficial.

Appendices

Appendix A. Cost and Benefits of Stream-Simulation Culverts

Appendix B. Select Estimates of the Values of Freshwater Recreation in New Hampshire

Appendix C. Bibliography Listing all Data Sources

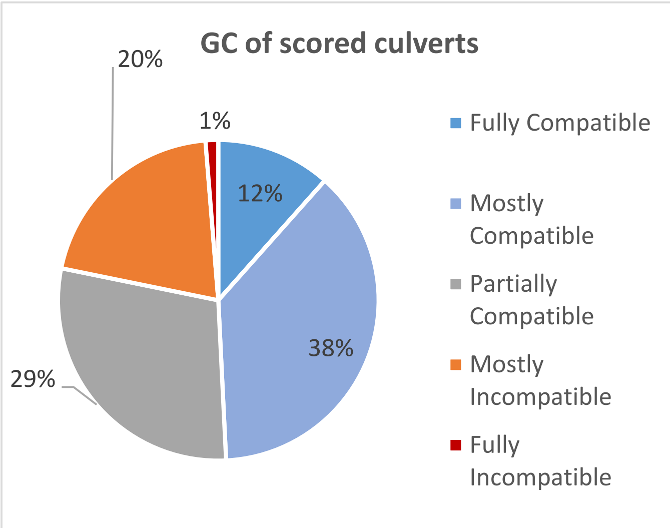
Appendix A - Cost and Benefits of Stream-Simulation Culverts

Culverts are abundant throughout New Hampshire. They provide essential infrastructure in the form of relatively low cost, reliable means of managing road/stream intersections. The costs associated with culverts are usually cited as simply the cost to construct and install, while the benefits, are acknowledged, but rarely quantified in terms of economic impact. In this section we will briefly review the status of culverts in New Hampshire and summarize relevant studies which consider a broader definition of costs to include the full lifespan of the structure, as well as economic benefits accrued from improved ecosystem passage, reduced flood risk, and other factors.

Culverts in New Hampshire

An exact count of existing culverts in New Hampshire is not available; but estimates indicate approximately 17,000-20,000 (University of New Hampshire, 2009; NH DES, 2017). The type, structure, and viability of these culverts ranges from undersized or partially blocked pipes, to geomorphic compatible designs that allow free passage of stream flow under all but the most extreme conditions. Although the NH Department of Transportation (NHDOT) encourages annual maintenance inspections for culverts as a best management Practice (Urban, 2016), no program exists to ensure regular culvert maintenance and inspection. Poorly maintained or undersized culverts may create upstream ponding, flooding or road damage, and block movement of trout and other fish. In extreme cases, catastrophic failure of a culvert has resulted in loss of life and millions of dollars in property damage.

The New Hampshire stream crossing initiative is a multiagency collaboration working to assess and rank existing culverts. Approximately 70% of culverts in New Hampshire have been assessed using a standardized framework (NHDES 2017) that evaluates geomorphic compatibility (GC) and aquatic organism passage (AOP). GC is a measure of a culvert's "fit" with its river or stream. When scoring a culvert's GC, stream channel size and shape, bank erosion, bed scour, and sediment deposition are considered. AOP is evaluated based on inlet obstructions, outlet grade, and substrate and water depth throughout the structure. Currently, approximately 50% of culverts are fully or mostly compatible with river form and processes, but only 16% allow full aquatic organism passage, and 24% of culverts allow for absolutely no passage by aquatic organisms. This data is publicly available on the New Hampshire SADES (Statewide Asset Data Exchange System). More information on the assessment categories is available in Appendix A.1.



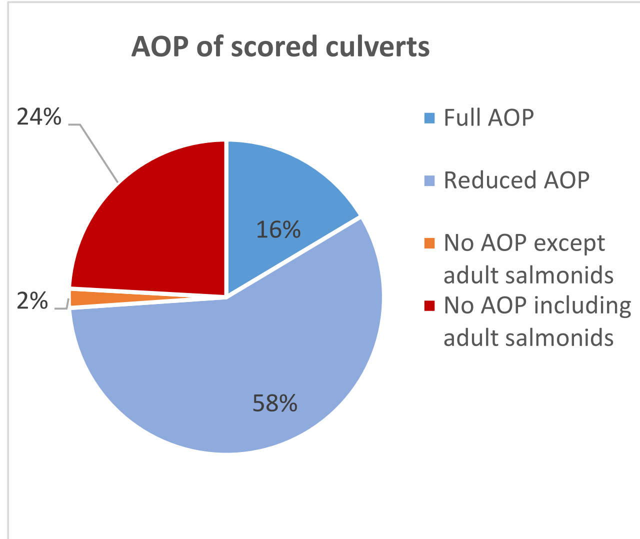


Figure A1. Geomorphic compatibility (GC) and aquatic organism (AOP) passage scores for New Hampshire culverts.

Culvert Installation Costs

Larger, more compatible culverts are more expensive to install, and cost may be a barrier to upgrading or replacing structures. However, when long term lifespan costs are considered, the cost of upgraded culverts may, in fact, be lower than traditionally sized corrugated pipe installations. Upgraded culverts are sometimes referred to as stream-simulation culverts, and are generally designed to span 1.2 times the bankfull width of the stream. New culverts installed in New Hampshire must meet this standard (NH Code of Administrative Rules – Wt-900 Stream Crossings), however existing culverts can be replaced without upgrading the culvert size or type.

A study conducted in Maine, *Are Stream Simulation Culverts Cost-Effective? A Lifetime Cost Comparison,* (RBouvier 2017) estimated the lifetime costs associated with traditional corrugated metal culverts by considering the engineering, construction, and installation costs, as well as the expected costs of flooding (calculated as the probability of the culvert's design capacity being exceeded over its lifetime, multiplied by the costs of cleanup and maintenance associated with such an event). Costs that are expected to take place in the future are discounted into 2016 dollars. The study examines lifetime costs over a 50-year and 100-year period, where traditional culverts are assumed to have an average life of 25 years and stream simulation culverts are assumed to have an average life of 70 years. Traditional culverts are assumed to fail a 25-year flood. A 25-year flood is estimated to occur twice in a 50-year time period, with an estimated maintenance and clean-up cost of $5,000 per flooding event. It is important to note that the study does not include costs incurred as a result of travel delays to road users, flood damages caused by catastrophic failure, the ecological benefits of improved aquatic organism passage, or risks posed to sensitive infrastructure. Table 1 gives the cost comparison for a 48" culvert. Costs were also assessed for a 72" culvert, and twin culverts, with similar results.

The study found that in almost all hypothetical scenarios analyzed, stream simulation arch culverts are more cost-effective than traditional culverts in the long run. The initial costs of traditional corrugated metal pipe culverts are lower than box or arch culverts, but over time the difference diminishes as a result of low maintenance costs until the arch culverts becomes a more cost-effective option than the traditional culvert.   Box culverts are more expensive to install than arch culverts, and the reduced maintenance may not outweigh the difference in installation costs.

Table A1: Comparison of Lifetime Costs of Traditional 48" CMP and Alternative Arch and Box Culverts

	Initial Costs	50-Year Lifetime Costs	100-Year Lifetime Costs
48" CMP	$22,660	$67,401	$75,671
12'W X 6'H arch	$58,028	$60,849	$69,938
12'WX8'H box	$91,338	$94,159	$109,413

Assumptions: 50-foot CMP with an 8-foot distance between the bottom of the stream and the top of the road pavement; two-lane rural or suburban road with low daily traffic and several possible detour routes; traditional culvert designed to withstand a 25-year storm. All costs given in 2016 dollars, with a 2.5% discount rate. Adapted from RBouvier, 2017.

Actual culvert installation costs will be highly dependent on site characteristics, including the depth of the excavation required to place the culvert, the size and traffic volume on the road, and stream width. But the study clearly illustrates the long term value associated with reduced maintenance and replacement associated with geomorphically compatible structures. Note that this study does not consider lost opportunity costs, or costs associated with financing the initial construction. It is important to acknowledge constraints in municipal budgets may present a barrier to the higher cost of larger installations.

Cost Benefits Associated With Upgrading Culverts

There are multiple benefits associated with upgrading culverts, including reduced risk of flooding, and improved stream ecosystems. In many cases economic benefits can be directly evaluated either as avoided costs or as increased income. These cost benefits are often considered in terms of infrastructure costs or ecosystem costs. Infrastructure cost benefits are primarily avoided costs associated with reduced flooding, maintenance or road repair. A culvert which meets all of the geomorphic compatibility criteria may protect infrastructure investments.   Ecosystem cost benefits are often harder to quantify, but improved aquatic organism passage supports recreational fishing, and generates economic benefits through travel, goods and fishing licenses.

Infrastructure Cost Benefits

Culverts in New Hampshire have traditionally been designed to convey water from a 25-year storm.   In a larger storm event, the culvert forms a dam, restricting flow and forcing water to pond upstream. If the storm is large enough, the upstream ponding may flood the road and adjacent areas, potentially damaging structures and causing traffic delays. In extreme cases the culvert will fail, releasing the ponded water in a dangerous flood.

There are few studies that specifically identify the flood related risk and costs associated with culverts, but there are many examples of costs incurred from flooding. Federal disasters expenditures in New Hampshire indicate that flood events commonly incur millions of dollars of damage. Between 2005-2008 New Hampshire experienced at least three disastrous flooding events each costing the state around $25 million or more in disaster expenditures. During one of those floods in 2005, a 12-foot-diameter culvert that extended underneath a 30-foot-high embankment in Alstead, NH failed catastrophically, resulting in four deaths and loss or damage to over 100 buildings.

Irene: a case study in Vermont

In 2011 tropical storm Irene brought over 30cm of rain to much of New England, exceeding the 100-yr storm flow in rivers across parts of Vermont, Massachusetts, and New Hampshire. Flood damage was particularly extreme in the upper White River Region in VT, where 70 culverts were destroyed or damaged, including one failure that resulted in $1 million in direct damages (Gillespie et al. 2014). A culvert assessment conducted prior to the storm indicated that over 90% of culverts in the region constricted that natural channel. Of the four stream crossings in the region that were considered adequately sized, only one failed, and that was primarily due to large debris. Although this is not a large enough study to present statistical correlation, it supports the effectiveness and sustainability of adequately designed infrastructure.

The New Hampshire stream crossing initiative presents an opportunity to perform a quantitative assessment of culvert resiliency in New Hampshire. Anecdotal accounts suggest that culverts that rate highly for geomorphic compatibility are less likely to be damaged in high rain events. A quantitative assessment of culverts failures compared to assessed GC scores could be conducted in a region, such as the Ammonoosuc watershed, where a regional culvert assessment was completed in 2016. The study found that over half of the culverts in the region did not meet geomorphic compatibility criteria (Lyons and Lawson, 2016). In October 2017, large storms caused severe flooding, road damage and culvert failure in the region. A review of specific culvert failures compared to GC scores would present a relatively low cost analysis of the relationship between assessed viability and real failure.

Stream Ecosystem Cost-Benefits

Healthy stream and riparian habitats directly and indirectly support many benefits including healthy fish populations, reduced flooding and associated road user delays, reduced erosion, improved water quality, and wetlands protection. In New Hampshire, recreational fishing generates $6 million per year in license fees. Fishing related spending in New Hampshire generates at least $208.5 million in economic benefits, as discussed in more detail in Appendix B. Inadequate stream crossings may prevent fish from moving to different reaches, and reduces wild fish populations. Over 75% of licensed anglers in New Hampshire support managing selected streams for wild populations, although generally anglers prefer the larger fish that are supplied to streams through stocking programs (Duda et al. 2016). New Hampshire Fish and Game stocks many of these streams with adult fish to support recreational fishing. The economic benefits of improved fish passage can be assessed as both the avoided costs of stocking fish, and the economic benefit of recreational fishing in New Hampshire.

Figure A2. This perched culvert on Slide Brook, NH, blocked passage for all fish species. When the culvert was replaced with an open span in 2010, the number of brook trout upstream of the crossing increased significantly within 2 months (Magee, 2013, photo: NH Fish and Game).

A detailed cost-benefit analysis of improved stream ecosystems has not been conducted in New Hampshire, but two detailed studies from the mid-west show significant financial benefits. In the Driftless River basin, which encompasses areas of Iowa, Minnesota and Wisconsin, recreational trout fishing contributes over $400 million to the regional economy (Anderson, 2016). Christiansen et al (2014) estimated the cost-benefit of installing stream simulation culverts in this region. They found that the combined benefits accrued though reduced flood damage, maintenance, traffic delays, and replacement, combined with benefits from improved fish passage and wetlands protection yields an average lifetime benefit of up to $7,800 per culvert in small streams. They also found that the benefit is higher at locations where a scour pool is present (indicating hydrologic incompatibility), where fish passage is fully blocked, and in streams with sensitive wetlands. The cost benefit decreases with stream size, due to the upfront costs in construction, and there is no significant cost benefit in streams larger than about 10 feet in width. Although the scale of this region is very different from New Hampshire, the methods and overall results are applicable here, and could be used to develop a state or regional cost-benefit.

Appendix A.2 - Additional Information on Stream Assessment Categories

Categories Used to Summarize Geomorphic Compatibility (NH Fish & Game, 2017)

Categories Used to Summarize Geomorphic Compatibility	
Fully Compatible	These structures are fully compatible with natural river channel form and process, and are at a low risk of failure. Culvert replacement is not expected over the lifetime of the structure. When replaced, a structure similar to the currently existing one is recommended. Culverts that rank in this category provide examples of the proper sizing and construction at sites where replacements occur to ensure compatibility with flow and sediment transport processes.
Mostly Compatible	These structures are mostly compatible with natural river channel form and process, and are at a low risk of failure. Culvert replacement is not expected over the lifetime of the structure. When replaced, minor design adjustments are recommended to make the culvert fully compatible with river form and process.
Partially Compatible	These structures are either compatible with current form or process, but not both, with any compatibility only likely in the short term. Culvert replacement may be needed, given the moderate risk of failure during its design lifetime. When replaced a redesign of the culvert installation is suggested to improve the compatibility of the culvert with river form and process.
Mostly Incompatible	These structures are typically undersized for the river or stream channel that contains them, and/or are poorly aligned with the upstream channel geometry, creating a condition where the structures are mostly incompatible with river form and process. As a result, these structures are at a moderate to high risk of structural failure. When replaced, a redesign of the culvert should be initiated to improve the geomorphic compatibility.
Fully Incompatible	These structures are typically undersized for the river or stream channel that contains them, and/or are poorly aligned with the upstream channel geometry, while also showing reduced sediment continuity (passage of bed material through the culvert) and an increased risk for erosion. Culverts ranking in this category are not compatible with river form and process and are at a high risk of failure. Culverts ranking in this category should be prioritized for replacements to improve river geomorphology process compatibility.

Categories Used to Summarize Aquatic Organism Passage (NH Fish & Game, 2017)

Categories Used to Summarize Aquatic Organism Passage (AOP)	
Full AOP	Stream crossings have one culvert with an outlet that is at grade with the channel bed downstream with no drop (the culvert is not perched), have sediment throughout the structure, and have an upstream structure opening that is not partially obstructed. The crossing is functionally no different than the river/stream channel upstream or downstream of it, which leads to the ability of the structure to fully pass aquatic organisms through.

Reduced AOP	Stream crossings in this category can have any of the following conditions, either individually or in combination with each other: (1) have a culvert outlet where flow cascades into the river/stream channel directly downstream of it; (2) have more than one culvert at a crossing; (3) have an upstream structure opening that has some type of obstruction; or (4) a culvert where sediment is not present throughout the structure. These are factors that work to potentially limit AOP for some species or life stages.
No AOP except for adult trout	Stream crossings in this category have a free fall outlet and a measureable drop directly downstream of the culvert that is less than or equal to 1 foot, given the known strong swimming and leaping abilities of salmonid species. Additionally, cases where a pool exists directly downstream where data is not available for water depth at pool entry are placed into this category since salmonid species could jump into the culvert.
No AOP including adult trout	Stream crossings in this category have a free fall outlet and a measureable drop directly downstream of the culvert that is greater than 1 foot. Crossings are also placed into this category if the downstream pool has a depth at the point of entry that is less than the outlet drop height, or if the water depth in the culvert at the outlet is less than 0.3 feet.

Appendix A.2 - Additional Cost Comparison for Traditional and Upgraded Stream Crossings

Engineering Study and Recommendations for Two Bridges in Exeter, NH

CMA Engineers (2014). *Engineering Study And Recommendations: Replacement of NHDOT Bridge No. 087/062 and 095/063 Linden and Court Street over Little River*. Town of *Exeter*, NH.

Design	**53’ Span Prestressed Box Beams on Piles (box culvert)**
Installation $	576,707.50
Engineering $	76,210.00
Incidentals $	58,380.00
Total $	**711,297.50**

Design	**45’ Span CONSPAN “O-Series” on Piles (arched culvert)**
Installation $	711,150.00
Engineering $	93,220.00
Incidentals $	65,650.00
Total $	**870,020.00**

Design	**55’ Span Prestressed Box Beams on Piles (box culvert)**
Installation $	908,885.00
Engineering $	118,010.00
Incidentals $	74,540.00
Total $	**1,101,435.00**

Design	**54’ Span CONSPAN “O-Series” on Piles (arched culvert)**
Installation $	960,445.00
Engineering $	124,490.00
Incidentals $	77,000.00
Total $	**1,161,935.00**

These cost estimates include all associated materials, mobilization, roadway reconstruction, water, drainage, and sewer underground utility systems extending to the proposed limits of work, and construction inspection and administration. These costs do not include private utility relocation or any possible right-of-way negotiation and acquisition.

Comparative Studies:

1. Cost Analysis of Alternative Culvert Installation Practices in Minnesota

Hanson, B., Niebr, J., & Lenhart, C. (2009). *Cost Analysis of Alternative Culvert Installation Practices in Minnesota* (Minnesota Department of Transportation). St.Paul, MN: MDOT.

Design	Width of stream. Baffles, roughened channels and backwater weirs	
Cost	Traditional	Alternative
Installation $	$20,178 – 167,095	$22,320 – 188,604
Engineering $	Included in total cost	Included in total cost
Maintenance $	Not provided	Not provided

Study primarily reviews the impact on fish populations but also looks at the installation cost comparison between traditional culverts and alternative culvert designs. Cost differences ranged from -5 % to 33% between traditional and alternative culvert installation. Costs include materials, labor, design/engineer, and installation but only total cost is given. The study does not look at maintenance costs.

2. Community Benefits of Stream Barrier Removal (Massachusetts)

Community Benefit of Stream Barrier Removal Projects in Massachusetts: Cost and Benefits at Six Sites (Massachusetts Department of Fish and Game 2015). MA: MDFG

Design	Width of stream, natural stream bottom, open bottom	
Cost	**Traditional**	**Alternative**
Installation $	$120,000 – 180,000	$230,000 – 440,000
Engineering $		
Maintenance $	$9,000-24,000 (annually)	$708-734 (annually)

This study reviews dam and culvert replacement projects in Massachusetts. The costs of conventional replacement and alterative upgrades that meet current Massachusetts stream crossing requirements are calculated for three culvert replacement projects. Cost savings of 75-90% were noted primarily due to saving in maintenance costs. Initial installation costs for culverts that meet state criteria were greater than those of conventional culverts. Costs included engineering, construction and materials. Actual costs to the communities after grants and subsidies were awarded was also covered. The study also reviews community benefits such as safety, increased property values and impacts on recreational/commercial fishing opportunities.

3. The Economics of Culvert Replacement: Fish Passage in Eastern Maine

Long, J. (2010). *The Economics of Culvert Replacement: Fish Passage in Eastern Maine.* Natural Resources Council of Maine

Design	Width of stream arch culvert	
Cost	**Traditional**	**Alternative**
Installation $	$2,460 – 4,752	$28,189 – 50,910
Engineering $	Not given	Not given
Maintenance $	$1,135 – 1,623 (annually)	$184 – 333 (annually)

The paper looks at installation and maintenance costs of traditional culverts verses width of stream arch culverts. Installation costs are estimated for a 25-year period following the culvert installation. While initial installation costs for the arch culverts are over ten times higher, the great reduction in maintenance costs proves to make the arch culvert more cost effective over the long term.

4. Cost Benefit Analysis of Stream Simulation Culverts (Wisconsin)

Christiansen, C., Filer, A., Landi, M., O'Shaughnessy, E., Palmer, M., and Swartz, T. (2014). *Cost Benefit Analysis of Stream Simulation Culverts.* Wisconsin Department of Natural Resources

Design	Stream simulation design	
Cost	**Traditional**	**Alternative**
Installation $	$24,068 (avg. replacement cost)	$40,668 (avg. replacement cost)
Engineering $		
Maintenance $	$1,017 – 4,147 (annually)	$708-734 (annually)

This study looks specifically at the costs associated with stream culvert replacement in Wisconsin. The study compares conventional and alternative stream simulation designed culverts. Cost included in the study are replacement and maintenance costs. The study also reviews other benefits such as fish repopulation, reduced flooding issues, increased lifetime usability and wetland restoration.

5. An Economic Analysis of Improved Road Stream Crossings (New York)

Levine, J. (2013) *An Economic Analysis of Improved Road Stream Crossings*. The Nature Conservancy, Adirondack Chapter

Design	Stream simulation design	
Cost	**Traditional**	**Alternative**
Installation $	$23,632 – 91,000 (estimates)	$218,097
Engineering $		
Maintenance $	$2,726 (annually over 70 years)	$2,900 (annually over 70 years)

The study reviews the benefits of stream simulation culverts with a closer look at a Lewis Brook culvert replacement as a case study. The case study reviews costs including installation and maintenance. The study also looks at the ecological benefits such as fish passage, reduction in flooding and wetland restoration. Estimated costs for watershed wide culvert improvements are also included in this study.

6. Flood Effects on Road–Stream Crossing Infrastructure: Economic and Ecological Benefits of Stream Simulation Designs (Vermont)

Gillespie, N. (2014) *Flood Effects on Road–Stream Crossing Infrastructure: Economic and Ecological Benefits of Stream Simulation Designs.* Fisheries. Vol 39, No2. Pgs 62 – 76

Design	Stream simulation design	
Cost	**Traditional**	**Alternative**
Installation $	$92,950 – 112,175	$130,250 – 172,200 (estimate) $113,738 – 119,835 (actual)
Engineering $	Included in estimate	Included in estimate
Maintenance $	Not given	Not given

This article looks at the cost and benefits of culvert replacement projects in Green Mountain National Forest in Vermont after tropical storm Irene in 2011. The article reviews the costs of damage that occurred due to stream crossing failure and the cost of replacing the failed crossings with stream simulation design. The study does not include maintenance costs but it should be noted that of the culverts that were replaced, all were completed at costs lower than estimated.

Non-comparative studies and articles

1. Bronson Brook at Dingle Road Culvert Replacement and Large Wood Installation (Massachusetts)

Banks, C. (2009). *Bronson Brook at Dingle Road Culvert Replacement and Large Wood Installation. Retrieved* May 31, 2016, from http://www.stream.fs.fed.us/fishxing/case/dingle_creek/

Design	Stream simulation – open bottom arch
Cost	**Costs**
Installation $	$198,707
Engineering $	$84,762
Maintenance $	Not given

A close look at the replacement costs of a stream simulation culvert in Worthington, Massachusetts. The study included unexpected issues and challenges faced during the project. Costs provided in the study are actual costs. Maintenance costs are not included.

Replacement of washed out culvert with a stream simulation bottomless arch culvert. The project had a very short window of construction opportunity (4-8 weeks) but proceeded smoothly. Costs given are actual. Maintenance costs were not provided.

NOTE – The following projects are cost estimates only.

4. Town of Orland, Maine, Maine DEP Grant Application

Design	Stream simulation – open bottom arch
Cost	**Costs**
Installation $	$59,896
Engineering $	Not given
Maintenance $	Not given

Application includes estimated costs of construction and installation of a culvert replacement project at the Winkumpaugh crossing on Happytown Road in Orland. The town was awarded a grant of $47,946. It is not known if the project has been completed.

5. Town of Woodstock, Maine, Maine DEP Grant Application

Design	Stream simulation – concrete box culvert
Cost	**Costs**

Installation $	$80,000
Engineering $	Not given
Maintenance $	Not given

Application includes estimated costs of construction and installation of a culvert replacement project on Concord Pond Road in Woodstock, Maine. The town was awarded a grant of $80,000. It is not known if the project has been completed.

6. Town of Groton- Municipal Road Erosion and Stream Crossing Inventory and Capital Budget (2015-2019) (Vermont)

Morton, D., Ross, P., Ryan, J. and Smith, B. (2014) *Town of Groton- Municipal Road Erosion and Stream Crossing Inventory and Capital Budget (2015-2019).* Town of Groton, Vermont

Design	Stream simulation – open bottom arch, concrete box culvert
Cost	**Costs**
Installation $	$41,468 – 149,671
Engineering $	Not given
Maintenance $	Not given

Four project culvert projects for the town of Groton, Vt. that utilize stream simulation methods. Costs given are estimated. Projected maintenance costs are not included.

Table 4: Comparison of Lifetime Costs of Traditional 72" CMP, and Alternative Arch and Box Culverts

	Initial Costs	**50-Year Lifetime Costs**	**100-Year Lifetime Costs**
72" CMP	$43,358	$123,970	$138,270
16'W X 6'H arch	$77,855	$78,983	$93,434
16'WX6'H box	$104,222	$105,350	$124,680

Assumptions: 50-foot CMP with a 10-foot distance between the bottom of the stream and the top of the road pavement; two-lane rural or suburban road with low daily traffic and several possible detour routes; traditional culvert designed to withstand a 25-year storm. All costs given in 2016 dollars, discounted at 2.5%.

Table 5: Comparison of Lifetime Costs of Twin HDPE pipes, and Alternative Arch and Box Culverts

	Initial Costs	50-Year Lifetime Costs	100-Year Lifetime Costs
Twin HDPE	$41,226	$96,063	$103,050
16’W X 6’H arch	$77,855	$78,983	$93,434
16’WX6’H box	$104,222	$105,350	$124,680

Assumptions: 50-foot CMP with a 10-foot distance between the bottom of the stream and the top of the road pavement; two-lane rural or suburban road with low daily traffic and several possible detour routes; traditional culvert designed to withstand a 25-year storm. All costs given in 2016 dollars, discounted at 2.5%.

Appendix B – Select Estimates of the Values of Freshwater Recreation in New Hampshire

Introduction

New Hampshire's Freshwater Resources provide numerous values to both residents and visitors. New Hampshire has over 1,000 lakes and 10,000 miles of rivers and streams that are part of New Hampshire's impressive "nature economy." Tourism is a large part of New Hampshire's economy and our water resources are one of the main attractions that bring visitors to our state. In 2017, visitors to New Hampshire spent over $5 billion dollars at New Hampshire destinations. Recreation is also a part of the high quality of life residents of New Hampshire enjoy. Additionally, communities in New Hampshire with waterfront properties benefit from the value of water through property tax revenue. In the following analysis we show select economic benefit of three types of freshwater recreation: swimming, boating, and fishing. We also provide a case study of a community that benefits from water's impact on its property values.

Findings from our Analysis:

- The economic impact of recreational fishing in New Hampshire is approximately $215 million dollars per year.
- The economic impact of visitors who came to swim in New Hampshire's freshwater state parks during the summer of 2017 is approximately $40 million dollars
- The economic impact of non-New Hampshire registered boaters visiting New Hampshire during the Summer of 2017 is estimated at over $100 million dollars
- New Hampshire's waterfront properties are very valuable to both town and state budgets. For example, in Meredith, New Hampshire, waterfront properties make up 25% of the total properties in the town but they make up over 50% of the town's total assessed property value.

We used IMPLAN, an economic modeling software, to develop estimates for economic outputs associated with selected recreation activities. We combined this with several other recent data sources from surveys and other analysis. The results are discussed below, and the methods and assumptions used in the IMPLAN model are given in the Methods section later in the document.

The Economic Impact of Recreational Fishing in New Hampshire

According to the most recently available data, 228,000 anglers spent 4.37 million days fishing in New Hampshire and spent $208.5 million on trip and equipment related expenditures. The majority of these anglers (over 90%) were fishing in New Hampshire's freshwater. These figures include both residents and nonresidents (2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. US Fish and Wildlife Service and US Census Bureau).

In addition to the spending by visitors and residents, the State also collects revenue in the form of fishing licenses. The State of New Hampshire collected over $6.2 million dollars in fishing license revenue in 2017 (NH Fishing License Sales, 2017. Prepared by Jason M. Smith).

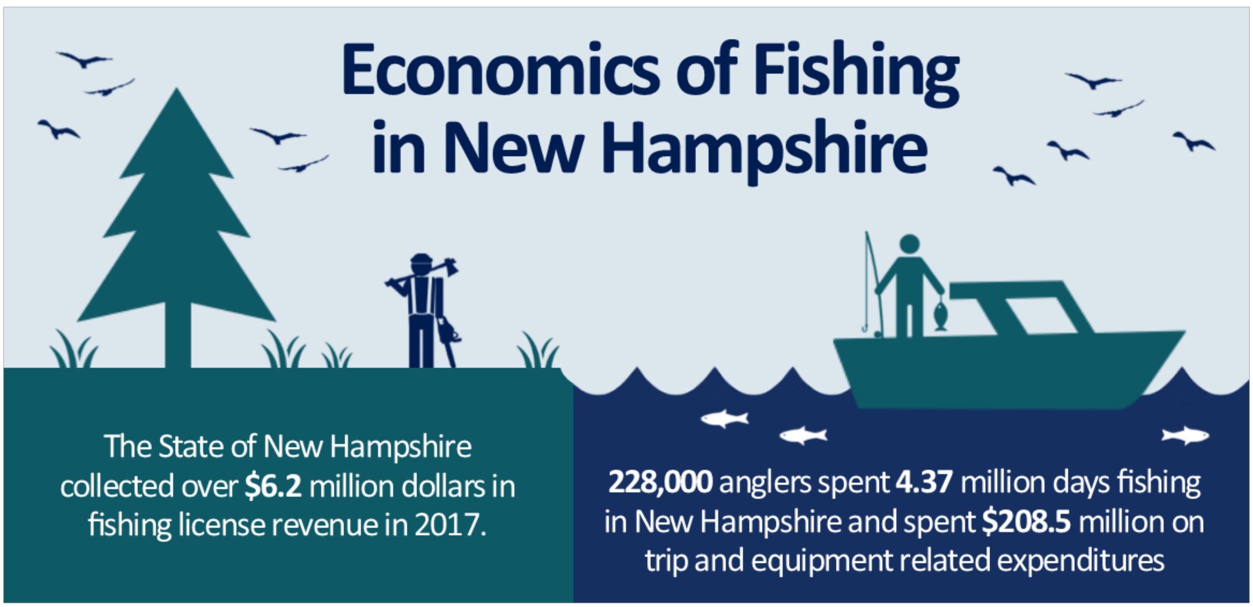


Figure B1. Economic benefits from fishing in New Hampshire

Swimming-Economic Impacts of Visitors to New Hampshire's Freshwater State Parks

New Hampshire's state parks provide access to freshwater resources, especially for swimming. We were able to obtain a data set of visitors to freshwater state parks in New Hampshire for June, July, and August 2017 from the New Hampshire Department of Natural and Cultural Resources Division of Parks and Recreation that showed a total of 323,285 cars coming to state parks with freshwater swimming. In order to estimate the total number of people visiting the parks from out of state, we used a recent "license plate survey" that showed an average of three people visit per car and that 45% of cars are from out of state. Thus, 323,285 x 3 x .45 = 436,434 out of state visitor days. The following output of $41 million dollars results from that estimate, with the details of the categories below.

Impact Type	Employment (jobs)	Labor Income ($ million)	Total Value Added ($ million)	Output ($ million)
Direct Effect	273	$7,825,000	$14,865,000	$24,299,000
Indirect Effect	49	$2,653,000	$4,888,000	$8,115,000
Induced Effect	62	$3,044,000	$5,254,000	$8,611,000
Total Effect	**384**	**$13,522,000**	**$25,006,000**	**$41,025,000**

Table B1. Economic impact of swimming visitor spending w/436,434 visitor days

Economic Impact of non-New Hampshire Registered Boaters in New Hampshire

19,945 non-New Hampshire boats were registered in the State in 2017 (DMV). This does not count smaller watercraft, under 12 feet (NH Department of Safety Division of Motor Vehicles). National Marine Manufacturers' data suggests that boat owners spend an average of 28 days per year on the water. So, 19, 945x28= 558,460 boating days. Finally, we use the research supported assumption that an average of two people are on a boat at any one time, resulting in a total of 1,116,920 visitor days. This is a conservative estimate and does not capture any boating for crafts under the size of 12 feet, including canoes or kayaks. Additionally, not all non-New Hampshire boaters register their boats with New Hampshire's Department of Motor Vehicles. However, we have not yet adjusted for the time spent in a boat that is for swimming or fishing and not just boating.

Using the spending profile above for overnight tourist visits and 1.16 million visitor days, we get the following economic output of $104 million dollars, broken down into the labor income and direct sales as well as total jobs.

Impact Type	Employment (jobs)	Labor Income ($ million)	Value Added ($ million)	Output ($ million)
Direct Effect	700	$20,024,000	$38,042,000	$62,186,000
Indirect Effect	126	$6,791,000	$12,509,000	$20,767,000
Induced Effect	159	$7,790,000	$13,445,000	$22,037,000
Total Effect	**985**	**$34,605,000**	**$63,996,000**	**$104,990,000**

Table B2. Total economic impact of recreational boaters visiting New Hampshire

Case Study of Waterfront Property Values: Meredith, New Hampshire

Many New Hampshire communities have valuable waterfront property. Below, we present a brief case of one New Hampshire community and how waterfront property contributes to its tax base.

Meredith is a town of over 6,000 residents located in the heart of the Lakes Region. It is also a popular tourist destination and has many rental properties. It is also home to a number of waterbodies, including parts of five lakes (Winnipesaukee, Waukewan, Winnisquam, Pemigewassett, and Wicwas) and three ponds (Forest, Randlett, and Spectacle Pond). Waterfront properties make up twenty-five percent of the total properties in Meredith but the value of these properties is about half of the town of Meredith's total residential valuation.

Figure B2. Value of waterfront property in Meredith, NH

Total Number of Residential Properties	6,076
Number of Waterfront Residential Properties	1,544
Total Value of all Assessed Properties	$2,060,350,825
Average Value of all Assessed Properties	$340,000
Total Value of *Waterfront* Properties	$1,058,169,300
Average Value of *Waterfront* Properties	$680,000
2017 Average Tax Rate	$15.23 per 1,000

Table B3. Property values in Meredith, NH (Data courtesy of Meredith Assessor Jim Commerford).

Hesky Park, Meredith, NH. Photo credit: NH Lakes.

A deterioration in water quality could reduce property values and thus lower the economic benefit of waterfront properties (e.g. Gibbs et al. 2002 and Poor et al. 2007).

Methods: Conducting a Tourism Economic Impact Analysis:

Two of the analyses we conducted are based on a tourism impact model. The "net new" value added by visitors who come to a region for a specific purpose is an accepted method for showing the value of certain natural resources. Figure 3 illustrates the steps to estimating economic impact of visitor spending and is developed from an excellent resource on estimating the economic impact of park and recreation services (Crompton 2010). In its most basic form, visitor economic impact is a simple equation of the number of visitors multiplied by the average spending per visitor and then by a multiplier that captures the ripple effect of spending. However, within each of those categories, decisions and assumptions about the available data need to be made. This section provides details on our approach.

To complete the first step of a tourism impact study, one needs to determine the number of visitors participating in the specific activity. As noted above, typically, tourism impact studies are done on visitors only to capture the "net new" spending.

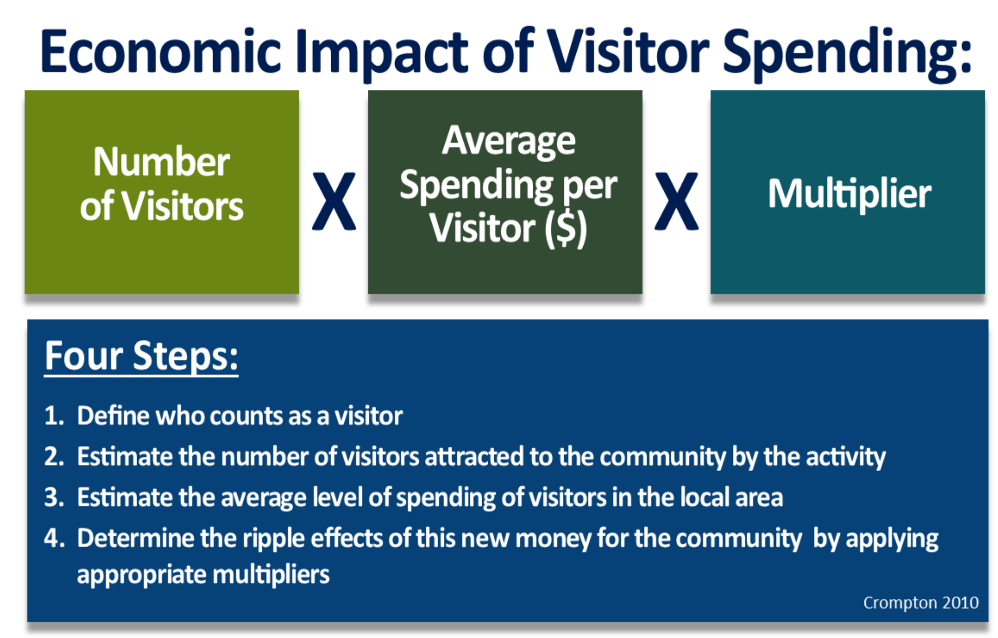


Figure B3. Steps for estimating economic impact of visitor spending (from Compton 2010).

The next steps of a recreational economic impact analysis are determining how much visitors are spending when they come to New Hampshire. We utilized the economic impact data available on the New Hampshire Travel and Tourism Industry Resources website. We also spoke with the consulting firm that runs this interactive website- Dean Runyon. https://www.visitnh.gov/industry-members/industry-resources/research/new-hampshire-travel-impacts

Table 4 shows an average spending profile for an overnight visitor to New Hampshire and the numbers are in dollars per day.

Category	Dollars/visitor/day
Accommodations	16
Food & Beverage	15
Food Stores	7
Local Transport & Fuel	9
Arts, Entertainment, Recreation	11
Retail Sales	22
Total	**80**

Table B4. Spending profile for overnight visitors (Lakes Region, Summer 2017).

Multipliers:

The final piece of an economic impact study is determining the ripple effects of spending in certain categories. We used a well-respected economic input-output modeling software called IMPLAN http://www.implan.com/ to determine the ripple effects of spending by visitors participating in swimming, boating, and fishing.

An economic input-output model takes direct spending in one sector and models how that spending may impact another sector of the regional economy through either spending in the supply chain (e.g. spending at hotels can lead to spending for paper supplies and cleaning products) and through wages that are paid to employees of the sector. IMPLAN's modeling can show the direct, indirect, and induced economic impacts of a change in the regional economy.

In order to model the economic impacts we need to connect the visitor spending to a specific sector in the economy. Table 5 shows the categories of spending, and the corresponding IMPLAN code

IMPLAN Sector	Description	Spending (dollars/day)
499	**Accommodations**	16
502	**Food & Beverage**	15
400	**Food Stores**	7
395	**Local Transport & Fuel**	9
496	**Arts, Entertainment, Recreation**	11
403	**Retail Sales**	22

Table B5. Categories of spending and IMPLAN code.

Table B6 (below) defines direct, indirect, and induced economic impacts based on IMPLAN's definitions of the terms.

Type of Economic Effect	Definition
Direct	The set of expenditures applied to the predictive model (i.e., I/O multipliers) for impact analysis. It is a series (or single) of production changes or expenditures made by producers/consumers as a result of an activity or policy. These initial changes are determined by an analyst to be a result of this activity or policy. Applying these initial changes to the multipliers in an IMPLAN model will then display how the region will respond, economically to these initial changes. https://implanhelp.zendesk.com/hc/en-us/articles/115009668548-Direct-effects
Indirect	The impact of local industries buying goods and services from other local industries. The cycle of spending works its way backward through the supply chain until all money leaks from the local economy, either through imports or by payments to value added. The impacts are calculated by applying Direct Effects to the Type I Multipliers. https://implanhelp.zendesk.com/hc/en-us/articles/115009499547-Indirect-effects
Induced	The response by an economy to an initial change (direct effect) that occurs through re-spending of income received by a component of value added. IMPLAN's default multiplier recognizes that labor income (employee compensation and proprietor income components of value added) is not a leakage to the regional economy. This money is recirculated through the household spending patterns causing further local economic activity. https://implanhelp.zendesk.com/hc/en-us/articles/115009668568-Induced-effects

Table B6. Definitions for IMPLAN economic-input output modeling.

Data Gaps and Research Needs:

When a similar analysis on the value of select uses of freshwater resources was conducted 15 years ago (Shapiro et al. 2003) there was much more information on visitor spending and behavior in the state of New Hampshire and particularly more information on recreational activities. This data was collected through survey methodologies and reported by the Institute for New Hampshire Studies at Plymouth State University. This institute is not in operation anymore and data related to visitor behavior is not collected regularly. The NH Division of Travel and Tourism does collect spending information through its contract with Dean Runyon (http://www.deanrunyan.com/NHTravelImpacts/NHTravelImpacts.html) but this aggregates spending for all types of visitors, not necessarily ones that are participating in water recreation.

Additionally, the former state office of energy and planning used to keep track of all waterfront properties in the state, making an estimate of the property values and tax revenue generated by waterfront property much more feasible. This data is no longer centralized.

Following on the data gaps detailed above, future research should focus on a methodology for more specifically collecting information on visitors to the state and how they benefit from our water resources. A multi-institution, regularly coordinated survey effort would go a long way to helping to meet this need. Additionally, the method laid out for the Town of Meredith could be replicated in any town with waterfront property.

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