2010

Fisheries & Aquatic Habitat Restoration Feasibility Study, Royal River Restoration Project Yarmouth, Maine

Stantec Consulting Services, Inc.

FISHERIES & AQUATIC HABITAT RESTORATION FEASIBILITY STUDY

ROYAL RIVER RESTORATION PROJECT YARMOUTH, MAINE

Prepared For:

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Project Partners:

NOAA Restoration Center
Restoring Our Nation's Estuarine and Marine Habitats

MAINE RIVERS

CLF Protecting New England's Environment

Yarmouth — Maine
Our Latchstring Always Out

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Executive Summary

The Royal River Restoration Project – Fisheries and Aquatic Habitat Restoration Feasibility Study (FS) evaluates alternatives to restore native diadromous and resident fisheries resources in the Royal River by improving fish passage in Yarmouth (Cumberland County), Maine. The objective of the FS is to evaluate approaches for achieving the project goal of restoring native diadromous and resident fisheries resources to the Royal River. Work conducted as part of the FS includes characterization of existing natural resources, reconnaissance-level topographic and bathymetric surveys, preliminary engineering analyses, development of preliminary cost estimates for evaluated alternatives, and comparison of beneficial and adverse impacts associated with evaluated alternatives, such as the potential to restore views of the natural river cascades in the vicinity of the dams.

The presence of the East Elm Street and Bridge Street dams, and anthropogenic encroachment along the banks of the Royal River associated with historical industrial uses along the river's natural bedrock falls, have adversely affected resident and diadromous fish populations in the Royal River. Despite installation of upstream fish passage facilities at the Bridge Street and East Elm Street dams in the 1970s, populations of diadromous fish remain depressed or absent in the river.

The feasibility study was initiated with a review of historical information regarding previous efforts to improve upstream fish passage, identifying project constraints, and developing conceptual alternatives that could potentially satisfy the project goals. The original conceptual alternatives were subsequently pared down following their review and determination as unfeasible options due to project constraints. The remaining alternatives underwent a thorough feasibility assessment, which included quantitative and qualitative evaluations.

The three Project Alternatives selected from the conceptual alternatives and evaluated as part of this study include:

- Project Alternative 1: No Action;
- Project Alternative 2: Installation/renovation of fish passage structure(s);
- Project Alternative 3: Removal of the dam(s) and restoration of the natural stream channel.

Based on the alternatives analysis, it was determined that Project Alternative 3 (Removal of the dam(s) and restoration of the natural stream channel) would most efficiently achieve project goals: providing unhindered upstream (and downstream) fish passage through the Royal River Corridor Study Area; restoring the currently impounded reaches of the Royal River to riverine habitat; and would also restore views of the natural river cascades. Specific native resident and diadromous fish that are anticipated to benefit from implementation of this alternative include American shad (*Alosa sapidissima*), river herring (collectively alewife [*Alosa pseudoharengus*] and blueback herring [*Alosa aestivalis*]), brook trout (*Salvelinus fontinalis*), white sucker (*Catostomus commersoni*), American eel (*Anguilla rostrata*), and sea lamprey (*Petromyzon marinus*), which are currently present in the watershed but have likely experienced adverse impacts due to the presence of the dams and channel encroachment. These species serve as sources of prey for commercially, ecologically, and recreationally important species, as sources of bait for both commercial and recreational fisheries, and high value sport fish.

The project is being funded by the Conservation Law Foundation in partnership with the National Oceanic and Atmospheric Administration and the Town of Yarmouth, Maine. Project work is being performed by Stantec Consulting Services Inc., in coordination with Titcomb Associates, Inc. of Falmouth and Bath, Maine, and Test America Inc. of Burlington, Vermont. The project also benefits from a local committee that includes engineers, landscape architects, and the Yarmouth town manager, engineer, planner, and Parks and Lands Committee chair.

1.0 INTRODUCTION

This report presents a discussion of the initial results of a study to develop and assess options for fisheries and aquatic habitat restoration within the Royal River. The goal of this study is to explore opportunities for restoration of natural river function and native and diadromous fish passage between the lower Royal River and spawning and rearing habitat upstream in the watershed, including tributaries such as Chandler, East Branch, Collins, and Eddy Brooks.

1.1 Project Background

The Royal River was identified by the Gulf of Maine Council on the Environment and the Maine State Planning Office (SPO) as a restoration priority, with the removal of the Bridge Street and East Elm Street dams being identified as restoration sub-projects by the State Planning Office (SPO) restoration inventory conducted in 2005. The restoration and protection of the Royal River and its estuary has further been highlighted through support received from the National Oceanic & Atmospheric Administration's (NOAA) Coastal and Estuarine Land Conservation Program (CELCP) for land acquisition.

Beginning in January 2008, the Town of Yarmouth (hereafter referred to as the Town) undertook a planning process aimed at guiding development along the Royal River Corridor. The 2008 Royal River Corridor Study (RRCS) involved evaluating the history, natural resources, recreational usage, zoning, and future development of the Royal River Corridor and the lands that abut it. The Royal River Corridor Master Plan (RRCMP 2009) was prepared as a result of the RRCS on behalf of the Town by the team of Terrence J. DeWan & Associates, Stantec Consulting Services Inc. (Stantec), and the Greater Portland Council of Governments in coordination with the Town's Royal River Study Committee and the Yarmouth Historical Society. At this time, the section of the river corridor between the East Elm Street Dam and the Town's harbor area is the continued focus of evaluations.

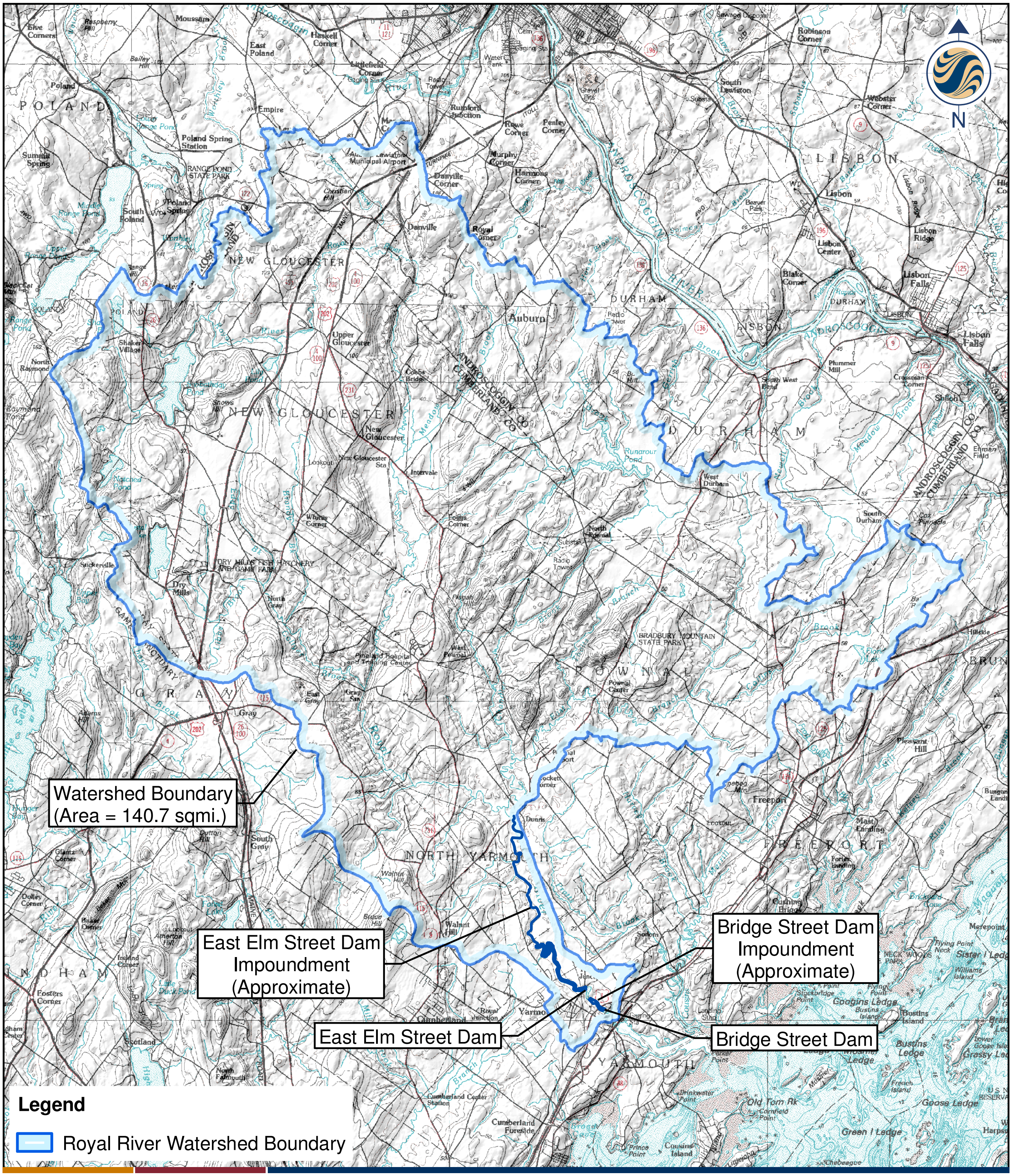
The guiding principles of the RRCS, as adopted by the Town Council-appointed Study Committee, include the protection and enhancement of habitat, improvements to water quality, and the encouragement of the river as a community focus point while encouraging appropriate economic development within the study area. The RRCMP was developed to guide future land-use decision making within the corridor for the foreseeable future.

Bridge Street Dam as viewed from north side of the Bridge Street bridge

Among recommendations stated in the RRCMP for guiding development along the Royal River Corridor was the recommendation to improve fish passage corridor-wide and to conduct a comprehensive feasibility study to assess the advantages and disadvantages of removing the Bridge Street and East Elm Street dams. Consistent with these recommendations, the Town contracted with Stantec to evaluate alternatives for restoration of aquatic resources on this lower stretch of the Royal River.

1.2 The River

The Royal River watershed encompasses approximately 141 square miles of mixed-use land largely in the towns of Auburn, Durham, Gray, New Gloucester, Pownal, North Yarmouth, and Yarmouth, Maine (Figure 1). The Royal River flows from Sabbathday Lake in New Gloucester and generally flows in a southeasterly direction for 25.5 miles, falling approximately 299 feet before terminating at Casco Bay in Yarmouth, approximately 2.3 miles downstream from the Bridge Street Dam.



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Client/Project
Town of Yarmouth
Royal River
Restoration Project

Figure No.
1

Title
Royal River Watershed

11/22/2010

00348-F01-Watershed.mxd

The Royal River has also been referred to as the Westcustogo River, Royalls River, Royels River, Yarmouth River, and Pumgustuck River.[1] The current name stems from the settlement of William Royall along the river in 1636.

The Royal River watershed is largely unaffected by industrial development, with the exception of the areas immediately surrounding the natural cascades in Yarmouth. The cascades within the town were formerly developed for industrial use, including paper and cotton manufacturing, lumber processing, tanneries, poultry processing plants, and iron forging. A notable exception to the watershed being largely unaffected by industrial development, the former McKin Company Superfund Site (CERCLIS #: MED980524078), is located in Gray, Maine, which lies in the upper watershed; however, sediment samples collected from the upper watershed indicate little impact to the river from this facility.[2] Several current and former rail systems also pass through the watershed.

The Maine Department of Environmental Protection (MEDEP) has designated the Royal River as Class B water. Waters regulated as Class B waters are considered general purpose waters managed by the MEDEP to attain good quality water and to maintain aquatic life. Designated uses for Class B regulated waters include fishing, recreation, navigation, hydropower, and industrial discharge provided specific water quality criteria are maintained or exceeded. More information on the Water Classification Program administered by the MEDEP can be found at: www.maine.gov/dep/blwq/docmonitoring/classification/ index.html.

A 1958 report by the Maine Department of Inland Fisheries and Wildlife[3] identified eight man-made dams, three natural barriers to fish passage, and one fish screen within the Royal River watershed. The dams included the Bridge Street and East Elm Street dams, the Smith Dam (now removed) and the Jordan Dam on the main stem of the Royal River; the Pownal School Dam and “Old” Dam on Collyer Brook; and the Sawmill Dam and Runaround Pond Dam on Chandler Brook. Two natural barriers were noted in the vicinity of the Jordan Dam and one on Collyer Brook below “Old” Dam. The fish screen was located on the outlet of Sabbathday Lake near Tobey Road and was intended to keep fish from emigrating from the lake. Lily Pond and Runaround Pond comprise the only other ponds within the Royal River watershed. A more recent inventory of restoration opportunities and barriers was completed by the Maine SPO in 2005 as part of the Gulf of Maine Council on the Marine Environment, Restoration Project Inventory. That study identified only two remaining man-made dams in the main stem of the river below New Gloucester, at East Elm Street and Bridge Street in Yarmouth.

1.2.1 Royal River Corridor

The Royal River Corridor (Figure 2) is the section of the lower river from the Yarmouth Water District building on East Elm Street to the end of Yarmouth harbor at the Sewer treatment plant, as defined by the RRCS. For the purposes of this report, however, the Royal River Corridor shall be considered to extend upstream to Route 9 as the impoundment created by the East Elm Street Dam backwaters a considerable distance upstream of the Yarmouth Water District building. Three sites of interest to the project goals are described below.

[1] Attwood, Stanley B. 1946 Length and Breadth of Maine, 231 pp.

[2] Eric Hutchins, NOAA, personal communication.

[3] Stuart E. Deroche, 1958 Royal River Drainage: Fish Management, 16 pp.

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Legend

Notes

Client/Project
Town of Yarmouth, Maine
Royal River Restoration Project

Figure No.
2

Title
Royal River Corridor
Scale: 1" = 200'

Bridge Street Dam

The Bridge Street Dam is located approximately one-quarter mile upstream from the head-of-tide at a site known as the Second Falls of the Royal River in Yarmouth. The dam is a reinforced concrete, gravity-type, run-of-river structure spanning the river approximately 250 feet northeast of Bridge Street. The dam, which is founded on visible bedrock, measures approximately 275 feet in length and has a 10-foot structural height. It has a sloped upstream face and a vertical downstream face. The dam's spillway is located near the center of the dam and is approximately 75 feet long. Low-flow sluiceways are cast into the concrete at either end of the spillway and controlled by removable weir planks. A concrete Denil-type fishpass is situated at the southwest end of the spillway. Water flow into the fishpass is controlled by a vertical lift gate mounted on a steel I-beam frame; however, the gate was severely damaged in the spring floods of 2010 and is currently inoperable. An intake forebay constructed on a triangular plan measuring 40 by 60 feet is located on the northeast end of the dam. This substructure is surrounded by a chain link fence and is protected on its upstream side by a metal trash rack mounted on a rolled steel I-beam frame. The frame also supports a maintenance catwalk. A vertical lift gate is located on the downstream side of the forebay with a wood and timber frame and wood plank gate leaf. This gate is still operable and controls water into an approximately 200-foot-long welded steel penstock (a.k.a. flume) that supplies water to an operating micro-hydroelectric plant in the basement of what is now commonly referred to as the Sparhawk Mill. Due to additional topographic relief drop between the dam and the Sparhawk Mill tailrace, approximately 18-feet of head are assumed to feed the micro-hydroelectric plant. A granite retaining/training wall constructed of split-faced tabular block lines the river channel behind the penstock. Fish passage facilities were not part of the original dam configuration.

East Elm Street Dam

The East Elm Street Dam is located approximately one-half mile further upstream from the Bridge Street Dam at the Fourth Falls (also known as Gooch's Falls). The East Elm Street Dam is a stone, run-of-river, gravity-type structure approximately 250 feet in length (including abutments), with a 12-foot structural height. The dam is founded on a bedrock outcropping that is an extension of Gooch Island, immediately east of the dam, which splits the Royal into a main channel (west of Gooch Island), and a narrower back channel (east of Gooch Island). The entire length of the dam serves as a spillway, which has a granite block crest. The visible dam structure is composed of irregular split granite blocks that are 1 to 4 feet long and 6 to 18 inches high and stacked to create a vertical downstream face up to 12 feet in height. Iron bars are driven into bedrock on the downstream side of the dam to anchor the structure. The upstream profile of the dam was not determined. A concrete Denil-type fishpass is situated at the south end of the dam. Water flow into the fishpass is controlled by a vertical lift gate mounted in a steel I-beam frame. Adjacent to the fish ladder, a secondary concrete spillway has been cast into a notch cut into the dam crest, presumably to increase water flows in the vicinity of the fish ladder. Concrete box culvert type structures are integrated into the main and north sections of the dam and probably once served as low-level outlets. Fish passage facilities were not part of the original dam configuration.

Middle Falls

A set of falls, commonly referred to as the Middle Falls or Mill Street Falls, naturally occurs between the Bridge Street and East Elm Street dam sites. These falls were formerly the site of the Forest Paper Company mill, which spanned the river from the south shore to Factory Island. Encroachment of the mill complex into the river channel is evident as mill foundations remain, including a stone structure spanning the channel to the north of Factory Island. This encroachment into the river channel likely impacts fish passage at this site.

1.2.2 Previous Fisheries Restoration Efforts

Previous restoration efforts reflect the historical importance of both commercially and recreationally important fisheries resources in the Royal River. While it is uncertain whether the former East Main Street Dam at the head-of-tide on the Royal River included upstream fish passage facilities, construction of the Bridge Street Dam circa 1870 to power the nearby Sparhawk Mill effectively blocked upstream passage of resident and diadromous fish (fish that live parts of their lives in salt and parts in freshwater habitats).

Nearly 100 years later, the Maine Department of Marine Resources (MEDMR) wrote a report on fisheries resources associated with the Royal River and initiated discussions with the Town Conservation Commission to provide upstream fish passage in the Royal River Corridor.

A December 17, 1975, letter from James Pratt (former Town manager) to a Mr. Benjamin Bullman reads that "The content of this report was discussed with our Conservation Commission sometime in 1971 and based on their negative reaction to the removal of either or both dams, the Department of Marine Resources began developing plans for the Bridge Street Dam fishway."

As a result, MEDMR contracted with the Town to construct a fish passage facility at the Bridge Street Dam, and construction of a Denil-style fishway was completed at the site in 1974. Subsequently, the Town acquired the East Elm Street Dam and contracted with MEDMR to construct and operate a fishway at this dam as well. Construction of a Denil-style fishway was completed at the East Elm Street Dam in 1979. MEDMR apparently also blasted one side of the Middle Falls to improve fish passage, though it is unclear from the historical documentation provided to Stantec when this work occurred.

Following completion of the Bridge Street Dam fishway, MEDMR initiated a program to restore sea-run fish populations to the Royal River emphasizing river herring (collectively alewife [*Alosa pseudoharengus*] and blueback herring [*Alosa aestivalis*]) and American shad (*Alosa sapidissima*). The development of a larger run of river herring was apparently economically-driven, as river herring are a preferred source of bait to the local lobster fishing industry. The American shad restoration program was undertaken to determine the feasibility of reestablishing American shad within a river system where the natural run was extirpated and with a goal of creating a self-sustainable run capable of supporting a local recreational fishery.

MEDMR began keeping records of river herring passing through the Bridge Street Dam fishway in 1975. Initial river herring runs passing through the fishway numbered in the hundreds or less (see Table 1). The upstream spawning run of river herring got a boost from 1977 through 1994 during which time MEDMR trucked river herring caught in the Bridge Street Dam fishway trap to suitable spawning habitat upstream in the watershed. The Royal River run of fish was augmented with fish collected from the Androscoggin River during the latter half of the 1980s and early 1990s. The river herring run increased to an estimated 50,000 fish in the early years after fish passage was installed, with results variable between 6,000 and 46,000 in subsequent years. Recent returns have not been counted.

Table 1: Summary of River Herring Escapement and Stocking in the Royal River

Year	Total Run Bridge Street Fishway	Total Released Bridge Street Impoundment	Total Released Elm Street Fishway	Total Stocked in Sabbathday Lake	Total Stocked in Runaround Pond
1975	362	362	-	*	*
1976	263	263	-	*	*
1977	10	7	-	425‡	*
1978	119	119	-	*	*
1979	19	19	-	262‡	*
1980	2	-	-	533‡	*
1981	50,000 (est.)	50,000 (est.)	111	1,280	*
1982	24,160	16,955	427 (2,912)	582	*
1983	10,029	2,218	51 (806)	493	*
1984	46,485	33,693	60 (2,095)	527	*
1985	34,114	7,170	-	1,932	*
1986	18,050	7,200	572 (1,012)	514 (BF)	511
1987	14,747	11,895	1,314 (910)	515	527
1988	6,106	5,679	127 (33)	532 (BF)	*
1989	***	***	*** (556)	520	522 (BF)
1990	***	***	***	*	529 (BF)
1991	***	***	***	*	501 (BF)
1992	***	***	***	*	550 (BF)
1993	***	***	***	*	469 (BF)
1994	***	***	***	*	646 (BF)
1995	***	***	***	*	*

* No alewives stocked
*** Not counted
‡ Stock of unknown origin
(BF) Stock from the Brunswick Fishway (Androscoggin River)

Adult American shad were transplanted from the Narraguagus River in Cherryfield, Maine, to the Royal River from 1978 through 1981. Fish were stocked approximately 10 miles above the head of tide on the Royal River with a goal of natural reproduction occurring within the river system. Fall trap netting on the lower Royal River during those years revealed juvenile shad out-migrating from the Royal River, indicating that the transplanted adults had successfully reproduced in the system. The apparent inability of the Bridge Street Dam fishway to pass adult American shad, as evidenced by only one record of an adult shad being captured in the fishway trap between 1975 and 1989, is considered to be a barrier to restoration of this species within the Royal River watershed.

The timing of upstream passage of a more complete spectrum of fish using Royal River habitat was documented by the MEDMR from 1983 through 1989. Fish passing upstream through the East Elm Street and Bridge Street dams were detained via either internal or external fishway traps. The number of each species varied widely, and the timeframe of capture does not imply that this is the only time in which the fish were present; multiple conditions may delay or deter fish from entering the fishways. The types of traps utilized also do not hold certain species, such as American eel (*Anguilla rostrata*). This data is summarized in Table 2.

Table 2: History of Fishway Usage by Species for the Years 1983 Through 1989

Species	Dates of Capture	
	Bridge Street Dam	East Elm Street Dam
Alewife	May 1 through June 19	May 11 through July 3
American eel	May 13 through June 16	May 2nd through July 3
American shad	May 14	-
Brook trout	May 23 through May 27	May 13 through June 11
Brown trout	April 24 through July 3	May 5 through July 1
Bullhead	-	June 2
Creek chub	May 27	May 14 through June 11
Common shiner	-	June 13
River chub	-	May 19 through May 20
Fallfish	-	June 4
Largemouth bass	-	June 7 through July 20
Smallmouth bass	May 16 through June 16	May 24 through June 28
White sucker	April 24 through June 28	May 5 through July 1

Using historical fishway usage documentation provided by MEDMR, Friends of the Royal River initiated discussion of improving fish passage at the Bridge Street Dam, East Elm Street Dam, and at the Middle Falls in 1999. These discussions spurred general maintenance to be conducted on the Bridge Street and East Elm Street dam fishways. In 2004, the Gulf of Maine Council on the Environment provided grant funding for dredging aggraded material from the East Elm Street fishway entrance with the goal of making the fishway functional, however no evidence was discovered supporting that a dredge occurred. Despite the development of conceptual plans by Curt Orvis of the United States Fish and Wildlife Service, no further fish passage improvements have occurred at the Middle Falls site.

1.3 Feasibility Study Goals

The objective of the FS is to develop and evaluate alternatives for restoring aquatic resources on the lower reach of the Royal River. Specific restoration components include:

- Improvements to fish passage at the Bridge Street Dam;
- Improvements to fish passage at the Middle Falls;
- Improvements to fish passage at the East Elm Street Dam;
- Restoration of resident and diadromous fish habitat within the Royal River;
- Restoration of riverine ecosystems with natural flow and temperature regime;
- Restoration of scenic falls and riffles;
- Increased safety around dam sites and reduction in liability.

Restoration alternatives are evaluated in terms of their potential for addressing two primary ecological goals: restoration of fisheries, and enhancing ecological function.

1.3.1 Restoration of Fisheries

Poor performance of the existing fish passage facilities at the Bridge Street and East Elm Street dam sites and channel encroachment at the Middle Falls site limit access to upstream habitat for diadromous and resident fish. While American eels are able to pass upstream of these three sites due to their ability to traverse across moist land, the current dam configurations and fish passage facilities hinder upstream fish movement during periods of low and high flows, and increase exposure of fish to predators.

1.3.2 Enhanced Ecological Function

Primary ecological impairments resulting from the Bridge Street and East Elm Street dams include the loss of riverine and riparian continuity, the conversion of riverine (lotic) to lacustrine (lentic) habitat, and the loss of associated resources (e.g., inundation of wetlands, vernal pools). These impairments are compounded by ineffective fish passage facilities at both dams and the structural encroachments into the river channel at the Middle Falls site. These dams also alter local and downstream habitats through the interruption of the flow of sediment, nutrients, and trees and tree parts washed downstream. Potential secondary impacts associated with the dams include loss and/or alteration of seasonal forage base for dependent predators including the lack of sea-derived nutrients for riverine, riparian, and avian food webs. The primary benefit to ecological function considered in this report is restored passage for native and diadromous fish. Other potential benefits of restoration include improved water quality; reducing high water temperatures that build up behind and spill over the dams and increasing dissolved oxygen through the physical aeration from increased riffle and run habitat and a decreased acreage of slow-moving or stagnant water. The decrease in temperature and increase in oxygen could help with in-stream metabolism and the current downstream water quality problems around the mouth of the Royal River. These impoundments also impact the timing of up and downstream fish migration as they alter the critical natural cues of flow and temperature.

1.4 Methods of Feasibility Study

This FS includes the characterization of existing natural resources, topographic and bathymetric surveys, sediment analyses, preliminary engineering analyses, development of cost estimates for evaluated alternatives (including a No Action alternative), and comparison of beneficial and adverse impacts associated with each alternative. Project Alternatives are presented in Section 2.0, and existing resources and conditions are described in Section 3.0.

1.4.1 Alternative Development and Evaluation

The feasibility study was initiated with reviews of existing documentation of fish passage through the Royal River Corridor, documentation of previous fish passage improvement efforts, and the identification of conceptual alternatives which could potentially satisfy the project goals. Conceptual restoration approaches presented in this document are grouped by “Action Areas”, as defined by each of the three areas in the Royal River Corridor where deficiencies in upstream passage have been documented, including:

- Action Area 1 – Bridge Street Dam;
- Action Area 2 – Middle Falls;
- Action Area 3 – East Elm Street Dam.

Potential restoration approaches are described for each of the three Action Areas.

2.0 PROJECT ALTERNATIVES

This section presents a brief description of each of the Project Alternatives and a general evaluation of their abilities to achieve the project goals at each of the three Action Areas. Detailed assessments of their abilities to achieve the project goals and the potential associated impacts are presented in Section 4.0 of this report.

A qualitative evaluation of the project alternatives was performed to develop a set of criteria for subsequent decision-making. A No Action alternative was included as a basis for comparison of action alternatives.

2.1 General Discussion of No Action Alternative

The No Action alternative involves allowing the existing conditions and infrastructure to continue without modification or action. This potential action was put forward as a baseline for comparison with the other potential actions. This action avoids some short-term temporary impacts associated with other alternatives, such as might be involved in fish pass reconstruction or dam removal, but does not address existing impacts to fisheries resources, the loss of riverine continuity and habitat, or existing public safety or liability concerns poised by the aging dams and constrictions. This potential action, therefore, would not achieve the project goals.

Implementation of the No Action alternative would result in continued adverse impacts to the natural resources dependent on in-stream fish passage, including continued loss of riverine habitat continuity, the continued loss of recreational fishing opportunities in the vicinity of the Bridge Street and East Elm Street dam fishpass facilities as required by the State of Maine, and the continued cost associated with maintaining and operating the Bridge Street Dam and/or the East Elm Street Dam indefinitely. A potential benefit of this alternative is potential revenue generated to the Town by retention of the Bridge Street Dam and impoundment, through lease of the water rights to a low-head hydroelectric plant located in the Sparhawk Mill complex.

2.2 Action Area 1 – Bridge Street Dam

2.2.1 Modification of the Bridge Street Dam Fishpass

A potential alternative to No Action at Action Area 1 includes maintaining the Bridge Street Dam and modifying the upstream fish passage structure. Structural fish passage facilities (e.g., Denil, Alaskan Steeppass, Pool and Weir type fishways) are used to mitigate fish passage blockages associated with anthropogenic barriers to fish migration; however, as noted below, such structures typically work moderately well for some species but not for others, and they are highly dependent on flow conditions. The type and design of the modifications would be based upon the target fish species.

2.2.2 Removal of the Bridge Street Dam

A second potential alternative to No Action at Action Area 1 includes removal of the Bridge Street Dam. Barrier removal, where appropriate, is often the most effective approach used to mitigate fish passage blockages associated with anthropogenic barriers to fish migration. Barrier removal also can provide secondary ecological benefits beyond increased fish passage performance, such as reconnection of artificially fragmented stream and riparian systems; restoration of natural flow regimes and stream processes; and improvements to local and downstream water quality. Barrier removal can also provide socioeconomic benefits, such as the elimination of costs associated with upkeep and operation of aging infrastructure and scenic values.

2.3 Action Area 2 – Middle Falls

2.3.1 Modification of the Middle Falls

A potential alternative to No Action at Action Area 2 includes modification of the river channel and represents a typical approach to mitigating impacts to fisheries resources at existing falls where historic mill building encroachment(s) into a river channel result in decreased fish passage performance. The type and design of the modifications would be based upon the target fish species. This alternative would have the potential to partially achieve the project goals and would result in some impacts associated with the project constraints.

2.4 Action Area 3 – East Elm Street Dam

2.4.1 Modification of the East Elm Street Dam Fishpass

A potential alternative to No Action at Action Area 3 includes maintaining the East Elm Street Dam and modification of the upstream fish passage structure. Structural fish passage facilities help mitigate fish passage blockages associated with anthropogenic barriers to fish migration; however, as noted above, such structures typically work well for some species but not for others, and they are highly dependent on flow conditions. The type and design of the modifications would be based upon the target fish species and the physical and hydrologic parameters of the site.

2.4.2 Removal of the East Elm Street Dam

A second potential alternative to No Action at Action Area 3 includes removal of the East Elm Street Dam. Barrier removal. Where appropriate, this is often the most effective approach used for river restoration. Barrier removal also can provide secondary ecological benefits beyond increased fish passage performance, such as reconnection of artificially fragmented stream and riparian systems; restoration of natural flow regimes and stream processes; and improvements to water quality. Barrier removal can also provide socioeconomic benefits, such as the elimination of costs associated with upkeep and operation of aging infrastructure.

3.0 AFFECTED ENVIRONMENT – EXISTING CONDITIONS

This section describes the affected environment in the Royal River relevant to the project goals and the objective of this study. The information presented addresses ecological, hydrologic, groundwater, infrastructure, socio-economic, and recreational resources as they relate to the feasibility of achieving the project goals of ecological restoration within the Royal River watershed. An assessment of impacts to these resources that may result from the implementation of alternatives is described in Section 4.0.

3.1 Ecological Resources

3.1.1 Fisheries

The Royal River in the vicinity of the Bridge Street impoundment hosts a variety of resident and diadromous fish species. Diadromous species attempting to migrate the Royal River Corridor, as documented by the MEDMR between 1983 and 1989, include anadromous river herring, American shad, and American eel. Resident fish species documented during that same timeframe include brook trout (*Salvelinus fontinalis*), white sucker (*Catostomus commersoni*), brown bullhead (*Ameiurus nebulosus*), creek chub (*Semotilus atromaculatus*), fallfish (*Semotilus corporalis*), common shiner (*Luxilus cornutus*), smallmouth bass (Micropt*erus dolomieui*), largemouth bass (*Micropterus salmoides*), and brown trout (*Salmo trutta*). Smallmouth bass, largemouth bass, and brown trout are exotic species in the Royal River, though the Royal River Corridor is actively managed for a stocked brown trout sport fishery[4]. Atlantic salmon (*Salmo salar*) historically used the Royal River but were extirpated from the river likely as a result of loss of access to upstream habitats due to impassable barriers (i.e., dams).

Specific impacts to fisheries resources in the Royal River Corridor associated with these dams include 1) ineffective upstream fish passage facilities; 2) conversion of approximately 27,000 linear feet of riverine habitat to approximately 8.75-acre and 65-acre impoundments largely comprised of lentic habitat; and 3) creation of lentic habitat suitable for exotic piscivorous fish including smallmouth bass and largemouth bass.

<u>Anadromous Fisheries</u>
Documentation of the presence of anadromous fish in the Royal River is limited to fishway trap surveys conducted by the MEDMR and include river herring and a single American shad. Anecdotal reports by anglers of American shad below the Bridge Street Dam indicates that they are present in the system, despite the lack of suitable passage above the Bridge Street Dam. Sea lamprey (*Petromyzon marinus*) are also likely present within the system. Some anadromous fish, such as rainbow smelts (*Osmerus mordax*) may naturally be blocked from migrating upstream from the head-of-tide into the freshwater section of the river by the cascade upstream from Route 88.

<u>Catadromous Fisheries</u>
Documentation of the presence of our only catadromous fish, American eel in the Royal River is limited. Some eels were captured in the fishway trap between 1983 and 1989 and this sampling is considered deficient as Denil-style fishways are not well-suited for passing American eel and individuals likely escaped from the type of fish trap utilized by MEDMR. Juvenile American eels (elvers), however, are regularly noted ascending damp, roughened, near vertical faces of dams and other natural features and are documented well into the upper Royal River watershed. In addition, there are anecdotal reports of eels observed in pools below the Sparhawk Mill and extensive seasonal elver netting activities under both the Route 88 and I-295 bridges.

<u>Resident Fisheries</u>
Native, non-diadromous fish species documented in the lower Royal River by MEDMR that would likely benefit from restoration of riverine continuity include brook trout and white sucker. Non-native brown trout are also well established in the drainage as a result of fisheries management goals and would likely

[4] Francis Brautigan, 2009, personal communication.

benefit from additional habitat connectivity provided by enhanced fish passage efficiency. Brook trout and brown trout support a local recreational fishery, while white suckers are often used as supplemental bait to river herring by the local lobster fishing industry.

3.1.2 Wetlands

Information on wetland resources along the project reach includes wetland characterization and delineation performed for this study, previous wetland resource surveys by Stantec, and mappings developed as part of the National Wetlands Inventory (NWI) by the U.S. Fish and Wildlife Service. The objective of this work was to characterize existing wetland communities and to provide information for evaluating potential future changes to those communities (i.e., wetland succession), such as conversion of wetland to upland, conversion of open water/riverine habitat to palustrine vegetated wetlands, and potential expansion of existing invasive plant species populations associated with the Royal River.

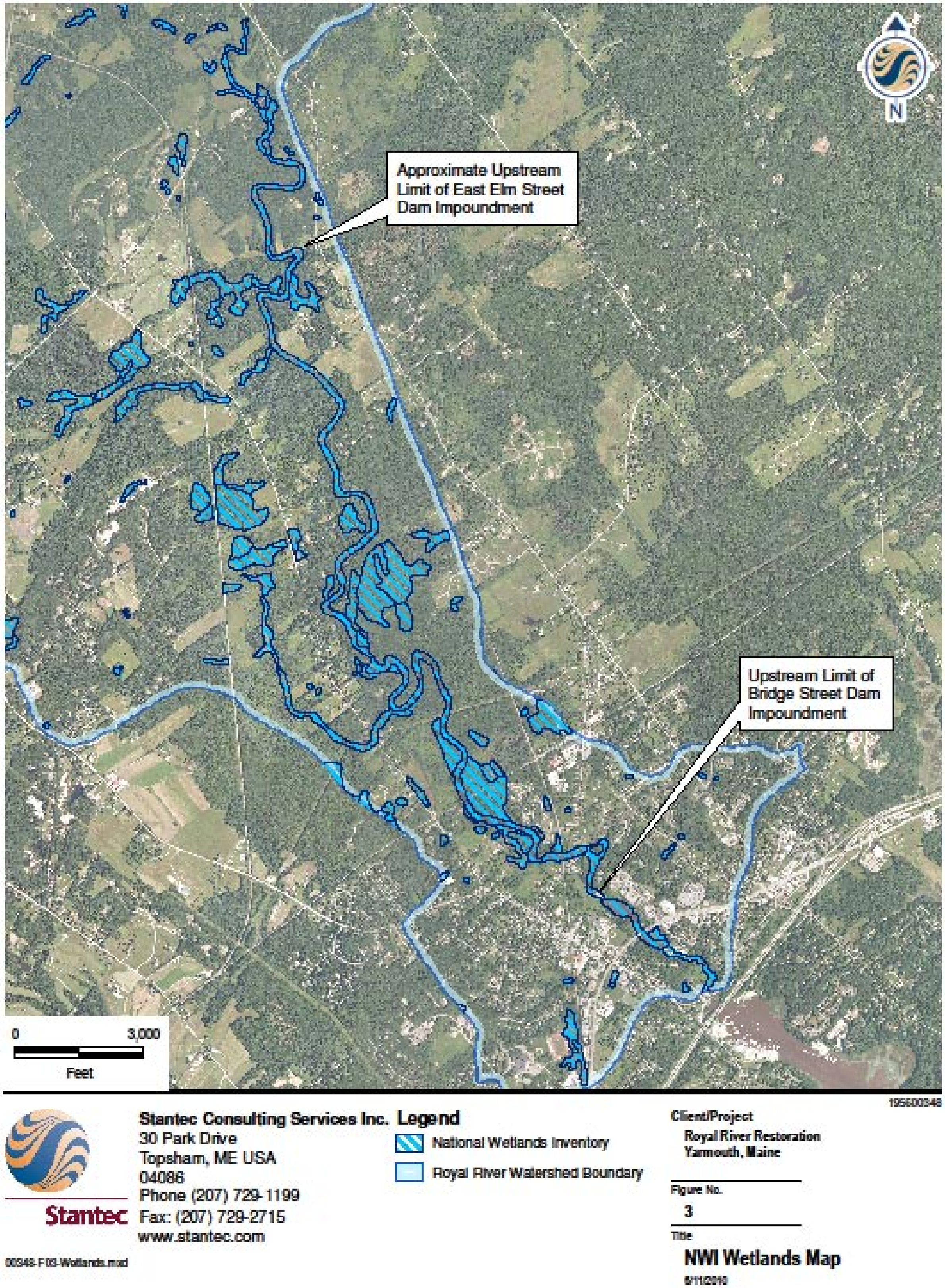
Wetland delineations were performed adjacent to the Bridge Street and East Elm Street dams by Stantec on August 25, 2009. The objective of this work was to identify resources that might be directly impacted by work on the project dams. Stantec delineated wetland boundaries within an approximately 3.5-acre area surrounding the Bridge Street Dam and an approximately 2-acre area surrounding the East Elm Street Dam to assess potential impacts to wetland resources should dam alteration occur. The survey area included approximately 100 feet upstream and 100 feet downstream from each dam and within 50 feet of the edge of the Royal River. Wetland boundaries were determined using the technical criteria established by the U.S. Army Corps of Engineers (USACE) and the MEDEP. Wetland boundaries were located using a Global-Positioning System (GPS) Trimble® Pro-Series receiver. The wetland delineation report for areas adjacent to the two dams in the project reach is presented in Appendix A ("Subject: Wetland Delineation Report – East Elm Street Dam and Bridge Street Dam, Royal River, Yarmouth, Maine" dated January 11, 2010) .

Stantec performed a characterization of wetland resources along the Royal River between the East Elm Street Dam and State Route 9 in North Yarmouth on November 2, 2009. The objective of this work was to characterize wetland resources in this reach of the river to provide information on potential effects of decreased surface water elevations on these resources. This characterization does not represent a formal wetland delineation; however, it does present a description of current and potential future changes in wetland communities (i.e., wetland succession). The wetland characterization and expected changes to wetlands report for the reach of the river between the East Elm Street Dam and State Route 9 are presented in Appendix A ("Subject: Expected Wetland Changes as a Result of a Decrease in Water Level with the East Elm Street Dam Impoundment, Royal River, Yarmouth, Maine" dated January 11, 2010).

Stantec previously characterized wetland resources present between East Elm Street and the town harbor as part of the completed RRCS during mid-September 2007. The purpose of the 2007 survey was to identify wetlands, streams, and other regulated natural resources that might affect potential future development within the Royal River Corridor Study Area; however, the detailed information contained in the RRCS is also suitable for this effort. This report is also included within Appendix A ("Royal River Corridor Study, Yarmouth, Maine, Natural Resource Reconnaissance Surveys" dated July 2008).

A map of NWI wetlands between head-of-tide and the expected upstream influence of the East Elm Street Dam is shown in Figure 3.

Figure 3: National Wetland Inventory Wetlands within the Project Reach of the Royal River Drainage



3.1.3 Wildlife

No dedicated wildlife field surveys were performed for this study, but wildlife observed within the project area during project work included beaver (*Castor canadensis*), white-tailed deer (*Odocileus virginianus*), raccoon (*Procyon lotor*), and muskrat (*Ondatra zibethicus*) tracks, osprey (*Pandion haliaetus*), double-crested cormorant (*Phalacrocorax auritus*), black ducks (*Anas rubripes*), mallard ducks (*Anas platyrhynchos*), great blue herons (*Ardea herodias*), red squirrel (*Tamiasciurus hudsonicus*), and mink (*Mustela vison*).

3.1.4 Listed Species

Potential occurrences of state and/or federally listed threatened and endangered species were evaluated based on responses from relevant agencies in response to consultation letters sent to them from Stantec. Contacted agencies include MDEP Natural Areas Program (MNAP), the Maine Department of Inland Fisheries and Wildlife (MDIFW), MEDMR, and the United States Fish and Wildlife Service. Agency response letters are included in Appendix C.

Based upon agency responses, it does not appear that there is any Significant Wildlife Habitat or federally listed threatened or endangered species located within or adjacent to the project site, however the New England cottontail rabbit, which is listed as an endangered species by MDIFW and is a candidate species for listing under the Federal Endangered Species Act, has been observed adjacent to the project area. Wild leek, a rare species typically found in forested floodplains, is also known to occur within the boundaries of the project area, however according to the MNAP response, it is unlikely that river restoration activities would adversely affect this occurrence.

3.2 Existing Upstream Fish Passage Facilities

Technical fishpasses were installed at the two dams on the project reach of the Royal River. Both of these are 3-foot width Denil-style fishpasses and are located on the west (river-right) side of each dam. The Bridge Street Dam fishpass was installed in 1974 and has a vertical rise of 13 feet. The East Elm Street Dam fish was installed in 1979 and has a vertical rise of 10 feet.

The 3-foot width Denil-style fishpass has a long history of use for upstream passage of anadromous fish, including those that occur in the Royal River (e.g., alewife). However, all anthropogenic fishpass systems can represent potential barriers to upstream passage of fish, as has been observed at the two referenced fishpasses on the Royal River. Specifically, the effectiveness of fishpass systems is dependent on a variety of factors such as design, maintenance and operations, and variability in operating conditions.

Relevant design conditions include selection and location of the fishpass. The basic design of the fishpass must be appropriate for the target fish species for upstream passage. The two 3-foot Denil fishpasses on the project reach of the Royal River are generally suitable for upstream passage of alewife, but can be problematic for upstream passage of other native anadromous fish, such as American shad, due to the reluctance of some fish to enter and continue moving upstream through the fishpass. In addition, Denil fishpasses are not ideal for upstream passage of some species and life stages, such as juvenile American eel. The location of a fishpass at a given site is critical to achieving reasonable upstream fish passage performance.

The Bridge Street Dam fishpass is located adjacent to the right spillway abutment and has a hydraulic discharge along the right bank of the low-flow channel downstream from the dam. This location is approximately 40 feet downstream from the dam, and is not ideal due to the lack of attraction flows emanating from the fishpass and the likelihood of fish swimming upstream to the base of the dam and therefore missing the fishpass entrance. The lack of a suitable holding pool in the immediate vicinity of the downstream end of the fishpass likely also contributes to poor performance of this fishpass.

The East Elm Street Dam fishpass is located adjacent to the right abutment of the dam and discharges to a narrow chute in the bedrock bottom of the plunge pool approximately 12 feet downstream from the dam. The siting of this fishpass has deficiencies similar to the one at the Bridge Street Dam, as there is the likelihood of fish swimming directly up to the base of the dam and thereby missing the fishpass entrance. In addition, the "Foundry Channel" to the south of the fishpass and channel around Gooch Island on the left side of the dam provide competing attraction flows, further compromising the effectiveness of the existing East Elm Street Dam fishpass facility.

Continued maintenance and operation is necessary for achieving effective fishpass performance. In the case of the two fishpasses discussed here, this includes maintenance of the Denil baffles in the fishpass, removal of debris, and operation of the manually-operated control gates at the upstream end of each fishpass to maintain appropriate flows in the fishpasses. The need for ongoing maintenance was evident in the spring of 2010, as flooding during February and March of 2010 resulted in substantial damage to both of the fishpasses, including loss of approximately 75 percent of the Denil boards and destruction of the inlet control gate system at the Bridge Street Dam fishpass, debris lodging in both fishpasses, and accumulation of boulders and cobbles in and on top of the outlet of the East Elm Street Dam fishpass. Note that this damage was not repaired for migrations in the spring of 2010, and remained unrepaired in late summer 2010; the Bridge Street Dam fishpass is incapable of passing fish until repairs are made.

Variability in operating conditions is related to conditions such as flow in the river and can further compromise the effectiveness of upstream fish passage systems. An example of this is overtopping of fishpasses during periods of high flow. Overtopping occurred at both of the project fishpasses in 2010, causing flows through the fishpasses well in excess of their design capacities which resulted in damage to both fishpasses. Prior to being damaged, high flows resulted in poor hydraulic conditions for the upstream passage of fish. Similarly, very low flows in the river may result in flows through the fishpass that are too low to provide suitable conditions for upstream passage.

An operational constraint on the effectiveness of the two fishpasses in providing upstream passage and riverine continuity for finfish in the Royal River is that they have historically only been operated in the spring of each year, and therefore do not provide opportunities for year-round upstream passage of fish in the Royal River. For example, fall spawning migrations of species like sea-run brook trout that may have migrated into the marine environment are effectively blocked.

3.3 Hydrology, Hydraulics, and Physical Processes

3.3.1 General Hydrology of the Watershed

A desktop evaluation was performed to evaluate minimum stream flows at the Bridge Street Dam. Hydrologic parameters developed as part of this work and presented here include monthly mean and median flow statistics, synthetic flow-duration statistics during the target adult anadromous fish migrations in the spring, and peak flows for relatively high-magnitude events (i.e., floods). All of the hydrologic parameters were developed using data collected by the United States Geological Survey (USGS) Royal River gage (USGS 01060000 Royal River at Yarmouth, Maine) The Royal River gaging station was operated by the USGS from 1949 to 2004.

<u>Methodology</u>
The analysis included a delineation of the Royal River watershed and the development of flow-duration statistics, including the lowest 7-day average flow that occurs on average once every 10 years (7Q10 low flow), annual mean and median flows, and monthly mean and median flows. The watershed delineation was performed using watershed polygon data obtained from the Maine Office of Geographic Information Systems website. This information included a delineation of a number of sub-watersheds within the tributary drainage area, including one terminating at the Bridge Street Dam. The absence of a major tributary to the Royal River downstream from Bridge Street Dam but above the USGS gaging station, and the relative proximity of the Bridge Street Dam to the USGS gaging station, allowed direct calculation of hydrologic parameters using data collected by the USGS gaging station without data scaling.

Annual flow statistics and monthly mean and median flow statistics are presented in Tables 3 and 4, respectively.

Table 3: Annual Flow Statistics

7Q10 Low Flow (cfs)	Annual Mean Flow (cfs)	Annual Median Flow (cfs)
23	270	120

Table 4: Monthly Flow Statistics

Statistic	Month/Flow (cfs)											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	223	232	550	732	316	183	91	76	86	145	304	305
Median	162	183	496	734	292	142	70	56	54	85	246	257

<u>Flow-Duration Statistics</u>
Flow-duration statistics were developed for the target fish species using daily average flow data collected by the USGS gaging station for the period from October 1949 through September 2004. Daily average flows were extracted from the data set for two upstream fish migration windows defined as May 15 – June 1 and May 1 – June 30. The resulting flow-duration curves are shown in Figure 4. Extracted 10th, 25th, 50th (median), 75th, and 90th percentile exceedance flow statistics are presented in Table 5.

Figure 4: Flow-Duration Curves during Target Fish Migration Periods

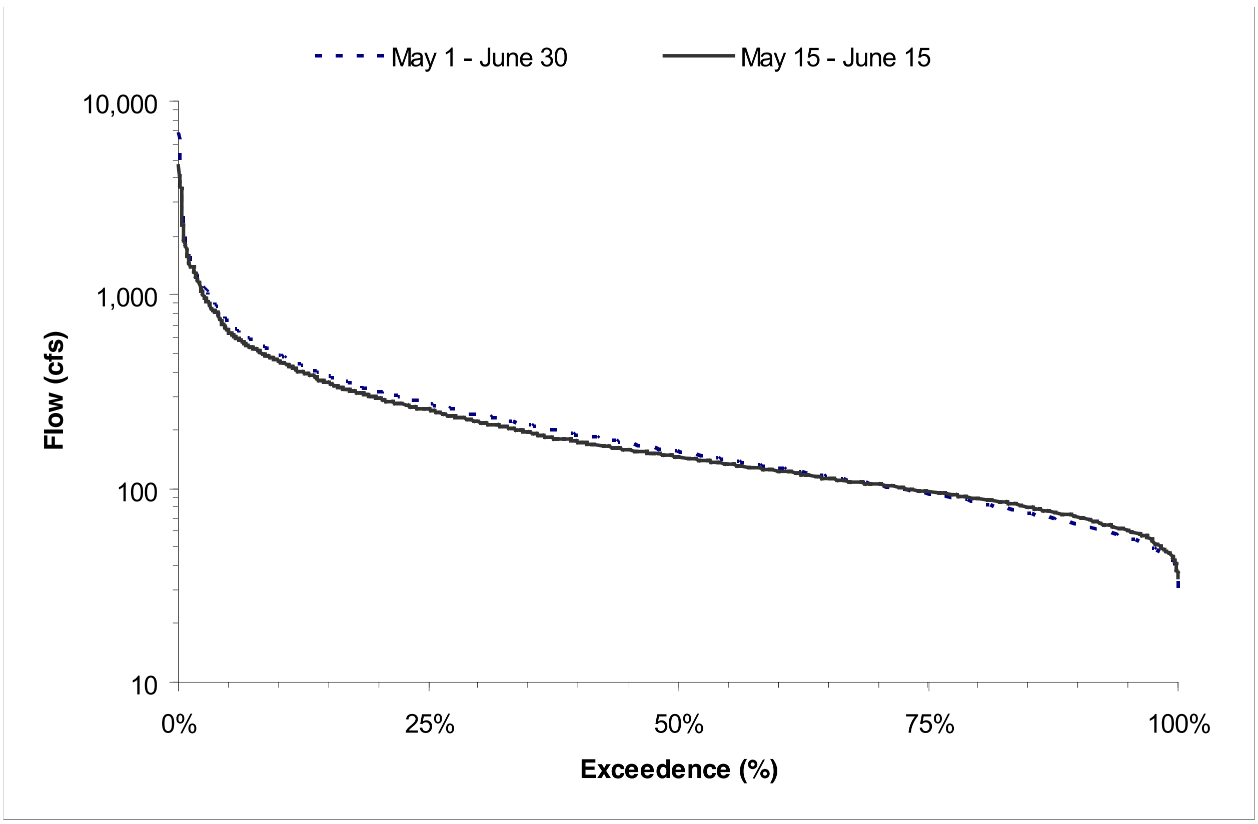


Table 5: Flow-Duration Statistics for the Royal River

Exceedance Percentile (%)	May 15 – June 15 (cfs)	May 1 – June 30 (cfs)
10	461	489
25	260	276
50	149	154
75	101	94
90	76	65

Peak Flows

Peak flows were calculated by incorporating data collected by the USGS gage into the National Flood Frequency (NFF) computer program software. The results of this analysis for eight events ranging from the 2-year to 500-year statistical return-interval storms are presented in Table 6.

Table 6: Peak Flows

Return-Interval Event (years)	Peak Flow (cfs)
2	3699
5	5485
10	6775
25	8519
50	9900
100	11350
200	12880
500	15030

Evidence suggests that changing climactic conditions within New England have been occurring since around 1970,[5] with higher peak flow events occurring at more frequent intervals. Such a trend suggests increased flood risk along riverine systems such as the Royal.

Summary

Flow statistics were calculated for the Royal River at the former gaging station located just below the Bridge Street Dam. The flow statistics reflect seasonal and annual variations of in-stream flows, typical flows during the normal upstream fish migration window, and storm events as indicated by the peak flow statistics.

3.3.2 Hydrology and Hydraulics in the Vicinity of the Dams

The hydrology of the Royal River immediately downstream from the Bridge Street Dam is substantially controlled by operations of the dam. When the penstock is closed the dam functions as a run-of-river facility. During this time, discharges to the river channel immediately downstream from the dam are likely equivalent to inflows minus evaporative losses from the surface of the impoundment. Discharges during such periods occur through either of the stop-log gates located on either side of the dam, over the spillway, and/or through the fishway. The hydrology of the channel immediately downstream of the Bridge Street Dam is highly dependent on the discharge location, with water spilling near the fishway preferred for fishway attraction flows. The Denil-style fishway is managed by MEDMR as run-of-river, where the flow of water through the fishway is dictated by the upstream impoundment elevation. Debris buildup in the vicinity of the upstream end of the fishway, as well as within the fishway, hampers fish passage performance and requires periodic maintenance to sustain proper hydraulic conditions within the fishway.

[5] Collins, M.J., 2009, Evidence for changing flood risk in New England since the late 20th century. Journal of the American Water Resource Association **45**: 1-12.

The use of the use of the penstock during periods of moderate to low flows (i.e., flows less than 100 cfs), such as those commonly encountered during the warmer months of the year, shifts water that would otherwise spill over the Bridge Street Dam to be largely diverted around the reach of river immediately downstream from the dam (utilizing a penstock diversion maximum diversion capacity of 90 cfs). Water remaining in the channel during such periods is largely passed through the fishway, with minor leakage occurring along the face of the dam. The impact of rapidly wetting and drying this reach of river has a detrimental effect on the fish community, as fish trapped in isolated pools as the water recedes face asphyxiation and/or predation as the isolated pools warm and shrink with evaporative water losses.

Bridge Street Dam Head Gate Structure and Sparhawk Mill Penstock

Flows through the Bridge Street Dam fishpass typically vary between 20 and 30 cfs during periods of upstream migration (May 1 and June 31) for numerous diadromous fish species. However, flows may dip lower when the penstock is drawing water from the impoundment or debris accumulates on the intake trash rack. A mechanical gate structure was formerly used to reduce flow through this fishway but it is currently inoperable due to damage sustained during high flow events in the spring of 2010.

The bedrock cascade, referred to locally as Middle Falls, located at the head of the Bridge Street Dam impoundment hydrologically isolates the upstream reach of the river from the effects of the dam. Any lowering or removal of the dam would therefore affect only the hydrology of the impoundment and not the upstream reaches of the river.

The East Elm Street Dam and Middle Falls locations are run-of-river, with the fishway at the East Elm Street Dam passing the majority of river flows during periods of low flow. A wooden gate structure is located mid-way across the East Elm Street Dam; however, there is currently no existing mechanical means of opening this gate structure. Water discharging over the spillway is split into a north and south channel by Gooch Island. Water may also pass around the East Elm Street Dam via the Foundry Channel. The braiding of the river below East Elm Street caused by the configuration of the East Elm Street Dam, the Foundry Channel, and channel topography around Gooch Island decreases the effectiveness of fishway attraction flows, fishway usage, and therefore function.

Flows through the East Elm Street Dam fishpass typically vary between 3 and 8 cfs during periods of upstream migration (May 1 and June 31) for numerous diadromous fish species. However, flows may dip lower when debris accumulates on the intake trash rack. Attraction flows at the fishway entrance are provided by a notch in the spillway crest adjacent to the fishpass intake structure.

The East Elm Street impoundment backwaters a considerable distance upstream from the dam. Visual observations made in the field during natural resource surveys place the potential upstream extent of the impoundment nearly 4 miles upstream from the dam. No physical barriers exist between the East Elm Street impoundment and the upper river, such as exist at the Bridge Street impoundment. Therefore, any lowering or removal of the East Elm Street Dam may affect the hydrology of the river upstream from the East Elm Street impoundment. A bedrock outcropping was, however, noted during field reconnaissance surveys in the vicinity of the Yarmouth Water Department building. This formation would limit the drawdown potential of the East Elm Street impoundment upstream from this feature to five and a half feet or less during low water conditions.

3.3.3 Flooding

The Bridge Street and East Elm Street dam impoundments are, as previously noted, generally regulated as run-of-river, with little to no storage capacity as compared to the size of the drainage and therefore likely have minimal effects on reducing downstream flooding. During numerous site visits, woody and herbaceous flotsam was noted deposited below what the 2009 HDR Engineering, Inc. dam inspection report (Appendix B) refers to as a 'non-overtopping' section of the Bridge Street Dam (to the south of the Bridge Street Dam fishpass facility). A photo taken shortly after a freshet during the summer of 2008 that was included in the RRCS (2009) shows the same "non-overtopping" section of the Bridge Street Dam overtopped. This is indicative of an inadequate spillway capacity, which may increase flooding potential upstream from the dam. A simple model of the spillway as a sharp-crested rectangular notch weir indicated inadequate spillway capacity to pass events as large as are expected to statistically occur , on average, only once every two years (2-year return interval event). A similar condition likely exists at the East Elm Street Dam, where modeling of the spillway indicated spillway capacity in the range of a 2-year return interval event.

Review of existing Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) for the Town of Yarmouth for the Royal River between Bridge Street upstream to Route 9 (Appendix D) show Special Flood Hazard Area designations of A, A4, A6, A9, B, and C, with detailed base flood elevations determined over much of the area using the National Geodetic Vertical Datum of 1929 (NGVD29). Detailed base flood elevations through the Bridge Street impoundment vary between 43 and 44 feet. Detailed base flood elevations through the East Elm Street impoundment vary from 77 feet near the dam to 79 feet immediately below the Maine Central Railroad (MCR) rail line bridge crossing. Base flood elevations upstream from the MCR bridge increase to 81, indicative that the railroad bridge embankments likely act as a hydraulic control during flood events within the Royal River. Currently, a review process is underway by FEMA to update the FEMA FIRMs located within the Town of Yarmouth to reflect changes in hydrology within the Royal River resulting from regional shifts in precipitation that have occurred since the prior FEMA FIRMs were published.

3.3.4 Morphology

The morphology of the Royal River channel varies substantially from the East Elm Street Dam impoundment to tidewater. Stream-reach morphology is strongly controlled by bedrock outcroppings and channel encroachment resulting in hydraulic control in the vicinity of the East Elm Street Dam and downstream to tidewater. Upstream from the East Elm Street Dam, the river is largely unconfined as it flows through deposits of sand, gravel, and glacio-marine silts and clays.

The reach of the Royal River between the Bridge Street Dam and tidewater is a moderate gradient (approximately 50:1, H:V) bedrock-cobble-boulder-bed system. The adjacent valley walls form a well-defined channel through most of this reach with readily apparent depositional bar along the right side of the middle section of this reach. The lack of woody vegetation along this bar suggests that some of this material may be mobilized during flood events.

Morphological characteristics of the reach of river within the Bridge Street Dam impoundment must be inferred from topographic and bathymetric data and observations of adjacent geological features. The slope of this reach is approximately 200:1 (H:V), and therefore substantially flatter than the downstream reach of the river. A preliminary bathymetric survey performed as part of this study (Figure 5, below) and the location of upland geological features suggest that this reach likely includes an inundated bedrock cascade a short distance upstream from the Beth Condon foot bridge. The bathymetric survey also noted the presence of an apparent scour pool in the vicinity of Route 1, likely a result of channel constriction between Route 1 Bridge abutments. Limited sediment deposits were noted along this section of the river during natural resource surveys.

A series of bedrock outcroppings form a cascade known as Middle Falls between the East Elm Street Dam and the Bridge Street Dam impoundment. The slope of this reach is approximately 50:1 (H:V), and therefore substantially steeper than the reach through the Bridge Street impoundment. Channel encroachment by historical industrial activities in this area reduces the channel width around the falls and the island located near the eastern shore. Limited sediment deposits were noted along this section of river during natural resource surveys.

The morphological characteristics of the East Elm Street impoundment vary significantly from the lower reaches of the river. The East Elm Street impoundment is a meandering, low gradient (approximately 3000:1, H:V) channel with a glacio-marine clay-silt-bed system reverting to bedrock near the East Elm Street Dam. A preliminary bathymetric survey of this impoundment noted substantial depth variations, including shallow bedrock areas near the dam and east Elm Street bridge (Figure 6a), as well as a number of deep pools upstream toward the Route 9 bridge (Figure 6b). Numerous locations of recent bank erosion were noted during a natural resources survey conducted in November 2009 and are indicative of active channel lateral migration. Sediment depositional areas were noted along the inside of channel meander bends along the entire length of the impoundment, as is typical of riverine (lotic) habitat, despite the impoundment being characteristic of lacustrine (lentic) habitat at the time of the site visit. Channel aggradation (i.e., increase in bed elevation due to sedimentation) was not noted elsewhere in the channel however, which is indicative of adequate sediment transport capacity to limit the occurrence of channel aggradation within the impoundment.

Similar to free-flowing riverine systems, sediment transport through the Royal River impoundments is a function of high flow events. The East Elm Street and Bridge Street dams do not appear to greatly interrupt sediment transport through the Royal River Corridor, as evidenced by lack of large areas of channel aggradation.

Preliminary bathymetric profiles of the study area are provided in Figures 5, 6a, and 6b.

Figure 5: Bridge Street Impoundment Bathymetric Survey

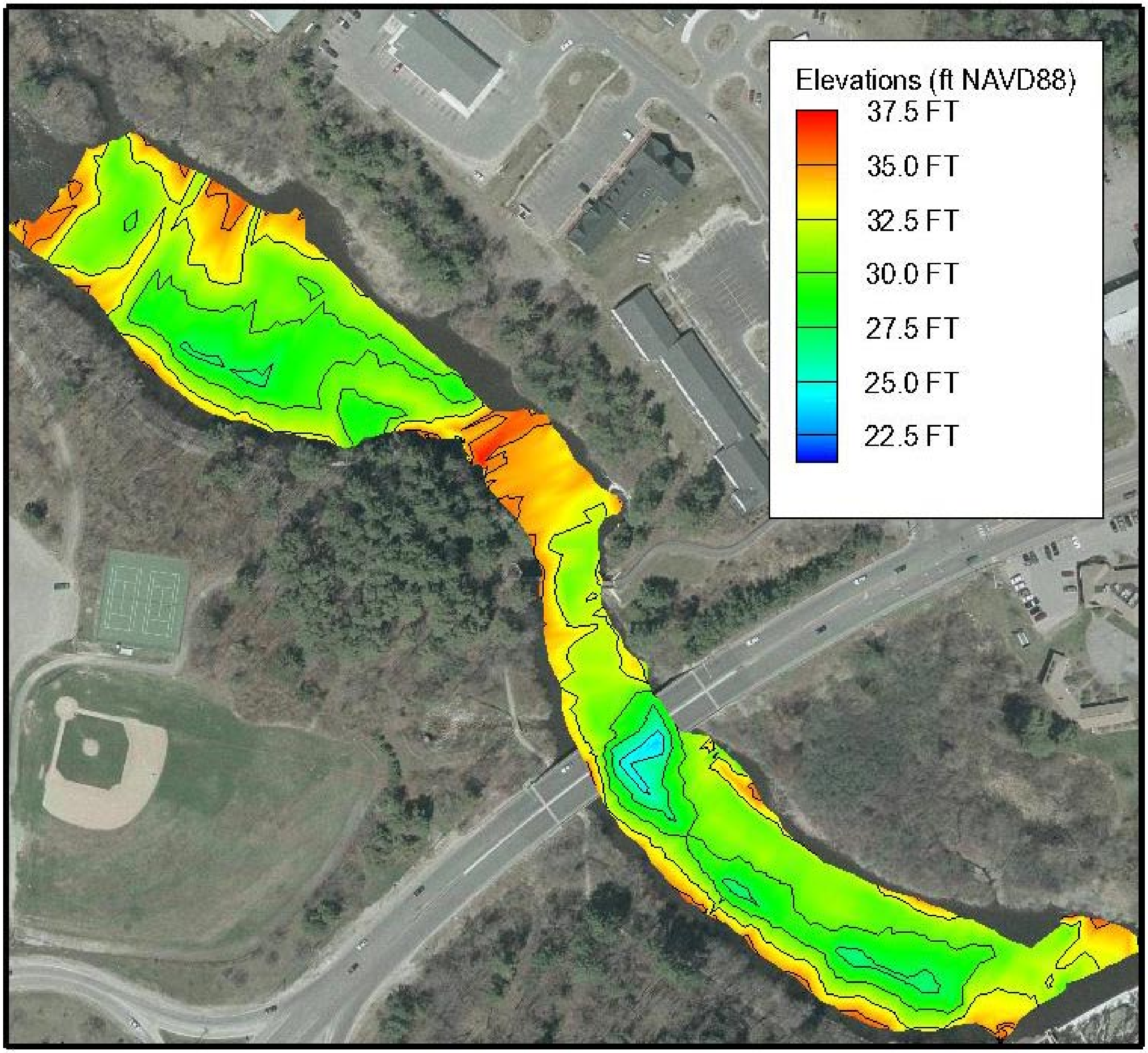


Figure 6a: East Elm Street Impoundment Bathymetric Survey, Proximal to East Elm Street

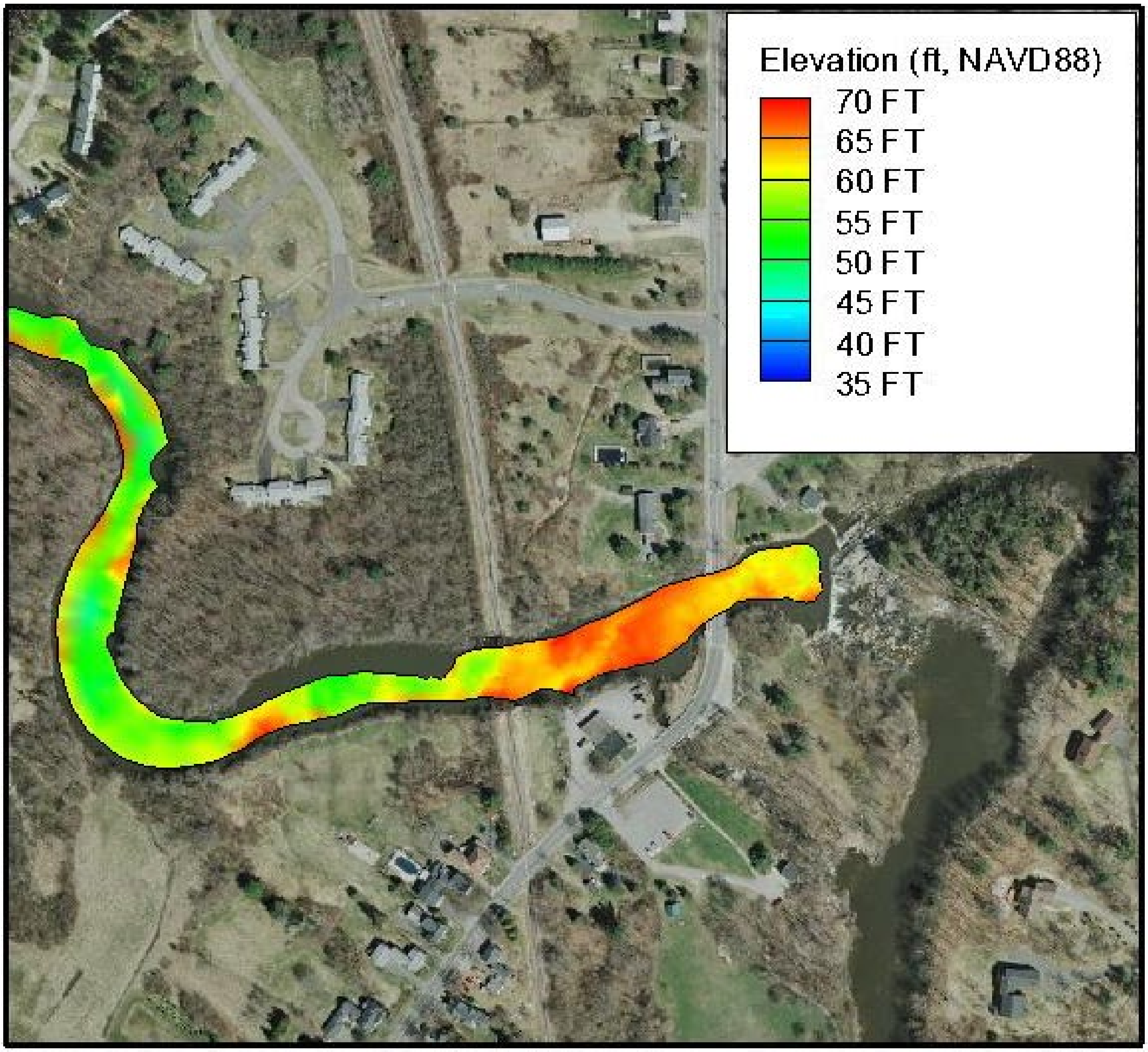
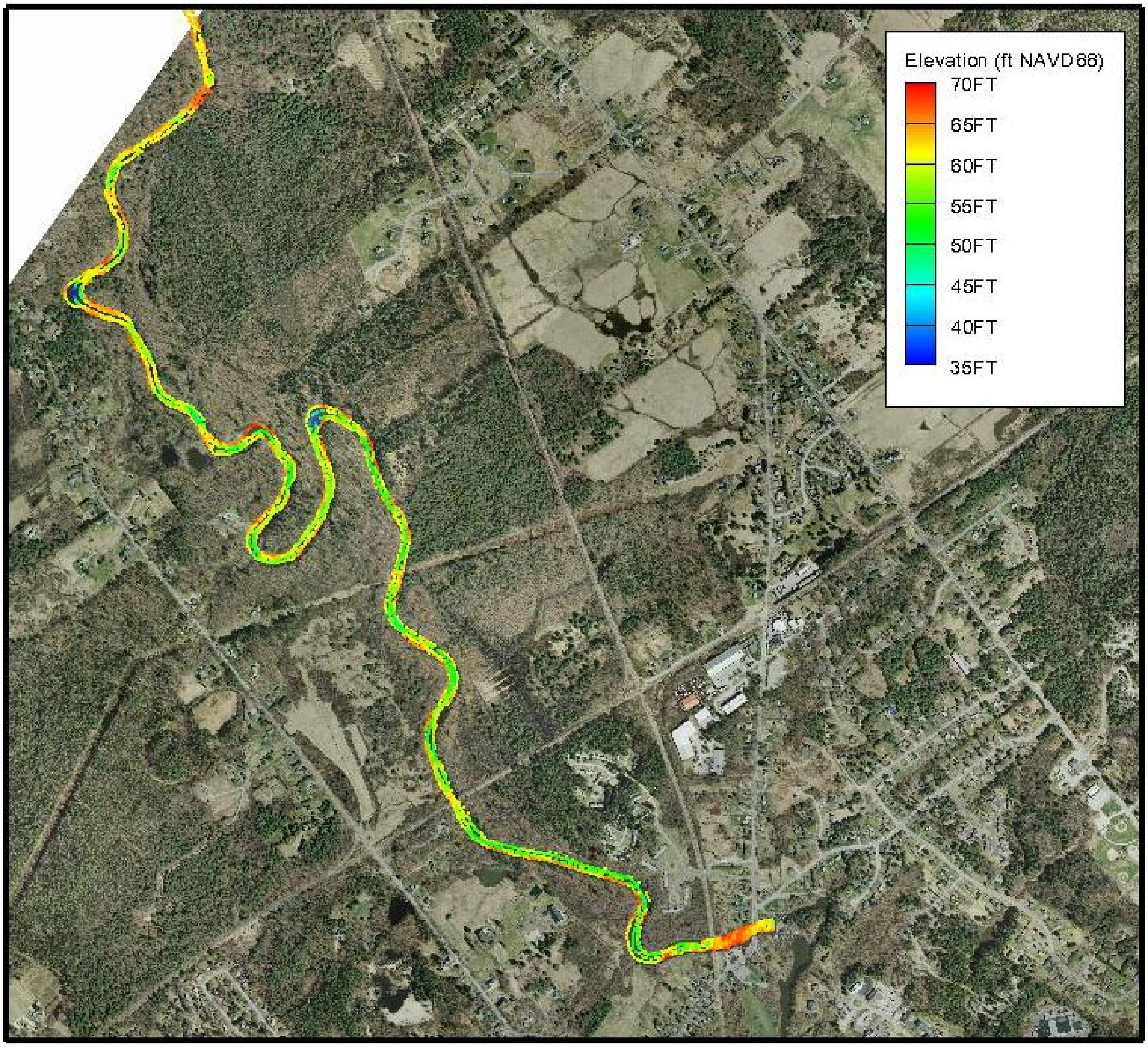


Figure 6b: East Elm Street Impoundment Bathymetric Survey, upstream to Route 9 Bridge



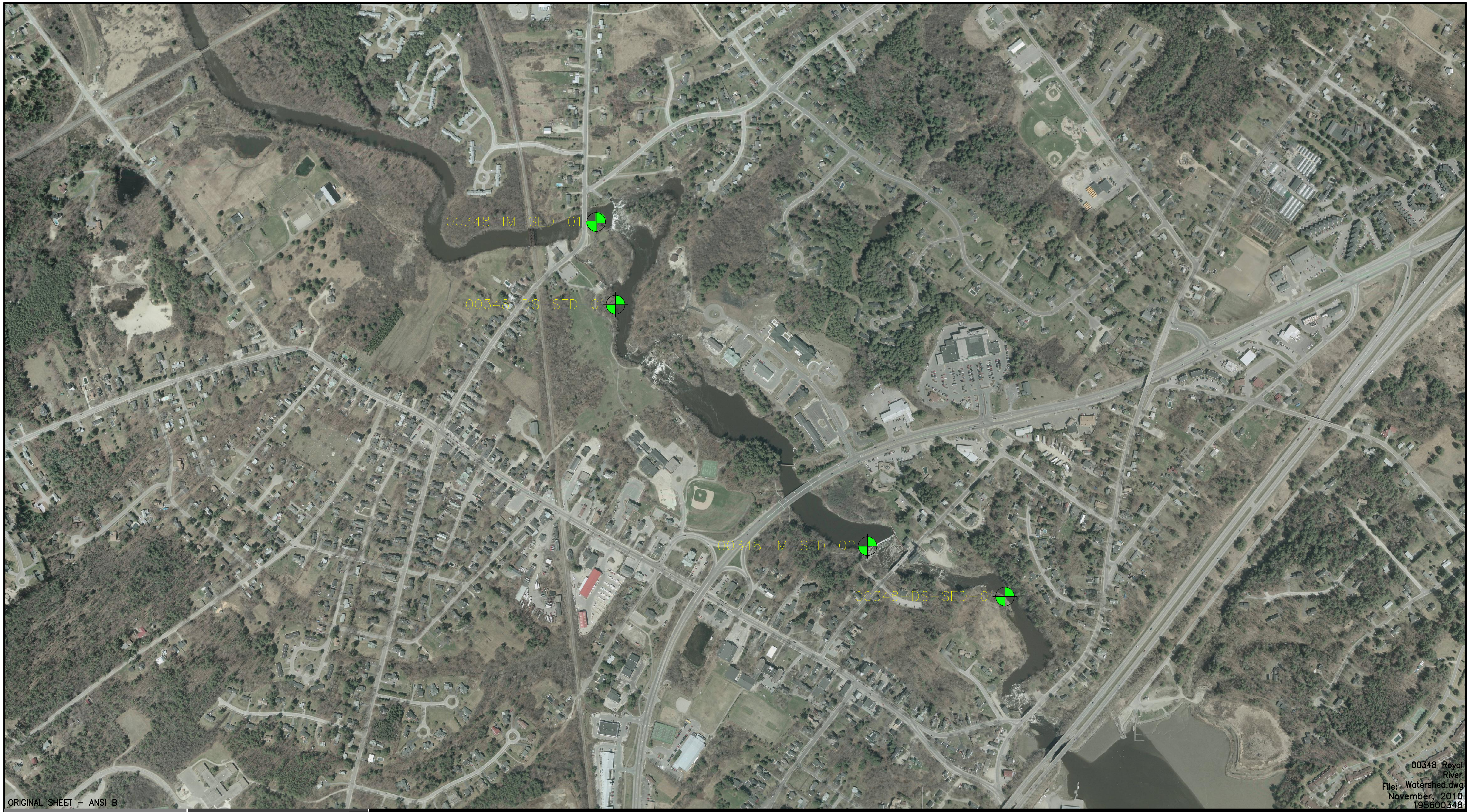
Potential Mobilization of Sediment Material
Observed sediment materials in the impoundments are largely composed of fine (fine sand and smaller) mineral materials and organic detritus. This material would be susceptible to mobilization during a full drawdown of either impoundment and during existing conditions high flow events. Therefore, as sediment transport is already occurring and is not expected to change drastically, an estimate of the volume of sediments that may be mobilized following a drawdown of either impoundment or removal of either dam was not made.

3.3.5 Sediment Quality Analysis

Industry historically relied on rivers as a source of transportation, power, and process water, and as a mechanism for the disposal of industrial and domestic wastes, often leaving legacy chemical constituents in river sediments that may be of public or environmental health concern. Industrial development of the Royal River started in the late 17th century with the development of an "iron forge." Industrial usage peaked in the mid 19th century with an intense period of development along the river corridor prior to a decline and eventual collapsed in the early to mid 20th century. As described below in Section 3.7 – *Historical and Archaeological Resources*, numerous industrial facilities were located along the Royal River corridor and may have been contributing sources of legacy chemical constituents within the river. These facilities include the former Hodsdon Shoe Company building, the former Weston's Machine shop building, a former poultry-processing facility, and likely foundry area (as the nearby channel is called "Foundry Channel"), the former "Forest Paper Company" Mill, and the Sparhawk "cotton fulling mill."

Due to the historical industrial usage of the Royal River, sediments in and downstream from the East Elm Street and Bridge Street dam impoundments were evaluated based upon visual observation and laboratory constituent analyses. The constituents to be tested for in the laboratory were determined based upon relevant project experience on similar projects, knowledge of the previous industrial usage of the Royal River, and consultation with the MEDEP.

Sediment Quality Analysis
Sediment samples were collected in December 2009 at one location in both the East Elm Street and Bridge Street dam impoundments, and at one location downstream of both the East Elm Street and Bridge Street dams, for a total of four collected samples. Samples designated IM-01 and DS-01 are associated with the East Elm Street; samples Dam IM-02 and DS-02 are associated with Bridge Street Dam. The sediment samples were subjected to chemical analyses to screen for likely contaminants. The sediment sampling plan is included as Appendix E. Chemical analyses were performed by a laboratory certified by the National Environmental Laboratory Accreditation Program using U.S. Environmental Protection Agency (USEPA)-approved methods for analytes (pesticides, heavy metals, etc.) that are required by state and federal agencies. Results of the sediment analyses are presented in Appendix F. Sampling locations are presented in Figure 7.



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Legend

Notes

Client/Project
Town of Yarmouth, Maine
Royal River
Restoration Project

Figure No.
7

Title
Sediment Sampling Locations
Scale: 1" = 200'

Chemicals of potential concern (COPCs) were measured from the collected sediment samples and compared with screening criteria values reported in the literature. Screening benchmarks, such as threshold effect concentrations[6] (TEC) benchmarks, were used to evaluate the measured chemical concentrations. If the results exceeded the screening benchmark, the constituent was retained as a COPC for further screening using risk-level benchmarks, such as probable effects concentration[7] (PEC) benchmarks. If COPC concentrations exceeded the risk-level benchmark, it was suggestive of probable risk to receptors (i.e., aquatic life). Note that where the measured concentration is reported as less than the laboratory reporting limit (RL[8]), it is considered a non-detected (ND) concentration (designated a "U" as the laboratory qualifier). It is also possible that the RL is greater than a benchmark even though the measured concentration may be reported as a ND. Specific instances where the RL was greater than a benchmark are described in the analytical screening parameter discussion below.

The purpose of the sediment sampling and evaluation for Royal River was to evaluate whether the impounded sediments have elevated levels of COPCs, which may become mobilized under a change in water regime management. A screening-level evaluation of the local sediments was conducted on the analytical data to determine if detected sediment concentrations of COPCs were within acceptable State and Federal guideline levels for the environment.

Analytical Evaluation of Sediment Data

Sediment samples were analyzed for physical parameters (i.e., total organic carbon [TOC], grain size), and chemical parameters such as volatile petroleum hydrocarbons, organochlorine pesticides/pesticides, polychlorinated biphenyls (PCBs) as PCB congeners (abbreviated list including 27 congeners), and select total metals (e.g., arsenic, cadmium, chromium, copper, lead, nickel, silver, zinc, and mercury).

This report provides a comparison of the laboratory results with relevant sediment screening benchmark criteria. The concentrations of COPCs for each sediment sample were screened using the selected sediment benchmarks, when a criterion was available for each of the specific constituents. If the sample result exceeded the screening level benchmark, it was then compared against the risk-level benchmark (a value that is expected to show probable effects to an organism if exposed). The results for the samples were compiled and data were compared against screening benchmarks for sediment quality (Appendix F) using applicable criteria for ecological exposure in freshwater sediment such as:

- Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1, Seattle WA, Office of Response and Restoration Division, National Oceanic and Atmospheric Administration, 34 pages.
- Buchman, M.F. 1999. NOAA Screening Quick Reference Tables. NOAA HAZMAT Report 99-1, Seattle WA, Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration, 12 pages.
- MacDonald et al. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. *Arch Environ Contam Toxicol,* 39:20-31.
- USEPA. 1997. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: National sediment quality survey. EPA 823-R-97-006, September.

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[6] The Threshold Effects Concentration (TEC) is the concentration of a constituent that has the potential to cause risk to receptors that may be exposed.

[7] The Probable Effects Concentration (PEC) is the concentration of a constituent above which risk of adverse effects to exposed receptors is probable.

[8] The Reporting Limit (RL) is the lowest reported concentration, provided on the laboratory sample analysis data report, after corrections have been made for sample dilution, sample weight, and (for soils and sediments) amount of moisture in the sample. The RL is the value that indicates whether the analytical method quality objectives (MQOs) have been achieved for the sample. The RL can be as low as the method detection limit (MDL) or exceed the practical quantitation limit (PQL), depending on the matrix encountered during the analysis.

- USEPA. 2005. Predicting toxicity to amphipods from sediment chemistry. National Center for Environmental Assessment, Washington, DC; EPA/600/R-04/030.
- USEPA – Region 3. 2009. Freshwater Sediment Benchmarks. Accessed 17 July, 2009 at http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/ R3_BTAG_FW_Sediment_Benchmarks_07-06.xls.
- USEPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response Washington, DC; OSWER Directive 9285.7-55, November 2003.

The evaluation of results of the analytical parameters and the screening evaluation are described below.

Volatile Petroleum Hydrocarbons (VOCs)

Results for VOCs are reported in micrograms per kilograms (µg/kg, or parts per billion [pbb]). There were only two constituents that were detected above the laboratory RLs in the sediment samples, but screening benchmarks were not exceeded for either constituent. The constituent 2-Butanone was detected in samples IM-01 and DS-01 (corresponding to the East Elm Street Dam impoundment and tailwater). Acetone was detected in the four sediment samples; however, this is suggestive of potential residual from the decontamination process used between sample collections (due to severe weather conditions it was noted that the liquids used during the cleaning stages would freeze during the rinse phase). No other VOC was detected above the RL in the sediment samples.

Organochloride Pesticides / Pesticides

Pesticide results are reported in µg/kg. There were no pesticides detected above laboratory RLs in the four samples analyzed. However, several of the RLs for pesticides were above the applicable screening benchmark, including dieldrin (ND, 4.4 to 5.7 µg /kg), endrin (ND, 4.4 to 5.7 µg /kg), chlordane (ND, 22 to 29 µg /kg), and toxaphene (ND, 220 to 290 µg /kg). It was determined that since no pesticide was detected above its corresponding Method Detection Limit (MDL) or the sample specific RL, none were retained as a COPC, and are considered not to pose risk to ecological receptors.

Polycyclic Aromatic Hydrocarbons (PAH)

Results for PAHs, as in this case of semi-volatile organic carbons (SVOCs), are reported in µg/kg. There were several detected PAH concentrations above RLs in the sediment samples. There were also several laboratory RLs, as well as MDLs, that were above the screening benchmarks. These include acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene. If a constituent was a non-detect (i.e., the concentration was not above the RL and there was no qualifier designating it as an estimated value) it was not considered to exceed the screening benchmark, nor was it considered to pose risk. If the result was an estimated value (based on the qualifier of a "J") and exceeded the screening benchmark (blue bold text, light yellow highlight), it was then compared to additional criteria (e.g., the risk-level benchmark) to determine if there was potential for the constituent to pose risk. If not, the constituent was considered not to cause risk of harm, and was not carried forward for additional evaluation ("No" as designated in the last column on the table provided in Appendix F).

A number of PAH constituents were detected above the RL in sample DS-02 (corresponding to the Bridge Street Dam tailwater) only. A number of PAHs in this one sample also exceeded the screening benchmarks, these included benzo(a)anthracene, benzo(a)pyrene, benzo(k)fluoranthene chrysene, fluoranthene, phenanthrene, and pyrene. The results that exceeded screening benchmarks were compared to risk-level benchmarks, and two were found to exceed the risk-level values as well. These exceedances included phenanthrene (1500 µg /kg) and pyrene (2300 µg /kg) indicating the potential for probable risk. The two exceedances were retained as COPCs because the concentrations are indicative or suggestive of potential risk to aquatic life.

Metals
In Appendix F, metal concentrations are reported in milligrams per kilograms (mg/kg or ppm).

Arsenic was detected in the four sediment samples above RLs (the mean concentration was 1.66 mg/kg). These detections did not exceed the screening benchmark (9.79 mg/kg), and were also well below the background level of arsenic for Maine (9.4 mg/kg) as reported in Eco-SSLs.

Cadmium was only detected above the RL in sample IM-01; cadmium was not detected above the RLs in the remaining three samples. The concentration of cadmium (0.31 mg/kg) in sample IM-01 was below the screening benchmark (0.99 mg/kg).

Chromium was detected in the four sediment samples above the RL. The mean concentration (17.83 mg/kg) for chromium, and the maximum result for chromium (26 mg/kg) did not exceed the screening benchmark (43.3 mg/kg). Additionally, this maximum chromium concentration was below the Maine state-specific background concentration (71.2 mg/kg) as reported in Eco-SSLs.

Copper was detected in the four samples above the RL, but not the screening benchmark (31.6 mg/kg). Both the mean (6.58 mg/kg) and the maximum (11.7 mg/kg) concentration for copper were also below the Maine state-specific background concentration for copper of 28 mg/kg.

Lead was detected above the RL in the four sediment samples. However, both the mean (7.78 mg/kg) and the maximum (11.9 mg/kg) concentration for lead were below the screening benchmark (35.8 mg/kg). These concentrations were also below the specified background concentrations of Lead for Maine (19 mg/kg).

Nickel was also detected above the RL in the four sediment samples. Both the mean (10.3 mg/kg) and the maximum (16.7 mg/kg) concentration for nickel were below the screening benchmark (22.7 mg/kg). These concentrations were also below the background concentration of Nickel for Maine (30 mg/kg) as reported in Eco-SSLs.

Silver was not detected above the RL in any of the four samples.

Zinc was detected above the RL in the four sediment samples. Both the mean (34.63 mg/kg) and the maximum (58.9 mg/kg) concentration for zinc were below the screening benchmark (121 mg/kg). These concentrations were also well below the background concentration of Zinc for Maine (80 mg/kg) as reported in Eco-SSLs.

Mercury was only detected above the RL in one sample, DS-02, at a concentration of 4.1 mg/kg (total mercury). This concentration for total mercury exceeded the screening benchmark (0.18 mg/kg) as well as the risk-level benchmark (1.06 mg/kg). The exceedance of mercury was four-times greater than the probable risk level to potentially cause adverse risk to aquatic life. Therefore, it was determined that mercury would be retained as a COPC.

Polychlorinated Biphenyls (PCBs)
PCBs were analyzed as PCB congeners – ITM List or the NOAA & WHO Congener List (reporting concentrations for 27 congeners) by Method SW846 8082. Results for PCB congeners for the four sediment samples are reported in micrograms per kilograms (µg/kg, or ppb).

A few PCB congeners were detected just above laboratory RLs in the four samples; none of the detected congeners were consistent across the four samples (see Appendix F for more details). Because there are no sediment screening criteria established for PCBs, PCB congener data were summed (including those reported as the RL as they were non-detected concentrations) to provide a conservative estimate of total PCBs in order to be compared to the PCB, total screening benchmark (59.8 µg/kg). This benchmark was not exceeded in any of the four samples. Therefore, PCB congeners were not considered to exceed criteria.

A few PCB congeners were detected just above laboratory RLs in the four samples; none of the detected congeners were consistent across the four samples (see Appendix F for more details). Because there are no sediment screening criteria established for PCB congeners, PCB congener data were summed (including those reported as the RL as they were non-detected concentrations) to provide a conservative estimate of total PCBs in order to be compared to the total PCB screening benchmark (59.8 µg/kg). This benchmark was not exceeded in any of the four samples and, therefore, PCB congeners were not considered to pose risk to the environment in this area of the Royal River.

Conclusions

The mercury levels detected are at a concentration that is known to cause adverse effects to aquatic life and wildlife that may be exposed to river resources. This concentration represents total mercury, including that which is not fully bioavailable and the more bioavailable form of methylmercury. A point-source for the elevated mercury was not identified. However, as mercury was commonly used in the pulp and paper industry, it can only be speculated at this point that the mercury exceedance may be related to the historical paper company located on the river. It is unknown at this time whether this sample is a ‘hot spot’, or if this particular area may be a depositional area; additional sampling in the area would be required to address this concern. The collection and analysis of additional samples is recommended specifically for methylmercury, to determine if the concentrations of mercury are bioavailable.

Table 7: Threshold Effects Concentration Exceedances

Threshold Effects Concentration Exceeded	Screening Benchmark (ug/kg)	East Elm Street Dam		Bridge Street Dam	
		00348-IM-SED-01	00348-DS-SED-01	00348-IM-SED-02	00348-DS-SED-02
Benzo(a)anthracene	108				870
Benzo(a)pyrene	150				770
Benzo(b)flouranthene	240				760
Chrysene	166				880
Flouranthene	423				1800
PAHs Total	1610	3555	2738	2906	11048
Phenanthrene	204				1500
Pyrene	195				2300
Mercury	180				4100

Table 8: Probable Risk Concentration Screening Benchmark Exceedances

Probable Risk Concentration Exceeded	Screening Benchmark (ug/kg)	East Elm Street		Bridge Street	
		00348-IM-SED-01	00348-DS-SED-01	00348-IM-SED-02	00348-DS-SED-02
Phenanthrene	204				1500
Pyrene	195				2300
Mercury	180				4100

The multiple PAH exceedances were reported in the same sample as the mercury exceedance (DS-02). The two PAHs (phenanthrene and pyrene) that exceeded the risk-level benchmarks are at levels to potentially cause adverse risk to aquatic life and wildlife that may rely on the aquatic life and river resources. It is unknown at this time if this particular area has the potential to cause risk due to sediment exposure of PAHs.

Although a few PCB congeners were detected above the RL, PCBs are not considered COPCs for the Royal River at the concentrations reported. PCBs are considered to be ubiquitous environmental contaminants and are dispersed via atmospheric transport along with other transport mechanisms. Therefore, at such low levels as the detected concentrations, these constituents are not expected to cause adverse risk in the environment.

In summary, there appears to be no potential risk of adverse effects to aquatic life from three of the four sediment samples that were analyzed: IM-01; DS-01; and IM-02. In sediment sample DS-02, there were exceedances of both the screening benchmarks and the risk-level benchmarks for three constituents (mercury, phenanthrene and pyrene). The location of this sample is some distance downstream of the Bridge Street Dam and below the Sparhawk Mill, however, and it is unknown at this time if sediments at this downstream location would be mobilized following the removal of this dam.

3.3.6 Ice Jams

A dedicated evaluation of the potential for ice jams resulting from project actions was not performed as part of this feasibility study; however, two historical ice jams below the Bridge Street Dam near the USGS gaging station were located in a query of the Ice Jam Database maintained by the USACE Ice Research Group, Cold Regions Research and Engineering Laboratory (CRREL). The relatively flat gradient along sections of the Royal River, including the impoundments formed by the Bridge Street and East Elm Street dams, may enhance the formation of ice jams within the Royal River Corridor.

3.4 Groundwater Resources

A qualitative analysis was performed to evaluate impacts to groundwater resources in the Royal River watershed resulting from the modification or removal of the Bridge Street and East Elm Street dams and the associated effects on upstream water levels. A site conceptual model was developed and applied to each site to allow for qualitative analysis of the impacts of impoundment drawdown on nearby domestic wells. Based on the inferred hydrogeologic conditions, a qualitative approach is deemed adequate to draw reasonable conclusions.

<u>Site Conditions</u>

The Royal River watershed encompasses approximately 141 square miles (Figure 1) and receives approximately 45 inches of precipitation each year. The Bridge Street and East Elm Street dams convert approximately 27,000 linear feet of riverine habitat into approximately 8.75-acre and 65-acre impoundments, respectively.

The morphology of the Royal River varies substantially from the head of the East Elm Street Dam impoundment to tidewater, with reach-scale morphology being strongly controlled by bedrock outcroppings and channel encroachment resulting in hydraulic control in the vicinity of the East Elm Street Dam and downstream to tidewater. Upstream from the East Elm Street Dam, the river is largely unconfined as it flows through deposits of sand, gravel, and glacio-marine silts and clays.

Surficial soils within the project area are primarily glacio-marine clays and silts and sand and gravel deposits associates with marine fans and marine near shore deposits formed along the margin of the Late Wisconsin Ice Sheet during marine resurgence and regression following the last glacial epoch. Stream alluvium consisting of sand, silt, and minor amounts of gravel form the river corridor along the East Elm Street Dam impoundment. Downstream from the East Elm Street Dam, stream terraces, formed by the down cutting of the river through previously deposited material of glacial or post-glacial age, are situated above the modern day floodplain. Bedrock outcroppings are prevalent at the in the vicinity of the East Elm Street Dam downstream to tidewater.

Published hydrogeologic maps indicate that there are significant sand and gravel aquifers immediately upstream from the East Elm Street Dam impoundment (Maine Geologic Survey [MGS], 1999) and that overburden depths in the vicinity of the Bridge Street and East Elm Street dams range up to 140 feet (MGS, 1999). Several overburden wells currently being utilized by municipal and domestic water supplies were noted in the project vicinity. A review of overburden well depths indicates that overburden wells situated in the vicinity of the project area generally vary between 70 and 100 feet.

Groundwater in the vicinity of the site is generally close to the ground surface; depths to groundwater reported on maps developed by the MGS (1999) range from 4 to 12 feet below ground surface, and are presumed seasonally variable up to 10 feet. Deeper depths to groundwater are noted further from the river in areas where the ground surface gains in elevation. Site observations indicate that a number of spring seeps emerge elevated lands surrounding the impoundments.

Site Conceptual Model

Potentiometric surface data from MGS (1999) suggest that the Royal River is gaining water fed by groundwater discharge from overburden soils and underlying fractured bedrock. Because the local water table is relatively high compared to the surface of the river, it is likely that the river receives groundwater discharge from overburden soils and underlying bedrock for much of the year. An idealized diagram of the inferred site conditions, as presented in the Groundwater Handbook for Maine[9], is provided in Appendix G (Figure 1).

While a portion of the precipitation that infiltrates into overburden soils will daylight via springs and seepage, most of the water infiltrates to the underlying fractured bedrock. Fracture systems transmit infiltrated water downward into the larger regional flow. While the river serves as a potential source for downward infiltration, upward hydraulic gradients in the vicinity of the river likely limit the contribution of surficial waters to groundwater recharge. Recharge of the bedrock aquifer occurs on a regional level, with infiltration occurring over a large area, from saturated overburden in the region.

In the vicinity of the Royal River, water table depths and groundwater flow patterns are strongly influenced by surface topography. Depths to water as reported on the MGS (1999) show that groundwater contours follow surface topography. It is assumed that there are groundwater divides to the northeast and southwest of the river (similar to watershed boundaries), and that flow moves from northwest to southeast under the river valley floor. The impoundments likely influence the potentiometric surface data in the immediate vicinity of the impoundments; however, general subsurface flow patterns and potentiometric pressures develop on a regional level.

Analysis of Impacts to Wells

While not expected to be significant, a lowering of hydraulic pressures in the near-field vicinity of the impoundments will occur due to a lowering of river stage, causing a shift in subsurface flow patterns. Well bore storage may decrease in wells constructed in overburden immediately surrounding the impoundments, with a smaller change occurring in overburden wells located farther away from the impoundments. The magnitude of the groundwater potentiometric surface drawdown at a distance from the river is, in large extent, a function of subsurface soil properties. Porous soils, such as sands and gravels, would result in a larger area of drawdown, while less porous soils would tend to limit the overall extent of a drawdown. Well bore storage in shallow overburden (i.e., ‘dug’) wells would be the most severely impacted under a drawdown scenario, with relative well bore storage in deeper overburden wells less affected. As dug wells are becoming very uncommon and the majority of the wells in the project vicinity, as noted on the MGS (1999) significant sand and gravel aquifer map (Figure 2, Appendix G), are

[9] Caswell, W.B., 1975. Groundwater Handbook for the State of Maine. U.S. Department of the Interior, Maine Geologic Survey. Augusta, Maine.

located a minimum of several hundred yards distance from the river, impacts to well bore storage is anticipated to be minimal. However, a detailed water well survey of project abutters was not conducted as part of this study and it is therefore conceivable that several such wells may exist in the subject river reaches. The relative depths of saturated overburden in the vicinity of the river all but eliminate impacts to wells drilled into fractured bedrock.

Overall changes to the well bore storage in bedrock wells located near to the river as a result of fluctuation in river stage height are anticipated to be small unless a bedrock well and its associated fracture system are in hydraulic isolation with water infiltrating down from the river. Flow patterns and pressures typically developed on a regional level will continue to control water levels in bedrock wells. A cursory review of information available on a map of bedrock well yields (MGS, 1999; Figure 3, Appendix G) revealed no correlation between well yield compared to the distance from the impoundments.

In conclusion, the removal of either the Bridge Street Dam and/or the East Elm Street Dam would have negligible impacts to bedrock well users in the vicinity of the Royal River and elsewhere, with limited potential for localized effects on overburden well users.

3.5 Existing Infrastructure

Identified infrastructure in the immediate vicinity of the Bridge Street Dam includes the Bridge Street bridge, Sparhawk Mill penstock and hydroelectric generation facility, US Route 1 bridge, and the Beth Condon foot bridge. Infrastructure identified in the immediate vicinity of the East Elm Street Dam includes the East Elm Street bridge, the Grand Trunk Railroad bridge, the Maine Central Railroad bridge, overhead power transmission lines, a dry hydrant along Route 9, the Route 9 bridge, and a water supply pipeline to North Yarmouth. With the exception of the Sparhawk Mill penstock and hydroelectric facility, an evaluation of each of these structures as relates to the project alternatives was not undertaken as a part of this study but would likely be required should an alternative be selected which could decrease water levels in the vicinity of such structures. A study of the Sparhawk Mill penstock and hydroelectric generation station facility is included in Appendix I, with relevant information summarized below.

According to available public information, the Sparhawk Mill generation facility is currently owned by Sparhawk Mill Associates. Low-head hydroelectric power is generated at the Sparhawk Mill from water impounded at the Bridge Street Dam. The Sparhawk generation facility was approved by the Federal Energy Regulatory Commission (FERC) in 1984 at a 270 kW total output level, and operates under an exemption as FERC #08417. That exemption and continued operation is subject to compliance with requirements of the Maine Department of Inland Fisheries and Wildlife. As described elsewhere in this report, the dam and appurtenant structures are owned by the Town of Yarmouth, which is responsible for ongoing maintenance and repairs to the dam structures. It is unclear what infrastructure maintenance or repair responsibilities fall to the Sparhawk Mill owners.

The Sparhawk Mill generation facility located in the subbasement of the mill consists of three 1984 Hydrolec H-9-H “tube-type” full-immersion turbines with a maximum rated output of 90 kW per turbine at flows of 80 cfs or higher. Lower flows produce proportionally lower outputs. The turbines were manufactured by the Hydrolec Division of Leroy Somers, in Granby Quebec, in the mid-1980s. Hydrolec went out of business in 1989; as a result, spare and replacement parts are not readily available. Only two of the three turbines were reported to be functioning at the time of this study.

The Bridge Street dam provides low-head water to the turbines through a metal penstock that was reportedly fabricated from several old railroad tank cars. The penstock is approximately 200 feet long and 7 feet in diameter. The dam’s left abutment contains a 10-foot wide concrete intake structure that includes a 45-foot long fish screen and a 10-foot-wide trash rack. A head gate located behind the trash rack controls flow to the penstock. The penstock enters the mill and splits into three draft tubes that contain the three turbine units, with butterfly shutoff valves controlling flow to each turbine independently. The turbine units are fully-immersed in the water flow within the draft tubes. Below the turbine generators, the draft tubes discharge water back into the Royal River through a 15-foot-wide, 70-foot-long tailrace.

3.6 Recreational Factors

Recreational use of the existing impoundments is predominantly limited to the East Elm Street impoundment. The limited size and lack of dedicated public boat launching facilities are likely factors limiting usage of the Bridge Street Dam impoundment.

3.6.1 Boating

Recreational boating on the East Elm Street Dam impoundment is limited by the spacing of public access locations (State Route 9, East Elm Street); however, numerous private "hand carry" boat launch facilities and private docks were noted along the river between State Route 9 and East Elm Street during the wetlands characterization conducted during November 2009. No public boat launching facilities were noted along the Bridge Street impoundment. Three personal watercraft were observed along the East Elm Street Dam impoundment during field surveys for this project.

The primary recreational boating use of the East Elm Street impoundment is reported to be by individuals using canoes and kayaks. Scheduled boating activities appear to be limited to use by the Yarmouth High School physical education program, which reportedly conducts canoeing classes for a few days each spring for graduating seniors in the East Elm Street impoundment. The river downstream of East Elm Street is written up as a challenging white water stretch in the AMC River Maine River Guide.

3.6.2 Fishing

Evidence of recreational fishing was observed by Stantec during several site visits during late summer and early fall of 2009, including discarded fishing line, lures, bobbers, and hooks on snags in the impoundments. On several occasions people were noted actively fishing near the confluence of the "Foundry Channel" and the main stem of the Royal River below the East Elm Street Dam. The placement of a number of brown trout in the Royal River as part of the stocking program administered by MDIFW was noted as the primary attraction by one of the anglers encountered.

3.6.3 Hunting

Evidence of hunting was limited to shotgun shell casings found along the East Elm Street Impoundment during field surveys conducted in November 2009. The primary hunting usage of the Royal River impoundments is likely by duck hunters; however, due to statutory rules governing the legal set-back distances from residential units much of the primary waterfowl habitat along the river corridor is unavailable to duck hunters. A portion of the floodplain adjacent to the river is likely also utilized by hunters seeking upland game (e.g., wild turkey (*Meleagris gallopavo*), white-tailed deer).

3.6.4 Trapping

Evidence of the trapping of furbearing mammals (e.g., beaver, muskrat, mink) occurring in the East Elm Street Dam impoundment was noted during an October 2009 field survey. A sign was posted near a beaver slide asking trappers to please refrain from trapping beaver in the immediate area of the sign. A single drowning-set style trap setup was noted at another location along the impoundment. The Bridge Street Dam impoundment was not surveyed for trapping usage, as this is well within the developed portion of the town and therefore off-limits to trapping by law.

3.6.5 Other Recreational Uses

Reports of ice skating and cross-country skiing along the frozen course of the river were received but not observed during field surveys. Ice skating and skiing are limited to winter when the impoundment has suitable ice and snow cover. Several locations apparently popular among swimmers were also noted by the presence of such features as docks, rope swings, and steps carved into the clay banks of the river. Adjacent to the river, numerous private picnic and camping facilities were noted by the presence of picnic tables and stone fire rings.

3.7 Historical and Archaeological Resources

Stantec contacted the Maine Historic Preservation Commission (MHPC) by letter requesting information on historic resources within the project area. The response letter from the MHPC indicates that archeologically sensitive and historic properties may be affected by the project as presented to MHPC and further consultation with MHPC would be required prior to modification or removal of the East Elm Street and/or Bridge Street dams. The MHPC response is included as Appendix C.

Stantec subsequently contracted with Public Archaeological Laboratories (PAL) to conduct a cultural resources assessment as the first step in determining the presence of any significant archaeological or historical resources within the Project's preliminary Area of Potential Effect (APE). The objective of the cultural resources assessment was to identify previously surveyed above-ground resources over 50 years of age; identify known archaeological resources within the Project's APE that are listed or potentially eligible for listing in the National Register of Historic Places (National Register); and develop recommendations and cost estimates for additional survey efforts that may be required as part of future project planning. The PAL report is provided in Appendix H.

Historical Resources

Bridge Street Dam

The earliest reference to a dam located on the Bridge Street Dam site noted by PAL is from an 1871 map of Yarmouth Village[10]; however, the first documented industrial usage of the Second Falls occurred in 1816 therefore it is likely that a dam existed at Second Falls prior to the 1871 reference. Written descriptions from the turn of the century describe the 1871 dam structure as a stone and wood structure built to power and provide sanitation water to the Royall River Manufacturing Company facility, later known as the Sparhawk cotton fulling mill complex or Sparhawk mill. The exact date of the construction of the current concrete dam was not identified, but it seems likely that the current Bridge Street Dam was constructed circa 1910 when the breast wheel powering the mill was replaced with a new and more efficient Rodney Hunt Company turbine. Yale Cordage, a former mill tenant, renovated the hydropower infrastructure of the mill for hydroelectric generation in 1986. The work performed by Yale Cordage included rehabilitation of the dam and installation of new turbines and generators in the basement of the mill. The existing forebay and penstock gate on the northeast end of the dam were likely constructed at this time. The original construction configuration of the dam did not include fish passage facilities, effectively blocking upstream passage of resident and anadromous fish.

The Bridge Street Dam and a right-of-way over adjoining property were acquired by the Town in 1973. The flowage rights associated with the Bridge Street Dam were also acquired at that time; however, they are limited to maintaining or lowering the existing water level. The MEDMR contracted with the Town to construct a fish passage facility at the Bridge Street Dam in 1974, and a Denil-type fishpass was subsequently constructed adjacent to the right spillway abutment of the dam. The MEDMR maintains a lease from the Town to operate the fishpass; however, budget shortfalls periodically prohibit maintenance activities leaving the fishpass inoperable during some seasons.

According to the PAL assessment, the Bridge Street Dam does not appear to be individually eligible for the National Register under Criterion A, B, or C because of its late date of construction and common design characteristics. However, the dam is potentially eligible for the National Register under Criterion D as a contributing element to a potential industrial archeological district. The recent modifications to the dam, which took place outside of the historic period, are consistent with the continued usage of the dam for hydropower and do not result in a loss of historical integrity.

Middle Falls

The earliest manufacturing activities at the Third Falls (also known as Baker's, or 'Middle Falls') noted by PAL are said to have begun in 1805 and 1808, although accounts of these Federal-era works are

[10] F.W. Beers & Co. 1871 *Map of Cumberland County, Maine.* F.W. Beers & Co., New York, NY.

somewhat confused. In 1805, Jeremiah Baker opened a carding mill and grist mill on the east side of the river. These mills, or a fulling mill operated by Benjamin Gooch, are supposed to have continued operation until 1849. In 1808, an iron works or nail mill also began manufacturing goods at the site, although no other information concerning the mill's proprietor, location, or operating dates has been uncovered. By other accounts, Joseph C. Batchelder is supposed to have run a scythe and axe factory on the southwest side of the river during this period (Rowe 2000:323; Yarmouth Historical Society n.d.). An 1857 map of Yarmouth[11] shows a single unidentified mill building on the southwest side of the river. A bridge crossing (no longer extant) over the river is also shown, along with an unlabeled building on the northeast river bank.

The Yarmouth Paper Company mill was constructed at the Third Falls in 1864. The 1871 F.W. Beers & Co. map of Yarmouth mentioned above shows a complex of three or more interconnected buildings, identified as the Yarmouth Paper Mills on the southwest bank of the Royal River, opposite Factory Island. Another building was located on the northeast bank of the river and identified as the property of McHay (F.W. Beers & Co. 1871). In 1872, H.M. Clark, Homer F. Locke, and Henry Furbush purchased the site and built a new wood pulp mill for paper making that used the relatively new soda process, which cooked poplar wood chips in large pressurized vats, or digesters, with caustic soda to produce paper pulp. The partners were reportedly the first company to use the process in New England. In 1874, they sold their rights to S.D. Warren and George W. Hammond, who formed the Forest Paper Company. The soda process produced a high-quality pulp suited for book and magazine paper and the Forest Paper Company prospered for the next 50 years.[12]

Numerous expansions of the physical plant were made until the Forest Paper Company occupied 10 buildings on more than 10 acres of ground between the river and Main Street. These were located along the west bank of the river and on Factory Island. Two bridges and an elevated platform allowed workers to pass between the main factory and the digesters, which were located on Factory Island. During this period, the Forest Paper Company was reputed to be the largest single soda mill in the country, employing about 250 men and consuming thousands of tons of coal and chemicals, as well as 35,000 cords of wood annually. Waste products from the mill, including coal firebox clinker and the so-called black ash that resulted from the chemical recovery process of spent caustic soda were deposited widely in Brickyard Hollow, adjacent to Main Street between the two villages of Yarmouth, and on the northeast bank of the river at the current location of Forest Falls Drive. The machinery from the mill was salvaged for use elsewhere after the mill closed in 1923. The plant burned in a fire in 1931, with the ruins of the mill demolished piecemeal and converted to part of the Royal River Park in the 1980s. During the same period, the 15-20-foot deep black ash waste piles on the northeast bank of the Royal River were converted into Forest Falls Drive commercial park.[13] No mention of a the date of demolition of a dam at this site was identified by PAL during the course of this work; however, it is likely that one or more existed to power the former mills constructed around the Middle Falls.

East Elm Street Dam

The earliest reference to a dam located near the existing East Elm Street Dam site noted by PAL is credited to a dam built by Jeremiah Powell and partners at the Fourth Falls in 1759, under a mill privilege let by the Town, to power an "iron refinery" (likely a blast furnace or bloomer forge) that converted ore mined in the watershed to cast or wrought iron. According to Town historian William H. Rowe[14], the blast furnace or forge was reputedly on the southwest bank of the river immediately upstream of the inlet to

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[11] Chace, Jr., J. *1857 Map of Cumberland County, Maine*. J. Chace, Jr. Philidelphia, PA.

[12] S.D. Warren Company. 1959. *A Short History of the S.D. Warren Company, 1854-1955*. The S.D. Warren Company, Westbrook, Maine.

[13] Holman, Mary. 1995. "Forest Paper Company, 1874-1923: Yarmouth's Industrial Legacy and the Royal River." *River Times* Winter 1995:5.

[14] Rowe, William Hutchinson, 2000. *Ancient North Yarmouth and Yarmouth, Maine: 1636-1936. A History*. Reprinted by the Yarmouth Historical Society, Yarmouth, ME and Picton Press Rockport, Maine.

Forge Mill Stream (placing it at or near the present location of the Yarmouth Water Department building). If this is the case, it is likely that the early dam(s) at the Fourth Falls was located upstream from the present dam location at or near a bedrock outcropping visible from the public boat launch behind the Yarmouth Water Department building, as engineering principles would suggest that the furnace/forge would have been located where it could take full advantage of the fall of water, not upstream of the falls in a becalmed impoundment. Rowe also reported that Forge Mill Stream was constructed by Powell, but this has not been confirmed.

John Gooch took occupancy of the mill privilege in 1795 and operated a gristmill on the north bank of the river until 1819. Gooch also established a sawmill in 1813 associated with the falls; however, the location of this mill is also uncertain. Rowe states that a large double sawmill built "on the dam" (Rowe 2000:323) made a successful business milling the pine forests of inland Maine until 1831, when a large flood swept away the mill (Rowe 2000:323-324; Yarmouth Historical Society n.d.).

Between 1813 and 1876, use of the Fourth Falls was decentralized amid a rapid succession of occupants in several smaller mills whose exact locations, infrastructure, and proprietorships have yet to be determined. These included a smaller sawmill on the northeast bank of the river; a carding/fulling mill on the southwest bank; a turning mill; and a paper mill. Chace's 1857 map of Yarmouth identified a sawmill on the southwest bank of the river and a second sawmill and a tannery on the northeast bank of the river. Neither the dam nor the Forge Mill Stream were indicated (Chace, Jr. J. 1857; Rowe, 2000:328). The 1871 map of Yarmouth Village indicated the location of a dam between the southwest river bank and Gooch Island, but no dam between Gooch Island and the northeast river bank. Also shown were three buildings on the southwest river bank belonging to the Yarmouth Flour Mills, which supplanted the sawmill. These were located on the island formed by the Forge Mill Stream, which was also indicated, although not labeled as such (F.W. Beers & Com. 1871).

Charles H. Weston consolidated control of the Fourth Falls to power his machine chops in 1876. This complex was built at the former location of the Yarmouth Flour Mills on the southwest side of the main channel, adjacent to the dam. The company produced a variety of equipment and machines for mill infrastructure and manufacturing until circa 1892-1898, when it vacated the premises for unknown reasons. An 1885 map of Yarmouth Village[15] indicates Weston's machine shops, but not the dam itself (F.W. Beers 1885; Rowe 2000:328). The 1885 map also shows the Hodsdon Brothers & Company Shoe Factory on Forge Mill Stream. One Mr. Farris had built a "modern tannery" at the Hodsdon Brothers location in the 1870s (Rowe 2000:324); the operation failed in 1877, and the building was subsequently occupied by the Hodsdon Shoe Company beginning in 1880. Prior to moving into the new facility, the Hodsdon Shoe Company had occupied space in a portion of the Weston Machine Shops. The Maine state dam inventory records indicate that the current dam structure was constructed in 1890, placing it under the tenure of the Hodsdon Brothers & Company Shoe Factory and Charles H. Weston's machine shops. A 1902 plan of land shows a dam situated on the approximate alignment of the current structure, as well as a small dam on the upstream end of the shoe factory over Forge Mill Stream. The Fourth Falls provided power for manufacturing and water for industrial sanitation until the 1960s, when the last industrial facility at the Fourth Falls, a poultry slaughter house, closed.

The Town acquired the East Elm Street Dam, flowage rights, and adjacent property in 1971. The MEDMR contracted with the Town to construct a fish passage facility at the East Elm Street Dam in 1979, and a Denil-type fishpass was subsequently constructed adjacent to the right spillway abutment of the dam, on or near the former location of the Weston Machine Shops. The MEDMR maintains a lease from the Town to operate the fishpass; however, similar to the Bridge Street fish passage facilities, budget shortfalls periodically prohibit maintenance activities leaving the fishpass inoperable during some seasons.

[15] F.W. Beers & Co. 1885 *Map of Cumberland County, Maine.* F.W. Beers & Co., New York, NY.

According to the PAL assessment, the East Elm Street Dam does not appear to be individually eligible for the National Register under Criteria A, B, or C due to a loss of integrity that renders it unable to convey its significance as an ancillary structure supporting industrial development at the Fourth Falls. Industrial facilities associated with the dam are now demolished and the dam has been altered by the insertion of a fishpass in the historical location of the Weston Machine Shops raceway. The dam setting has also been impacted by the construction of a modern residence at the structure's north end. However, the dam may be eligible for the National Register under Criterion D as a contributing resource to a potential industrial archeological district.

<u>Archaeological Resources</u>
The preliminary cultural resources assessment of the Bridge Street and East Elm Street Dams study area indicates that favorable conditions exist for both pre-contact and post-contact/industrial archaeological resources to be present within the planning area. For the purposes of clarity, the pre-contact archaeological sensitivity and potential associated resources are discussed with reference to the entire proposed APE, while post-contact sensitivity and resources are discussed first by reference to the entire proposed APE and then by individual Action Area.

Pre-contact Archaeological Resources
In its comment letter regarding the Project, the MHPC provided a map showing the location pre-contact period site 14.159 (approximately one mile upstream of the East Elm Street Dam near the bank of the river). The map also illustrates the extent of pre-contact archaeological survey adjacent to and near the project corridor, as well as "archaeological sensitive river bank that would require some level of survey prior to alteration" of riverine water levels.

The potential for the survival of pre-contact resources will be largely dependent on the degree of landscape alteration that has occurred as part of the industrial, commercial, and residential development of the river. The area between the two documented mill complexes located between the two dams likely has been heavily modified by industrial mill and factory activities as well as more recent landscaping activities associated with the greenspace trail of the Royal River Park. While this historical disturbance may not completely preclude the recovery of pre-contact period materials, the stratigraphic integrity and associated interpretive value of those materials likely would be compromised.

Conversely, there are several areas within the project area that appear to have undergone relatively minimal historic period or modern disturbance, such as Gooch Island, the area between the mill remains, and the stretch of impoundment above the East Elm Street Dam. The identification of site 14.159 in the latter corroborates this assessment, and it is likely that additional pre-contact archeological sites may be present within the portions of the project planning area that exhibit similar favorable environmental attributes. Based on a preliminary review of its constituent soils, the study corridor is dominated by moderately to well-drained silty and sandy loams on gently to moderately sloped terrain. These soil conditions, combined with the proximity to the river and its many natural falls, would have made it an attractive location for camp sites associated with riverine/estuarine subsistence activities, especially during the Late Archaic and Woodland periods.

Post-contact Archaeological Resources
There are numerous locations within the study area between the East Elm Street and Bridge Street dams that contain visible surface remains of industrial sites associated with the historically documented nineteenth- and twentieth-century mill complexes (see above). Archaeological deposits associated with these mills may include additional foundation/masonry remains, dam structures, raceways (headrace, tailrace, and spillways), wheel and turbine pits, other water power features (water control gates), machine parts, ancillary work areas, domestic refuse, and features (e.g., trash middens, privies).

The study area also has the potential to contain domestic and/or worker housing/tenement sites. These types of archaeological sites are generally located in proximity to large mill complexes and typically contain foundation remains, sheet refuse, trash middens, garden plots, privies and outbuilding structures.

A review of the 1871 map of Yarmouth indicates numerous buildings along the river between the Bridge Street and East Elm Street dams. Many of these buildings are likely associated with the visible mill foundation remains along the river. The identification of an extant late eighteenth-century farmstead within the study area north of the East Elm Street Dam suggests that potential for other similar site types within the study corridor as well, such as barn and outbuilding foundations, cart paths, and sheet middens associated with agricultural activities throughout the eighteenth, nineteenth, and twentieth centuries.

The known and potentially industrial archaeological remains throughout the study corridor could constitute individual archaeological districts as indentified by each Action Area, or a single archaeological district spanning the entire river corridor from Bridge to East Elm Streets. Such a district(s) may be eligible for the National Register under Criterion D for its potential to provide substantive information about the evolution and maturation of industrial development of Yarmouth. Industrial resources within the district(s) such as stone dams have the potential to reveal important information about vernacular dam construction techniques that are poorly documented in the written record. Additionally, they may contain portions of earlier dams or hydropower infrastructure that can supplement or improve our understanding of the history of industrial activity at water privileges as it appears in the written record.

Based upon the summary history provided above, several specific potential resources can be identified in the current Action Areas:

Action Area 1

Action Area 1 upstream and downstream of the Bridge Street Dam was the site of several mill interests dating from 1816 to the early twentieth century. Paper production was the first industry followed by fulling, cabinet works, and brick. Potential industrial resources that might survive upstream of the dam include structural and/or landscape remains associated with: the Hawes & Cox paper mill/Yarmouth Paper Company (ca. 1816-1840); the True & Gooch fulling mill (ca. 1818-1830); and the Kimball cabinet works (circa 1840-1849). It should be noted that these mills reportedly were built on or near the same locations as one another, and that in at least one instance, the Hawes & Cox mill foundation elements were reputedly visible until circa 1940 (Rowe 2000:323).

Downstream of the dam, the Royall River Manufacturing Company began producing textile in 1857, later transitioning to grain bag production under various different owners from 1869 – 1951. In addition to the primary mill buildings themselves, a broad range of associated structural and landscape resources have been documented through photographs, maps, and town histories, including a stone or timber crib dam, mill race, boardinghouses, storehouses, a boiler house, a blacksmith shop, and offices.

Action Area 2

Action Area 2 contains visible remains of the Forest Paper Company pulp mill within Royal River Park on the southwest river bank and on Factory Island. These remains include foundation walls, dam abutments, and training walls lining the stream channel, as well as bridge piers, machine pads, and a wheel pit and associated wheel house. While no archaeological survey work has been completed to date, the site may be eligible for the National Register under Criterion D for its potential to reveal information concerning the development of Yarmouth's paper industry, which was an important local economic pursuit.

Action Area 3

Action Area 3 and the surrounding proposed APE contain the documented sites of important industrial activity along both banks of the Royal River and the Forge Mill Stream that began in the Colonial period. Historical industries in the area included Jeremiah Powell's 1753 bloomery forge or furnace; a succession of early and mid-nineteenth-century mills and or tenancies including sawmills, a grist mill, a tannery, a turning mill, a paper mill, and a fulling mill; and the Hodsdon's Shoe Company and Weston Machine Shops in the early twentieth century. Brick and stone foundations are visible along the Forge Mill Stream and at the documented tannery site on the northeast river bank.

3.8 Penobscot Indian Nation, Passamaquoddy Tribe, and Houlton Band of Maliseet

Stantec contacted the Penobscot Indian Nation (PIN; Penobscot), Passamaquoddy Tribe (Passamaquoddy), and Houlton Band of Maliseet (Maliseet) by letter requesting information on potential impacts to Penobscot, Passamaquoddy, and Maliseet tribal concerns within the project area. The Passamaquoddy Tribe Historic Preservation Officer (THPO) responded via email recommending that an action plan be implemented using trained archeologists to collect native American artifacts that would likely be exposed should an impoundment drawdown or full dam removal occur. The PIN THPO responded via letter stating that the PIN does not have concerns related to a change in water levels within the system, but requested that contact be initiated with the PIN THPO should native American artifacts be found. A response from the Maliseet was not received. The Penobscot and Passamaquoddy THPO responses are included in Appendix H.

3.9 Potential Future Uses of the Dams

3.9.1 Bridge Street Dam

This study included an analysis of the existing and potential hydropower generation at the Bridge Street site. The analysis focused on evaluating 1) the theoretical maximum power potential at Bridge Street based solely on river flows; 2) the estimated power output from the existing generation equipment at the Sparhawk Mill; and 3) the estimated dollar values of both scenarios. This analysis was based on observations made at the dam and river locations, calculations from historic river flow data, and publicly available reports. No engineering inspection of the generation equipment inside the Sparhawk Mill was made for this study, but a previous engineering study from 2007 was reviewed.

The complete hydropower analysis is provided as Appendix I.

The current power generation output from the Sparhawk Mill is not reported publicly or to the Town on a regular basis. According to an article in the Portland Press Herald (PPH, 2008), former mill owner Daniel Coyne reported that the site's "annual typical output is 850,000 kilowatt hours", although the operation slows to a nearly complete halt in July and August. The system reportedly runs at irregular rates at other times throughout the year. Based on operational and flow assumptions, Stantec has estimated the annual energy output for the Sparhawk hydropower facility to average 1,111,000 kWH per year with all three turbines running at normal operational levels, and 784,000 kWH per year with only two turbines operational. The actual production figures would fluctuate from year to year based on river flows, the condition of the turbines, and penstock flow management. Using a current 2010 energy price of $0.07 per kWH, and assuming net metering remains applicable (i.e., unused power is purchased by the utility, in this case CMP) the annual energy output of three operating turbines could have a value of approximately $78,000 if all power was sold to CMP and no power was consumed within the mill. With only two turbines operational, the value would be in the vicinity of $55,000.

Due to the dam's distance and relative impoundment elevation as compared to nearby vehicular access points, the Bridge Street Dam impoundment is not considered to be a viable source of water for fire suppression.

3.9.2 East Elm Street Dam

The East Elm Street impoundment was identified as a potentially viable source of water for fire suppression in the vicinity of East Elm Street due to the ease of vehicular access and the relative elevation of the impoundment compared to vehicular access; however. no dry hydrant was noted in this area. A bedrock formation located in the river channel immediately above the Water Department building would likely maintain a pool of water sufficient for fire suppression purposes should a hydrant be constructed in this area.

A dry hydrant was noted near the Route 9 bridge crossing the Royal River in North Yarmouth; however, the relative elevation difference between the existing average water surface elevation and the dry hydrant head is significant as it may limit the capacity of the existing dry hydrant. Any action that lowered riverine stage in the vicinity of this structure would need to consider alternatives for the dry hydrant.

4.0 IMPACT ASSESSMENT

Direct and indirect adverse and beneficial impacts to the affected environment were assessed for the three project alternatives for each dam presented in this study. Impacts were evaluated with respect to existing conditions and the project goal of improving habitat connectivity between the lower and upper river for resident and diadromous fish. A qualitative impact rating system was used to assess impacts based on the assignment of varying levels of intensity of impacts associated with the project alternatives.

Level of intensity refers to the severity of the impact, whether it is negligible, minor, moderate, or major. The gradient of this system can be general or very detailed, but ultimately the assumptions and subjectivity of the system affect is sensitive. A simple and subjective rating system was used, which included a rating scale of No Effect, Negligible, Minor, Moderate, and Major impacts. The authors of this study based the rating system score on professional opinion and took into account the context or setting of the action and its resulting impact.

The definition of No Effect would be the same for each of the general impact topics. No effect would mean that no measurable effects could be recorded or surmised. Furthermore, the following definitions are used for the other, qualitative ratings.

- **Negligible:** Impacts would not be detectable, measurable, or observable.
- **Minor:** Impacts would be detectable, but not expected to have an overall effect on the resource.
- **Moderate:** Impacts would be clearly detectable and could have short-term, appreciable effects on the resource.
- **Major:** Impacts would be long-term or permanent, highly noticeable effects on the resource.

4.1 Project Action Area: Bridge Street Dam

4.1.1 No Action

Fisheries Resources
It is expected that this alternative would continue to have major adverse impacts and negligible beneficial impacts to fisheries resources in the upstream reach of the Royal River. A major adverse intensity level was assigned based on the current poor condition of native diadromous species populations in the Royal River.

Wetland Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to wetland resources between the dam and Middle Falls.

Wildlife Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to wildlife resources between the dam and Middle Falls.

Hydrology, Hydraulics, and Physical Processes
It is expected that this alternative would have continued major adverse impacts and negligible beneficial impacts to river hydrology, hydraulics, and physical processes. A major adverse impact intensity level was assigned to this alternative due to the continued presence of the dam affecting natural riverine processes such as flood storage capacity. While the impoundment could act beneficially as a

depositional area for sediments and woody debris, the nature of riverine conditions present during periods of high flow likely transport much of this material downstream under existing conditions therefore a negligible beneficial impact intensity level was assigned to this alternative.

Groundwater Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to groundwater resources between the dam and Middle Falls.

Existing Infrastructure
It is expected that this alternative would have negligible adverse and beneficial impacts to existing infrastructure (i.e., the Beth Condon bridge, US Route 1 bridge, and Bridge Street bridge) resources in vicinity of the dam. While the backwater created by the dam likely mitigates the potential for scour in the vicinity of the Beth Condon and US Route 1 bridges, the backwater alone does not eliminate the need for scour countermeasures at these structures due to the presence of riverine flow conditions that exist during high-flow events. The Bridge Street bridge is founded upon a bedrock outcropping and subject to riverine flows under existing conditions.

Recreational Factors
Implementation of this alternative would result in negligible adverse and beneficial impacts to the existing recreational usage in the Bridge Street impoundment. The recreational fishery supported by stocking of cold-water salmonids by the Department of Inland Fisheries and Wildlife would remain unchanged as long as supported by the state agency; however, the adverse effects on the recreational fishery for diadromous species such as shad would continue. Impacts to other recreational uses such as boating, cross country skiing, ice skating, and hiking are anticipated to be negligible.

Historic and Archaeological Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to historical and archeological resources.

Potential Future Use of the Dam
It is expected that this alternative would have negligible adverse and beneficial impacts to future uses of the dam.

4.1.2 Modified Fish Passage Facilities

Fisheries Resources
It is expected that this alternative would have negligible adverse impacts and moderate beneficial impacts to fisheries resources in the upstream reach of the Royal River. A moderate beneficial intensity level was assigned based on the current poor condition of native diadromous species populations in the Royal River and the potential to improve upstream fish passage with a better performing and maintained fishpass.

Wetland Resources
It is expected that modification of the Bridge Street Dam fishpass would have negligible adverse and beneficial impacts to wetland resources between the dam and Middle Falls.

Wildlife Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to wildlife resources between the dam and Middle Falls.

Hydrology, Hydraulics, and Physical Processes
It is expected that modification of the Bridge Street Dam fishpass would have negligible adverse and minor beneficial impacts to river hydrology, hydraulics, and physical processes.

Groundwater Resources
It is expected that modification of the Bridge Street Dam fishpass would have negligible adverse and beneficial impacts to groundwater resources between the dam and Middle Falls.

Existing Infrastructure
It is expected that this alternative would have negligible adverse and beneficial impacts to existing infrastructure (i.e., the Beth Condon bridge, US Route 1 bridge, and Bridge Street bridge) resources in vicinity of the dam. The backwater created by the dam would remain, mitigating the potential for scour in the vicinity of the Beth Condon and US Route 1 bridges. A redistribution of flow within the river channel below the Bridge Street Dam during periods of low-flow may occur; however, conditions would remain the same during high-flow events. A redistribution of flow within the river channel during periods of low flow is not anticipated to affect the Bridge Street bridge. Depending on requirements to maintain minimum flows in a modified fish passage, there could be a reduction in water availability to the Sparhawk Mill penstock during periods of low flow, which could periodically reduce hydropower generation at the facility. A potential benefit of this alternative is revenue generated to the Town by retention of the Bridge Street Dam and impoundment, and subsequent lease of the water rights to a hydroelectric plant located in the Sparhawk Mill complex.

Recreational Factors
Implementation of this alternative would result in negligible adverse and moderate beneficial impacts to the existing recreational usage in the Bridge Street impoundment. The recreational fishery supported by stocking of cold-water salmonids by the Department of Inland Fisheries and Wildlife would remain unchanged as long as supported by the state agency; however, the adverse effects on the recreational fishery for diadromous species such as shad would be reduced. Impacts to other recreational uses such as boating, cross country skiing, ice skating, and hiking are anticipated to be negligible.

Historic and Archaeological Resources
It is expected that this alternative would have minor adverse and negligible beneficial impacts to historic and archaeological resources. A minor adverse intensity level was assigned based upon the possibility of surficial ground disturbance associated with the movement of heavy machinery cutting, filling, and grading around the dams to accommodate the reconstruction of the fish passage; the installation of temporary coffer dams to re-direct the flow of the river during construction; and the creation of construction staging and access road(s) affecting potential historic and archaeological resources. A minor intensity level was chosen over higher intensity levels due to the ability of qualified individuals to recover or protect such artifacts prior to construction.

Potential Future Use of the Dam
It is expected that this alternative would have minor adverse and negligible beneficial impacts to future uses of the dam. A minor adverse intensity level was assigned based upon the possible reduction in water available for mill intake due to increased conveyance through the modified fishpass facilities.

4.1.3 Dam Removal

Fisheries Resources
It is expected that this alternative would have negligible adverse impacts and major beneficial impacts to fisheries resources in the upstream reach of the Royal River if upstream fish passage is improved at Bridge Street Dam and Middle Falls. A major beneficial intensity level was assigned based on potential for restoration of native diadromous species populations in the Royal River relative to their current poor condition. Beneficial impacts would also result from the commensurate increased awareness of natural resources and their dependence on the human stewardship in anthropogenically altered ecological systems.

Wetland Resources
It is expected that removal of the Bridge Street Dam would include minor impacts to wetland resources along the margins of the existing impoundment and some loss of lacustrine habitat between the dam and Middle Falls. A minor intensity level was assigned to these impacts as it is expected that wetland resources along the margins of the impoundment would reestablish at lower elevations along the waterway and ledge in this reach of the river, including in the vicinity of the dam and upstream from the existing footbridge.

Wildlife Resources
It is expected that this alternative would have negligible adverse and major beneficial impacts to wildlife resources between the dam and Middle Falls. Beneficial impacts associated with this resource result from the presence of increased numbers of forage fish, as represented by adult and juvenile diadromous species upstream from the dam, and increased riparian zone connectivity. Changes to the fish population would likely benefit wet-land dependent species such as river otter, osprey, and kingfisher by providing a larger and more diverse forage base. Open water habitat for waterfowl would decrease slightly, but not enough to affect use of the river by this group of wildlife species. Use of the river by opportunistic animals such as beaver, deer, and raccoon is not expected to change. Upstream from the Bridge Street Dam, the drawdown resulting from dam removal could have short-term benefits to shorebird species by providing larger areas of exposed impoundment substrates for feeding; however, these benefits would not likely persist for long as the exposed shoreline areas would likely become densely vegetated with plant species known to commonly inhabit riparian zones.

Hydrology, Hydraulics, and Physical Processes
The existing hydrology (flood regime) in the Royal River would not change; however, implementation of this alternative would result in minor adverse impacts and minor beneficial impacts to the hydraulic conveyance under the Beth Condon and US Route 1 bridges. Increased hydraulic conveyance under these structures would result in a reduction of upstream flood levels. A second beneficial impact is associated with the increased rate of flushing limiting the current eutrophication of the impoundment upstream of the Bridge Street Dam. Sediment transport capacity through this reach would increase, however, as this reach is not currently a major sediment depositional area due to the nature of riverine flows experienced during periods of high-flow, the impacts resulting from increased sediment transport as a result of dam removal are likely minimal.

Groundwater Resources
It is expected that removal of the Bridge Street Dam would include minor impacts to groundwater resources along the margins of the existing impoundment between the dam and Middle Falls. A minor intensity level was assigned to these impacts as it is expected that groundwater resources along the margins of the impoundment would be drawn down immediately surrounding the impoundment, with bedrock control limiting the depth of drawdown.

Existing Infrastructure
It is expected that this alternative could have moderate to major adverse and beneficial impacts to existing infrastructure the Beth Condon and US Route 1 bridges, and a minor adverse and beneficial impact to the Bridge Street bridge. A major intensity level was assigned to these impacts as removal of the dam may require scour countermeasures to be installed in the vicinity of the Beth Condon and US Route 1 bridges in anticipation of more powerful riverine flows during high-flow events. If such scour measures are required but are not installed, bridge failure could occur. Bedrock outcroppings are visible in the vicinity of the Bridge Street Dam impoundment, which is indicative of the likely presence of bedrock located a short distance below the ground surface. Therefore, a moderate intensity level was also assigned to this alternative, as these structures are likely founded upon bedrock. A scour analysis in the vicinity of these structures should be conducted prior to removal of the Bridge Street Dam. The Bridge Street bridge is founded upon a bedrock outcropping and subject to riverine flows under existing conditions and therefore is unlikely to be affected by removal of the Bridge Street Dam.

Removal of the Bridge Street Dam would necessitate the removal or modification of the existing penstock allowing water to be diverted from the river into the Sparhawk mill complex. This would result in elimination of hydropower generation at the mill and elimination of water use lease revenues to the Town.

Recreational Factors
Implementation of this alternative would result in minor adverse and major beneficial impacts to the existing recreational usage in the Bridge Street impoundment. The recreational fishery supported by stocking of cold-water salmonids by the Department of Inland Fisheries and Wildlife would remain as long as supported by the state agency; however, the impoundment would revert to a moving water fishery with a larger area of optimal fish habitat available. The adverse effects on the recreational fishery for diadromous species such as shad would be eliminated. Impacts to other recreational uses such as boating, cross country skiing, ice skating, and hiking are anticipated to be negligible; however, increased abundance of diadromous fish species within the project reach would afford additional opportunities for observing and photographing a variety of wildlife species targeting concentrated migratory fish species (e.g., bald eagles, ospreys, river otters, kingfisher).

Historic and Archaeological Resources
This alternative would have major adverse and negligible beneficial impacts to historic and archaeological resources. A major adverse intensity level was assigned based upon the removal of the dam and the possibility of surficial ground disturbance associated with the movement of heavy machinery cutting, filling, and grading around the dam to facilitate removal; the installation of temporary coffer dams to re-direct the flow of the river during construction; and the creation of construction staging and access road(s) affecting potential historic and archaeological resources. Additionally, a decrease in water level upstream of the dam could potentially affect archaeological resources that may be located along the impoundment.

Potential Future Use of the Dam
This alternative would remove the dam; therefore, a major adverse impact to future uses of the dam would result from this alternative.

4.2 Project Action Area: Middle Falls

4.2.1 No Action

Fisheries Resources
It is expected that this alternative would continue to have major adverse impacts and negligible beneficial impacts to fisheries resources in the upstream reach of the Royal River. A major adverse intensity level was assigned based on the current poor condition of native diadromous species populations in the Royal River.

Wetland Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to wetland resources in the vicinity of Middle Falls.

Wildlife Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to wildlife resources between the dam and Middle Falls.

Hydrology, Hydraulics, and Physical Processes
It is expected that modification of the Middle Falls would have negligible adverse and beneficial impacts to river hydrology, hydraulics, and physical processes.

Groundwater Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to groundwater resources in the vicinity of Middle Falls.

Existing Infrastructure
No existing infrastructure was identified in the vicinity of the Middle Falls; therefore, negligible adverse and beneficial impacts to existing infrastructure resources are anticipated to result from this alternative.

Recreational Factors
It is expected that this alternative would have negligible adverse and beneficial impacts to recreation in the vicinity of the Middle Falls.

Historic and Archaeological Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to historical and archeological resources.

4.2.2 Modification of the Middle Falls

Fisheries Resources
It is expected that this alternative would have minor adverse impacts and major beneficial impacts to fisheries resources in the upstream reach of the Royal River. A minor adverse intensity level was assigned based on the current poor condition of native diadromous species populations in the Royal River. A major beneficial intensity level was assigned based on the potential future condition of native diadromous species populations in the Royal River.

Wetland Resources
While a wetlands evaluation was not conducted at this site as part of this study, based upon previous work conducted by Stantec in the vicinity of the Middle Falls, it is expected that this alternative would have minor adverse and beneficial impacts to wetland resources in the vicinity of the Falls. A minor intensity level was assigned to these impacts as it is expected that wetland resources along the margins of the river would reestablish along disturbed reaches of the waterway and ledge in this reach of the river.

Wildlife Resources
It is expected that this alternative would have negligible adverse and minor beneficial impacts to wildlife resources in the vicinity of the Middle Falls (such as riparian zone habitat reconnectivity).

Hydrology, Hydraulics, and Physical Processes
It is expected that modification of the Middle Falls would have negligible adverse and minor beneficial impacts to river hydrology, hydraulics, and physical processes. A minor beneficial intensity level was assigned to this alternative because modification of the Middle Falls may result in increased hydraulic conveyance through this area, resulting in a reduction in upstream flood levels.

Groundwater Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to groundwater resources in the vicinity of Middle Falls.

Existing Infrastructure
No existing infrastructure was identified in the vicinity of the Middle Falls; therefore, negligible adverse and beneficial impacts to existing infrastructure resources are anticipated to result from this alternative.

Recreational Factors
It is expected that this alternative would have negligible adverse and beneficial impacts to recreation in the vicinity of the Middle Falls.

Historic and Archaeological Resources
This alternative would have major adverse and negligible beneficial impacts to historic and archaeological resources. A major adverse intensity level was assigned based upon the removal of an existing causeway to factory island and/or mill foundation structures constructed within the channel and the possibility of surficial ground disturbance associated with the movement of heavy machinery cutting,

filling, and grading around the falls to facilitate modification of the falls; the installation of temporary coffer dams to re-direct the flow of the river during construction; and the creation of construction staging and access road(s) affecting potential historic and archaeological resources.

4.3 Project Action Area: East Elm Street Dam

4.3.1 No Action

Fisheries Resources
It is expected that this alternative would continue to have major adverse impacts and negligible beneficial impacts to fisheries resources in the upstream reach of the Royal River if upstream fish passage is improved at Bridge Street Dam. A major adverse intensity level was assigned based on the current poor condition of native diadromous species populations in the Royal River.

Wetland Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to upstream wetland resources.

Wildlife Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to wildlife resources.

Hydrology, Hydraulics, and Physical Processes
It is expected that this alternative would have continued major adverse impacts and negligible beneficial impacts to river hydrology, hydraulics, and physical processes. A major adverse impact intensity level was assigned to this alternative due to the continued presence of the dam affecting natural riverine processes such as flood storage capacity. While the impoundment could act beneficially as a depositional area for sediments and woody debris, the nature of riverine conditions present during periods of high flow likely transport much of this material downstream under existing conditions therefore a negligible beneficial impact intensity level was assigned to this alternative.

Groundwater Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to upstream groundwater resources.

Existing Infrastructure
It is expected that this alternative would have negligible adverse and beneficial impacts to existing infrastructure (i.e., the East Elm Street bridge, the Grand Trunk Railroad bridge, the Maine Central Railroad bridge, a dry hydrant in the vicinity of Route 9, the Route 9 bridge, an overhead electrical transmission line, and a water supply pipeline to North Yarmouth) resources in vicinity of the dam. While the backwater created by the dam likely mitigates the potential for scour in the vicinity of these resources, the backwater alone does not eliminate the need for scour countermeasures at these structures due to the presence of riverine flow conditions that exist during high-flow events. Probing of river depths in the vicinity of the two railroad bridges and the East Elm Street bridge indicated the presence of rock along the river bed, which likely limits the potential for scour at these locations.

Recreational Factors
Implementation of this alternative would result in negligible adverse and beneficial impacts to the existing recreational usage in the East Elm Street impoundment. The recreational fishery supported by stocking of cold-water salmonids by the Department of Inland Fisheries and Wildlife would remain unchanged as long as supported by the state agency; however, the adverse effects on the recreational fishery for diadromous species such as shad would continue. Impacts to other recreational uses such as boating, cross country skiing, ice skating, and hiking are anticipated to be negligible.

Historic and Archaeological Resources

It is expected that this alternative would have negligible adverse and beneficial impacts to historical and archeological resources.

Potential Future Use of the Dam
It is expected that this alternative would have negligible adverse and minor beneficial impacts to future uses of the dam. A minor beneficial impact intensity level was assigned due to the proximity of the East Elm Street impoundment to East Elm Street and the potential for use of the impoundment as a fire fighting water supply.

4.3.2 Modified Fish Passage Facilities

Fisheries Resources
It is expected that this alternative would have negligible adverse impacts and moderate beneficial impacts to fisheries resources in the upstream reach of the Royal River. A moderate beneficial intensity level was assigned based on the current poor condition of native diadromous species populations in the Royal River and the potential to improve upstream fish passage with a better performing and maintained fishpass. Note that the assigned beneficial impact intensity level is predicated on improved upstream fish passage at Middle Falls and Bridge Street Dam. A higher beneficial impact intensity level was not assigned as the efficiency of fish passage facilities is not typically as good as that of a free-flowing river.

Wetland Resources
It is expected that modification of the East Elm Street Dam fishpass would have negligible adverse and beneficial impacts to upstream wetland resources.

Wildlife Resources
It is expected that this alternative would have negligible adverse and beneficial impacts to wildlife resources.

Hydrology, Hydraulics, and Physical Processes
It is expected that modification of the East Elm Street Dam fishpass would have negligible adverse and beneficial impacts to river hydrology, hydraulics, and physical processes.

Groundwater Resources
It is expected that modification of the East Elm Street Dam fishpass would have negligible adverse and beneficial impacts to upstream groundwater resources.

Existing Infrastructure
It is expected that this alternative would have negligible adverse and beneficial impacts to existing infrastructure (i.e., the East Elm Street bridge, the Grand Trunk Railroad bridge, the Maine Central Railroad bridge, a dry hydrant in the vicinity of Route 9, the Route 9 bridge, an overhead electrical transmission line, and a water supply pipeline to North Yarmouth) resources in vicinity of the dam and impoundment. While the backwater created by the dam likely mitigates the potential for scour in the vicinity of these resources, the backwater alone does not eliminate the need for scour countermeasures at these structures due to the presence of riverine flow conditions that exist during high-flow events. Probing of river depths in the vicinity of the two railroad bridges and the East Elm Street bridge indicated the presence of rock along the river bed, which likely limits the potential for scour at these locations.

Recreational Factors
Implementation of this alternative would result in negligible adverse and moderate beneficial impacts to the existing recreational usage in the East Elm Street impoundment. The recreational fishery supported by stocking of cold-water salmonids by the Department of Inland Fisheries and Wildlife would remain unchanged as long as supported by the state agency; however, the adverse effects on recreational fisheries for diadromous species such as shad would be reduced. Impacts to other recreational uses such as boating, cross country skiing, ice skating, and hiking are anticipated to be negligible.

Historic and Archaeological Resources
It is expected that this alternative would have minor adverse and negligible beneficial impacts to historic and archaeological resources. A minor adverse intensity level was assigned based upon the possibility of surficial ground disturbance associated with the movement of heavy machinery cutting, filling, and grading around the dam to accommodate the reconstruction of the fish passage; the installation of temporary coffer dams to re-direct the flow of the river during construction; and the creation of construction staging and access road(s) affecting potential historic and archaeological resources. A minor intensity level was chosen over higher intensity levels due to the ability of qualified individuals to recover or protect such artifacts prior to construction.

Potential Future Use of the Dam
It is expected that this alternative would have negligible adverse and minor beneficial impacts to future uses of the dam. A minor beneficial impact intensity level was assigned due to the proximity of the East Elm Street impoundment to East Elm Street and the potential for use of the impoundment as a fire fighting water supply.

4.3.3 Dam Removal

Fisheries Resources
It is expected that this alternative would have negligible adverse impacts and major beneficial impacts to fisheries resources in the upstream reach of the Royal River if upstream fish passage is improved at Middle Falls and Bridge Street Dam. A major beneficial intensity level was assigned based on potential for restoration of native diadromous species populations in the Royal River relative to their current poor condition. Beneficial impacts would also result from the commensurate increased awareness of natural resources and their dependence on the human stewardship in anthropogenically altered ecological systems.

Wetland Resources
It is expected that removal of the East Elm Street Dam would include moderate adverse and beneficial impacts to wetland resources along the margins of the existing impoundment and some loss of lacustrine habitat. A moderate intensity level was assigned based on the relatively large reach of river that in the potentially impacted area. Of the more than 50 resources identified within the project area, only 8 are expected to result in a loss of wetland habitat and conversion to upland habitat. Wetland hydrology for the identified resources primarily consists of upland sources that would not be influenced by a change in the water level in the Royal River. A few of the wetlands that potentially could be impacted will likely only experience a wetland type conversion, primarily palustrine unconsolidated bottom/palustrine emergent wetland to palustrine scrub-shrub/palustrine forested wetland. Several of the identified resources hold the potential for the formation of palustrine vegetated wetlands. These locations correspond to areas of wetland where the primary source of hydrology is the river itself. Potentially mitigating factors include the likely reestablishment of wetland resources at lower elevations, the apparent presence of bedrock ledges in the river upstream from the dam, and the potential for these ledges to result in hydraulic conditions that are similar to existing conditions during regular (annual) high water. Invasive plant species are present throughout the river corridor, and colonization by these species would be expected in areas of exposed soil if proper controls are not implemented.

Wildlife Resources
It is expected that this alternative would have negligible adverse and major beneficial impacts to wildlife resources between the dam and Middle Falls. Beneficial impacts associated with this resource result from the presence of increased numbers of forage fish, as represented by adult and juvenile diadromous species upstream from the dam, and increased riparian zone connectivity. Changes to the fish population would likely benefit wet-land dependent species such as river otter, osprey, and kingfisher by providing a larger and more diverse forage base. Open water habitat for waterfowl would decrease slightly, but not enough to affect use of the river by this group of wildlife species. Use of the river by opportunistic animals such as beaver, deer, and raccoon is not expected to change. Upstream from the Bridge Street Dam, the

drawdown resulting from dam removal could have short-term benefits to shorebird species by providing larger areas of exposed sediments for feeding; however, these benefits would not likely persist for long as the exposed shoreline areas would likely become densely vegetated with plant species known to commonly inhabit riparian zones.

Hydrology, Hydraulics, and Physical Processes
The existing hydrology (flood regime) in the Royal River would not change; however, implementation of this alternative would result in minor adverse impacts and minor beneficial impacts to the hydraulic conveyance under the East Elm Street bridge, the Grand Trunk Railroad bridge, the Maine Central Railroad bridge, and the Route 9 bridge. Increased hydraulic conveyance under these structures would result in a reduction of upstream flood levels. A second beneficial impact is associated with the increased rate of flushing to limit the current eutrophication of the impoundment upstream of the East Elm Street Dam. Sediment transport capacity through this reach would likely increase.

Groundwater Resources
It is expected that removal of the East Elm Street Dam would include minor impacts to groundwater resources along the margins of the existing impoundment upstream of the dam. A minor intensity level was assigned to these impacts as it is expected that drawdown of groundwater resources would be limited to along the margins of the impoundment. Due to the distance that the majority of the nearby structures are located from the river, the effects of the drawdown on groundwater extraction wells in the project vicinity are anticipated to be minimal.

Existing Infrastructure
It is expected that this alternative could have major adverse and negligible beneficial impacts to existing infrastructure (i.e., the East Elm Street bridge, the Grand Trunk Railroad bridge, the Maine Central Railroad bridge, a dry hydrant in the vicinity of Route 9, the Route 9 bridge, an overhead electrical transmission line, and a water supply pipeline to North Yarmouth) resources in vicinity of the dam and impoundment. A major adverse impact was assigned to this alternative due to the potential for scour along bridge foundations and the North Yarmouth water line leading to bridge or water line failure and the potential for adversely affecting the ability of a dry hydrant located along Route 9 to provide a viable water supply during emergency situations. Removal of the dam would decrease the riverine elevations by approximately 5 – 7 feet during periods of low flow and increase the potential for scour during high-flow events in the vicinity of these resources. Probing of river depths in the vicinity of the two railroad bridges and the East Elm Street bridge indicated the presence of rock along the river bed, which likely limits the potential for scour at these locations. A scour analysis in the vicinity of these structures should be conducted prior to removal of the East Elm Street Dam as well as a review of the functionality of the dry hydrant under drought conditions. Removal of the East Elm Street Dam is not anticipated to affect the over head electrical transmission line.

Recreational Factors
Implementation of this alternative would result in minor adverse and major beneficial impacts to the existing recreational usage in the East Elm Street impoundment. The recreational fishery supported by stocking of cold-water salmonids by the Department of Inland Fisheries and Wildlife would remain as long as supported by the state agency. Impacts to other recreational uses such as boating and hiking are anticipated to be minor; however, increased abundance of diadromous fish species within the project reach would afford additional opportunities for photography of various wildlife species targeting concentrated migratory fish species (e.g., bald eagles, ospreys, river otters, kingfisher).

Historic and Archaeological Resources
This alternative would have major adverse and negligible beneficial impacts to historic and archaeological resources. A major adverse intensity level was assigned based upon the removal of the dam and the possibility of surficial ground disturbance associated with the movement of heavy machinery cutting, filling, and grading around the dam to facilitate removal; the installation of temporary coffer dams to re-direct the flow of the river during construction; and the creation of construction staging and access road(s)

affecting potential historic and archaeological resources. Additionally, a decrease in water level upstream of the dam could potentially affect archaeological resources that may be located along the impoundment.

Potential Future Use of the Dam
This alternative would remove the dam and therefore a major adverse impact to future uses of the dam would result from this alternative. A potential beneficial impact of dam removal would include the availability of stone blocks utilized in the construction of the dam for beneficial reuse in the surrounding park landscape (e.g., park benches).

5.0 ECONOMIC CONSIDERATIONS

Detailed economic modeling or analyses were not performed as part of this initial feasibility study, but the following section presents a summary of economic aspects to be considered.

As noted above, the objective of this study has been to develop and evaluate alternatives for restoring aquatic resources on the lower reach of the Royal River, with a primary goal of restoring resident and diadromous fisheries resources within the river. The presence of the Bridge Street Dam, Middle Falls, and East Elm Street Dam on the Royal River and lack of functional upstream fish passage facilities at these sites has an adverse effect on resident and diadromous fisheries within the river. Specific restoration components include: 1) restoration of fish passage at the three sites, and 2) restoration of resident and diadromous species habitat. Target fish species that would likely benefit from restoration of riverine continuity in the Royal River include river herring, American shad, American eel, sea lamprey, and several species of salmonids, including brook trout and brown trout.

Three project alternatives were evaluated at each dam site to achieve the project goal of restoring native diadromous and resident fisheries resources:

- Project Alternative 1: No Action;
- Project Alternative 2: Installation/renovation of fish passage structure(s);
- Project Alternative 3: Removal of the dam(s) and restoration of the natural stream channel.

Each Alternative presents different capitalized costs and economic ramifications, which are discussed below and summarized in Table 9.

The discussion includes opinions of capitalized costs based on estimates of annual maintenance and operation funding requirements. The estimates of annual funding requirements utilized in the capitalized cost calculations were based upon knowledge of similar capital expenses expended by owners of similar dam projects. For potential additional major repairs or replacements, estimated cost ranges are provided based on similar projects in the region.

Table 9: Summarized Infrastructure Management Costs

		Recurring Costs					One-time Costs			Cost Apportioning		
		Capitalized cost of $5000 Annual Dam Maintenance	Capitalized cost of $6000 Annual Fishway Maintenance	Design, Permitting & Regulatory Approval Costs	Construction Costs	**Total Capitalized Costs**	Design, Permitting & Regulatory Approval Costs	Dam Replacement /Construction Costs	**Total Capitalized Costs**	Town Share of Costs	Potential Grant Funding	**Potential Net Capitalized Cost to Town**
Project Alternative 1: No Action	**Bridge Street Dam**	$250,000	$300,000	$0	$0	**$550,000**	$200,000	$1,000,000	**$1,200,000**	100%	0%	**$550,000[a] $1,550,000[b]**
	East Elm Street Dam	$250,000	$300,000	$0	$0	**$550,000**	$200,000	$1,000,000	**$1,200,000**	100%	0%	**$550,000[a] $1,550,000[b]**
Project Alternative 2: Installation of Fish Passage Structure	**Bridge Street Dam**	$250,000	$300,000	$50,000	$300,000	**$900,000**	$200,000	$1,000,000	**$1,200,000**	80-100%	0-20%	**$720,000 to $900,000 [a] $1,680,000 to $2,100,000 [b]**
	East Elm Street Dam	$250,000	$300,000	$50,000	$300,000	**$900,000**	$200,000	$1,000,000	**$1,200,000**	80-100%	0-20%	**$720,000 to $900,000 [a] $1,680,000 to $2,100,000 [b]**
Project Alternative 3: Dam Removal	**Bridge Street Dam**	$0	$0	$0	$0	**Not Applicable**	$150,000‡	$250,000	**$400,000**	20-40%	60-80%	**$80,000 to $160,000**
	East Elm Street Dam	$0	$0	$0	$0	**Not Applicable**	$200,000‡	$300,000	**$500,000**	20-40%	60-80%	**$100,000 to $200,000**

[a] Based on recurring costs without replacement of dam.
[b] Based on recurring costs with replacement of dam.
‡There may be efficiencies to overall projected cost found by coordinating and conducting surveys (e.g., historic and cultural resource) for both the Bridge Street and East Elm Street dams concurrently.

5.1 Economic Considerations - Project Alternative 1 – No Action

This alternative would not achieve the project goals of restoring fish passage and habitat in the Royal River, but would involve the Town continuing to own and maintain the two dams and associated infrastructure. It is assumed that all costs associated with this Alternative would be borne by the Town of Yarmouth, since grant funds are generally unavailable for dam maintenance, only for restoration.

The primary costs associated with this Alternative would involve ongoing periodic dam inspections, ongoing maintenance of the dams and relevant appurtenances, and the installation and maintenance of property restrictions (e.g., fencing, posting signage). Given the age of the current dams, and the condition of the East Elm Street dam in particular, it is likely that future maintenance costs will also need to accommodate repairs or replacements of flow control structures, periodic impoundment draw-downs for inspections of dam foundations, re-mortaring of dam stonework, and re-facing of concrete portions. Major construction activities may involve state and federal environmental permitting.

With regard to ongoing maintenance requirements for the two existing fish passage structures, it is understood that the Maine DMR has previously been responsible for maintaining fish pass operation and function. However, the current East Elm and Bridge Street fish passes are in disrepair and not functioning, and have not been repaired since high flows damaged them in 2009. It is unclear whether DMR will proceed with repairs, since DMR has suffered significant budget cutbacks and is no longer receiving federal funding for fish pass installations or maintenance. The current lease status and maintenance responsibilities for the fish passes is unclear, but it should be noted that regulatory changes are anticipated in Maine that may require all owners of dams to provide appropriate and functional fish passage. This may shift all responsibility and regulatory compliance for repairing, maintaining, and replacing the fish passes to the Town in the future.

Although current Maine statutes do not require towns to maintain town-owned dams and presently appear to exempt towns from liability associated with dam failures, recent regulatory changes in adjoining states have imposed a number of maintenance and performance requirements onto dam owners. These new regulatory requirements include maintaining minimum flows through fish pass structures, improving spillway capacity to avoid overtopping and erosion around abutments, and increasing the frequency of formal dam inspections and reporting. Although the state of Maine does not currently require dam safety inspections for FERC-exempt dams such as these, it is assumed that the Town would wish to at least maintain dam integrity and conditions that minimize risks to public safety or property damage.

It is not clear whether the Town is responsible for ongoing maintenance of the head gate and penstock associated with the Sparhawk Mill hydropower facility at Bridge Street. If the Town is required to provide infrastructural support for those appurtenances, that would suggest that maintenance and improvements at the Bridge Street dam would be the Town's responsibility as well. If the hydropower facility continues to operate under a lease from the Town, income from any lease could defray a portion of the related dam maintenance costs. Major dam repairs, however, would likely exceed the lease revenues. As noted in the attached hydropower study, maximum energy production value from the Bridge Street site is estimated to be in the range of $78,000 annually. However, it is unclear whether the hydropower facility would remain feasible to operate if a significant portion of dam maintenance and associated costs were to be paid by the Sparhawk Mill owner instead of the Town.

The estimated capitalized cost of the No Action alternative for long-term Operation and Management (O&M) of the Bridge Street and East Elm Street dams is estimated at $250,000 per dam. This opinion of probable cost is based upon the assumption that a fixed sum of money would be set aside with interest on this sum providing for an indefinite period. This estimate was developed using an effective interest rate of 2 percent per year (interest rate minus inflation rate), and a conservative estimated annual cost of $5,000 per dam, and it was used to provide a present value for comparison of this cost with the construction costs associated with other alternatives. This probable opinion of cost does not account for maintenance of the existing fish passage facilities, major repairs that could occur periodically, or other improvements to spillway capacity, fish pass flows, or head gate/penstock repairs.

Given the regulatory uncertainty with regard to fish passage requirements, planning for fish passage maintenance is recommended. An estimated capitalized cost for long-term O&M of the existing fish passage facilities at the Bridge Street and East Elm Street dam locations would be an additional $300,000 per dam, assuming the fish passes are to be maintained on a weekly basis throughout the year for a $6,000 annual cost, which would be incurred for an indefinite period.

The added costs for repairs to existing dam structures will need to be determined through a separate study, but it is reasonable to expect a cost of $10,000 to $20,000 for moderate repairs to masonry and flow control structures such as replacing stop logs. This would include the costs of performing temporary drawdowns to accommodate repairs to the upstream side of a dam.

Additional costs for immediate needed repairs to the current non-functioning fish passes have not been determined, but may be in the range of $5,000 to $15,000 depending on the extent of damage to flow control structures from the 2009 flooding events. For planning purposes, it may also be prudent to assume there could be similar damage occurring periodically from similar flood events, requiring similar repair expenditures.

Any economic evaluation of dam ownership should include an assumption of the eventual need to rebuild or replace the dams themselves, which are typically considered to have a 30-year functional life. Routine maintenance and localized repairs can only be done up to a point before dam integrity becomes questionable. Although this study did not evaluate detailed dam replacement costs, rebuilding similar dams in the region can cost in the range of $1 million to $1.2 million per dam. It should also be noted that major construction activities such as dam rebuilding would require a full spectrum of environmental studies, design, and permitting related costs estimated to be around $200,000 per site. Costs for design and permitting of dam replacement are higher than dam removal design and permitting because additional studies would have to occur to bring the dam(s) into compliance with current dam standards.

Table 9 provides a summary of estimated potential costs associated with the No Action Alternative, and includes O&M costs, fish passage maintenance costs, periodic repair costs, and dam replacement costs as a possible future cost element.

5.2 Economic Considerations - Project Alternative 2 – Fish Passage Facilities

Project Alternative 2 represents the installation of fish passage structure(s) alternative. This alternative includes the construction of new or modified fish passage facilities at the dam(s), and continued ownership and maintenance of the dams by the Town. All costs associated with dam ownership and maintenance would be the same as Project Alternative 1.

The estimated capitalized cost of this alternative for the construction of improved fish passage facilities, and long-term O&M of the Bridge Street and East Elm Street dams and associated fish passage facilities are $800,000 and $1,100,000, respectively. The estimated cost of this alternative for each site includes construction costs for the fish pass and associated permitting, and capitalized costs for long-term maintenance and operation of the fishpass, dam, and relevant appurtenances, dam safety inspections, and the installation and maintenance of property restrictions (e.g., fencing, posting signage). Modification of the Middle Falls to facilitate fish passage is estimated at an additional $20,000 to $100,000. Neither of these opinions of probable cost includes the removal and disposal of contaminated materials or cultural resource considerations, which cannot be determined at this point.

Funding for the design and construction of new fish passes may be available through federal or NGO grant programs, although there are few grant vehicles focused on building fish passage facilities. If such funding can be obtained for installing new fish passes, the Town would remain responsible for 100% of the costs for dam maintenance and repairs, and future fish pass maintenance.

5.3 Economic Considerations - Project Alternative 3 – Dam Removal

Project Alternative 3 represents the dam removal alternative. The removal of the dams would achieve the project goals while reducing future costs associated with regulatory uncertainty related to fish passage and dam ownership requirements.

The opinion of probable costs for Project Alternative 3 includes only construction/removal costs and related permitting costs. No ongoing maintenance or repair costs would be incurred due to the removal of the dam and fish pass infrastructure.

Estimated costs for mechanical removal of the Bridge Street and East Elm Street dams are $250,000 and $300,000, respectively. Neither of these opinions of probable cost includes the removal and disposal of contaminated materials or cultural resource considerations, which cannot be determined at this point. It is estimated that additional design, permitting, and regulatory approval-related costs for this alternative would be in the range of $150,000 for the Bridge Street dam and $200,000 for the East Elm Street dam.

It is assumed that significant grant funding would be available for dam removal activities, likely reducing the capitalized costs to the Town to 40% or less of the project cost.

Appendix A

Regulated Resource Delineation and Characterization Reports

Stantec

Appendix B

Dam Inspection Report

Appendix C

Agency Response Letters

Appendix D

Federal Emergency Management Agency Flood Maps

Appendix E

Sediment Sampling Plan

Appendix F

Results of Sediment Quality Analysis

Appendix G

Background Information on Groundwater Resources

Appendix H

Cultural Resources

Appendix I

Hydropower Analysis

Stantec