Orland Village Dam
Alternatives Feasibility Study

Evaluation of Alternatives
Orland Village Dam
Narramissic and Orland Rivers
Orland, Maine

Stantec

June 13, 2013

Sign-off Sheet

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Executive Summary

The Orland Village Dam Alternatives Feasibility Study presents information for use by the Town of Orland, Maine, to evaluate a course of action regarding the Orland Village Dam. The dam is located at the head-of-tide on the Orland River and separates the tidally affected Orland River from the Narramissic River in the Town of Orland, Hancock County, Maine, and was acquired by the Town of Orland from Verso Corporation (Verso) in 2010 after Verso considered abandoning the dam.

This study was prepared in coordination with the Town of Orland Dam Committee, which was convened by the Town to evaluate alternatives for management of the dam. The goal of this study is to present information to the committee for its use in selecting a prudent, feasible, and cost-effective course of action regarding the dam.

This study identifies and evaluates a range of potential alternatives associated with the dam, including no action, rehabilitation of the dam and fishpass, reconstruction of the dam and fishpass, and removal of the dam. The four evaluated alternatives include:

- Alternative A – No Action;
- Alternative B – Dam and Fishway Rehabilitation;
- Alternative C – Dam and Fishway Modification; and
- Alternative D – Dam Removal.

A fifth alternative (Alternative E – Nature-Like Fishway) was preliminary identified but not evaluated in detail as it does not appear to be feasible, practical, or cost-effective at this site.

The primary study area is the freshwater-dominated reach of the Narramissic River between the Alamoosook Lake Dam and Orland Village Dam and the adjacent reach of Wight's Brook. Potential impacts to identified resources, including those associated the environmental, infrastructure, cultural, and social factors, are evaluated for each of the alternatives.

Project work included characterization of existing natural resources, topographic and bathymetric surveys, engineering analyses, development of an opinion of probable cost (OPC) for each evaluated alternative, and comparison of beneficial and adverse impacts associated with each evaluated alternative. The OPCs for the evaluated alternatives include costs for associated design, permitting, upkeep, and repair but do not include costs for impacts to other structures or uses, such as modifications to existing structures that may be indirectly impacted by removal of the dam, or increased flooding that may result from the dam.

Factors that were considered in the alternatives evaluation also included regulatory issues associated with species that are listed under the federal Endangered Species Act, and potential impacts associated with sea level rise.

The **No Action Alternative** (Alternative A) represents existing conditions and provides a baseline for comparison of the other alternatives. This alternative would largely retain existing uses of and conditions in the project reach of the Narramissic River as long as the dam remains in good condition. The OPC for this alternative, including long-term operations and maintenance, is $375,000.

The **Dam and Fishway Rehabilitation Alternative** (Alternative B) includes rehabilitation of the dam and the existing technical fish passage facilities. It is assumed that rehabilitation of the dam would preserve the existing spillway configuration and elevation. This alternative would partially address cost factors associated with longer-term operations and maintenance of the dam and would largely retain existing uses of and conditions in the project reach of the Narramissic River as long as the dam remains in good condition. The OPC for this alternative, including long-term operations and maintenance, is $905,000.

The **Dam and Fishway Modification Alternative** (Alternative C) includes modification of the dam and construction of a new technical fish passage facility. It is assumed that modification of the dam would result in a spillway elevation similar to that of the existing dam and replacement of the existing technical fish passage facilities with an alternative technical fishpass that is well-suited for the target fish species and the tidal nature of the site. This alternative would require greater initial costs relative to dam rehabilitation (Alternative B), but it is expected to result in lower costs for long-term operations and maintenance of the dam and would largely retain existing uses of and conditions in the project reach of the Narramissic River as long as the dam remains in good condition. The OPC for this alternative, including long-term operations and maintenance, is $1,525,000.

The **Dam Removal Alternative** (Alternative D) is for removal of Orland Village Dam. This alternative includes removal of the timber crib spillway, adjacent concrete abutments and gate systems, and the technical fishpass. Implementation of this alternative would include removal of the visible elements of the dam and some fill upstream from the dam. Implementation of this alternative would result in readily apparent impacts to resources in and adjacent to the impoundment reach of the Narramissic River upstream from the dam, including alteration of regulated natural resources, current recreation and functional uses (e.g., water withdrawals) associated with the impoundment, and aesthetic and cultural resources. The OPC for this alternative, including long-term operations and maintenance, is $535,000.

1 INTRODUCTION

The Orland Village Dam Alternatives Feasibility Study (FS) presents information for use by the Town of Orland, Maine (Town), to evaluate a course of action regarding future use of the Orland Village Dam. The dam is located at the head-of-tide on the Orland River and separates the tidally-affected Orland River from the Narramissic River in the Town of Orland, Hancock County, Maine, and was acquired by the Town of Orland from Verso Corporation (Verso) in 2010 after Verso considered abandoning the dam.

This study was prepared on behalf of the Town by Stantec Consulting Services Inc. (Stantec) of Topsham, Maine, in coordination with the Town of Orland Dam Committee, which was convened by the Town to evaluate alternatives for management of the dam. The Dam Committee is evaluating the future of the dam and associated impoundment. The goal of this study is to present information to the committee for its use in selecting a prudent, feasible, and cost-effective course of action regarding the dam.

This study identifies and evaluates a range of potential alternatives associated with the dam, including no action, rehabilitation of the dam and fishpass, reconstruction of the dam and fishpass, and removal of the dam. Potential impacts to identified resources, including those associated the environmental, infrastructure, and social factors, are evaluated for each of the alternatives. The primary study area is the freshwater-dominated reach of the Narramissic River between the Alamoosook Lake Dam and Orland Village Dam, the reach of Wight's Brook from State Route 46 (SR 46) downstream to its confluence with the Narramissic River, and adjacent and associated resources (i.e., regulated wetlands, recreational and socio-economic uses, and infrastructure).

Work included in the FS includes characterization of existing natural resources, topographic and bathymetric surveys, engineering analyses, development of an opinion of probable cost (OPC) for each evaluated alternative, evaluation of existing cultural and socioeconomic information, and comparison of beneficial and adverse impacts associated with each evaluated alternative. The OPCs for the evaluated alternatives include costs for associated design, permitting, upkeep, and repair but do not include costs for impacts to other structures or uses, such as modifications to existing structures that may be indirectly impacted by removal of the dam, or increased flooding that may result from the dam.

The project is being funded by the Habitat Restoration Grants Program, a partnership between the Gulf of Maine Council on the Marine Environment and the National Oceanic and Atmospheric Administration (NOAA); the U.S. Fish and Wildlife Service (USFWS); the Town, Verso; the Davis Conservation Foundation; and the Maine Corporate Wetlands Restoration Partnership. Project work was performed by Stantec, in coordination with Plisga & Day Land Surveyors of Bangor, Maine. Additional components of the study are being performed by the Dam Committee.

1.1 PROJECT SITE

Orland Village Dam is located at the junction of the Narramissic and Orland rivers adjacent to the Orland town center. The dam is the landward (upstream) terminus of the Orland River and provides a convenient means to harvest alewife during their annual spring spawning migration. The dam creates a freshwater-dominated impoundment on the Narramissic River that extends upstream beyond Upper Falls Road. This impoundment provides a variety of benefits to the local populace, including augmentation of the naturally occurring space for recreation (e.g., boating, fishing, and waterfowl hunting) and as a source of freshwater for potable and non-potable water supplies (e.g., fire protection, irrigation). Extensive freshwater wetland communities are located around the fringe of the impoundment. A seasonal river herring (collectively alewife [*Alosa pseudoharengus*] and blueback herring [*Alosa aestivalis*]) harvesting operation is located in the Orland River immediately downstream from the dam.

The Narramissic River watershed at Orland Village Dam encompasses approximately 112.7 square miles of mixed-use land largely within the Towns of Bucksport, Dedham, Orland, Penobscot, and Surry. The watershed is defined in this report as being comprised of the "upper" watershed, which is the area upstream from the Alamoosook Lake Dam, and the "lower" watershed, which consists of the watershed of the Narramissic River between Orland Village Dam and the Alamoosook Lake Dam.

The upper watershed has an area of 94.3 square miles of rural land, including farmland and mixed-use forest, interspersed with low-density residential development. The upper watershed includes The Great Pond Mountain Conservation Trust's Great Pond Mountain Wildlands conservation area. Lakes and ponds in the upper watershed, including Alamoosook Lake and Toddy Pond, provide substantial storage and buffering of flows in the project reach of the Narramissic River downstream from Alamoosook Lake Dam. Verso diverts water from the dam at the outlet of Alamoosook Lake to Silver Lake in Bucksport for industrial use at the Bucksport Mill and residential used in Bucksport. This water withdrawal can result in relatively low flows discharges to the project reach of the Narramissic River during periods of lower flows in the upper watershed.

The lower watershed has an area of 18.4 square miles. Land use in the lower watershed is similar to that in the upper watershed but has increased residential development. Specific features of the watershed immediately adjacent to the project reach of the Narramissic River include residential parcels along the lower section of the project reach and the Bucksport Golf Club, which abuts the west side of the river approximately halfway between Upper Falls Road and Orland Village Dam.

Orland Village Dam is located in the vicinity of Lower Falls on the Narramissic River, and the backwater from this dam extends approximately 2.6 miles upstream to just downstream from the Alamoosook Lake Dam. Information developed as part of this study suggests that, in the absence of the dam, there may be a tidally influenced, reversing falls in the vicinity of the State Route 175/Castine Road Bridge (SR 175 Bridge) adjacent to the Orland town center.

1.1.1 Orland Village Dam

Orland Village Dam is owned by the Town and located on the Narramissic River at the current head-of-tide approximately 250 yards downstream from SR 175 Bridge in the Town of Orland, Maine. The dam is comprised of concrete and timber crib components, and includes concrete abutments, two head gate structures, a pair of Alaskan steep pass-style fishways, and rock, gravel, and rubble fill between the banks of the river upstream from the dam. The Orland Village Dam is occasionally overtopped by higher high tides and storm surges. Photographs of the dam taken during project work as well as historic photographs[1] are included as Appendix A.

The dam has a hydraulic height of approximately 8 feet (ft) at low tide, a structural height of approximately 14 ft, a spillway length of 110 ft, and an overall length of approximately 175 ft. This spillway elevation is approximately 7.3 ft (NAVD88[2]). The dam has two lift actuated spillway gates with invert elevations of approximately 3.3 ft (NAVD88) and approximate widths of 3.5 ft. Stantec performed a visual inspection of the dam and prepared a report that is included as Appendix B.

Two Alaska steeppass-style fishways are located in the outlet gates between the right[3] spillway abutment and the right abutment of the dam. One of the two fishpass segments is approximately half the length of the other segment. Both fishway sections have entrances that are above the downstream tailwater during periods of each tidal cycle. The results of tidal monitoring efforts downstream from the dam described in Section 3.2.1.3 indicate that the longer fishway provides potentially suitable conditions for upstream fish passage approximately 50 percent of the tidal cycle and the shorter fishway provides potentially suitable conditions for upstream fish passage for approximately 33 percent of the tidal cycle.

Fishway performance can be further reduced by poor hydraulic conditions within the fishway caused by such factors as debris lodging within the fishway or damage to fishway internal elements (e.g., baffles).

1.1.1.1 Orland Village Dam History

A variety of dams have been constructed in the Narramissic River upstream from and on the location of Orland Village Dam. The current dam was substantially constructed in 1994 following severe damage to the dam as a result of a tidal surge event in January of that year. Information obtained as part of this study indicates that the pre-1994 dam was constructed circa-1930 by the Maine Seaboard Paper Company (now Verso) to develop a source of water for industrial use at their Bucksport, Maine mill; however, it was never utilized for this intended purpose as a dam constructed at the Alamoosook Lake outlet proved to be a more efficient alternative than pumping from the Orland Village Dam impoundment.

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[1] Historic photographs provided to Stantec by Sharon Thompson (Orland Historical Society)
[2] North American Vertical Datum 1988 (NAVD88).
[3] Directionals “right” and “left” are based on an observer facing downstream/seaward.

Improvements to the existing dam were installed circa 1965 and consisted of a steel superstructure for raising and lowering the gates, as well as a walkway and railings. Significant repairs were made to concrete and timber crib sections of the dam to correct structural deterioration in 1985 at a cost of $83,845. Damages to the dam sustained after a storm surge advanced up the Orland River and struck the dam in January 1994 resulted in major reconstruction of the timber crib portion of the dam at a cost of approximately $93,855 in the summer of 1994. An additional $4,385 was expended on concrete repairs to the dam during the summer of 1995 along with other expenses during the 1990s to improve upstream passage of river herring at the dam. In 1998, the custom-designed and fabricated aluminum and stainless steel Alaska Steeppass fishway was installed at a cost in excess of $10,000. Subsequent repairs consisting of placement of fill along the upstream face of the dam and riprap adjacent to the left abutment were made in late 2012.

In 2010 the Town took ownership of the dam from Verso after Verso initiated discussions of dam removal with the town. According to James Brooks of Verso (via email correspondence with Stantec), Verso maintains ownership of water rights in the stretch of the Narramissic River between Alamoosook Lake and the Orland Village Dam. At least one abutting landowner also claims a water right within this reach of river.

Several prior dam structures are known to have formerly existed at the site. According to information provided to Stantec by local resident Sharon Thompson, a dam and mills associated with the site were rebuilt after being destroyed by British troops in 1779 during the American Revolutionary War. At different points in time, various saw mills, grist mills, and shipyards occupied space around the site. At least one of the previous dams at the site included locks for to allow for upstream passage of ‘live car’ boats carrying Atlantic salmon (*Salmo salar*) to a hatchery now known as Craig Brook National Fish Hatchery.

1.1.1.2 Dam Safety & Stability

Transfer of ownership of the dam from Verso to the Town occurred in 2010, but there were no previously performed Condition Assessment, Dam Safety Inspections, or Stability Analyses available for review at the time of development of this study.

For the purposes of dam safety, Orland Village Dam is under the jurisdiction of State of Maine Department of Defense, Veterans and Emergency Management. According to Maine Revised Statute Title 37-B, Chapter 24: Dam Safety, this dam is classified as a “Low Hazard Potential Dam” where failure or errors in operation results in no probable loss of human life and low economic and environmental losses. Because of this classification, there are no specific requirements for dam safety evaluation other than on-site inspection by the State Dam Inspector at 6-year intervals.

Based on observations during the visual inspection of the dam as part of this study, the overall condition of the dam appears to be good. The spillway timbers exhibit good alignment and uniform section loss. The rock ballast is adequately sized and appears stationary. The gates are in fair to poor condition from an operational point of view but appear to pose little threat to dam safety. There is obvious movement of surface cobbles in the tailrace, but no apparent indications of bedrock scour were noted within the plunge pool below the spillway.

The primary concern identified with Orland Village Dam is the rock fill upstream of the spillway, which diminishes spillway capacity and results in reduced seepage through the upstream face, exposing the timber cribs to wet/dry cycling and therefore an increased rate of decay. There are also signs of movement at the left abutment and spillway crest, which should be monitored to confirm if this is active movement or a result of past construction activity; there is some concern that failure of the downstream alewife trap could compromise integrity of the left embankment.

1.2 FEASIBILITY STUDY OBJECTIVE

The objective of this FS is to present information for use by the Town in evaluating a prudent, feasible, and cost-effective course of action regarding the Orland Village Dam.

1.3 METHODS OF FEASIBILITY STUDY

Work encompassed in the FS includes characterization of existing natural resources; topographic and bathymetric surveys; engineering analyses; development of OPCs for the various alternatives, including a No Action alternative; and comparison of beneficial and adverse impacts associated with each alternative.

1.3.1 Alternative Development and Evaluation

The FS began by identifying alternatives that could potentially satisfy the project goals. Selected Project Alternatives underwent a thorough feasibility assessment, which included quantitative and qualitative evaluation. The five alternatives are:

1) Alternative A – No Action
2) Alternative B – Dam Rehabilitation
3) Alternative C – Dam and Fishway Modification
4) Alternative D – Dam Removal
5) Alternative E – Nature-Like Fishway

The five alternatives are described in Section 2. Identified resources in the vicinity of Orland Dam, including environmental, infrastructure, and social factors, are described in Section 3. Section 4 evaluates impacts to identified resources associated with implementation of the five alternatives, and Section 5 presents a summary of the study.

2 ALTERNATIVES

This section presents a brief description of each Project Alternative and a general evaluation of its ability to achieve the project goals, including a "No Action" alternative that is the basis for comparison of the other alternatives. A more detailed assessment of each project alternative's ability to achieve the project goals and associated impacts is presented in Section 4 of this report. Conceptual drawings of four of the five alternatives are presented in Appendix C.

2.1.1 Alternative A – No Action

The No Action alternative represents existing conditions and a baseline for comparison of the other alternatives. This alternative avoids short-term, temporary impacts associated with the other alternatives and does not result in direct impacts to existing resources evaluated as part of this study, such as current recreational uses of the impoundment, infrastructure (e.g., bridges, water withdrawals), or aesthetic factors.

This alternative would largely retain existing uses of and conditions in the project reach of the Narramissic River as long as the dam remains in good condition.

2.1.2 Alternative B – Dam and Fishway Rehabilitation

The Dam and Fishway Rehabilitation alternative addresses rehabilitation of the dam and the existing technical fish passage facilities. It is assumed that rehabilitation of the dam would preserve the existing spillway configuration and elevation. This alternative includes short-term, temporary impacts associated with construction related activities and one-time capital costs associated dam rehabilitation and restoration of the technical fish passage facilities[4]. This alternative would partially address costs associated with longer-term maintenance and operation of the dam.

This alternative would largely retain existing uses of and conditions in the project reach of the Narramissic River as long as the dam remains in good condition.

2.1.3 Alternative C – Dam and Fishway Modification

The Dam and Fishway Modification alternative addresses modification of the dam and construction of a new technical fish passage facility. It is assumed that modification of the dam would result in a spillway elevation similar to that of the existing dam, but that the dam would be reconstructed to provide for a more durable structure. This alternative includes rehabilitation and modification of the existing dam and replacement of the existing technical fish passage facilities with an alternative technical fishpass that is well-suited for the target fish species and the tidal nature of the site. This alternative would require greater initial costs relative to dam

[4] The fishpasses were repaired during the winter of 2012/2013; costs for such repairs and maintenance are referenced in this report to reflect such work.

rehabilitation (Alternative B), but it is expected to result in lower costs for long-term operation and maintenance of the dam.

This alternative would largely retain existing uses of and conditions in the project reach of the Narramissic River as long as the dam remains in good condition.

2.1.4 Alternative D – Dam Removal

The Dam Removal alternative is for removal of Orland Village Dam. This alternative includes removal of the timber crib spillway, adjacent concrete abutments and gate systems, and the technical fishpass. Construction of this alternative would include removal of the visible elements of the dam and fill upstream from the dam.

Implementation of this alternative would result in readily apparent impacts to resources in and adjacent to the impoundment reach of the Narramissic River upstream from the dam, including alteration of regulated natural resources, current recreation and functional uses (e.g., water withdrawals) associated with the impoundment, and aesthetic and cultural resources.

2.1.5 Alternative E – Nature-Like Fishway

The Nature-Like Fishway alternative would include removal of the dam and construction of an alternative, “nature-like” fishpass system, such as a rock ramp structure intended to mimic natural riffle-type habitat and serve as grade control to preserve all or part of the existing impoundment.

Rock ramp fishpass structures are limited to maximum slopes of 20:1 (horizontal:vertical), and the typical construction methods require placement of fill (e.g., rock) in the waterway. Due to limited space adjacent to the dam abutments and concerns over impacts to cultural resources, an off-channel, rock ramp structure does not appear appropriate for this site. Due to the hydraulic height of the existing dam (i.e., approximately 10 ft), an in-channel rock ramp structure would need to extend landward (upstream) from the dam a minimum of 200 ft to facilitate upstream fish passage at low tide and to not exceed maximum slope limits.

It is not expected that environmental permits could be obtained to place fill in the Orland River immediately seaward from the dam, and the downstream end of a nature-like fishway would therefore need to be at the downstream face of the dam. The balance of the structure would be upstream from the dam. Based on observed conditions, this structure is similar to the Dam Removal alternative (Alternative D) with the exception that the upstream limit of the nature-like fishway would be set at an elevation similar to the crest of the existing timber crib spillway to largely maintain the existing impoundment.

Nature-like fishways, and rock ramp structures in particular, are typically constructed of angular rock (rip-rap), and maintaining surface flow during periods of low flow may be difficult. This concern is particularly relevant to this site because of water withdrawals at Alamoosook Lake Dam that can result in very low flows during the summer. A nature-like fishway is a built structure and would require maintenance similar to maintaining a dam. A particular concern with a nature-like fishway at this site is the presence of tidal conditions and regular reversal of flow that would occur along the crest of a constructed ramp and could result in aggressive hydraulic conditions that would need to be addressed as part of design of this alternative.

Based on a preliminary review of this alternative relative to the other evaluated alternatives, this alternative does not appear to be feasible, practical, or cost-effective at this site, and this alternative is therefore not evaluated as a potentially feasible alternative in Section 4.

3 AFFECTED ENVIRONMENT

3.1 INTRODUCTION

This section describes the affected environment in the project area relevant to the project goals and the objectives of this study. Information presented in this section addresses physical processes, ecological resources, infrastructure, cultural resources, and aesthetic and socio-economic resources as they relate to the feasibility of achieving the project goals of ecological restoration within the Narramissic River watershed. An assessment of impacts to these resources that may result from the implementation of the project alternatives is described in Section 4.

3.2 HYDROLOGY, HYDRAULICS, AND PHYSICAL PROCESSES

Hydrology, hydraulics, and associated physical processes represent the primary forcing conditions in the Narramissic and Orland rivers if Orland Village Dam is altered.

3.2.1 Watershed Hydrology

3.2.1.1 Surface Water Hydrology

Hydrologic parameters for use in this analysis were developed using regional regression equations[5] developed by the United States Geologic Survey (USGS) and information provided by a representative of Verso. Hydrologic parameters were developed for a sub-watershed upstream of the Alamoosook Lake outlet dam and for a sub-watershed between the Alamoosook Lake Dam and the Orland Village Dam due to an industrial water withdrawal privilege currently owned by Verso.

3.2.1.1.1 Seasonal Flows in the Narramissic River

Regional regression equations provided in USGS Scientific Investigations Report 2004-5026 were used to estimate monthly and annual streamflows for the Narramissic River watershed at the project site. The regression equations were developed by the USGS and input parameters include sub-watershed areas, PRISM rainfall data, the percentage of each sub- watershed's area underlain by significant sand and gravel aquifers, and the distance of the centroid of each sub-watershed from an imaginary line drawn in the Gulf of Maine extending from 71.00W, 42.75N to 65.50W, 45.00N. Estimates of monthly and annual mean and median streamflows for each sub-watershed and for the watershed are presented in Table 1.

Estimated flows downstream presented in Table 1 reflect a continuous withdrawal of 13 million-gallons-per-day (MGD [20.1 cubic feet per second, cfs]), which is the typical daily water

[5] Estimating Monthly, Annual, and Low 7-Day, 10-Year Streamflows for Ungaged Rivers in Maine. Dudley, R.W., U.S. Department of Interior, United States Geologic Survey Scientific Investigations Report 2004-5026.

withdrawal by Verso at the Alamoosook Lake Dam, upstream from the Orland Village Dam impoundment[6]. James Brooks (Verso) indicated to Stantec via email that water withdrawn from the Narramissic system at the outlet of Alamoosook Lake is pumped to Silver Lake where it is then apportioned between the mill (11 to 12 MGD) and the Town of Bucksport (0.5 to 1 MGD). Actual water withdrawal rates may vary, depending on mill process water needs, drinking water needs of the Town of Bucksport, natural inflow into Silver Lake, and non-binding minimum and maximum water level targets Verso has established as internal guidelines to reduce impacts to bird nesting issues, the river herring run in the Narramissic River system, and abutting landowner uses and needs.

Table 1: Estimated Monthly and Annual Streamflows (cfs) for the Narramissic River Watershed

	A	B	C	D	E	F	G
	Upstream from Alamoosook Lake Dam (cfs)		**Verso Water Withdrawal (cfs)**	**Downstream from Alamoosook Lake Dam (cfs)**		**Flow At Orland Village Dam (cfs)**	
Period	**Mean**	**Median**		**Mean**	**Median**	**Mean***	**Median****
Annual	176.4	85.8	20.1	35.6	16.9	191.9	82.6
Jan	171.7	115.6	20.1	32.0	20.6	183.6	116.0
Feb	163.6	113.2	20.1	31.2	20.6	174.7	113.7
Mar	306.8	195.3	20.1	65.3	36.0	352.0	211.2
Apr	478.7	360.7	20.1	94.4	70.7	553.0	411.2
May	259.2	206.2	20.1	50.4	37.9	289.5	224.0
Jun	147.8	97.4	20.1	28.0	17.2	155.7	94.5
Jul	68.4	40.2	20.1	12.0	6.5	60.3	26.6
Aug	48.0	25.8	20.1	8.7	4.4	36.6	10.1
Sep	52.5	25.3	20.1	9.9	4.5	42.2	9.7
Oct	98.3	42.0	20.1	20.2	7.7	98.3	29.5
Nov	185.3	116.9	20.1	40.1	23.1	205.3	120.0
Dec	223.6	150.9	20.1	44.6	29.0	248.1	159.8

Notes:
* The value in Column F is equal to Column A minus Column C plus Column D.
** The value in Column G is equal to Colum B minus Column C plus Column E.

Approximately 1.5 percent of the approximately 93.48-square-mile sub-watershed located upstream from the Alamoosook Lake outlet dam and 2.9 percent of the approximately 18.71-square-mile sub-watershed located between the Alamoosook Lake outlet dam and the Orland Village Dam are underlain by significant sand and gravel bearing materials. The project site is located between PRISM precipitation data collection sites in Ellsworth and Bangor; therefore, PRISM data from both sites were averaged and used in the hydrologic parameter analysis.

[6] Water withdrawals by Verso vary; subsequent analyses in this report are based on Verso's right to withdraw water from Alamoosook Lake.

3.2.1.1.2 Peak Flows in the Narramissic River

No existing information was obtained for peak flows in the project reach of the Narramissic River, such as information that is typically included in studies developed by the Federal Emergency Management Agency (FEMA) for flood hazard identification. A preliminary evaluation of peak flows was performed as part of this study using general information on watershed characteristics and specific features of the upstream watershed.

The most apparent characteristic of the upstream watershed is the presence of two large impoundments in the watershed upstream from the Alamoosook Lake Dam, including Alamoosook Lake and Toddy Pond, which have surface areas of approximately 1,000 acres and 2,400 acres, respectively. The tributary watershed upstream from Alamoosook Lake Dam is approximately 94.3 square miles and includes the 25.2-square-mile watershed upstream from the outlet of Toddy Pond, which flows into Alamoosook Lake. These lakes are expected to substantially attenuate flows at their outlets; this characteristic forms the basis of the peak flow calculation presented here. In addition to the watershed upstream from Alamoosook Lake Dam, there is an 18.4-square-mile sub-watershed that drains to the Narramissic River between Alamoosook Lake Dam and Orland Village Dam.

The basis of the peak flow calculation was to develop peak flow statistics for inflows to Toddy Pond and to Alamoosook Lake using regional regression equations. This analysis includes 1) calculation of peak flows into Alamoosook Lake excluding the watershed upstream of the outlet of Toddy Pond; 2) calculation of peak flows into Toddy Pond; and 3) performing a simple routing of flows through the outlet dams at Toddy Pond and Alamoosook Lake. Flows from the outlet of Toddy Pond are routed into Alamoosook Lake. Parameters of the outlet dams on Alamoosook Lake and Toddy Pond are presented in Table 2 and are based on visual observations of the two dams, including a spillway coefficient (“C”) and spillway length (L).

Table 2: Watershed and Dam Parameters

Location	**Watershed Area (sq. mi.)**	**Outlet Dam Parameters**	
		C	**L (ft)**
Toddy Pond and Outlet	25.2	10	3
Alamoosook Lake	94.3	3.5	90
Alamoosook Lake Watershed – Toddy Pond Watershed	69.1	N/A	N/A

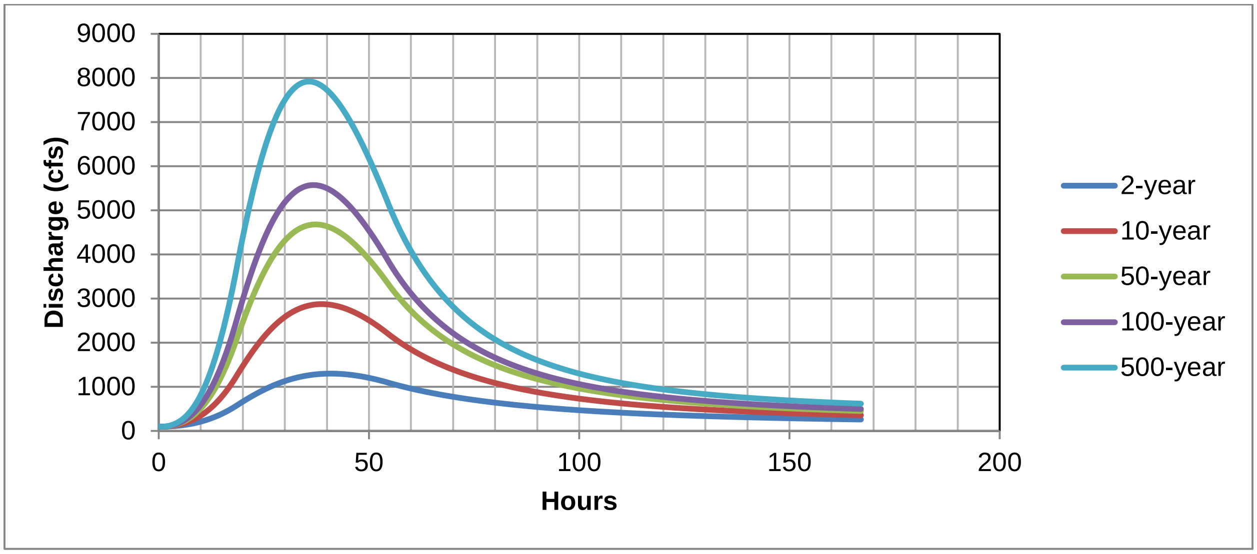
Peak flows into the two sub-watersheds described above were calculated using regional regression equations developed by the USGS as presented in the State of Maine Department of Transportation (MaineDOT) Urban and Arterial Highway Design Guide (2002). Site specific input parameters used for this analysis included the drainage area and percentage of wetland areas in the tributary drainage area. Peak flows in the two sub-watersheds were used to develop triangular hydrographs with a rise-duration from an assigned base flow of 18 hours and an overall duration of 54 hours (3-times the rise duration). Assigned base flows were 100 cfs and 20 cfs for the Alamoosook Lake and Toddy Pond sub-watersheds, respectively. Routing of peak flows was calculated using a time-step of 1 hour. Input flows and discharges at the two dams are presented in Table 3.

Table 3: Inflow and Discharge Peak Flows

Return Interval (years)	Alamoosook Lake Sub-Watershed	Toddy Pond Sub-Watershed		Alamoosook Lake Dam Discharge (cfs)
	Peak Inflow from Watershed (cfs)	Peak Inflow (cfs)	Peak Outflow (cfs)	
2	3,051	1,296	50	1,300
10	6,095	2,700	90	2,900
50	9,227	4,196	130	4,700
100	10,687	4,905	160	5,600
500	14,389	6,718	220	7,900

Calculated discharge hydrographs at Alamoosook Lake Dam are presented in Figure 1.

Figure 1: Alamoosook Lake Discharge Hydrographs



This hydrologic analysis does not include flows from the 18.4-square-mile sub-watershed between Alamoosook Lake Dam and Orland Village Dam. As depicted in Figure 1, the outflow hydrograph peaks at Alamoosook Lake Dam occur at simulation hours 35 to 40, approximately 17 to 22 hours after the peak of the inflow hydrographs at hour 18. Based on the lag that results from routing of flows through Toddy Pond and Alamoosook Lake, it is expected that peak runoff from the sub-watershed that drains to the Narramissic River between Alamoosook Lake Dam and Orland Village Dam will occur prior to the peak hydrographs at Alamoosook Lake Dam.

3.2.1.2 Tidal Hydrology

Information on tidal hydrology in the Orland River immediately seaward from Orland Village Dam was collected with an unvented, data-logging pressure transducer (in-water device) installed in the dam plunge pool adjacent to the left abutment of the dam. A second unvented data-logging pressure transducer (barometric device) was stored in an open area at a residence in Orland to obtain atmospheric pressure data for correction of data collected from the in-water device. Both devices were Hobo Water Level Loggers manufactured by Onset Computer Corporation (Onset). Setup, downloading, and post-processing were performed using Onset's HOBOware Pro software (version 3.3.0).

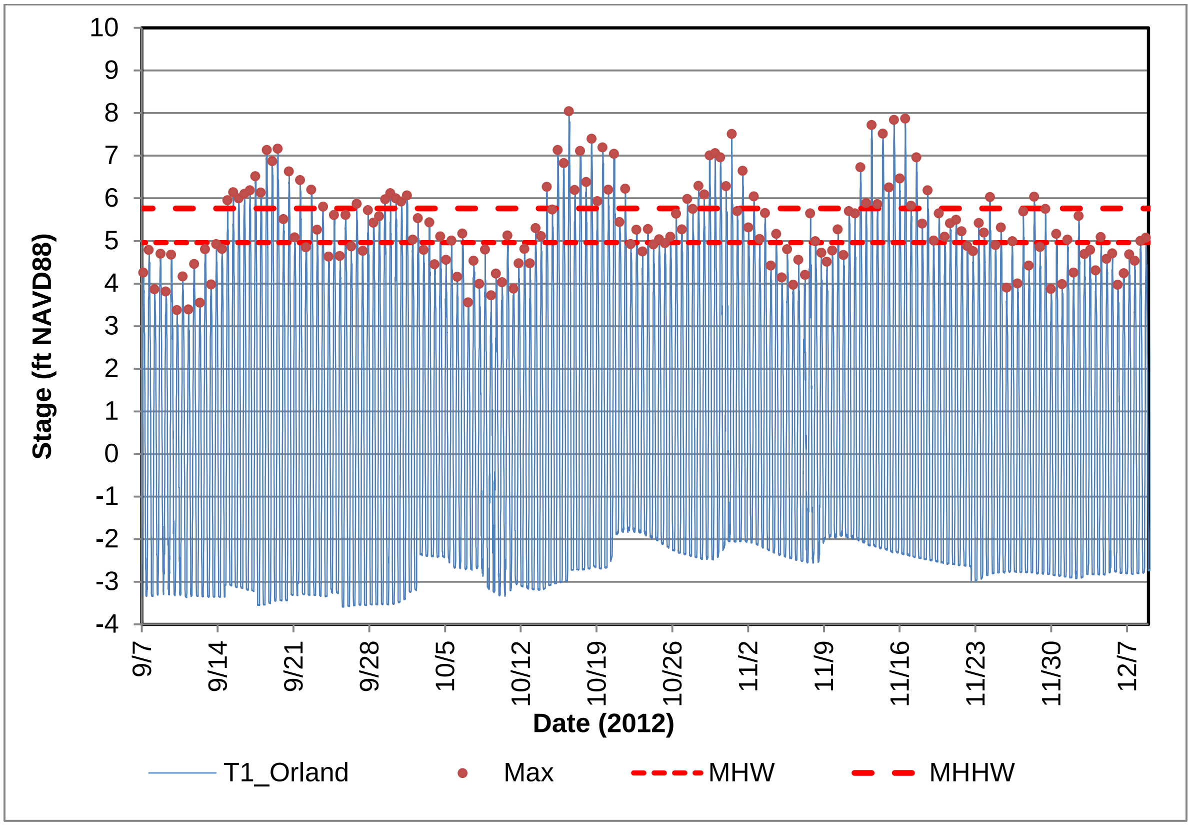
The two devices were set to log pressure data at 15-minute intervals and were installed in early September 2012 with the intent of retrieving the devices approximately one month later during other project studies. The devices could not be retrieved in October during subsequent studies due to rock rip-rap that was placed as part of repairs to the dam during the fall of 2012. Stantec made a number of attempts to retrieve the in-water device between late-October and early December 2012 and successfully retrieved the in-water device on December 9, 2012.

Post-processing of the pressure data was performed by 1) correcting for variations in atmospheric pressure using data collected with the barometric device; 2) calculating the overlying head of water based on the assumption of saltwater; and 3) rectifying the overlying water surface elevation at a noted time and date to a vertical measurement from a known elevation on the dam.

A plot of the tidal stage data is presented in Figure 2. The vertical axis is referenced to NAVD88, which is the vertical datum used for a topographic survey of Orland Village Dam that was performed as part of this study. For reference, the crest of the Orland Village Dam spillway is at an elevation of 7 ft NAVD88.

As previously noted, the tidally affected reach of the Orland River along the downstream face of Orland Village Dam results in "stranding" of the fishpass entrances (hydraulic exits) during periods of low tide during each tidal cycle.

Figure 2: Tidal Stage Data, Orland River Seaward from Orland Village Dam



Additional information that is depicted on Table 2 includes each diurnal tidal peak (maximum ["Max"]) and calculated Mean High Water (MHW) and Mean Higher High Water (MHHW) statistics. MHW and MHHW were calculated based on the average of the lower and higher high tides each day, which were elevation 4.96 ft NAVD88 and 5.77 ft NAVD88, respectively. The Mean Diurnal High Water Inequality (DHQ) based on these two values is 0.81 ft; this value is approximately two-times greater than the typical value DHQ of approximately 0.42 ft reported for tide stations maintained by NOAA along the coast of Maine, such as NOAA Station No. 8413320 in Bar Harbor.

Based on concerns regarding the validity of the calculated DHQ value of 0.81 ft, a similar analysis was performed on 15-minute stage data collected at the USGS gaging station on the Penobscot River in Bangor, Maine (USGS Station No. 01037050), for the period during which tidal stage data was collected in the Orland River as part of this project. The results of that analysis include a DHQ of 0.89 ft. Based on this value, it is assumed that the calculated DHQ in the Orland River is reasonable and reflects an increased diurnal tidal range relative to coastal stations due to narrowing of Penobscot Bay.

Tidal statistics including Mean Tide Level, Mean Low Water (MLW), and Mean Lower Low Water (MLLW) were not calculated using the tidal stage data collected as part of this project because the Orland River immediately seaward from the dam is above the elevation of the actual low tide and reverts to a riverine condition at low tide. Based on data and information from the NOAA tide station and the USGS gaging station in Bangor, it is estimated that the Mean Range of Tide (MN) immediately seaward from Orland Village Dam is approximately 11 ft. This MN can be used to estimate elevations of MLW and MLLW as approximately -6 ft NAVD88 and -7 ft NAVD88, respectively.

3.2.1.2.1 Changes in Sea Level

Long-term mean sea level collection efforts at various water level stations within the Gulf of Maine as presented by NOAA Technical Report NOS CO-OPS 53[7] and updated to include data through 2011 (available online at http://tidesandcurrents.noaa.gov/sltrends/sltrends_states.shtml?region=me), indicate that sea levels are rising relative to the local land mass at a rate commensurate with approximately 0.6 feet per century, with local variability. The rate calculated from a Portland, Maine, sea level gage indicates a rate of sea-level rise of approximately 1.90 millimeters per year (MMY), while the rate calculated from a Bar Harbor, Maine, sea level gage indicates a rate of sea-level rise of approximately 2.21 MMY. A report prepared by the Maine Geologic Survey (MGS) for the Maine Coastal Program[8] indicates that the State of Maine is planning for a predicted 2-ft rise in sea level over the next 100 years. Such a rise in sea level would subject the Orland Village Dam impoundment to increased saltwater intrusion, including increased frequency and flux (volume) of saltwater intrusion.

3.2.1.3 Surface Water Hydraulics

Surface water hydraulics in the Narramissic River were evaluated based on visual observation during multiple site visits and use of a one-dimensional, numerical hydraulic model developed using the U.S. Army Corps of Engineers (USACE) HEC-RAS software system. The project HEC-RAS model was executed for both steady-state (time-invariant) and unsteady-state (time-variant) hydraulic model evaluations.

Hydraulic model evaluations were performed for existing and proposed conditions reflecting removal of Orland Village Dam. It is assumed that any changes to the dam or fishpass would result in hydraulic conditions that are largely similar to existing conditions.

3.2.1.3.1 Observed Conditions

Surface water hydraulics in the project reach were observed by Stantec during site visits in 2012 and 2013, including transits of the impoundment by small boat between Orland Village Dam and

[7] Sea Level Variations of the United States 1854-2006. NOAA Technical Report NOS CO-OPS 53, 2009.
[8] Impacts of Future Sea Level Rise on the Coastal Floodplain. MGS Open File 06-14. Peter Slovinsky and Stephen Dickson, Maine Geologic Survey, 2006

an informal boat launch immediately upstream from Upper Falls Road. During these site visits, which coincided with periods of relatively low flow in the river, the backwater from the dam extended upstream through the Upper Falls Road culverts to the riverine reach of the river adjacent to the Verso pump station immediately downstream from the Alamoosook Dam.

The backwater from the dam effectively results in the river having lacustrine characteristics at low flow. Little apparent flow was observed through the Upper Narrows Road culverts, and no apparent flow was observed under the US Route 1 (US Rt. 1) Bridge or the SR 175 Bridge due to the large wetted area relative to the flow in the river.

The Town lowered the water in the impoundment to facilitate work on the dam in late-September 2012 at a time that coincided with project field studies. The lowering was affected by opening the gate structure to the right of the spillway and coincided with a period of relatively low flow in the Narramissic River. Stantec measured the water surface elevation immediately upstream from the dam on September 27, 2012; the measured water surface elevation was 1.5 ft below the spillway crest (Elevation 5.5 ft NAVD 88). The observed condition on this date indicates that there is very limited capacity to draw down the impoundment due to the relatively high elevation of the spillway gate inverts and features in the channel immediately upstream from the dam. Of note is that the elevation of the impoundment as measured on September 27, 2012, during the drawdown approximates the elevation of MHHW seaward from the dam as determined from data that was obtained as part of this study.

3.2.1.3.2 Hydraulic Model Development

The project HEC-RAS model was developed using information that was developed and obtained as part of this study[9]. Geometric information used in the development of the HEC-RAS model included bathymetric data and the survey of Orland Village Dam that were performed as part of this study and information on the US Rt. 1 and SR 175 bridges obtained from the MaineDOT. The geometry of the Upper Falls Road culvert crossing was not surveyed as part of this study and plans were not obtained from the Town; approximate geometries of the culvert and roadway embankment were incorporated into the HEC-RAS model.

Two geometric domains (HEC-RAS geometry files) were developed for the HEC-RAS model, including 1) an existing conditions domain; and 2) a domain reflecting removal of Orland Village Dam. These two geometric domains were used for steady-state evaluations in the HEC-RAS model. Two additional geometric domains, each with interpolated cross-sections at maximum spacings of 50 ft, were developed for unsteady-state flow evaluation of existing and proposed conditions. Interpolated cross-sections were used to improve the numerical stability of the HEC-RAS model for unsteady-state evaluations. Each geometric domain was evaluated using steady flow.

[9] Hydraulic modeling performed as part of this study is intended to provide general information relevant to evaluation of alternatives for management of Orland Village Dam. While high-flow hydraulic model evaluations were performed as part of this study, this information was not developed or intended for use in evaluating regulatory flood hazards.

Geometric domain files representative of the dam removal condition reflect identified uncertainty regarding the natural (pre-European development) elevation of the bed of the Narramissic River in the vicinity of Orland Village Dam, SR 175, and the area between these two structures. Professional judgment was used to modify cross-sections in these areas to reflect potential conditions with the dam removed along with bathymetric data indicative that there may have been a reversing falls in the vicinity of these structures.

Table 4 provides information on the HEC-RAS geometric domain files.

Table 4: HEC-RAS Geometric Domain Files

File Title	File Number	Description
EXISTING GEOMETRY	*.g03	Existing conditions geometry.
NO DAM GEOMETRY	*g04	Dam removal geometry.
US_EXISTING GEOMETRY_Interp	*.g08	Existing conditions geometry with interpolated cross-sections for unsteady-state evaluations.
US_NO DAM GEOMETRY_Interp	*.g06	Dam removal geometry with interpolated cross-sections for unsteady-state evaluations.

Hydrologic boundary conditions for the HEC-RAS model were obtained from project studies, including base and peak flow parameters at the upstream end of the modeled reach between Upper Falls Road and the Alamoosook Lake Dam and applied normal depth and tidal stage data at the downstream end of the HEC-RAS model seaward from the Orland Village Dam.

Two steady-state flow files were developed for the HEC-RAS model, including 1) a “low-flow” file with a range of 12 flows from 5 cfs to 1,000 cfs; and 2) a “high-flow” file with the 2-, 10-, 50-, 100-, and 500-year return-interval flows (from 1,300 cfs to 7,900 cfs) as presented in Table 3. Boundary conditions for the steady-state flow files were set as normal depth in the Orland River seaward from Orland Village Dam. Results from the steady-state high-flow HEC-RAS model evaluations indicate that supercritical flow occurs at the SR 175 Bridge during high flow events, and the HEC-RAS model projections upstream from the bridge are therefore not sensitive to the applied downstream boundary condition. Supercritical flow does not occur at the SR 175 Bridge during lower flows, and two additional boundary conditions reflecting downstream water surface elevations in the Orland River corresponding to MHW and MHHW were also evaluated for the low-flow steady-state HEC-RAS model evaluations. Table 5 provides information on the HEC-RAS steady-state flow files.

Table 5: HEC-RAS Steady-State Flow Files

File Title	File Number	Description
Low Flow Data	*.f02	Low flow data with normal depth ("low tide") downstream boundary condition.
High Flow Data	*.f03	High flow data with normal depth ("low tide") downstream boundary condition.
Low Flow Data_MHW	*f05	Low flow data with MHW downstream boundary condition.
Low Flow Data_MHHW	*.f04	Low flow data with MHHW downstream boundary condition.

The steady-state flow files were combined with geometric domain files to develop six HEC-RAS steady-state "plan" files that were used for steady state hydraulic model evaluations as part of this study. Information on the six steady-state plan files is presented in Table 6.

Table 6: Steady-State Plan Files

Plan Title	Filename (abbreviated)			Description
	Short ID/Plan File	Geometry File	Flow File	
DAM_LF	D_LF/ *.p07	*.g03	*.f02	Existing conditions, low flows
DAM_HF	D_HF/ *.p01	*.g03	*.f03	Existing conditions, high flows
NO DAM_LF	NH_LF/ *.p06	*g04	*.f02	Dam removed, low flows
NO DAM_HF	ND_HF/ *.p05	*g04	*.f03	Dam removed, high flows
NO DAM_LF_MHW	ND_LF_MHW/ *.p02	*g04	*.f05	Dam removed, low flows, MHW downstream boundary condition.
NO DAM_LF_MHHW	ND_LF_MHH W/ *.p03	*g04	*.f04	Dam removed, low flows, MHHW downstream boundary condition.

Unsteady-state flow files were developed to perform unsteady-state hydraulic evaluations using 1) tidal stage data collected immediately seaward from the dam as part of this study; and 2) fixed inflows at the upstream limit of the HEC-RAS model of 10 cfs and 100 cfs. The unsteady-flow evaluations were limited to modeling of these relatively low-flow conditions based on the results of the steady-state evaluations, which indicate that supercritical flow occurs at the SR 175 Bridge at very high flows. Table 7 provides information on the HEC-RAS unsteady-state flow files.

Table 7: Unsteady-State Flow Files

File Title	File Number	Description
Tidal Stage Data FT NAVD88_10cfs	*.u02	Tidal stage downstream with 10 cfs inflow.
Tidal Stage Data FT NAVD88_100cfs	*.u03	Tidal stage downstream with 100 cfs inflow.

The unsteady-state flow files were combined with geometric domain files with interpolated cross-sections to develop the four HEC-RAS unsteady-state "plan" files that were used for unsteady-state hydraulic model evaluations as part of this study. The unsteady-state hydraulic evaluations were setup to evaluate time-varying conditions represented by changes in tidal stage immediately seaward from Orland Village Dam over a period from 10:00 AM on September 9, 2012, through 12:00 PM (noon) on December 12, 2012, using tidal stage data collected as part of this study. The unsteady-state HEC-RAS model was run with a computational time step of 0.05 hrs (3 minutes).

Information on the four unsteady-state plan files is presented in Table 8.

Table 8: Unsteady-State Plan Files

Plan Title	Filename (abbreviated)			Description
	Short ID/Plan File	Geometry File	Flow File	
US_DAM_10cfs	US_DAM_10cfs/*.p12	*.g08	*.u02	Existing conditions, 10 cfs river flow.
US_DAM_100cfs	US_DAM_100cfs/*.p13	*.g08	*.u03	Existing conditions, 100 cfs river flow.
US_NO_DAM_10cfs	US_No_DAM_10cfs/*.p14	*.g06	*.u02	Dam Removed, 10 cfs river flow.
US_NO_DAM_100cfs	US_DAM_100cfs/*.p15	*.g06	*.u03	Dam Removed, 100 cfs river flow.

3.2.1.3.3 Hydraulic Model Evaluations

Hydraulic model evaluations were used to evaluate hydraulic conditions for a range of hydrologic events in the project reach of the Narramissic River for existing and evaluated conditions as represented by removal of the dam.

Existing Conditions – Low Flows

The hydraulic model evaluations of existing conditions at low flows are consistent with observed conditions and indicate that the impounded reach of the Narramissic River between Upper Falls

Road and Orland Village Dam has little apparent flow and the surface of the impoundment is effectively "flat."

Unsteady-state evaluations were performed using the time-varying tidal stage data at the downstream hydraulic model boundary. The tidal stage data includes some tides that overtop the Orland Village Dam spillway, and the hydraulic model results indicate that tidal overtopping of the dam results in increased water surface elevations in the reach of the Narramissic River between Orland Village Dam and Upper Falls Road during higher high tides.

Existing Conditions – High Flows

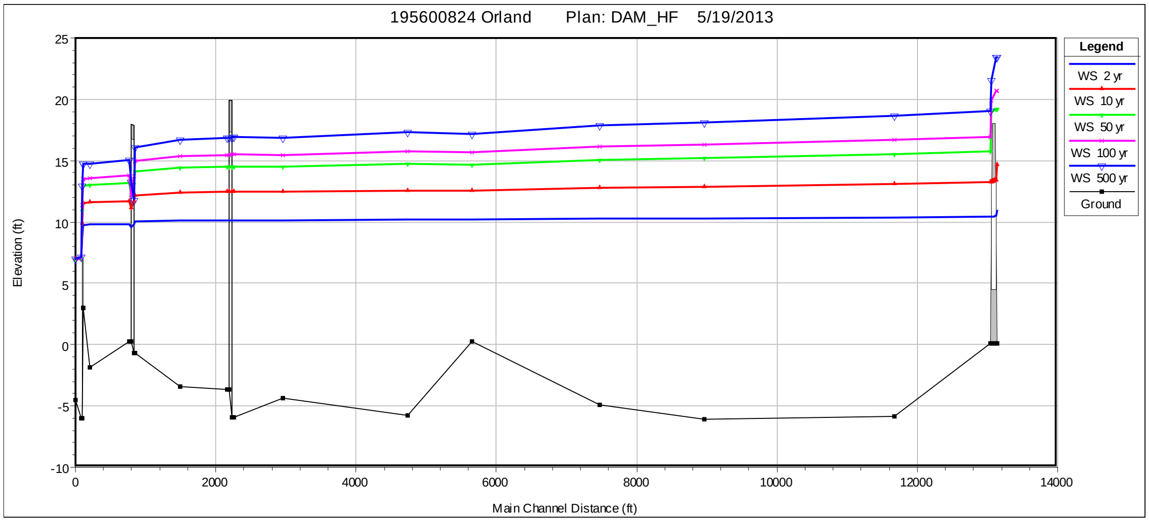
The hydraulic model evaluations of existing conditions with high flow conditions indicate that that SR 175 Bridge is a restriction on flow and that supercritical[10] flow may occur through the bridge opening during the 50-year return-interval and greater magnitude runoff events[11]. Note that the hydraulic model domains do not include relatively low-lying areas to the west of the SR 175 Bridge, and flooding and flow in that area could reduce the hydraulic conveyance through the bridge opening. The hydraulic model results also indicate that Upper Falls Road may be subject to overtopping during high-flow events.

Figure 3 depicts calculated water surface profiles in the project reach of the Narramissic River. The direction of flow in this (and all subsequent, similar images) is from right to left. Built features that are rendered in Figure 3 (from right to left) include the Upper Falls Road culvert crossing, that US Rt. 1 Bridge, the SR 175 Bridge, and Orland Village Dam.

For reference, the calculated elevation of the 100-year return-interval event at Upper Falls Road is approximately 10 ft above the normal impoundment elevation and approximately 8 ft above the normal impoundment elevation immediately upstream from the SR 175 Bridge.

[10] "Supercritical" flow occurs when inertial forces exceed gravitational forces. This ratio is typically expressed as the "Froude Number" (Fr), which is the ratio of inertial to gravitation forces ($Fr = sqrt(v^2/gy)$), and reflected supercritical flow when Fr>1.
[11] Supercritical flow may occur in the bridge at lower-magnitude events that were not evaluated (e.g., during the 25-year return-interval runoff event).

Figure 3: Existing Conditions – High-Flow Water Surface Profiles



Conditions with Dam Removed – Low Flows

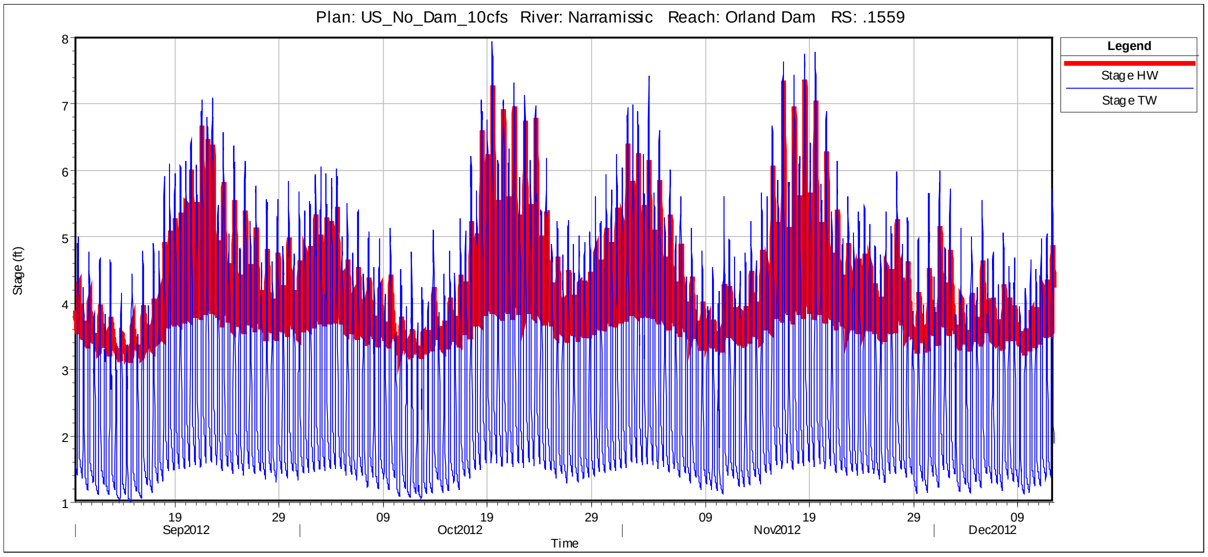
Hydraulic model evaluations with the dam removed and low flows were performed using steady- and unsteady-state numerical methods. Steady-state evaluations were performed assuming "low tide" in the Orland River over a range of flows from 5 cfs to 1,000 cfs.

The steady-state hydraulic evaluations are of limited use for evaluating water surface elevations in the Narramissic River with Orland Village Dam removed as they do not account for the substantial storage volume in the impoundment.

Unsteady-state evaluations were performed using the time-varying tidal stage data at the downstream hydraulic model boundary and inflows at Alamoosook Lake Dam of 10 cfs and 100 cfs. The results of these evaluations indicate that the SR 175 Bridge would be a tidal restriction and limit both filling and emptying of the tidally influence reach of the Narramissic River upstream from the bridge. Attenuation of the tidal "signal" at the SR 175 Bridge was pronounced in the unsteady-state evaluations; upstream low tide elevations upstream from the bridge would range between 3 and 3.75 ft NAVD 88, normal high tide elevations would range between 3.5 and 7.2 ft, and the tidal range would vary from less than 1 ft during neap tides to approximately 3 ft during spring tides.

Figure 4 depicts calculated water surface elevations on the upstream ("State HW" [red line]) and downstream ("Stage TW" [blue line]) sides of the SR 175 Bridge at a flow into the Narramissic River from Alamoosook Lake of 10 cfs. The difference between the two lines reflects the modeled tidal restriction at the SR 175 Bridge.

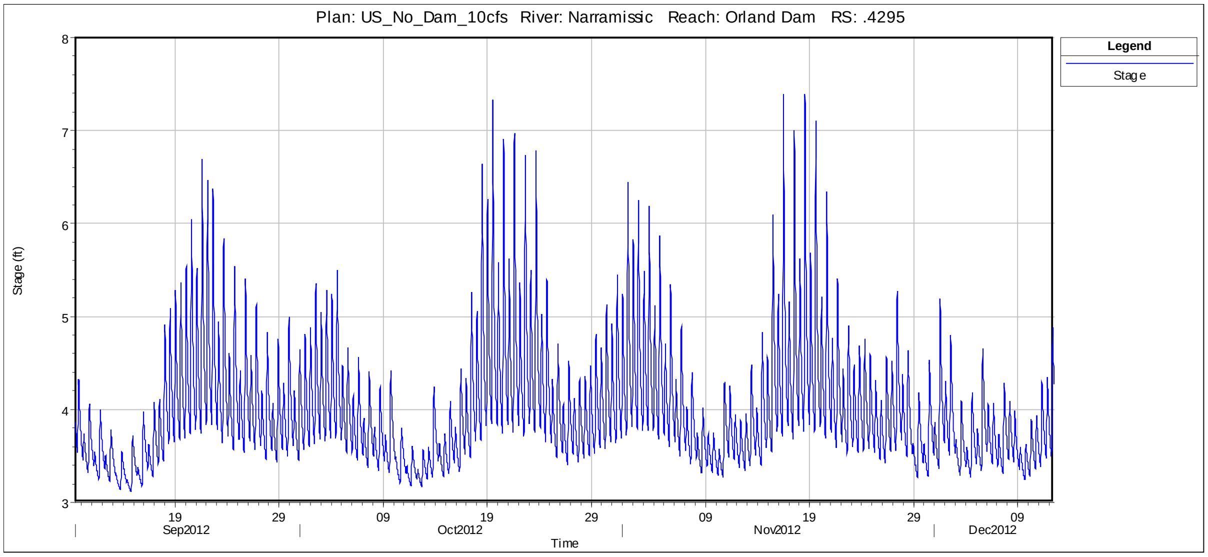
Figure 4: Dam Removed – Calculated Water Surface Elevations Adjacent to SR 175 Bridge



Based on the magnitude of the hydraulic restriction at the SR 175 Bridge as depicted in Figure 4, it is recommended that further evaluation of removal of Orland Village Dam include additional bathymetric survey work in the vicinity of the bridge and the Orland Village Dam, including evaluation of subsurface conditions to determine whether there is bedrock or other material that may have historically resulted in a reversing falls.

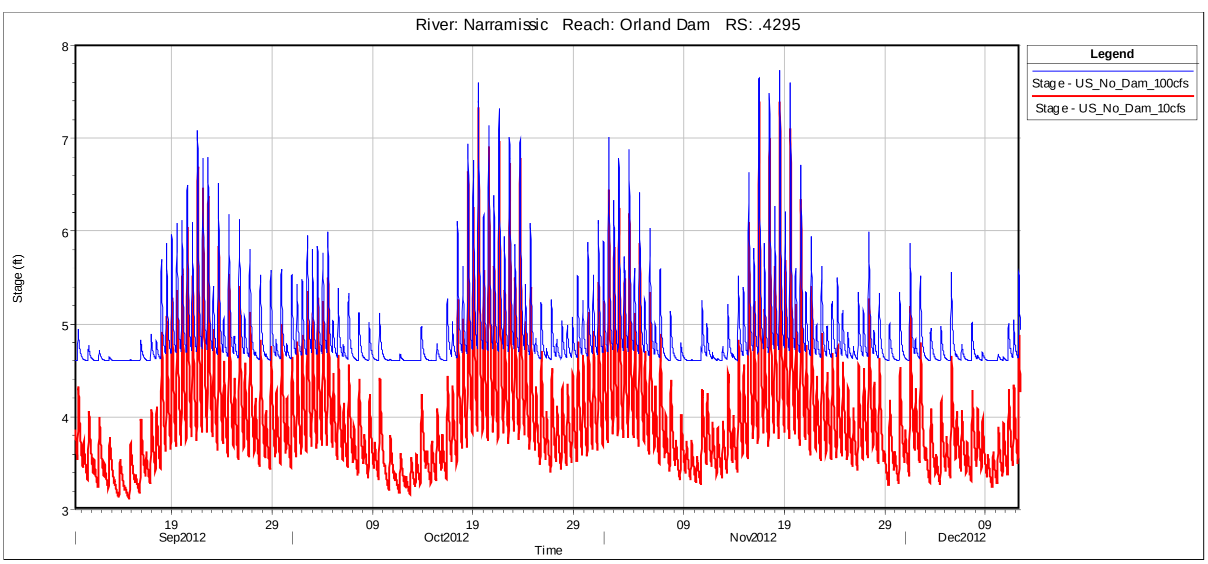
Figure 5 depicts calculated water surface elevations in the vicinity of the US Rt. 1 Bridge upstream from the SR 175 Bridge with Orland Village Dam removed. The calculated water surface elevations at the US Rt. 1 Bridge are similar to those at the upstream side of the SR 175 Bridge. The relatively large cross-sectional area under the US Rt. 1 Bridge does not result in an appreciable tidal restriction during normal flows in the Narramissic River or during typical tides.

Figure 5: Dam Removed – Calculated Water Surface Elevations at US Rt. 1 Bridge Upstream from SR 175 Bridge



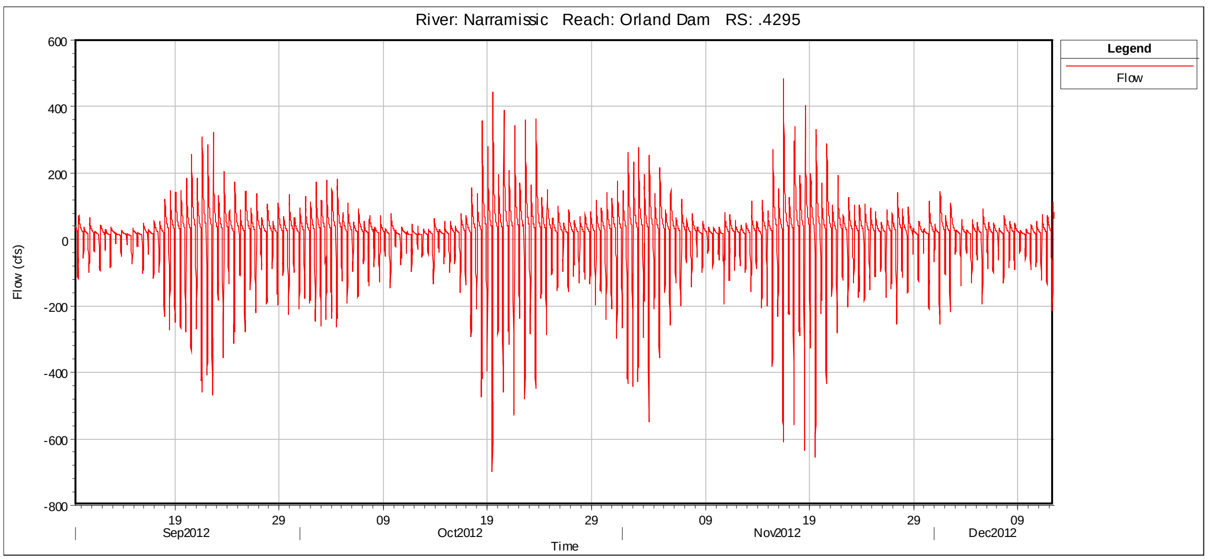
Water surface elevations in the Narramissic River with Orland Village Dam removed would also be affected by the total freshwater inflow. Figure 6 depicts calculated water surface elevations in the vicinity of the US Rt. 1 Bridge with freshwater inflows of 10 cfs (red line) and 100 cfs (blue line). Note that the calculated low tide water surface elevations with the modeled freshwater inflow of 100 cfs are approximately 1 ft higher than with the modeled freshwater inflow of 10 cfs.

Figure 6: Dam Removed – Variation in Water Surface Elevations with Freshwater Inflow at US Rt. 1 Bridge.



The unsteady-state hydraulic evaluations indicate that removal of Orland Village Dam would result in substantial flow into the Narramissic River from the Orland River, and it is presumed that this flow would be largely saltwater and result in substantially increased salinities in the Narramissic River. Figure 7 depicts the calculated flow (or “flux”) at the US Rt. 1 Bridge with a modeled freshwater inflow of 10 cfs from Alamoosook Lake Dam. Positive values reflect seaward (downstream) flow, and negative values represent landward (“tidal”) flow. The modeled flux of water into the Narramissic River with a freshwater inflow of 100 cfs was similar to that for the 10 cfs inflow, but it is expected that the increased freshwater inflow would result in dilution and reduced salinities in the Narramissic River.

Figure 7: Dam Removed – Variation in Water Surface Elevations with Freshwater Inflow at US Rt. 1 Bridge.



In addition to landward flow of saltwater into the Narramissic River, the relatively large volume of flow associated with semidiurnal tidal action would result in a moderately high speed flow in the vicinity of the SR 175 Bridge. The hydraulic model evaluations indicate that typical flow speeds in the vicinity of the SR 175 Bridge would range from 0 up to 4 to 8 ft-per-second (fps) during higher high tides.

The hydraulic model evaluation results indicate that the Upper Falls Road culverts would be perched (above the downstream water surface elevation) most of the time if Orland Village Dam were removed. As previously noted, the Upper Falls Road culvert geometries in the hydraulic model were not surveyed as part of this study, and information used to incorporate the culvert geometry into the project hydraulic models was based on limited field observations. It is therefore recommended that additional measurements be obtained to better evaluate conditions at that culvert as part of future studies if dam removal is further evaluated.

Conditions with Dam Removed – High Flows
Hydraulic model evaluations with the dam removed and high flow conditions indicate water surface elevations upstream from the SR 175 Bridge will be reduced for the 2-, 20-, 50-, and 100-year return-interval high-flow events, but that the SR 175 Bridge is a hydraulic restriction in the river. In addition, calculated flow speeds through the bridge opening are approximately twice as fast with the dam removed due to the loss of backwater effects from the dam. Removal of the dam would not substantially reduce the potential for overtopping of Upper Falls Road during flood events, however, as potential overtopping of the roadway is influenced by conveyance at the SR 175 Bridge and the hydraulic capacity of the Upper Falls Road culverts.

3.2.1.4 Groundwater Hydrology

A qualitative analysis was performed to evaluate impacts to groundwater resources in the Narramissic River watershed resulting from the modification or removal of the Orland Village Dam and the associated effects on upstream water levels. A site conceptual model was developed and applied to the site to allow for qualitative analysis of the impacts of impoundment drawdown on nearby water supply wells. Based on the inferred hydrogeologic conditions, a qualitative approach is deemed adequate to reasonably address concerns related to groundwater hydrology as part of this study.

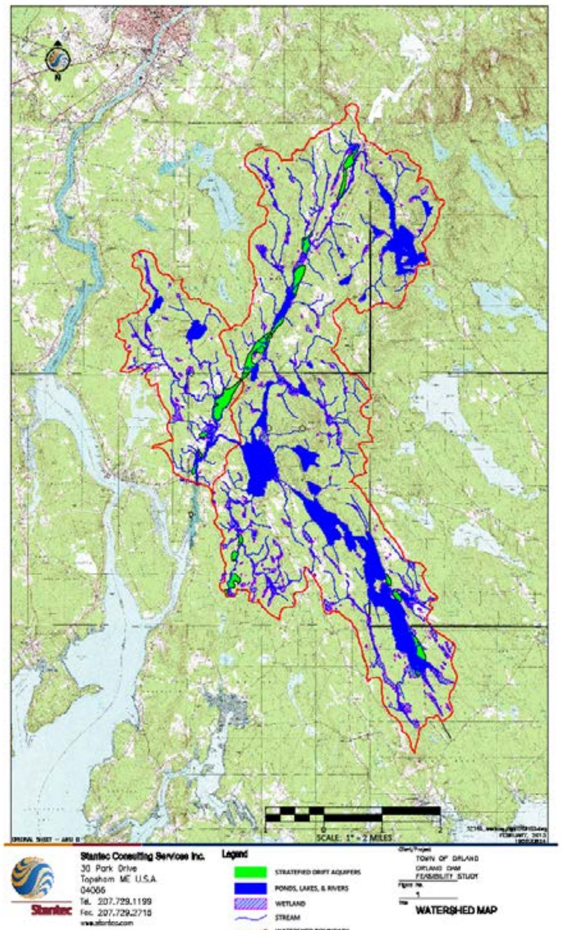
A survey of property owners near the Narramissic River was also performed by the Project Partners to assess potential for well impacts. The intent of this survey was to obtain information on existing groundwater wells in the vicinity of the Narramissic River to inform discussion and evaluation of various alternatives under consideration for management of the dam. A total of 22 responses were received and are included as Appendix D.

3.2.1.4.1 Site Conditions

The Narramissic River watershed encompasses approximately 113 square miles (Figure 8) and receives approximately 43 inches of precipitation each year. The Orland Village Dam converts approximately 19,000 linear ft of riverine habitat along the Narramissic River and Wight's Brook into an approximately 92-acre impoundment.

Surficial soils within the project area are primarily glacio-marine clays, glacial till, 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. Significant sand and gravel deposits occur along the northwestern side of the project reach in the vicinity of Narramissic Drive north of US Rt. 1 and the Bucksport Golf Club and within the Wight's Brook drainage in the vicinity of SR 46. Stream alluvium consisting of sand, silt, and minor amounts of gravel form the river corridor along the Orland Village Dam impoundment. Peat deposits associated with wetlands are also present in the vicinity of Duck Cove and Wight's Brook. Bedrock outcroppings are prevalent in the vicinity of the Orland Village Dam.

Figure 8: Orland Village Dam Watershed Map



Published hydrogeologic maps indicate that there are significant sand and gravel aquifers upstream from the Orland Village Dam impoundment (MGS, 2010, Appendix E) and that overburden depths in the vicinity of the Orland Village Dam impoundment range up to 90 ft (MGS, 2011, Appendix E) but are generally less than 30 ft.

Groundwater in the vicinity of the site is generally close to the ground surface; depths to groundwater reported on maps developed by the MGS (2011) average less than 10 ft below ground surface and are presumed seasonally variable up to 10 ft. Deeper depths to groundwater are noted further from the river in areas where the ground surface gains in elevation.

3.2.1.4.2 Site Conceptual Model

Potentiometric surface data from MGS (2011) suggest that the Narramissic 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.

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 Narramissic River, water table depths and groundwater flow patterns are strongly influenced by surface topography. Depths to water as reported on the MGS (2011) show that groundwater contours follow surface topography. It is assumed that there are groundwater divides to the northwest and southeast of the river (similar to watershed boundaries) and that flow moves from northeast to southwest under the river valley floor. The impoundments in the system 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.

3.2.1.4.3 Analysis of Potential Impacts to Wells

This section presents a conceptual analysis of potential impacts to water withdrawal wells associated with a lowering of the dam impoundment. This section is included here to provide a basis for evaluation of potential impacts in Section 4. 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, and would be further compounded by tidal influence. Well bore storage may decrease in wells constructed in overburden immediately surrounding the impoundment, 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. Based upon the responses from the survey of property owners in the vicinity of the project, several of these types of wells do exist within the project reach; however, they appear to be used mainly for non-potable uses (e.g., irrigation). The relative depths of saturated overburden in the vicinity of the river limit potential impacts to wells drilled into fractured bedrock; however, hydraulic connectivity is possible in glacially-shaped terrain. One well survey response indicated belief of direct hydraulic connectivity between a residential well and the Orland Village Dam impoundment. Several public water supply wells are located in proximity to the project area, with the closest one to the Orland Village Dam impoundment located near to the Bucksport Golf Club clubhouse.

A potential for displacement of freshwater within overburden, and to a lesser extent bedrock, by heavier, saline water also exists. Such conditions can be exacerbated where prolonged drawdown of localized groundwater potentiometric surface via pumping creates conditions favorable for entrainment of surface waters.

Overall changes to the well bore storage in bedrock wells located near 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 connectivity with water infiltrating 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, 2011) revealed no apparent relation between well yield compared to the distance from the impoundment.

In conclusion, it is not expected that removal of the Orland Village Dam would likely cause impact to the majority of bedrock well users in the vicinity of the Narramissic River, but that some impacts to overburden wells and/or wells in direct connectivity with the Orland Village Dam Impoundment could occur as a result of changes in groundwater elevations and/or saltwater intrusion. Surface water withdrawals extracted directly from the impoundment would be impacted by conversion of the freshwater impoundment to a tidally influenced brackish estuarine ecosystem.

3.2.2 Water Quality

The Orland Village Dam impoundment is primarily a freshwater impoundment fed by surficial and groundwater resources within the watershed. Estimates monthly and annual streamflows are provided in Section 3.2.1. Seasonal low flows during July through mid-October, especially during August and September, combined with physical and biological processes within the impoundment, also affect water quality within the impoundment. For example, periods of lower in-stream flows may hamper flushing of nutrients from this impoundment, resulting in conditions favorable for algae growth and decreased water quality. The following provides a description of processes that affect water quality and, based upon observations made during project work, may be occurring within the impoundment. No dedicated water quality work was performed as part of this study.

The expansive surface area, combined with shallow water depths, allows the impoundment to more rapidly adjust in response to surface air temperatures than an impoundment with a smaller surface area and deeper depths. The relatively dark bottom and high dissolved organic carbon content of the water also readily absorb energy, resulting in elevated water temperatures. The expansive surface area of the impoundment also permits evaporative cooling to occur. Resulting evaporative losses from a warm impoundment can be substantial and can affect in-stream flows available for downstream water usage, such as flows through fish passage facilities.

The solubility of atmospheric gases in water decreases with increasing water temperatures. Oxygen is added to water from the atmosphere by diffusion across the air-water interface and by aquatic plant photosynthesis. In nutrient-rich water with algae blooms or large amounts of aquatic plants, such as within the Orland Village Dam impoundment, dissolved oxygen (DO) levels generally decrease at night due to respiration of algae/plants, while values during the day increase and may sometimes be supersaturated due to photosynthesis. Decay of organic matter can also result in biological oxygen demand, which can impair water quality by reducing DO concentrations (hypoxia). Biological oxygen demand can result in die-off of aquatic organisms not adapted to low-oxygen environments.

Hypoxic conditions can result in the production of hydrogen sulfide gas during the biological breakdown of organic matter. Hydrogen sulfide is marginally soluble in water and acts as a weak acid known as hydrosulfuric acid. The oxidation of hydrogen sulfide, particularly during periods of water column stratification or ice covering that limits the exchange of oxygen with the atmosphere, can lead to mass of asphyxiation of aquatic organisms through chemical oxygen demand. Such events, sometimes referred to as ‘winter kills’, are fairly common in eutrophic systems in northern climates.

Diurnal variations in pH can also occur due to aquatic plant and algae uptake of dissolved carbon dioxide during photosynthesis faster than diffusion of the gas across the atmosphere-water interface occurs, resulting in an increase in pH during such periods. Dissolved carbon dioxide levels return to equilibrium with atmospheric concentrations of carbon dioxide at night, when photosynthesis processes are not active. One concern related to elevated pH in aquatic environments is that, in combination with elevated water temperature, elevated pH may trigger a shift in available nitrogen from ammonium ions to dissolved ammonia, which can also trigger die-off of aquatic organisms.

Periodic overtopping of the dam by tidal and/or storm related surges introduce saline waters to the impoundment and may result in ‘shocking’ of salt-intolerant species in the vicinity of the dam. Buoying of water intakes near the surface of the impoundment near the Orland Village Dam suggest entrainment of saline laden waters through the porous structure of the dam during seasonal low-flow periods may occur. This statement is supported by an anecdotal communication received by Stantec from a project abutter that the lower water column in this area of the impoundment periodically reverts to a saline condition. Sea-level rise would increase the frequency of such events.

A review of information publicly available through the Maine Department of Environmental Protection (MaineDEP) Maine Center for Disease Control and Prevention website pertaining to hazardous materials and oil spills in the vicinity of the Orland Village Dam impoundment indicate that several spills have occurred within the project area, mostly involving Number 1 or Number 2 Fuel Oil. Available information suggests that such spills were likely contained or of limited impact to nearby wells and surficial water bodies at the time of occurrence and therefore likely have had little impact on the water quality or sediment chemistry within the Orland Village Dam impoundment.

Additional study is recommended to evaluate existing water quality in the Narramissic River. Suggested studies include regular sampling of DO, temperature, and salinity at selected locations between SR 175 and Upper Falls Road, and should emphasize sampling during periods of lower freshwater flow. Furthermore, it is recommended that sampling of DO, temperature, and salinity include sampling along vertical profiles in deeper areas of the impoundment to determine whether there is seasonal stratification and/or hypoxia or anoxia.

3.2.3 Flooding & Ice Jams

FEMA Flood Insurance Rate Maps (FIRMs) and Flood Hazard Boundary Maps (FHMBs) are not currently available through the FEMA Map Service Center, and it was not determined whether the Town is a participant in the National Flood Insurance Program. The results of the hydraulic model evaluations performed as part of this study indicate that anthropogenic features along the Narramissic River likely increase the potential for flooding of low-lying areas along the river, including the built-up area along the west side of the river immediately adjacent to the SR 175 Bridge. Historical information provided to Stantec indicates that at least one flood event sent floodwaters over Narramissic Drive in this area. While hydraulic model evaluations without Orland Village Dam and with a wider spanning SR 175 Bridge were not performed as part of this study, it is expected that removal of the dam and replacement of the SR 175 Bridge with a larger structure could result in reduced floodwater elevations associated with upland runoff events.

The potential for coastal flooding was not quantitatively evaluated as part of this study. Low-lying areas in Orland may be subject to coastal flooding, but protection of such areas would likely require extensive measures that would need to be designed with care to avoid increasing risk of flooding from upland runoff events.

A dedicated evaluation of the potential for ice jams resulting from project actions was not performed as part of this feasibility study; however, a search of the Ice Jam Database maintained by the USACE Ice Research Group, Cold Regions Research and Engineering Laboratory (CRREL) was performed and did not result in the identification of historical records of ice jams within the project reach. While the relatively flat gradient through the project reach and high existing width to depth ratio enhance the formation of ice, the existing hydraulic conditions within the reach may limit it.

Information provided by a stakeholder[12] to this study indicates that ice jams formed at the former SR 175 Bridge prior to its replacement with the current structure. Information on the previous bridge indicates that it had a single, relatively small opening and was subject to ice and debris jamming.

An additional factor that may contribute to increased flooding and overtopping of Orland Village Dam during regular and extreme tidal events is sea level rise. The dam is currently overtopped by higher high tides, and increased sea level elevations would result in increased frequency and magnitude of overtopping. While there is uncertainty in the magnitude of potential sea level rise in the vicinity of the Orland River and Orland Village Dam, recent information indicates a trend of increased sea levels.

3.2.4 Morphology and Sediments

3.2.4.1 Channel Morphology

The sediment supply is limited within the project reach due to the presence of naturally occurring, though enlarged due to anthropogenic alteration, lakes and ponds located immediately upstream from the project reach. Therefore, the morphology of Narramissic River channel upstream from the Orland Village Dam is largely derived from pre-dam hydraulic conditions and local geologic features. Pre-dam riverine and tidal hydraulic forces worked to shape the existing channel through glacial features shaped by the Late-Wisconsin glacial epoch, depositional features associated with hydraulic forces, and peat formations derived from historically occurring wetland features.

Much of the channel through the impoundment is bordered by fairly vertical side slopes up to a horizontal plane currently covered by an extensive growth of aquatic vegetation. Such features are common in tidally affected marshes. The channel thalweg has been shaped by hydraulic forces into a series of pools varying to depths of up to 15 ft, separated by shallower reaches associated with lower energy depositional zones.

Underlying geologic features also work to shape the channel. Historically occurring hydraulic controls formed by the presence of coarse bed material (e.g., cobble, boulder, and/or bedrock) occur between the Orland Village Dam and the SR 175 Bridge and in the vicinity of Station 57+00 measured upstream from the dam along the channel thalweg. Both sites are possible locations of reversing falls, based on local channel thalweg elevations and tidal stage elevations

[12] Material dated March 21, 2013, included with email correspondence from Sharon Thompson of Orland.

recorded downstream from the existing dam. A bathymetric map[13] of the impoundment is included in Appendix F.

3.2.4.2 Sediment Characterization

Information and data used to evaluate sediment depth and composition was obtained as part of project field studies performed on September 27, 2012, which included measurement of the impoundment water surface elevations and manual probing of the impoundment at select locations to measure depths of water and apparent depths of sediment. Where sediment composition could not be evaluated with manual probing, a petit-Ponar sampling apparatus was used to obtain grab samples for further visual evaluation of sediment material.

The reference elevation for the manual probe data collection work was the water surface elevation in the impoundment as determined using measurement from vertical benchmarks on the dam established as part of project work. The reference water surface elevation (WSEL) for the impoundment at the time of manual probing was 5.49 ft (NAVD88) as determined from a measurement of the water surface at Orland Village Dam.

Sediment depths were measured via probing with a survey rod deployed from a small boat along the apparent thalweg through the impoundment, and probing locations were obtained with a WAAS-enabled GPS receiver. Depths of sediment were determined by setting the base of a survey rod on the apparent bottom at each location, recording the depth of water on the survey rod, and then measuring the height on the survey rod when manually forced to refusal; the depth of sediment used for this analysis is the absolute value of the difference between the first and second measurements. The measurements were recorded on the GPS data logger at each probe location with a pair of codes representing the apparent bottom and depth of refusal. The depth of sediment at each location was obtained by post-processing the data. A total of 79 sediment probe locations were mapped in the impoundment as part of this work.

The following subsections include discussion of relevant observations. Stationing is given in feet starting at zero near the dam and increasing upstream from the dam as depicted on Figure 9, with measurements taken along the apparent thalweg through the dam impoundment.

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[13] Bathymetric map is not suitable for navigation.

Figure 9: Sediment Probing Locations

Orland Village Dam to Station 7+00 (SR 175 Bridge)

Sediment probing was performed at 10 locations within this reach. Visual classification of the bottom was possible throughout much of this reach, with manual probing showing no appreciable amount of sediment and a hard, rock bottom where the bottom could not be visually classified. The bottom is characterized by boulder/cobble/bedrock intermixed with limited amounts of fine grained sediment (e.g., sand). Tidal stage data collected immediately seaward from Orland Village Dam suggests that a reversing falls or rapids may have been present at this location prior to dam construction.

Station 7+00 (SR 175 Bridge) to Station 21+00 (US Rt. 1 Bridge)

Sediment probing was performed at eight locations spaced approximately 175 ft apart within this reach. At Station 7+50 (immediately upstream from the SR 175 Bridge) bottom substrates were classified as boulder/cobble/rock. From Station 7+50 to approximately Station 19+00, bottom substrates were characterized as soft, organic/inorganic silt and clay varying in thickness up to 2.1 ft. Fine grained sediment was noted to stick to the survey rod upon retrieval throughout areas with soft sediment. No sediment was noted at Station 12+50 and a hard, glacial till bottom was observed via petit-Ponar grab sample at this location.

Station 21+00 (US Rt. 1 Bridge) to Station 48+00 (upstream of Duck Cove)

Sediment probing was performed at seven locations approximately 375 ft apart through this reach. No sediment was noted at Station 24+50 and a hard, glacial till bottom was observed via petit-Ponar grab sample at this location. Between Station 29+00 to approximately Station 48+00, bottom substrates were characterized as soft, organic/inorganic silt and clay varying in thickness up to 3.3 ft, with the greatest amount of sediment located within a large outside meander bend adjacent to a small tributary entering the Narramissic River at Duck Cove. Fine grained sediment was noted to stick to the survey rod upon retrieval throughout areas with soft sediment.

Station 48+00 (upstream of Duck Cove) to Station 60+00

Sediment probing was performed at 14 locations spaced approximately 80 ft apart within this reach, with closer spacing near the middle of the reach in the vicinity of an apparent transverse bar formed of boulders and bedrock across the channel at approximately Station 57+00. The channel appears constricted through this reach, with course material (i.e., large boulders) forming the edges of the impoundment near the mid channel bar. Relatively deep water is present upstream and downstream from the apparent bar, and tidal stage data collected immediately seaward from Orland Village Dam suggests that a reversing falls or rapids may have been present at this location prior to dam construction. No appreciable sediment aggradation was noted through this reach. Limited gravel substrates in the vicinity of the transverse bar and glacial till substrates located downstream from the transverse bar were identified using the petit-Ponar grab sampler in this reach.

Station 60+00

Sediment probing was performed at two locations spaced approximately 75 ft apart in the vicinity of Station 60+00. An apparent transverse channel bar was located in this area and the petit-Ponar grab sampler utilized to identify the composition of the bar as being composed of fine sand.

Station 60+00 to Station 100+00
Sediment probing was performed at 18 locations along this reach. Bottom substrates throughout this reach were characterized as soft, organic/inorganic silt and clay varying in thickness up to 5.1 ft, underlain by an abrupt transition to a solid material (possible glacial till). Fine grained sediment was noted to stick to the survey rod upon retrieval throughout this reach. The heaviest sediment accumulation is located in the vicinity of the confluence with Wight's Brook. Petit-Ponar grab samples indicated the presence of surficial organic detritus overlying organic/inorganic silt and clay in the vicinity of Wight's Brook.

Station 100+00
Sediment probing was performed at two locations spaced approximately 75 ft apart in the vicinity of Station 100+00. An apparent transverse bar was located via probing in this area and a petit-Ponar grab sampler utilized to identify the composition of the bar as being composed of fine sand.

Station 100+00 to Station 121+00
Sediment probing was performed at eight locations spaced approximately 300 ft apart through this reach. Bottom substrates throughout this reach were characterized as soft, organic/inorganic silt and clay varying in thickness up to 4.9 ft, with depth to refusal thickness generally decreasing as the station increment from the dam increased (i.e., decreasing in the upstream direction). The sediment deposition is influenced by the Narramissic River becoming more riverine in the upstream direction. Large woody debris (particularly beaver-felled oak trees) is located along the east bank of this reach. Some boulder/cobble substrates were noted along a glacial till deposit along the west bank near Station 116+00.

Station 121+00 to Station 129+50 (Upper Falls Road)
Sediment probing was performed at four locations spaced approximately 100 ft apart through this reach. Bottom substrates throughout this reach were characterized as fine to medium sand. Probing depths were limited to 0.2 ft or less to refusal. Woody debris and slab lumber litter the reach. A depositional bar resulting from scour just downstream from the Upper Falls Road crossing is located at approximately Station 121+00 to 124+50.

3.2.4.2.1 Sediment Characterization Summary

Observations during the sediment probing and bathymetric survey work in the dam impoundment suggest that most of the accumulated sediment in this impoundment is soft inorganic and organic silt and clay (i.e., fine 'muck' and organic detritus) located upstream from channel bars and in the vicinity of tributary brooks and more granular deposits as a result of scour forces below stream crossings and adjacent to natural 'hard' channel features. The observed conditions and findings are consistent with the expected minimal amount of sediment transport into the project reach due to trapping of sediment in Alamoosook Lake and other water bodies in the upstream watershed.

3.3 ECOLOGICAL RESOURCES

3.3.1 Fisheries

The project reach of the Narramissic River hosts a variety of resident and diadromous fish species. Resident fish species documented through visual observation include largemouth bass (*Micropterus salmoides*), pumpkinseed sunfish (*Lepomis gibbosus*), yellow perch (*Perca flavescens*), and chain pickerel (*Esox niger*). Diadromous species documented through visual observation as part of this study include anadromous river herring.

Consultation with the Maine Department of Inland Fisheries and Wildlife (Maine DIFW) as part of this study indicates that the Narramissic River supports coldwater populations of brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and American eel (*Anguilla rostrata*). Maine DIFW currently supplements the wild brook trout population with stocked brook trout twice annually and occasionally stocks landlocked Atlantic salmon and brown trout within the project reach of the Narramissic River.

Correspondence with the Maine Department of Marine Resources (Maine DMR) and USFWS indicated that the project reach of the Narramissic River and Wight's Brook are within listed Critical Habitat for Atlantic salmon. Additional information provided by Maine DMR indicated that Maine DMR does not have an active Atlantic salmon restoration program on the Narramissic River, but information obtained from NOAA indicates that there are 1,583 units (158,300 square meters) of Atlantic salmon habitat in the Narramissic River watershed upstream from Orland Village Dam. Maine DMR indicated the presence of Craig Brook National Fish Hatchery on the shores of Alamoosook Lake may provide olefactory cues and increase the likelihood of stray adults returning to the Narramissic River. Maine DMR reported that they have a confirmed report of an adult Atlantic salmon caught by a recreational angler in the Narramissic River immediately downstream from Alamoosook Lake Dam in December 2010.

Maine DMR indicated that the project reach is considered an important migratory corridor for river herring and American eels, and that both species would be benefited by removal of the Orland Village Dam. The estimated production potential for river herring, provided by the Maine DMR for the system above the Orland Village Dam is 1,167,480 fish; however, the existing river herring run is substantially lower[14]. In addition, Maine DMR indicated that shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon (*Acipenser oxyrinchus*) may occur in the tidal estuary downstream from the Orland Village Dam.

Other native fish species that likely occur in the Orland River immediately seaward from the dam include sea lamprey (*Petromyzon marinus*), rainbow smelt (*Osmerus mordax*), Atlantic tomcod (*Microgadus tomcod*), and American shad (*Alosa sapidissima*). The native fish communities in the Orland and Narramissic Rivers are bisected by Orland Village Dam, and the existing fishpass at the dam is largely unsuitable for upstream passage of these fish species. A specific consequence of this is that fish species that would naturally be present in the

[14] Claire Enterline, Maine Department of Marine Resources, personal communication.

Narramissic River are prevented from moving upstream. In addition, the impoundment formed by the dam creates habitat that is well suited to introduced species, such as largemouth bass and chain pickerel.

3.3.1.1 Recreational Fisheries

The Maine DIFW also annually stocks the Narramissic River near the upstream end of the Orland Village Dam impoundment with brook trout to support a seasonal recreational fishery for such downstream of the dam on the outlet Alamoosook Lake. The Narramissic River below Alamoosook Lake is managed as a 'put and take' coldwater fishery, as spawning and rearing habitat is limited and extensive populations of predatory warmwater species exist within the project reach. A fishery for introduced (exotic) chain pickerel, largemouth bass, and smallmouth bass (*Micropterus dolomieu*) exists within the Orland Village Dam impoundment.

3.3.1.2 Commercial Fisheries

Eel 'pots' located within the lower impoundment are indicative of an existing commercial fishery for American eel. A seasonal river herring harvesting operation is constructed downstream from the Orland Village Dam in the Orland River when deemed feasible by the Maine DMR. A poster formerly located on the river herring harvesters' building[15] indicated that the current status of the commercial river herring fishery in the Orland River is 'closed'; however, harvest is currently allowed under a management plan approved on an annual basis by the Maine DMR. The river herring harvest plan is included as Appendix G.

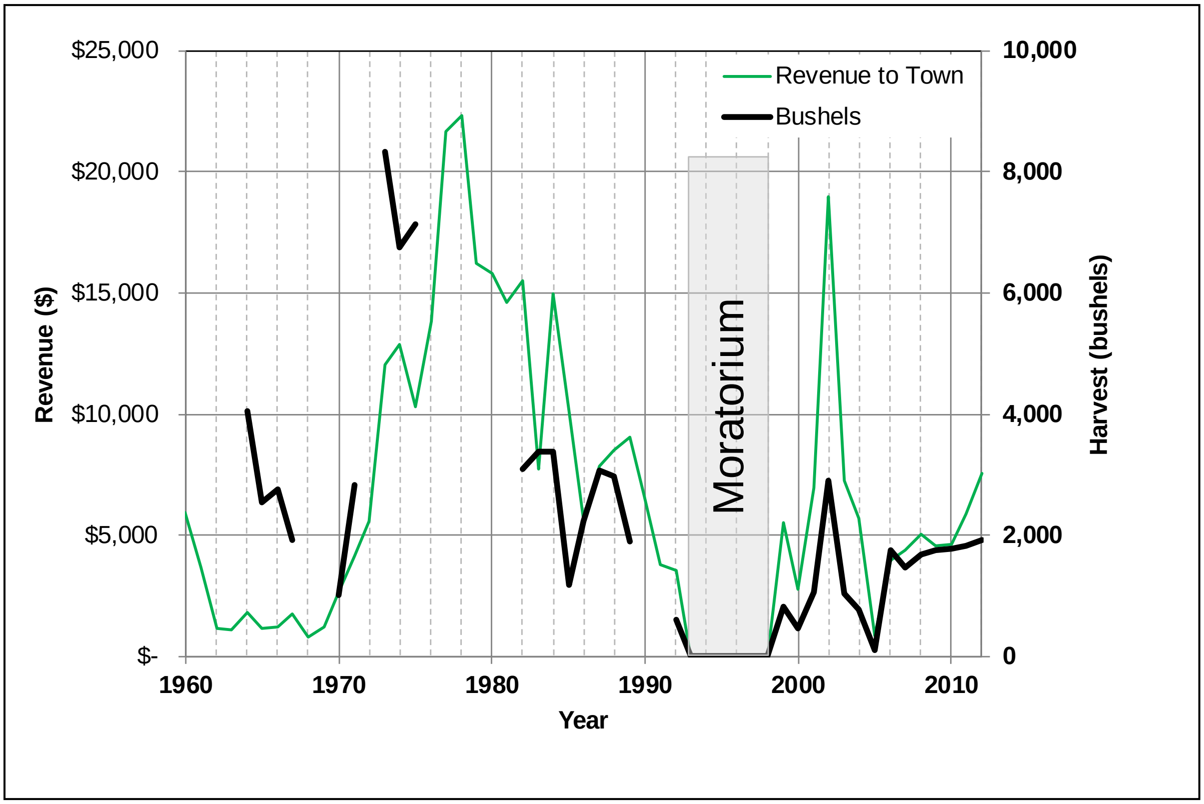
Information provided to Stantec by the Maine DMR indicates that the allowance for commercial harvest of river herring in the Town is based upon sustainability criteria for the fishery established by the Maine DMR as authorized under Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring (2009) approved by the Atlantic States Marine Fisheries Commission (ASMFC). The current sustainability criteria for the existing river herring fishery within the Town to remain open is that the total production (measured as river herring harvested plus escapement) must exceed the estimated production of Alamoosook Lake (estimated at 234,295 fish, or 235 fish per acre). Due in part to factors including potential underperformance of the Orland Village Dam fish passage facilities, fish passage performance elsewhere in the Narramissic River water, and adult escapement into suitable spawning habitat in in the watershed, there is concern amongst resource managers that commercial harvest may be curtailed in the future.

Alewife harvest data based on catch immediately downstream from Orland Village Dam were provided to Stantec by the Dam Committee for inclusion in the FS. The harvest data are for the years from 1960 through 2012, including a period from 1993 through 1998 during which there was a partial moratorium on alewife harvesting at the dam.

[15] The alewife harvesters building was demolished during dam renovations performed by the Town in 2013.

Information pertaining to the existing river herring harvest and value to the Town of Orland provided to Stantec by the Town is provided in Figure 10.

Figure 10: Commercial River Herring Harvest & Approximate Revenue

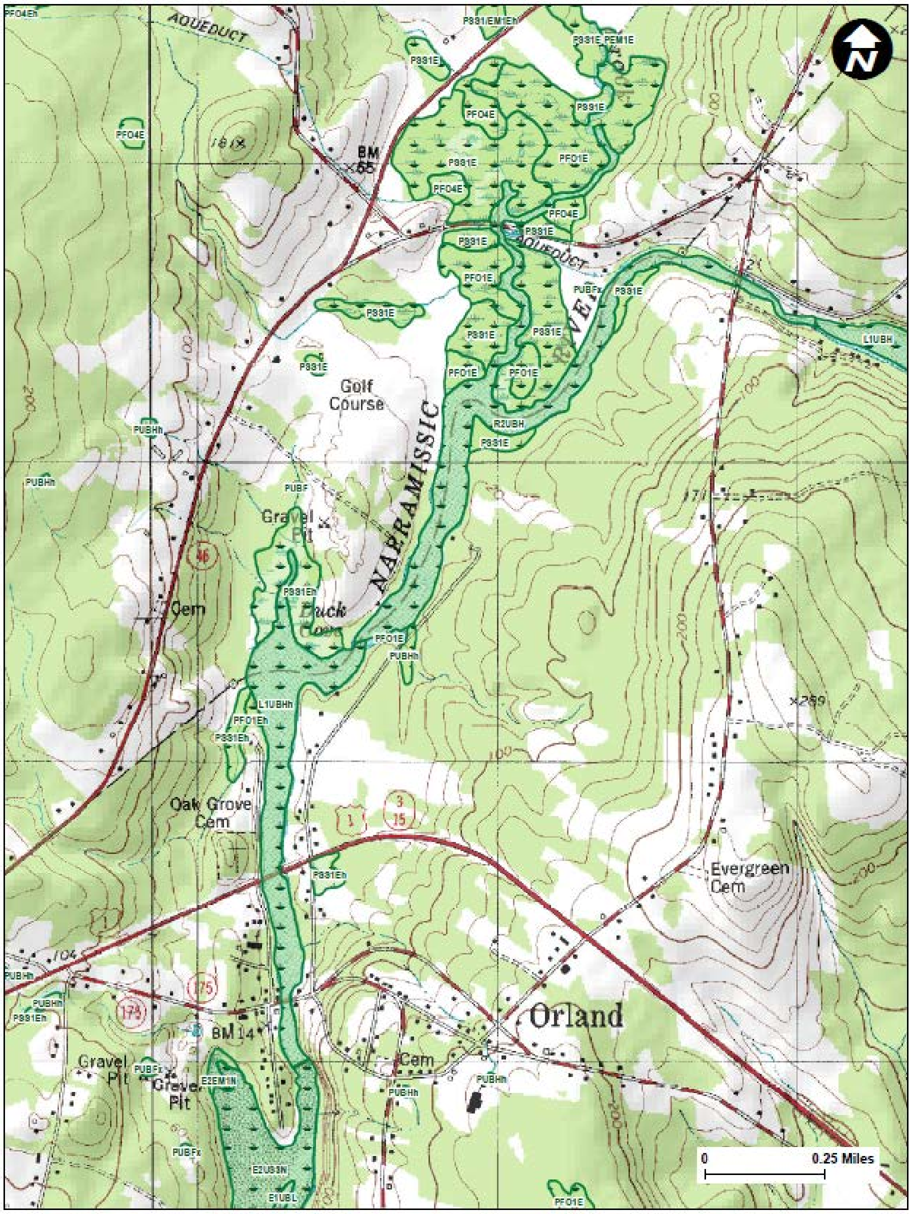


3.3.2 Wetlands

Extensive wetland communities were noted in the vicinity of Duck Cove, Wight's Brook, and along the fringe of the Narramissic River during field work performed by Stantec. A desktop characterization of wetlands was performed using National Wetland Inventory (NWI) data[16] obtained from the Maine Office of GIS (MEGIS) (Figure 11) and field observations. Detailed wetland delineation of the project area, including plant identification, was not performed as part of project work. Regulatory permitting of a selected project alternative other than the No Action alternative would require wetland resource delineation work.

16 NWI wetlands data utilizes a classification system described by Cowardin, L.M, V. Carter, F. C. Golet and E. T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 131pp.

Figure 11: Project Reach National Wetland Inventory (NWI) Map



Wetland habitat seaward from the Orland Village Dam is mapped as Estuarine Intertidal with unconsolidated bottom (NWI Classification Type E2US3N) prevalent outside of the area impacted by anthropogenic gravel and cobble fill associated with former industrial usage such as the building of wooden mast ships that formerly occurred just downstream from the dam. Vegetation was limited to along the fringes of the intertidal reach.

The Orland Village Dam impoundment is characterized as a lacustrine wetland (NWI Classification Type L1UBHh) with a permanently unconsolidated bottom covering approximately 90 acres. A fringe of palustrine emergent wetlands that transitions to palustrine scrub shrub wetlands and eventual uplands surrounds the majority of the impoundment.

A small, unnamed intermittent stream channel flows through an approximately 3.6-acre palustrine scrub shrub wetland (NWI Classification Type PSS1Eh) and an approximately 0.9-acre palustrine forested wetland (NWI Classification Type PFO1Eh) before confluence with the Narramissic River just south of the area known as Duck Cove. Hydrology for these wetlands appears to be driven by stream hydrology. A beaver dam lies just upstream from the confluence with the Narramissic River, limiting the influence of the Narramissic River on these wetlands.

An approximately 16.4-acre palustrine scrub shrub wetland (NWI Classification Type PSS1Eh) surrounds Duck Cove. This area experiences seasonal inundation, especially early in the growing season and soil substrates remain saturated near the surface for much of the remainder of the year. Hydrology for this wetland is primarily derived from the Narramissic River; however, ephemeral and small, intermittent stream channels draining adjacent uplands also likely have some hydrologic influence.

A small, unnamed ephemeral stream channel enters the impoundment to the east of Duck Cove after passing under Lower Falls Road. An approximately 0.4-acre palustrine forested wetland (NWI Classification Type PFO1E) exists between Lower Falls Road and the confluence of the unnamed tributary with the Narramissic River. Hydrology of this wetland is largely derived from the Narramissic River; however, it may also be influenced by stream hydrology seasonally. An approximately 1.6-acre palustrine unconsolidated bottom wetland (NWI Classification Type PUBHh) is located just upstream from Lower Falls Road. Lower Falls Road appears to act as a dike for the stream, permanently flooding the wetland upstream from the road. Hydrology for this wetland is derived from the unnamed stream channel.

A large wetland complex is located in the vicinity of the confluence of Wight's Brook with the Narramissic River, extending upstream along Wight's Brook to the SR 46 stream crossing. This wetland complex is comprised of approximately 71.1 acres of palustrine scrub shrub wetlands (NWI Classification Type PSS1E) with broad leaved deciduous vegetation, 48 acres of palustrine forested wetlands with by broad leaved deciduous vegetation, and approximately 11.1 acres of palustrine forested wetlands (NWI Classification Type PFO1E) with needle-leaved evergreen vegetation. An approximately 0.5-acre palustrine emergent persistent wetland (NWI Classification Type PEM1E) also exists just downstream from SR 46. Primary surface water hydrology for this wetland complex appears to be derived from the Narramissic River, with secondary hydrology due to the influence of Wight's Brook. Limited ephemeral and intermittent stream channels draining the uplands are noted on the NWI maps.

An approximately 2.2-acre palustrine scrub shrub wetland (NWI Classification Type PSS1E) is located approximately 750 ft downstream from the Upper Falls Road stream crossing over the Narramissic River. Hydrology for this wetland is derived almost entirely from the hydrology of the Narramissic River in this reach.

Upstream from this wetland to the confluence with Alamoosook Lake the Narramissic River is characterized as an approximately 4-acre section of riverine lower perennial unconsolidated bottom stream channel (NWI Classification Type R2UBH) with a fringe of palustrine scrub shrub type wetland.

3.3.3 Wildlife

No dedicated wildlife field studies were performed for this study. Wildlife observed within the project area during other project work included bald eagle (*Haliaeetus leucocephalus*), beaver (*Castor Canadensis*), belted kingfisher (*Megaceryle alcyon*), great blue heron (*Ardea herodias*), double-crested cormorant (*Phalacrocorax auritus*), blue-winged teal (*Anas discors*), wood duck (*Aix sponsa*), black duck (*Anas rubripes*), mallard duck (*Anas platyrhyncos*), Canada geese (*Branta Canadensis*), blue jay (*Cyanocitta cristata*), black-capped chickadee (*Poecile atricapillus*), painted turtle (*Chrysumys picta*), snapping turtle (*Chelydra serpentina*), and snowy egret (*Egretta thula*).

Correspondence with the Maine DIFW as part of this study indicates that no Rare, Threatened, or Endangered Species wildlife are currently mapped within the project reach areas of the Narramissic River and Wight's Brook. Additionally, no Essential Habitat for designated wildlife species occurs within this area. However, Significant Wildlife Habitat is located within the project reach. The tidally influenced mudflats located immediately below the Orland Village Dam have been mapped as a high value Tidal Wading Bird and Waterfowl Habitat (TWWH). The wetland complexes located at Duck Cove and the mouth of Wight's Brook, both located upstream of the Orland Village Dam, have been mapped as a moderate value Inland Wading Bird and Waterfowl Habitat (IWWH).

Tidewater mucket (*Leptodea ochracea*) occur in Alamoosook Lake, but mapped habitat for this species in the Narramissic River was not noted in correspondence received in response to letters sent to state and federal natural resource agencies (Appendix H).

3.4 INFRASTRUCTURE

Stantec performed a visual infrastructure assessment within the project area to identify existing infrastructure that may be affected by implementation of the project alternatives. For the purposes of this infrastructure assessment, "infrastructure" is defined as built features in the Project area that appear to be useable for their intended purpose and does not address historical resources (e.g., remnants of former mill building foundations). The infrastructure assessment is not intended to negate the need to contact DigSafe or conduct other due diligence as may be required prior to project implementation.

Visual observations of infrastructure within the project area were made in the course of site visits conducted on September 5, September 14, and September 27, 2012. Infrastructure observations were conducted via visual observations from a small boat along the reach of the Narramissic River (i.e., the freshwater portion of the Orland River) between the project dam and Alamoosook Lake outlet dam and vehicular access along public right-of-ways around the impoundment. An additional site visit was conducted on September 28, 2012, to perform a visual assessment of the existing condition of the Orland Village Dam.

The following represent infrastructure identified during the infrastructure assessment.

3.4.1 River Herring Harvesting Facilities

A river herring harvest facility is located directly below the Orland Dam on the east bank of the Orland River. The facility is constituted of a concrete harvesting platform set within the bed of the Orland River, an adjacent timber crib retaining wall, harvesting equipment and a transformer pad. Formerly, a small building (the “alewife harvesters’’ shack) was located on the site adjacent to the timber crib retaining wall; however, this building was removed from the site prior to field investigations in September 2012.

River herring harvesting activities include installation of a barrier net across the Orland River downstream from the Orland Village Dam. Fish are allowed within the pound formed between the Orland Village Dam, the net, and the river banks on the incoming tide. Fish not ascending above the Orland Village Dam are trapped by the net during the outgoing tide. Laborers use a conveyor system to transport river herring from the pound to shipping containers on trucks located adjacent to the site for ready transport to market.

3.4.2 Alamoosook Lake Dam & Vicinity

Alamoosook Lake Dam is owned by Verso and its primary function is to provide a source of water for diversion to Silver Lake and for industrial use at the Bucksport Mill. A pump house is located adjacent to the short, free-flowing reach of the river immediately downstream from the Alamoosook Lake Dam and fishway. The Narramissic River passes through the approximately 500-ft long free-flowing reach of the river downstream from the Alamoosook Lake Dam and enters the impounded reach of the river.

3.4.3 Water Supply

Information provided by James Brooks (Verso) indicated Verso maintains the rights to water within the impoundment; therefore, water withdrawn from the impoundment may be in violation of such rights. At least one abutting landowner claims to have maintained water rights to the impoundment from prior to construction of the Orland Village Dam; however, investigation of this claim is beyond this study. Below follows a description of existing water supply uses noted along the impoundment during field survey efforts.

3.4.3.1 Residential Water Supplies

A pair of 1-inch diameter, black polyethylene pipes were observed in the impoundment approximately 200 ft upstream from the Orland Dam. One pipe was attached to a buoy and suspended just below the surface of the water column. The second pipe was freely floating, with the end extending up from the water into the air. Piping was not noted to extend into the upland surrounding the impoundment; therefore, the origin of the piping was not determined. Such piping is commonly used in the delivery of water for small systems and it is therefore possible that these pipes are utilized for seasonal or year-round water withdrawal.

An approximately 1-inch diameter, black polyethylene pipe is suspended by a buoy located just below the impoundment surface approximately 200 ft upstream from the SR 175 Bridge. Piping was not noted to extend into the upland surrounding the impoundment; therefore, the origin of the piping was not determined. Such piping is commonly used in the delivery of water for small systems and it is therefore possible that the pipe is utilized for seasonal or year-round water withdrawal.

Several respondents to the Town's well survey indicated use of impoundment water for potable and non-potable uses (e.g., irrigation). At least two residences indicated usage of the impoundment as the primary source of potable water for those residences.

3.4.3.2 Commercial Water Supplies

A seasonal surface water withdrawal occurs 8,100 ft upstream from the Orland Dam. Water is pumped via an approximately 6-inch ID pipeline to water an adjacent golf course. A pump house is located adjacent to the impoundment associated with the water withdrawal system. The water withdrawal intake is coarsely screened via a 55-gallon plastic barrel perforated with drilled holes. The barrel and associated float holding the intake pipe off bottom were removed prior to the September 2012 site visit.

3.4.3.3 Municipal Water Supplies

A hydrant is located along the Narramissic Drive (western side of river) approximately 550 ft upstream from the SR 175 Bridge. The hydrant appears to be a "dry hydrant" (i.e., non-pressurized hydrant allowing the extraction of water from the impoundment upon demand via separate pump apparatus); however, the impoundment area immediately adjacent to the hydrant is relatively shallow for approximately 75 ft out from the impoundment edge and no piping or hydrant inlet were noted in this vicinity or extending from the bottom into deeper water. It is possible that such appurtenances were obscured by the high dissolved organic carbon content of the impoundment water.

3.4.4 Bridges and Culverts

3.4.4.1 US Route 1 Bridge

The US Rt. 1 Bridge crosses the Narramissic River approximately 2,100 ft upstream from the Orland Dam. The river does not appear to be constrained through opening between the bridge abutments as compared to the width of the river immediately upstream and downstream from US Rt. 1. Two rows of piles support the bridge sections within the width of the river and appear to have been modified via encasement of the piles during bridge reconstruction work. Plans for the US Rt. 1 Bridge provided to Stantec by the MaineDOT are included in Appendix I.

3.4.4.2 State Route 175 Bridge

The SR 175 Bridge crosses the Narramissic River approximately 700 ft upstream from the Orland Dam. The river is constrained through opening between the bridge abutments as compared to the width of the river immediately upstream and downstream from Route 175, with the western abutment extending east from the current river bank and surrounded by riprap. The existing SR 175 Bridge was constructed in 2009 to replace a former bridge at this site. Plans for the SR 175 Bridge provided to Stantec by MaineDOT are included in Appendix I.

The hydraulic model analyses performed as part of this study indicated that the SR 175 has limited hydraulic capacity to convey high-flow upland runoff events, and that removal of Orland Village Dam could result in increased flow speeds (model results indicate doubling of flow speeds) through the bridge opening relative to existing conditions. It is therefore suggested that removal of the dam could increase scour adjacent to the bridge substructure elements, and additional study of the bridge is therefore recommended as part of future studies if dam removal is further evaluated.

3.4.4.3 Upper Falls Road Culverts

Upper Falls Road crosses the Narramissic River approximately 12,950 ft upstream from the dam. The crossing consists of four adjacent corrugated metal culverts with diameters of approximately 13 ft. Flow through the culverts during high flow events appears to be constricted, as evidenced by the existence of a scour pool located immediately downstream from the culverts and a depositional bar formed approximately 250 ft downstream from the crossing. Upper Falls Road is paved and has guard rails along the crossing. The existing culverts are currently backwatered by the dam and impoundment, and do not appear to represent a barrier to upstream movement of fish except during periods of higher flow in the Narramissic River. While a dedicated survey of the Upper Fall Road culverts was not performed as part of this study, field observations indicate that the culverts may be perched during normal flows in the Narramissic River if Orland Village Dam were removed. Additional survey to determine the geometry and elevations of the culvert barrel inverts is therefore recommended if dam removal is further evaluated.

3.4.4.4 Wight's Brook Bridges

Duck Cove Road crosses Wight's Brook approximately 2,100 ft upstream from the confluence with the Narramissic River. The crossing consists of a pile supported bridge. The crossing may be a slight constriction to the flow within Wight's Brook as evidenced by the width of the bridge opening as compared to the stream width adjacent to the bridge opening.

SR 46 crosses Wight's Brook approximately 4,000 ft upstream from Duck Cove Road. The SR 46 crossing consists of a concrete span, presumably constructed on piles. A dry hydrant is located adjacent to the SR 46 stream crossing. It is unclear whether a drawdown of the impoundment would affect the SR 46 crossing as the section of stream between SR 46 and Duck Cover Road was not assessed for hydraulic control (e.g., beaver dams).

An approximately 24-inch diameter pressured water main used to transport water from Alamoosook lake to Silver Lake for industrial usage parallels the Narramissic River between approximately 11,500 ft upstream from the dam to Alamoosook Lake (13,900 ft upstream from the dam). The pressurized main also continues across a wetland complex associated with Wight's Brook. The pressured main crosses Wight's Brook approximately 100 ft downstream from Duck Cove Road via a pile supported bridge.

3.5 CULTURAL RESOURCES

Pre- and post-European contact archaeological resources may be present in and adjacent to the project reach of the Narramissic River and adjacent to Orland Village Dam.

Stantec contacted the Maine Historic Preservation Commission (MHPC) by letter requesting information on cultural resources at the project site. The response received (Appendix H) indicates that 1) there are three known pre-historic archaeological sites present in the project area, including one at the dam itself; 2) there are historic archaeological resources, including historic dams and other properties in the project area; and 3) there may be architectural resources associated with the dam and therefore the dam may be eligible for the National Register status. No additional dedicated resource surveys were performed for this study.

A review of the information pertaining to maintenance records of the existing dam performed by Stantec indicates that the dam has undergone significant reconstruction and modification efforts within the last 50 years and may not be eligible for the National Register.

3.6 SOCIOECONOMIC AND AESTHETIC FACTORS

The Town undertook a recreational, aesthetic, and cultural use survey related to the Narramissic River within the project reach. This component of the project included a "community-value" assessment survey that was provided to local stakeholders and reports generated from a "Survey Monkey" online survey; both surveys were administered by members of the Dam Committee with results provided to Stantec. Copies of response to the written survey and information developed from the Survey Monkey online survey are provided in Appendix J.

A total of 22 responses to the community assessment survey were received, and there were 106 responses to the Survey Monkey survey. Personal knowledge of the project area was provided by local stakeholders through participation in the survey. Survey participants responded with observations and opinions related to current and future uses of the impoundment, future uses and management of the project area, deterioration of the dam, effects of changing water levels, water quality, ecological resources, and potential impacts to use of resources associated with the dam and impoundment.

Responses to the online survey indicate that recreation boating is the dominant recreational use of the impounded reach of the river, with 87 percent of the respondents indicating such use. Canoes and kayaks were noted as the most common watercraft for use of the impoundment, and that small boats are launched at multiple public and private locations between the Alamoosook Lake Dam and Orland Village Dam. Approximately two-thirds (62%) of the responses indicated wildlife and bird watching. Fishing and swimming were noted by approximately one-third (35% and 30%, respectively) of the responses, and 10 percent of the responses indicated hunting as a use. Other noted used included ice skating, photography, picnicking, the Orland River Day raft race, and water rescue training.

The online survey results indicate that use in summer is the highest (97% of responses), but that use occurs throughout the balance of the year. Many respondents noted frequent use, including daily observations throughout the year.

3.6.1 Recreation

While observed recreational use of the existing impoundment was limited during project site visits, the recreational use survey conducted by the Project Partners included responses that indicate substantial recreational use of the project area corridor, including boating, fishing, hunting, trapping, and scenic observation along the impoundment and the surrounding area.

3.6.1.1 Boating

Recreational boating on the Orland Village Dam impoundment is limited by the spacing of public access locations, but private “hand carry” boat launch facilities and private docks were observed along the river between the Orland Village Dam and Upper Falls Road during the project site visits in 2012. A hand-carry public boat launching facility was noted along Narramissic Drive. A separate, unimproved boat launch over property of unknown ownership was noted along Soper Road. Personal watercraft usage of the Orland Village Dam impoundment during field surveys for this project was limited to four individuals using canoes and kayaks during one site visit, but recreational boat usage of the Narramissic River was identified as the most frequent recreational use of the project reach during the recreational use survey and the Town promotes an annual event, Orland River Day. Per the Town of Orland website,

> "Orland River Day is a town celebration held each year on the last Saturday in June (rain or shine) – complete with a parade, food, crafts, a 'Downeast' raft race and many other activities. This (2013) will be the 38th year for this day of celebration."

Lack of dedicated public boat launching facilities is likely a factor limiting usage of the Orland Village Dam impoundment.

3.6.1.2 Fishing

Evidence of recreational fishing was observed by Stantec during several site visits during late summer and early fall of 2012, including discarded fishing line, lures, bobbers, and hooks on snags in the impoundments. The placement of a number of brook trout in the Narramissic River as part of the stocking program administered by Maine DIFW is one primary attraction, with fisheries for non-native warm water species also being a factor.

3.6.1.3 Hunting/Trapping

Evidence of hunting was limited to shotgun shell casings found along the Narramissic River Impoundment during field surveys conducted in October 2012. The primary hunting usage of the Narramissic River impoundment 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 such as wild turkey (*Meleagris gallopavo*) and white-tailed deer (*Odocoileus virginianus*).

One response to the recreational, aesthetic, and cultural use survey indicated trapping as an activity utilizing the project area. Numerous furbearers are available to support such activities within the project reach, including beaver (*Castor canadensis*) and muskrats (*Ondatra zibethicus*).

3.6.1.4 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. Adjacent to the river, numerous private picnic and camping facilities were noted by the presence of picnic tables and stone fire rings. Evidence of use for swimming (e.g., rope swings, floats) was not noted during field surveys.

3.6.2 Aesthetics

The values and attitudes attached to aquatic resources and their watersheds are often connected to the growth of secondary values that develop after the development of the initial project. In the case of the Orland Village Dam, use of previous dams at and adjacent to the location of the current dam for water power constitutes the primary value for which the dam was originally constructed. Secondary values, such as those attached to wildlife, fish habitat, the role of the resource in community history, recreational opportunities, visual qualities, and commercial potential, result in members of local communities having interest in management decisions and the effects of such decisions on the project site and community-specific circumstances.

4 IMPACT ASSESSMENT

This section presents assessment of direct and indirect impacts to identified components of the affected environment for four of the five evaluated alternatives. Construction of a nature-like fishway (Alternative E) is not evaluated in this section based on the general infeasibility of a nature-like fishway at Orland Village Dam as described in Section 2.1.5. 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 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 its sensitivity. A simple and subjective rating system was used, which included a rating scale of No Effect, Negligible, Minor, Moderate, and Major impact intensity levels. 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 and mean that no discernible impacts were found as part of this evaluation. 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 ALTERNATIVE A – NO ACTION

This section assesses the No Action alternative (Alternative A). This alternative avoids short-term, temporary impacts associate with other project alternatives, but does not address long-term maintenance and operations of the dam, existing and/or potential impacts to the affected environment, including those that could result from failure of the dam.

A plan of existing site conditions is included in Appendix C.

4.1.1 Hydrology, Hydraulics, and Physical Processes

4.1.1.1 Hydrology and Hydraulics

Implementation of Alternative A would have no effect on the existing hydrology or hydraulics of the project reach of the Narramissic River based on the assumption that the dam would remain in its current conditions indefinitely. A negligible intensity level is therefore assigned to both beneficial and adverse impacts associated with this criterion.

4.1.1.2 Water Quality

Implementation of Alternative A would result in minor beneficial impacts and minor adverse impacts to water quality along the Narramissic River within the project area.

A minor beneficial intensity level is applied based upon the conversion of the affected reach to a freshwater, lacustrine impoundment marginally suitable for residential, commercial, and municipal use of water. A moderate or major intensity level was not assigned to benefits associated with residential, commercial, and municipal use of the impoundment for water withdrawals because of the potential for increased intrusion of saltwater into the impoundment, which would reduce or eliminate the potential to readily use the impoundment as a water supply source.

A minor adverse intensity level is assigned based on the potential for saltwater intrusion into the impounded reach of the river when the dam is overtopped during higher tide events. Identified potential adverse impacts include conversion of freshwater wetland tidally mixed estuarine habitat into freshwater lacustrine habitat, continued loss of sediment transport capacity through the project reach, potential for anoxia/hypoxia conditions to occur within the impoundment, and increased water temperatures in the downstream reach of river during periods when water is spilling from the surface of the impoundment.

4.1.1.3 Flooding and Ice Jams

Implementation of Alternative A would result in negligible beneficial and adverse impacts associated with flooding and ice jams in the project reach of the Narramissic River. A negligible intensity level is therefore assigned to both beneficial and adverse impacts associated with this criterion.

4.1.1.4 Morphology and Sediments

Implementation of Alternative A would result in negligible beneficial impacts and moderate adverse impacts to the morphology of and sediment transport in the Narramissic River. A moderate adverse intensity level is applied based on the potential for accumulation of sediment due to the persistent backwater conditions from Orland Village Dam.

4.1.2 Ecological Resources

4.1.2.1 Fisheries

Implementation of Alternative A would result in continued negligible beneficial impacts and major adverse impacts to fisheries resources in the project area. A major adverse impact intensity level is applied based on the continued impacts to native resident and diadromous fish passage, fish spawning and rearing habitat, and the continued presence of habitat suitable for non-native, piscivorous fish species.

4.1.2.2 Wetlands

Implementation of Alternative A would result in moderate beneficial and adverse impacts to wetland resources within the project area. A moderate beneficial impact level is applied based on the amount of freshwater wetland resources created or enhanced by the presence of the Orland Village Dam impoundment. A moderate adverse intensity level is applied based on the likely conversion of freshwater marsh to estuarine intertidal marsh resources.

4.1.2.3 Wildlife

Implementation of Alternative A would result in continued moderate adverse and minor beneficial impacts to wildlife resources within the project area. A moderate adverse intensity level is assigned based on the continued loss of estuarine intertidal wading bird and waterfowl habitat upstream from the Orland Village Dam. A minor beneficial intensity level is assigned based on the creation of inland wading bird and waterfowl habitat upstream from the Orland Village Dam.

4.1.3 Infrastructure

4.1.3.1 River Herring Harvesting Facilities

Implementation of Alternative A would have negligible adverse and beneficial impacts to river herring harvesting facilities located immediately downstream from the Orland Village Dam.

4.1.3.2 Water Supplies

Implementation of Alternative A would result in negligible beneficial impacts and minor adverse impacts to existing usage of the Orland Village Dam impoundment as a water supply. A minor adverse intensity level is assigned based on the potential for deterioration of Orland Village Dam and associated intrusion of saltwater into the impoundment.

4.1.3.3 Bridges & Culverts

Implementation of Alternative A would have negligible beneficial and adverse impacts to existing bridge and culvert crossing over the project reach of the Narramissic River.

4.1.4 Cultural Resources

Implementation of Alternative A would have negligible beneficial or adverse impacts to historical and archeological resources within the project area.

4.1.5 Socioeconomic and Aesthetics Factors

4.1.5.1 Recreation

Implementation of Alternative A would result in negligible beneficial and adverse impacts to the existing recreational usage in the Orland Village Dam impoundment as it would retain its current form and maintain current recreational opportunities.

4.1.5.2 Aesthetics

Implementation of Alternative A would result in negligible beneficial and adverse impacts to aesthetic resources associated with the Orland Village Dam.

4.2 Alternative B – Dam and Fishway Rehabilitation

This section assesses rehabilitation of the dam based on its existing construction and current conditions (Alternative B). This alternative includes restoration of the existing technical fish passage facilities. This alternative includes short-term, temporary impacts associated with construction related activities and one-time capital costs associated with dam rehabilitation and restoration of the technical fish passage facilities.

A conceptual plan of Alternative B – Dam Rehabilitation site conditions is included in Appendix C.

4.2.1 Hydrology, Hydraulics, and Physical Processes

4.2.1.1 Hydrology

Implementation of Alternative B would have no effect on the existing hydrology or hydraulics of the project reach of the Narramissic River based on the assumption that the dam would remain in its current conditions indefinitely. A negligible intensity level is therefore assigned to both beneficial and adverse impacts associated with this criterion.

4.2.1.2 Water Quality

Implementation of Alternative B would result in minor beneficial impacts and minor adverse impacts to water quality along the Narramissic River within the project area.

A minor beneficial intensity level is applied based upon the conversion of the affected reach to a freshwater, lacustrine impoundment marginally suitable for residential, commercial, and municipal use of water. A moderate or major intensity level was not assigned to benefits associated with residential, commercial, and municipal use of the impoundment for water withdrawals because of the potential for increased intrusion of saltwater into the impoundment, which would reduce or eliminate the potential to readily use the impoundment as a water supply source.

A minor adverse intensity level is assigned based on the potential for saltwater intrusion into the impounded reach of the river when the dam is overtopped during higher tide events. Identified potential adverse impacts include conversion of freshwater wetland tidally mixed estuarine habitat into freshwater lacustrine habitat, continued loss of sediment transport capacity through the project reach, potential for anoxia/hypoxia conditions to occur within the impoundment, and increased water temperatures in the downstream reach of river during periods when water is spilling from the surface of the impoundment.

4.2.1.3 Flooding and Ice Jams

Implementation of Alternative B would result in negligible beneficial and adverse impacts associated with flooding and ice jams in the project reach of the Narramissic River. A negligible intensity level is therefore assigned to both beneficial and adverse impacts associated with this criterion.

4.2.1.4 Morphology and Sediments

Implementation of Alternative B would result in negligible beneficial impacts and moderate adverse impacts to the morphology of and sediment transport in the Narramissic River. A moderate adverse intensity level is applied based on the potential for accumulation of sediment due to the persistent backwater conditions from Orland Village Dam.

4.2.2 Ecological Resources

4.2.2.1 Fisheries

Implementation of Alternative B would result in continued major adverse impacts and minor beneficial impacts to fisheries resources within the project area. A major adverse impact intensity level is applied based on the continued impacts to native resident and diadromous fish passage, fish spawning and rearing habitat, and the continued presence of habitat suitable for non-native, piscivorous fish species. A minor beneficial intensity level is applied based on the limited improvements to existing fish passage facilities for river herring and salmonids species.

4.2.2.2 Wetlands

Implementation of Alternative B would result in moderate beneficial and adverse impacts to wetland resources within the project area. A moderate beneficial impact level is applied based on the amount of freshwater wetland resources created or enhanced by the presence of the Orland Village Dam impoundment. A moderate adverse intensity level is applied based on the likely conversion of freshwater marsh to estuarine intertidal marsh resources.

4.2.2.3 Wildlife

Implementation of Alternative B would result in continued moderate adverse and minor beneficial impacts to wildlife resources within the project area. A moderate adverse intensity level is assigned based on the continued loss of estuarine intertidal wading bird and waterfowl habitat upstream from the Orland Village Dam. A minor beneficial intensity level is assigned based on the creation of inland wading bird and waterfowl habitat upstream from the Orland Village Dam.

4.2.3 Infrastructure

4.2.3.1 River Herring Harvesting Facilities

Implementation of Alternative B would have negligible beneficial and adverse impacts to river herring harvesting facilities located immediately downstream from the Orland Village Dam. The negligible beneficial impact intensity level is assigned based on associated improvements to fish passage not affecting harvesting facilities.

4.2.3.2 Water Supplies

Implementation of Alternative B would result in negligible beneficial impacts and minor adverse impacts to existing usage of the Orland Village Dam impoundment as a water supply. A minor adverse intensity level is assigned based on the potential for continued overtopping of Orland Village Dam during higher tides and associated intrusion of saltwater into the impoundment.

4.2.3.3 Bridges & Culverts

Implementation of Alternative B would have negligible beneficial and adverse impacts to existing bridge and culvert crossings over the project reach of the Narramissic River.

4.2.4 Cultural Resources

Implementation of Alternative B would have negligible beneficial impacts and moderate adverse impacts to historical and archeological resources within the project area. A moderate adverse intensity level is assigned based upon the potential to impact historic and archaeological resources during construction.

4.2.5 Socioeconomic and Aesthetics Factors

4.2.5.1 Recreation

Implementation of Alternative B would result in negligible beneficial and adverse impacts to the existing recreational usage in the Orland Village Dam impoundment as it would retain its current form and maintain current recreational opportunities.

4.2.5.2 Aesthetics

Implementation of Alternative B would result in negligible beneficial and adverse impacts to aesthetic resources associated with the Orland Village Dam.

4.3 ALTERNATIVE C – DAM AND FISHWAY MODIFICATION

This section assesses modification of the dam and construction of a new technical fish passage facility (Alternative C). This alternative includes rehabilitation and modification of the existing dam and replacement of the existing technical fish passage facilities with an alternative technical fish pass more aptly suited for the target fish species and the tidal nature of the site. This alternative would improve conditions for both upstream and downstream passage for the target fish species. This alternative includes short-term, temporary impacts associated with construction related activities and one-time capital costs associated dam rehabilitation and restoration of the technical fish passage facilities.

A conceptual plan of Alternative C – Dam and Fishway Modification site conditions is included in Appendix C.

4.3.1 Hydrology, Hydraulics, and Physical Processes

4.3.1.1 Hydrology and Hydraulics

Implementation of Alternative C would have no effect on the existing hydrology or hydraulics of the project reach of the Narramissic River based on the assumption that the dam would remain in its current conditions indefinitely. A negligible intensity level is therefore assigned to both beneficial and adverse impacts associated with this criterion.

4.3.1.2 Water Quality

Implementation of Alternative C would result in minor beneficial impacts and minor adverse impacts to water quality along the Narramissic River within the project area.

A minor beneficial intensity level is applied based upon the conversion of the affected reach to a freshwater, lacustrine impoundment marginally suitable for residential, commercial, and municipal use of water. A moderate or major intensity level was not assigned to benefits associated with residential, commercial, and municipal use of the impoundment for water withdrawals because of the potential for increased intrusion of saltwater into the impoundment, which would reduce or eliminate the potential to readily use the impoundment as a water supply source.

A minor adverse intensity level is assigned based on the potential for saltwater intrusion into the impounded reach of the river when the dam is overtopped during higher tide events. Identified potential adverse impacts include conversion of freshwater wetland tidally mixed estuarine habitat into freshwater lacustrine habitat, continued loss of sediment transport capacity through the project reach, potential for anoxia/hypoxia conditions to occur within the impoundment, and increased water temperatures in the downstream reach of river during periods when water is spilling from the surface of the impoundment.

4.3.1.3 Flooding and Ice Jams

Implementation of Alternative C would result in negligible beneficial and adverse impacts associated with flooding and ice jams in the project reach of the Narramissic River. A negligible intensity level is therefore assigned to both beneficial and adverse impacts associated with this criterion.

4.3.1.4 Morphology and Sediments

Implementation of Alternative C would result in negligible beneficial impacts and moderate adverse impacts to the morphology of and sediment transport in the Narramissic River. A moderate adverse intensity level is applied based on the potential for accumulation of sediment due to the persistent backwater conditions from Orland Village Dam.

4.3.2 Ecological Resources

4.3.2.1 Fisheries

Implementation of Alternative C would result in moderate beneficial and adverse impacts to fisheries resources within the project area. A moderate beneficial intensity level is applied based on the improvements to existing fish passage facilities for river herring and salmonids species. A major intensity level was not assigned based on the inherent limitations of technical fishpasses. A moderate adverse impact intensity level is applied based on the continued impacts to native resident and diadromous fish passage, fish spawning and rearing habitat, and the continued presence of habitat suitable for non-native, piscivorous fish species.

Implementation of Alternative C would result in moderate beneficial and adverse impacts to wetland resources within the project area. A moderate beneficial impact level is applied based on the amount of freshwater wetland resources created or enhanced by the presence of the Orland Village Dam impoundment. A moderate adverse intensity level is applied based on the likely conversion of freshwater marsh to estuarine intertidal marsh resources.

4.3.2.2 Wetlands

Implementation of Alternative C would result in moderate beneficial and adverse impacts to wetland resources within the project area. A moderate beneficial intensity level is applied based on the amount of freshwater wetland resources created or enhanced by the presence of the Orland Village Dam impoundment. A moderate adverse intensity level is applied based on the likely conversion of freshwater marsh to estuarine intertidal marsh resources.

4.3.2.3 Wildlife

Implementation of Alternative C would continue moderate adverse and minor beneficial impacts to wildlife resources within the project area. A moderate adverse intensity level is assigned based on the continued loss of estuarine intertidal wading bird and waterfowl habitat upstream from the Orland Village Dam. A minor beneficial intensity level is assigned based on the creation of inland wading bird and waterfowl habitat upstream from the Orland Village Dam.

4.3.3 Infrastructure

4.3.3.1 River Herring Harvesting Facilities

Implementation of Alternative C would have negligible beneficial and adverse impacts to river herring harvesting facilities located immediately downstream from the Orland Village Dam. The negligible impact intensity level is assigned based on associated improvements to fish passage not affecting harvesting facilities.

4.3.3.2 Water Supplies

Implementation of Alternative C would result in negligible beneficial impacts and minor adverse impacts to existing usage of the Orland Village Dam impoundment as a water supply. A minor adverse intensity level is assigned based on the potential for continued overtopping of Orland Village Dam during higher tides and associated intrusion of saltwater into the impoundment and potential loss of use of the dry hydrant located along the right bank of the river between the SR 175 and US Rt. 1 bridges.

4.3.3.3 Bridges & Culverts

Implementation of Alternative C would have negligible beneficial and adverse impacts to existing bridge and culvert crossing over the project reach of the Narramissic River.

4.3.4 Cultural Resources

Implementation of Alternative C would have negligible beneficial and moderate adverse impacts to historical and archeological resources within the project area. A moderate adverse intensity level is assigned based upon the potential to impact historic and archaeological resources during construction. A major adverse intensity level was not assigned as the area of construction is considered to be relatively small and well-defined.

4.3.5 Socioeconomic and Aesthetics Factors

4.3.5.1 Recreation

Implementation of Alternative C would result in negligible beneficial and adverse impacts to the existing recreational usage in the Orland Village Dam impoundment as it would retain its current form and maintain current recreational opportunities.

4.3.5.2 Aesthetics

Implementation of Alternative C would result in negligible beneficial and adverse impacts to aesthetic resources associated with the Orland Village Dam.

4.4 Alternative D – Dam Removal

This section assesses removal of Orland Village Dam. The proposed conceptual approach is based on information presented in Section 3 of this report.

A conceptual plan for Alternative D – Dam Removal site conditions is included in Appendix C.

4.4.1 Hydrology, Hydraulics, and Physical Processes

4.4.1.1 Hydrology & Hydraulics

Implementation of Alternative D would result in major beneficial and adverse impacts to hydrology along the Narramissic River upstream from the Orland Village Dam. The assigned intensity levels result from gross changes in the hydrology and associated hydraulic conditions in the Narramissic River landward from the dam, including diurnal tidal flow to the vicinity of the Upper Falls Road culverts.

4.4.1.2 Water Quality

Implementation of Alternative D would result in major beneficial impacts and adverse impacts to water quality along the Narramissic River within the project area. The assigned intensity levels result from gross changes in water quality associated with the expected transition of the impoundment from a freshwater system to one that is saltwater-dominated.

4.4.1.3 Flooding and Ice Jams

Implementation of Alternative D could result in negligible beneficial and adverse impacts associated with flooding and ice jams in the project reach of the Narramissic River. The assigned intensity level is based on the expectation that removal of the dam would not substantially effect flooding along the project reach of the Narramissic River or the formation of ice jams.

4.4.1.4 Morphology and Sediments

Implementation of Alternative D would result in major beneficial and moderate adverse impacts to physical processes along the Narramissic River in the vicinity of the Orland Village Dam. The major beneficial intensity level is assigned based on the restoration of estuarine intertidal processes, including sediment transport continuity through the affected reach of river and dispersal in the downstream environment. The moderate adverse intensity level is assigned based on the short-term impacts associated with sediment transport following dam removal, the conversion of freshwater habitat to freshwater and saltwater intertidal and subtidal habitats.

4.4.2 Ecological Resources

4.4.2.1 Fisheries Resources

Implementation of Alternative D would result in major beneficial and minor adverse impacts to native resident and diadromous fish in the Narramissic River.

The major beneficial intensity level is assigned based on 1) the restoration of riverine intertidal habitat along approximately 2.5 miles of river, including potential spawning habitat for species such as rainbow smelt and Atlantic tomcod; 2) removal of an anthropogenic barrier to movement of fish in the adjacent reach of the Narramissic River; and 3) elimination of habitat that is very suitable for exotic fish such as largemouth bass and chain pickerel. Specific native resident and diadromous fish that are anticipated to benefit from implementation of this alternative include rainbow smelt, Atlantic tomcod, alewife, blueback herring, American shad, Atlantic and shortnose sturgeon, brook trout, Atlantic salmon, sea lamprey, and American eel, which are currently present in the watershed to some degree but have experienced adverse impacts due to the presence of the dam. In addition to the direct benefits given here, improved water quality resulting from implementation of this alternative would also benefit fisheries resources.

The minor adverse intensity level is assigned based on the loss of the impoundment and associated conversion of lentic habitat to riverine intertidal habitat.

4.4.2.2 Wetlands

Implementation of Alternative D would result in major beneficial and major adverse impacts to wetlands along the Narramissic River upstream from the Orland Village Dam. The major beneficial intensity level is assigned based on the restoration of riparian fringe wetlands, including freshwater and saltwater intertidal wetlands, within the currently impounded area. An estimated 90 acres of estuarine intertidal wetlands would be restored as part of this alternative. The major adverse impact intensity level is assigned based on short-term disturbance resulting from dam removal construction and associated long-term conversion of freshwater wetlands within the impoundment to estuarine intertidal wetlands.

The assignment of major adverse impacts to wetlands is consistent with the applied evaluation methodology, which is not intended to weight the relative beneficial impacts when assigning an intensity level. While restoration of estuarine intertidal wetlands may provide for a high-functioning resource, it does not negate the impact to the existing (freshwater wetland) resource.

4.4.2.3 Wildlife

Implementation of Alternative D would result in major beneficial and moderate adverse impacts to wildlife in the vicinity of the Orland Village Dam. The major beneficial intensity level is assigned based on 1) the restoration of natural habitats in the currently impounded area; and 2) the restoration of continuity along the riparian corridor. The moderate adverse intensity level is assigned based on the conversation of freshwater lentic habitat to estuarine intertidal habitat in the impoundment.

4.4.3 Infrastructure

4.4.3.1 River Herring Harvesting Facilities

Implementation of Alternative D would have moderate beneficial and moderate adverse impacts to river herring harvesting facilities located immediately downstream from the Orland Village Dam. The moderate beneficial impact intensity level is assigned based on the potential for increased alewife production and associated increased revenue for facilities operation and maintenance. A moderate adverse intensity level is assigned based on the assumption that the existing facility could still be used at low tide. A higher adverse intensity level would be appropriate if it was determined that alewife harvesting operations would need to be moved upstream to the vicinity of the Alamoosook Lake Dam.

It is expected that continued operation of the harvesting facility at its current location following dam removal could require changes in how block nets are used across the river, as removal of the dam would result in a substantial increase in the tidal prism landward from the harvesting facility and increased potential for water-borne debris to foul the netting that is current placed across the river.

4.4.3.2 Water Supplies

Implementation of Alternative D would result in negligible beneficial and major adverse impacts to existing direct residential, commercial, and municipal water supply withdrawals from the Orland Village Dam impoundment and potentially result in major adverse impacts to nearby groundwater wells. A major adverse impact intensity level is assigned due to saltwater intrusion following dam removal, particularly during periods of negligible freshwater input to Narramissic River downstream from the outlet dam at Alamoosook Lake. Implementation of Alternative D would likely require impact mitigation via development of alternative sources of water supply (e.g., drilled groundwater extraction wells, construction of irrigation ponds, and alternative location(s) for dry hydrant).

4.4.3.3 Bridges and Culverts

Implementation of Alternative D could result in negligible beneficial and moderate adverse impacts to existing river and stream crossing infrastructure upstream from the Orland Village Dam. A moderate adverse intensity level is assigned due to the potential for scouring of bottom substrates in the vicinity of the SR 175, the Duck Cove Road Bridge, and the Upper Falls Road culverts and due to potential for corrosive electrochemical interactions between saline intertidal water and river and stream crossing elements following dam removal.

4.4.4 Cultural Resources

Implementation of Alternative D could result in major beneficial and adverse impacts to existing cultural resources within the project area. A major beneficial intensity level is assigned based upon the potential for restoration of ecological resources that were a resource for Native Americans. A major adverse intensity level is assigned based upon the potential to impact archaeological resources, historic structures, and the loss of the dam impoundment.

4.4.5 Socioeconomic and Aesthetics Factors

4.4.5.1 Recreation

Implementation of Alternative D would result in moderate beneficial and adverse impacts to the existing recreational usage in the Orland Village Dam impoundment. This intensity level is assigned based on the loss of recreational resource afforded by the impoundment and additional recreational resources that would result from restoring tidal flow in the project reach of the river, including the potential to navigate small boats over the current location of the dam at appropriate tides.

4.4.5.2 Aesthetics

Implementation of Alternative D would result in moderate beneficial and major adverse impacts to aesthetic resources associated with the Orland Village Dam. A moderate beneficial intensity level is assigned due to longer-term restoration of freshwater and saltwater intertidal habitats and adjacent natural wetland communities and the potential for formation of natural ‘reversing’ falls along the currently impounded reach of river.

A major adverse intensity level is assigned due to short-term impacts associated with initial drawdown of the impoundment exposing areas for freshwater and saltwater intertidal wetland restoration and longer-term impacts associated with saltwater intrusion adversely affecting existing vegetation in wetland areas.

5 SUMMARY OF FEASIBILITY STUDY

This section presents synopses and summaries of the alternatives and identified impacts, a brief description of environmental permitting requirements, and opinions of probable costs for implementation of the four evaluated alternatives.

5.1 SYNOPSIS OF ALTERNATIVES

The section presents a synopsis of the five alternatives and addresses impacts with "major" assigned intensity levels for the four evaluated alternatives. A summary of the assigned impacts for the four evaluated alternatives is presented in Table 9.

5.1.1 Alternative A – No Action

The No Action alternative represents existing conditions and provides a baseline for comparison of the other alternatives. This alternative avoids short-term, temporary impacts associated with the other alternatives and does not result in direct impacts to existing resources that were evaluated as part of this study, such as current recreational uses of the impoundment, infrastructure (e.g., bridges, water withdrawals), or aesthetic factors.

This alternative would largely retain existing uses of and conditions in the project reach of the Narramissic River as long as the dam remains in good condition.

The single "major" impact intensity level assigned to Alternative A is for adverse impacts to fisheries resources and reflects the poor performance of the Orland Village Dam fishpass and conditions in the impounded reach of the Narramissic River that are generally suitable for introduced non-native fish species.

5.1.2 Alternative B – Dam and Fishway Rehabilitation

The Dam and Fishway Rehabilitation alternative addresses rehabilitation of the dam and the existing technical fish passage facilities. It is assumed that rehabilitation of the dam would preserve the existing spillway configuration and elevation. This alternative includes short-term, temporary impacts associated with construction related activities and one-time capital costs associated dam rehabilitation and restoration of the technical fish passage facilities. This alternative would partially address cost factors associated with longer-term maintenance and operation of the dam.

This alternative would largely retain existing uses of and conditions in the project reach of the Narramissic River as long as the dam remains in good condition.

The single "major" impact intensity level assigned to Alternative B is for adverse impacts to fisheries resources, and reflects the poor performance of the Orland Village Dam fishpass and conditions in the impounded reach of the Narramissic River that are generally suitable for introduced non-native fish species.

5.1.3 Alternative C – Dam and Fishway Modification

The Dam and Fishway Modification alternative addresses modification of the dam and construction of a new technical fish passage facility. It is assumed that modification of the dam would result in a spillway elevation similar to that of the existing dam. This alternative includes rehabilitation and modification of the existing dam and replacement of the existing technical fish passage facilities with an alternative technical fishpass that is well-suited for the target fish species and the tidal nature of the site. This alternative would require greater initial costs relative to dam rehabilitation (Alternative B), but it is expected to result in lower costs for long-term operation and maintenance of the dam.

This alternative would largely retain existing uses of and conditions in the project reach of the Narramissic River as long as the dam remains in good condition.

No “major” intensity levels were assigned to Alternative C.

5.1.4 Alternative D – Dam Removal

The Dam Removal alternative is for removal of Orland Village Dam. This alternative includes removal of the timber crib spillway, adjacent concrete abutments and gate systems, and the technical fishpass. Construction of this alternative would include removal of the visible elements of the dam and fill upstream from the dam.

Implementation of this alternative would result in readily apparent impacts to resources in and adjacent to the impoundment reach of the Narramissic River upstream from the dam, including alteration of regulated natural resources, current recreation and functional uses (e.g., water withdrawals) associated with the impoundment, and aesthetic and cultural resources.

“Major” impact intensity levels were assigned to both beneficial and adverse impacts associated with Alternative D.

Major beneficial and adverse impacts were assigned to the Watershed Hydrology and Water Quality criteria based on substantial impacts to the currently impounded reach of the Narramissic River that would result from removal of Orland Village Dam. Major beneficial impacts to Watershed Hydrology and Water Quality are largely based on restoration of regular tidal exchange in the Narramissic River landward (upstream) from the dam. Major adverse impacts to Watershed Hydrology and Water Quality are based on the loss of the impounded and elimination of its use as a water supply.

A major beneficial impact is assigned to Morphology and Sediment based on restoration of natural, tidally-affected regime in the Narramissic River landward (upstream) from the dam and the associated potential for renewed sediment transport into the Orland River seaward from the dam.

A major beneficial impact is assigned to Fisheries based on restoration of volitional upstream and downstream fish passage and fisheries habitat in the project reach of the Narramissic River. Similarly, major beneficial impacts were assigned to Wetlands and Wildlife based on restoration of tidally-affected conditions.

A major adverse impact is assigned to Water Supply based on the loss of the freshwater impoundment and associated impacts to water users along the impoundment.

A major adverse impact is assigned to Cultural Resources based on potential impacts to cultural resources in the immediate vicinity of the dam and along the upstream impoundment, as exposure of such resources at low tide would present opportunities for vandalism of these resources.

A major adverse impact is assigned to Aesthetics based on the loss of the persistent impoundment. While conditions at high tide would be very similar to the current conditions when the impoundment is full, conditions at low tide would vary substantially from existing conditions.

5.1.5 Alternative E – Nature-Like Fishpass

The Nature-Like Fishway alternative would include removal of the dam and construction of an alternative, “nature-like” fishpass system, such as a rock ramp structure intended to mimic natural riffle-type habitat and serve as grade control.

It is not expected that environmental permits could be obtained to place fill in the Orland River immediately seaward from the dam, and the downstream end of a nature-like fishway would therefore need to be at the downstream face of the dam. The balance of the structure would be upstream from the dam. Based on observed conditions, the Dam Removal alternative (Alternative D) would largely result in formation of this structure through exposure of the channel bed, with the exception that the upstream limit of the nature-like fishway would be set at an elevation similar to the crest of the existing to dam to maintain the existing impoundment.

A nature-like fishway is a built structure and would require maintenance similar to maintaining a dam. A particular concern with a nature-like fishway at this site is the presence of tidal conditions and regular reversal of flow that would occur along the crest of a constructed ramp and could result in aggressive hydraulic conditions that would need to be addressed as part of design of this alternative.

Based on a preliminary review of this alternative relative to the other evaluated alternatives, this alternative does not appear to be feasible, practical, or cost-effective at this site, and this alternative was therefore not evaluated as a potentially feasible alternative in Section 4.

Table 9: Summary of Impacts by Level of Intensity

	Alternative A "No Action"		Alternative B Dam and Fishway Rehabilitation		Alternative C Dam and Fishway Modification		Alternative D Dam Removal	
	Beneficial Impact	Adverse Impact	Beneficial Impact	Adverse Impact	Beneficial Impact	Adverse Impact	Beneficial Impact	Adverse Impact
Hydrology, Hydraulics, and Physical Processes								
Watershed Hydrology	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Major	Major
Water Quality	Minor	Minor	Minor	Minor	Minor	Minor	Major	Major
Flooding and Ice Jams	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Morphology and Sediments	Negligible	Moderate	Negligible	Moderate	Negligible	Moderate	Major	Moderate
Ecological Resources								
Fisheries	Negligible	Major	Negligible	Major	Moderate	Moderate	Major	Minor
Wetlands	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Major	Major
Wildlife	Minor	Moderate	Minor	Moderate	Minor	Moderate	Major	Moderate
Infrastructure								
River Herring Harvesting Facilities	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Moderate	Moderate
Water Supply	Negligible	Minor	Negligible	Minor	Negligible	Minor	Negligible	Major
Bridges and Culverts	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Moderate
Cultural Resources	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Major	Major
Socioeconomic and Aesthetic Factors								
Recreation	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Moderate	Moderate
Aesthetics	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Moderate	Major

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: Long-term or permanent, highly noticeable effects on the resource.

5.2 PERMITTING

This section addresses general environmental permitting requirements that would likely need to be address as part of implementation of the “action” alternatives (Alternatives B, C, and D). Note that maintenance of the existing dam (Alternative A) may also require environmental permits depending on the scope and scale of the work.

5.2.1 State and Federal Wetland Regulations

MaineDEP and USACE regulate the wetlands identified within the project area. Under the provisions of Section 404 of the Clean Water Act, USACE regulates activities within waters of the United States, which include navigable waters and all their tributaries, adjacent wetlands, and other waters or wetlands where degradation or destruction could affect interstate or foreign commerce. The USACE has issued a Programmatic General Permit for the State of Maine that merges the federal and state permit review process for many projects. In Maine, wetlands and waterbodies, as well as other protected natural resources, are regulated under M.R.S.A. 38 §§ 480A-480FF, the Natural Resources Protection Act (NRPA).

Projects that do not impact a wetland or projects that impact less than 4,300 square ft (sq ft) of wetland may be exempt from the NRPA Tier permitting requirements. This exemption does not apply if the impact is: 1) in, on, or over a coastal wetland, great pond, river, stream, or brook; 2) within 25 ft of those resources, or is more than 25 ft and no erosion control is used; 3) in a shoreland zone or a wetland protected by the shoreland zone; 4) part of a wetland with more than 20,000 sq ft of open water or emergent vegetation, except artificial impoundments; 5) in peatland; 6) part of a larger project; or 7) in Significant Wildlife Habitat. Typically, projects with cumulative impacts to freshwater wetlands between 4,300 and 15,000 sq ft are eligible for review under the Tier 1 process. The Tier 2 review process applies to alterations that affect between 15,000 and 43,560 sq ft (i.e., 1 acre) of freshwater wetlands. Cumulative freshwater wetlands impacts that exceed 1 acre typically require a Tier 3 review. Impacts to Wetlands of Special Significance, rivers, streams and brooks, great ponds, and Significant Wildlife Habitat typically require an Individual Permit. Based on Stantec’s site visit and spatial information obtained from the ME GIS regarding Wetland of Special Significance within the project area, either Tier 2 or Tier 3 review process would apply to project alternatives affecting other than the No Action alternative, depending on the potential area impacted.

5.2.2 Other Federal Permitting Requirements

Projects involving federal agency review (e.g., permitting under USACE) may require unique consultations under the Endangered Species Act (ESA) and Section 106 of the National Historic Preservation Act (NHPC Section 106). Alternatives B, C, and D would require, at a minimum, consultation with federal agencies to minimize project impacts to Atlantic salmon (and possibly Atlantic and shortnose sturgeon). Consultations would also be required to minimize impacts to cultural resources, and would involve coordination with the MHPC and Native American tribes located within the State of Maine.

5.2.2.1 Compliance with ESA[17]

The National Marine Fisheries Service (NMFS), and USFWS share responsibility for implementing the ESA, the purpose of which is to conserve and manage threatened and endangered species and the ecosystems upon which they depend. Generally, the USFWS has jurisdiction for land and freshwater species, while NMFS has jurisdiction for marine and anadromous species. There are three species of fish in the Orland River that are listed as threatened or endangered under the ESA:

- Atlantic salmon;
- Shortnose sturgeon; and
- Atlantic sturgeon.

NMFS and the USFWS share ESA responsibility for endangered Atlantic salmon in Maine. The USFWS is responsible for Atlantic salmon management in freshwater (with the exception of dams), while NMFS is responsible for managing Atlantic salmon in the estuary and marine environment, as well as addressing issues with dams. NMFS has sole jurisdiction for shortnose sturgeon and Atlantic sturgeon.

When a species is listed as threatened or endangered under the ESA, “take” of any listed species is prohibited unless it is authorized under Section 7 or 10 of the ESA. “Take” means to harass, harm, pursue, hunt, shoot, wound, kill, capture, or collect a listed species. Some examples of take that may occur at dams include upstream and downstream fish passage delays, handling of fish at fish passage facilities, and alteration of habitat (instream flows, stranding, water quality effects, among others). When a species is listed as threatened under the ESA, NMFS generally issues protective regulations pursuant to section 4(d) of the ESA. Section 7 of the ESA requires any federal agency that is conducting, funding, or authorizing an activity that may affect an endangered or threatened species to consult with either NMFS or the USFWS to ensure that their actions are not likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat. If the project is likely to adversely affect a listed species and take cannot be avoided, NMFS and the USFWS will work with the federal agency to minimize take the maximum extent possible after which an incidental take permit may be issued that authorizes a certain level of take. When non-Federal entities such as states, counties, local governments, and private citizens wish to conduct an otherwise lawful activity that might incidentally, but not intentionally, take a listed species, an incidental take permit, pursuant to section 10(a)(1)(B) of the ESA, may be obtained from NMFS or the USFWS. To receive a permit, the applicant must submit a Habitat Conservation Plan.

As such, owners of dams that seek incidental take coverage where there is no federal action would apply to NMFS for a section 10(a)(1)(B) incidental take permit. The application package

[17] This section was largely developed by representatives of NOAA/NMFS and provided to Stantec for use in this study.

would include a Habitat Conservation Plan that identifies ways to avoid and minimize take of the threatened or endangered species to the maximum extent practical.

5.2.2.2 Compliance with NHPC Section 106

Compliance with NHPC Section 106 is relevant to potential impacts to potentially historic features that may be impacted by project actions. The need and extent of work associated with such compliance would need to be determined based on consultation with federal agencies and may follow on coordination with MHPC.

5.2.3 Local Wetland Regulations

The Town follows MaineDEP regulations regarding Shoreland Zoning. Consultation with the Town Natural Resource Planner and/or Code Enforcement Officer is recommended to determine what restrictions would be placed on work and related impacts associated with a selected alternative.

5.3 OPINIONS OF PROBABLE COST

This section presents OPCs for the four evaluated alternatives. The OPCs include the sum of construction costs, operations and maintenance (O&M) costs, and costs for regular major repairs (RMR) at intervals of 30 years (the expected life of a timber crib dam). Costs associated with O&M and regular major repairs are capitalized over the long-term based on the following equation at an interest rate of 2 percent:

$$Capitalized\ Cost = \frac{O\&M + RMR}{Int}$$

A summary of the OPCs is presented in Table 10.

5.3.1 Alternative A – No Action

The OPC for Alternative A is based on an annual O&M cost of $7,500 and no budget for RMRs. No costs associated with engineering design, permitting, or other professional services associated with maintenance, operation, or inspections of the dam are included in this OPC. The total OPC for Alternative A is $375,000.

5.3.2 Alternative B – Dam and Fishway Rehabilitation

The OPC for Alternative B is based on $280,000 for design, permitting, construction bidding support, construction observation, and construction rehabilitation of the dam and fishway. The annual O&M and RMR costs are $7,500 (each). The total OPC for Alternative B is $905,000.

5.3.3 Alternative C – Dam and Fishway Modification

The OPC for Alternative C is based on $900,000 for design, permitting, construction observation, and construction for modification of the dam and fishway. The annual O&M and RMR costs are $7,500 (each). The total OPC for Alternative C is $1,525,000.

5.3.4 Alternative D – Dam Removal

The OPC for Alternative D is based on $535,000 for design, permitting, construction bidding support, construction observation, and construction for removal of the of the dam and fishway. The OPC for permitting is $120,000, and reflects approximately $80,000 in costs for work related to cultural and historic resources and associated coordination with the MHPC. There are no O&M and RMR costs associated with this alternative or costs associated with replacement of functions associated with loss of the dam impoundment, such as dry hydrants, surface water withdrawals, or impacts to wells, or modification to existing infrastructure, such as the SR 175 Bridge. The total OPC for Alternative D is $535,000.

5.4 FUNDING

Potential sources of funding for further development of the evaluated alternatives, including costs for design, permitting, and construction, vary for each alternative. Funding for rehabilitation or modification of the dam would likely need to come from “internal” sources, including the Town, as “external” funding (e.g., from state or federal agencies, non-governmental organizations [NGOs]) is very limited for work to repair and/or maintain small dams.

Small dam removal projects in Maine typically include substantial funding from external sources including state and federal agencies (NOAA, USFWS, Natural Resources Conservation Service), NGOs (e.g., American Rivers, the Atlantic Salmon Federation, The Nature Conservancy), and the In Lieu Fee Compensation Program that is administered by MaineDEP.

Table 10: Summary of OPCs

Alternative	Design and Permitting	Construction	Subtotal	Annual O&M	Major Repairs Fund (assumed to be $250,000/30 years)	Capitalized Cost	Total Cost Through Construction + Capitalized Cost
Alternative A No Action	$0	$0	$0	$7,500	$0	$375,000	**$375,000**
Alternative B Dam & Fishway Rehabilitation	$80,000	$200,000	$280,000	$7,500	$7,500	$625,000	**$905,000**
Alternative C Dam & Fishway Modification	$105,000	$795,000	$900,000	$7,500	$7,500	$625,000	**$1,525,000**
Alternative D Dam Removal	$210,000	$325,000	$535,000	$0	$0	$0	**$535,000**

6 RECOMMENDATIONS FOR ADDITIONAL STUDIES

This section presents a summary of items recommended for additional study. The following list is not intended as an all-inclusive list of additional studies that may be undertaken.

- Additional bathymetric survey work from the SR 175 Bridge downstream to the Orland Village Dam;
- Investigation of subsurface conditions from the SR 175 Bridge downstream to the Orland Village Dam to determine whether channel bed material is bedrock or potentially mobile cobble/boulder fill material;
- Detailed bridge scour analysis of the SR 175 Bridge crossing;
- Detailed assessment of Upper Falls Road crossing, including collection of topographic survey and subsurface geotechnical information; and
- Evaluation of water quality in the Narramissic River, including collection of dissolved oxygen, temperature, and salinity at select locations between the Upper Falls Road crossing and tidewater during periods of low freshwater flow (e.g., during summer). Vertical profiling of these parameters should be conducted at several locations within the impoundment to determine whether there is seasonal stratification and/or hypoxia or anoxia.

Following here are descriptions of some the recommended items for additional study.

Stantec discussed with technical specialists potential means to evaluate subsurface conditions between the SR 175 Bridge and Orland Village Dam. Based on these discussions, our understanding is that methods such as shallow seismic refraction surveys may not provide suitable resolution between native material and accumulated debris. An alternative method that may be possible would be to perform geotechnical borings in this reach. This method would likely require drawing down of the impoundment to operate boring equipment in areas that are temporarily exposed during a drawdown.

7 PHOTO-SIMULATION OF POTENTIAL CONDITIONS

This section presents graphical depictions of the project reach of the Narramissic River for existing and potential conditions associated with removal of Orland Village Dam. The graphical depictions include:

Image 1. A photograph of the Narramissic River looking seaward (downstream) from the US Rt. 1 Bridge; and

Image 2. A photo-simulation based on Image 1 of potential conditions at low tide associated with removal of Orland Village Dam.

Image 2 was developed by Stantec at the request of the Dam Committee using Image 1, bathymetric data collected as part of project studies, and estimated low tide water surface elevations using hydraulic model results. Areas in Image 2 that are below the current normal water surface in the impoundment and above the estimated low tide water surface elevation are depicted as having dormant marsh vegetation; actual conditions would very spatially and seasonally.

Image 1: Existing Conditions – View Seaward (downstream) from US Rt. 1 Bridge

Image 2: Simulated Conditions – View Seaward (downstream) from US Rt. 1 Bridge

Appendix A Photographs

Control gates and fishway sections, low tide (fishways non-operational, non-functional).

Control gates and fishway sections, middle of the tide (fishway non-operational, non-functional).

Timber crib section of dam.

Seepage under/through dam.

Degraded concrete near left control gate.

Spillway separation from left concrete abutment.

Dam prior to 2012 work performed by Town.

Dam following 2012 repair work performed by Town.

Dam from left abutment following 2012 repair work by Town.

Dam from upstream of left abutment following 2012 repair work by Town.

Dam spillway from downstream of right abutment. Note the high tide line on the near spillway abutment.

Dam from downstream of left abutment.

Alewife Harvesters shack (removed in 2012 by Town).

Closure notice formerly posted on Alewife Harvesters shack.

Alewife harvesting conveyor belt apparatus.

Fishway (operational, but non-functional) at low tide with flow over the dam. Note the alewife harvesting operations in background

Alewife harvesting weir, elver harvesting fyke nets in background.

The Verso Corporation water diversion aqueduct. A “water hammer” ruptured pipe in 2012.

Residential water withdrawal upstream from State Route 175.

6-inch diameter water withdrawal near Bucksport Golf Club.

Dry hydrant on Narramissic Drive (impoundment).

Dry hydrant on State Route 46 (Wight's Brook).

Upper Falls Road crossing from upstream.

Upper Falls Road crossing from downstream.

State Route 175 Bridge from upstream.

State Route 175 Bridge from downstream.

US Route 1 Bridge looking west.

US Route 1 Bridge looking east.

Verso Corporation water withdrawal aqueduct bridge over Wight's Brook (downstream from State Route 46 Bridge).

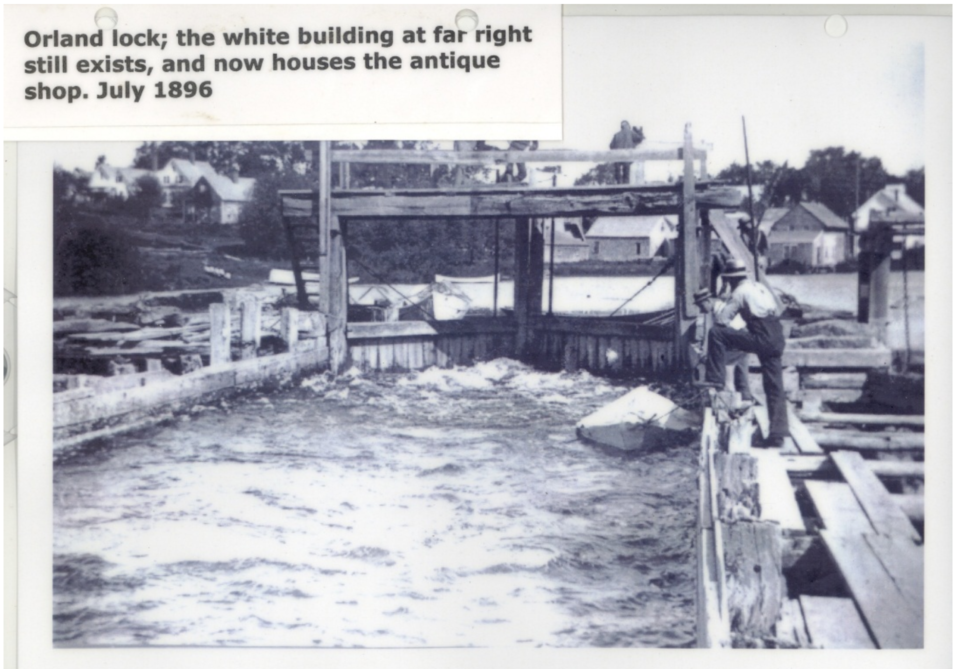
Duck Cove Road wooden bridge pilings (Wight's Brook).

State Route 46 Bridge over Wight's Brook.

1994 storm surge damage – photo courtesy of Sharon Thompson (Orland Historical Society).

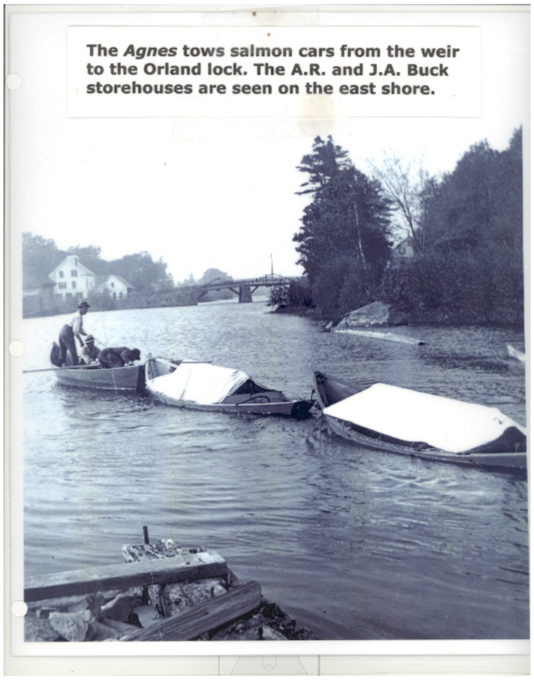
1994 storm surge damage – photo courtesy of Sharon Thompson (Orland Historical Society).

Orland Village Dam (circa 1910) – photo courtesy of Sharon Thompson (Orland Historical Society).



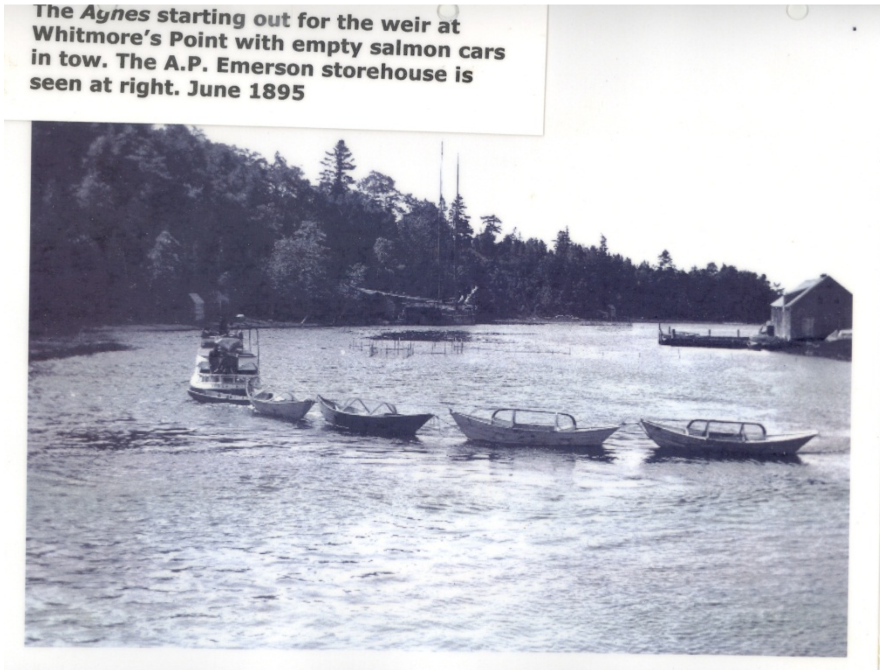
Orland Village Dam lock area 1896 (note salmon “live car” progressing through lock) – photo courtesy of Sharon Thompson (Orland Historical Society).

Orland Village Dam and lock (note salmon “live cars” in foreground; circa 1896) – photo courtesy of Sharon Thompson (Orland Historical Society).



Salmon "live cards" above Orland Village Dam (note State Route 175 Bridge in background; circa 1896) – photo courtesy of Sharon Thompson (Orland Historical Society).

The *Agnes* and salmon "live cars" stored downstream from Orland Village Dam (circa 1896) – photo courtesy of Sharon Thompson (Orland Historical Society).



The *Agnes* with salmon “live cars” in tow downstream from Orland Village Dam (circa 1896) – photo courtesy of Sharon Thompson (Orland Historical Society).

View of Orland Village Dam from State Route 175 (circa 1896) – photo courtesy of Sharon Thompson (Orland Historical Society).

Appendix B Dam Inspection Report

Appendix C Conceptual Designs

Appendix D Well Survey Responses

Appendix E Surficial Geology Maps

Appendix F Bathymetric Map & Longitudinal Profile

Appendix G 2013 Town of Orland – River Herring Harvest Plan

Appendix H Agency Response Letters

Appendix I Bridge Plan Information from the Maine Department of Transportation

Appendix J Responses to the Recreational Use Survey