Mayo Mill Dam Feasibility Study

Baseline Conditions Report

Piscataquis River

Dover-Foxcroft, ME

October 2023

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Executive Summary

Introduction to the Piscataquis River: Flowing through downtown Dover-Foxcroft, the Piscataquis River has long been a cultural and economic focal point of the region. The river powered multiple generations of mills and factories at the Mayo Mill Dam site, playing a role in elevating the village as an industrial hub within Piscataquis County since the 19th century. Though the last factory at the site closed in 2007, the river remains an important resource due to its high historical, recreational, and ecological value.

The Piscataquis River is a tributary to the Penobscot River, the largest watershed in Maine with the greatest potential for recovery of Atlantic salmon and other native sea-run fish. The Piscataquis River is a key to recovery in the Penobscot and in Maine, having more viable Atlantic salmon habitat than the other areas of the watershed. Restoration of fish passage at the site is seen as a potential major step in the watershed for the ecological benefits it would provide.

Project Goals and Objectives: The Town of Dover-Foxcroft is considering a range of actions at the Mayo Mill Dam, aligned with its Downtown Revitalization Plan (2003) and Town Comprehensive Plan (2016) objectives. Key objectives include resolving the long-term management of this Town-owned infrastructure, while contributing to the revitalization of the historic downtown, and enhancing the community experience through improved public safety, increased access to the river, and enhanced recreational opportunities. The core themes to the feasibility study of the Mayo Mill Dam site are long-term management of the dam; restoration of safe, timely and effective fish passage; and enhancement of the role that the site and adjoining areas plays in the community experience. This report summarizes the results to date of the first phase of the feasibility study which characterizes the existing or baseline conditions and functions of the site.

Historical and Current Conditions: This report provides a detailed description of past and current conditions of the Mayo Mill Dam site and the Piscataquis River in the area of the site. Review of the historical role and management of the river, combined with field observations and existing data review, lead to interpretation of the condition of the river and dam site as it exists today. In addition to data collected by Inter-Fluve on the topographic and bathometric conditions of the site, a structural inspection and stability analysis of the dam was conducted by Gomez and Sullivan.

The structural analysis of the dam site indicated that there are substantial structural condition issues with the dam and powerhouse building and that the dam did not meet FERC dam safety criteria for some of the loading cases evaluated.

Flooding Patterns: Nestled along the river, Dover-Foxcroft has experienced notable floods periodically through its history. Due to the hazards that these periodic floods present, the Federal Emergency Management Agency (FEMA) established a regulatory floodplain along the river to limit development, reduce damage, and protect the public in these flood prone areas.

Inter-Fluve evaluated the hydrologic characteristics of the Piscataquis River and the contributing watershed, and the associated flow patterns near Mayo Mill Dam. As part of their analysis Inter-Fluve reviewed hydrologic evaluations published in flood insurance studies, conducted water level monitoring at the site, and developed a detailed hydraulic model to represent current conditions and to understand flood levels, erosion forces, and water levels in the impoundment area.

Mayo Mill Dam has a direct impact on flood profiles upstream of the dam. The hydraulic evaluation performed by Inter-Fluve indicates that the impact of the dam extends upstream approximately 1.7 miles to the former Waterworks Dam location. The hydraulic modeling results also demonstrate that even small flood events interface with existing infrastructure and private property along the Piscataquis River. Model results estimate that the Mill Street parking lot may begin to inundate during the 2-year event, South Street may begin to inundate during the 10-year event, and overland flow may bypass the dam entirely during the 50-year event. These events are likely to occur more frequently in future years due to climate change (MCC STS 2020), increasing strain on infrastructure near the river.

Ecological Resources: The Piscataquis River is a major tributary to the Penobscot River and the focal point of a regionally important 1,459 square mile watershed which provides habitat for a diverse assemblage of native flora and fauna. The 62-mile-long river has been afforded federal and state protections to maintain water quality and habitat to support a diverse community of aquatic and terrestrial species. Much of the Piscataquis River is designated an outstanding river segment, and as such is afforded special protection under the Natural Resources Protection Act (NRPA).

Within the Mayo Mill project area, the hydrology of the Piscataquis River is controlled by the Mayo Mill dam which impacts the stream habitat present. Species of particular interest present within the project area include freshwater mussels, American eel (*Anguilla rostrata*), sea lamprey (*Petromyzon marinus*), Eastern brook trout (*Salvelinus fontinalis*), and the endangered Atlantic salmon (*Salmo salar*). Atlantic salmon migrations along the Piscataquis River are impeded by dams such as Brown’s Mill Dam, Mayo Mill Dam and Guilford Dam. In addition to creating passage constraints which lead to passage delays and associated delayed mortality, the impoundments formed by these dams reduce potential critical rearing and spawning habitat availability. The impoundments also create habitat conditions that favor invasive species over native fish.

Recreational Resources and Community Planning: There are currently two primary public access points to the Piscataquis River within the impoundment area that include a seasonal dock and an MDIFW boat launch. Recreational opportunities on the river itself focus primarily on the impoundment area upstream of the dam and include flatwater paddling, swimming, and recreational sport fishing for resident game fish. Additionally, sea planes may periodically use the impoundment for landings and takeoffs. The Town hopes to enhance public access and recreational opportunities in the future, particularly in the downtown area.

The Town of Dover-Foxcroft has been proactively pursuing downtown revitalization adjacent to and within the study area for two decades, starting with the 2003 Downtown Revitalization Plan (WBRC 2003). The revitalization plan included a master plan for the South Street/Pine Street corridor which among other improvements enhanced greenspace and pedestrian connectivity between the boat ramp area and Main Street. Subsequent efforts by the Town in conjunction with Maine DOT seek to further develop the connectivity and gateway along South Street to Main Street and across the river to the Mill and Riverfront Park area.

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1. Introduction

Flowing through downtown Dover-Foxcroft, the Piscataquis River has long been a cultural and economic focal point of the region. The river powered multiple generations of mills and factories at the Mayo Mill Dam site, playing a role in elevating the village as an industrial hub within Piscataquis County since the 19th century. Though the last factory at the site closed in 2007, the river remains an important resource due to its high historical, recreational, and ecological value.

Presently, the Town is considering a range of actions at the Mayo Mill Dam, aligned with its Downtown Revitalization Plan (2003) and Town Comprehensive Plan (2016) objectives. The site occupies a unique position at the heart of Dover Foxcroft (Figure 1). Key objectives include resolving the long-term management of this Town-owned infrastructure asset, while contributing to the revitalization of the historic downtown, and enhancing the community experience through improved public safety, increased access to the river, and enhanced recreational opportunities.

At the same time, the Piscataquis River has great regional ecological value. The Piscataquis is a tributary to the Penobscot River, the largest watershed in Maine with the greatest potential for recovery of Atlantic salmon and other native sea-run fish. The Piscataquis River is a key to recovery in the Penobscot and in Maine, having more viable Atlantic salmon habitat than the other areas of the watershed. Restoration of fish passage at the site is seen as a potential major step in the watershed for the ecological benefits it would provide.

Based on the above range of factors, the Town of Dover-Foxcroft (Town) and the Atlantic Salmon Federation (ASF), along with The Nature Conservancy in Maine (TNC) and the National Oceanic and Atmospheric Administration (NOAA), partnered in fall 2022 to conduct a feasibility study to examine three core themes: long-term management of the dam; restoration of safe, timely and effective fish passage; and enhancement of the role that the site and adjoining areas plays in the community experience.

This interim draft report summarizes the results to date of the first phase of the study which characterizes the existing or baseline conditions and functions of the site. The subsequent phase of the study will evaluate management options for the site and adjoining areas that address the three core themes listed above. It should be noted that the current report is an interim version of the baseline conditions report, as additional field study is ongoing in summer 2023 that will be summarized in the final version of the report, to be issued in September 2023.

Figure 1. Overview map of Mayo Mill Dam and vicinity.

2. Site History & Historical Resources

The Mayo Mill Dam site is steeped in history, at the center of the long and storied history of the Town of Dover-Foxcroft. Prior to European settlement, Native Americans inhabited Piscataquis County as part of their domestic range, and utilized the river for transportation between regions and as a source of sustenance. The name Piscataquis is derived from an Abenaki word meaning "branch of the river" or "at the river branch."

First settled shortly after the turn of the century and established as independent towns, Dover (incorporated 1822) and Foxcroft (incorporated 1812) were joined physically in 1820 with the construction of the first bridge across the Piscataquis River. The two towns merged formally in 1922 after many years of debate (Town of Dover-Foxcroft 2022). On the Foxcroft side (west side) of the river, E.R. Favor established the first textile mill at the Mayo Mill site in 1822. Following the dismantling of the Favor mill, Mayo, Bush and Hale established their first three story mill at the site in 1844 and began receiving wool in 1846 (Figure 2 to Figure 3). John Mayo Sr. soon purchased the interests of his partners, and the second mill at the site was constructed in 1883 (Figure 4) by his sons following his death (Piscataquis Observer 1908).

The first two mill buildings were supplemented with the current concrete structure, with segments constructed in 1908 by Mayo & Son (Figure 5), and in 1916 (Figure 9) by the American Woolens Company who acquired the facility in 1914 (Piscataquis Observer 1908, USDOI 2012). The Mayo Mill was one of the first textile mills in the country to be converted from mechanical to electrical power, with some electricity being generated as early as the 1890s. The concrete building structure was also an early adaptation of the emerging technology of the day. After utilization of multiple wheelhouse locations along the river, the current wheelhouse with two generating turbines was constructed in 1907 (USDOI 2012).

Following their acquisition, American Woolens operated the mill, at times intermittently, until it was shut down permanently in 1953. In 1959, the facility was subsequently purchased by the Moosehead Manufacturing Company, a maker of furniture, who operated at the site until its closure in 2007 (USDOI 2012). Following this closure, the mill lay dormant and vacant until it was redeveloped by Arnold Development in the decade that followed. Today, the Mill exists as a modern facility with commercial spaces, residential condominium units, and a boutique hotel facility. Redevelopment of the hydropower facility at the site was also part of the original redevelopment plans, but has not been realized.

On the Dover side (east side) of the river, a series of grist, furniture, and joinery mills were located directly adjacent to the east abutment of the dam through the 1800s and early 1900s. The mills were powered by water diverted from the headpond of the dam, with evidence of a penstock intake in this vicinity still observable today. Further east, a second diversion withdrew water from the headpond and delivered it and logs beneath East Main Street to a long-standing saw mill on the north side of Main Street (Figure 10). A small bridge carried East Main Street across this channel, present in historical maps until the 1910s, after which the area was occupied by the New Star Theatre (Figure 11) (Sanborn 1884, 1889, 1894, 1900, 1906, 1911, 1923, 1931). The general alignment of this water conveyance was through the present-day location of the building block immediately west of the Center Theatre (constructed after the New Star Theatre burned in the fire of 1940; USDOI 2021). The presence of this second conveyance channel and bridge suggests that the original width of the Piscataquis River channel may have extended further east than the current location beneath the Main Street bridge.

The first incarnation of the dam at the site appears to have been built in the early 1800s, with the establishment of Favor’s mill. Photographs dating to the late 1800s show the dam as a timber crib structure stretching across a natural bedrock outcrop across the river (Figure 12 to Figure 18). The dam was rebuilt as a concrete structure supplementing the timber crib by the American Woolens Company in 1920 (Figure 19 to Figure 21). This construction included a concrete spillway and a pool and weir fishway. Construction of fishways at the dams along the Piscataquis River was the subject of a 1919 order by Commissioner Willis Parsons (of Dover-Foxcroft), the first commissioner of the Maine Department of Inland Fisheries and Wildlife (Piscataquis Observer 1919). Interestingly, Parsons had also authored the ceremony to “wed” Dover to Foxcroft in 1922 (Town of Dover-Foxcroft 2022).

The dam was rebuilt again in 1982 by the Moosehead Manufacturing Company (Figure 22 to Figure 23). The Federal Energy Regulatory Commission (FERC) license exemption (FERC P-5912) authorizing generation was established concurrently, and is still held by the Town. The hydroelectric facility has not produced power since 2007 when it fell into disrepair concurrent with the closure of the Moosehead Manufacturing Company.

The dam is nestled between two national historic districts (Figure 1). The American Woolen Company Foxcroft Mill/Mayo & Son Woolen Mill Historical District was established on the national register in 2012. The district includes 11 buildings or structures, over the 2.77-acre area that contained the historical mill complex. The existing wheelhouse constructed in 1907 which generated power under the existing FERC exemption is included in the historic district, whereas the dam, which was reconstructed in 1982, is not included (USDOI 2012). Across the river, the Dover-Foxcroft Commercial Historic District (established 2021) includes 16 historical buildings stretching along East Main Street and the west side of South Street (USDOI 2021). These national historic districts are located within the larger Town of Dover-Foxcroft historic district, which encompasses the historical downtown area.

In 2021, a Memorandum of Agreement (MOA) was drafted between FERC and Maine State Historic Preservation Office regarding the amendment to the FERC license exemption proposed at the time (FERC & SHPO 2021). Specifically, the MOA addressed modifications to the historical wheelhouse/powerhouse that houses the generating turbines. This structure is listed on the national historic register as contributing to the American Woolen Company Foxcroft Mill/Mayo & Son Woolen Mill Historical District. However, the proposed modifications were not eventually implemented. Any future project actions which result in modifications to the wheelhouse structure will require similar consultation under Section 106 of the National Historic Preservation Act.

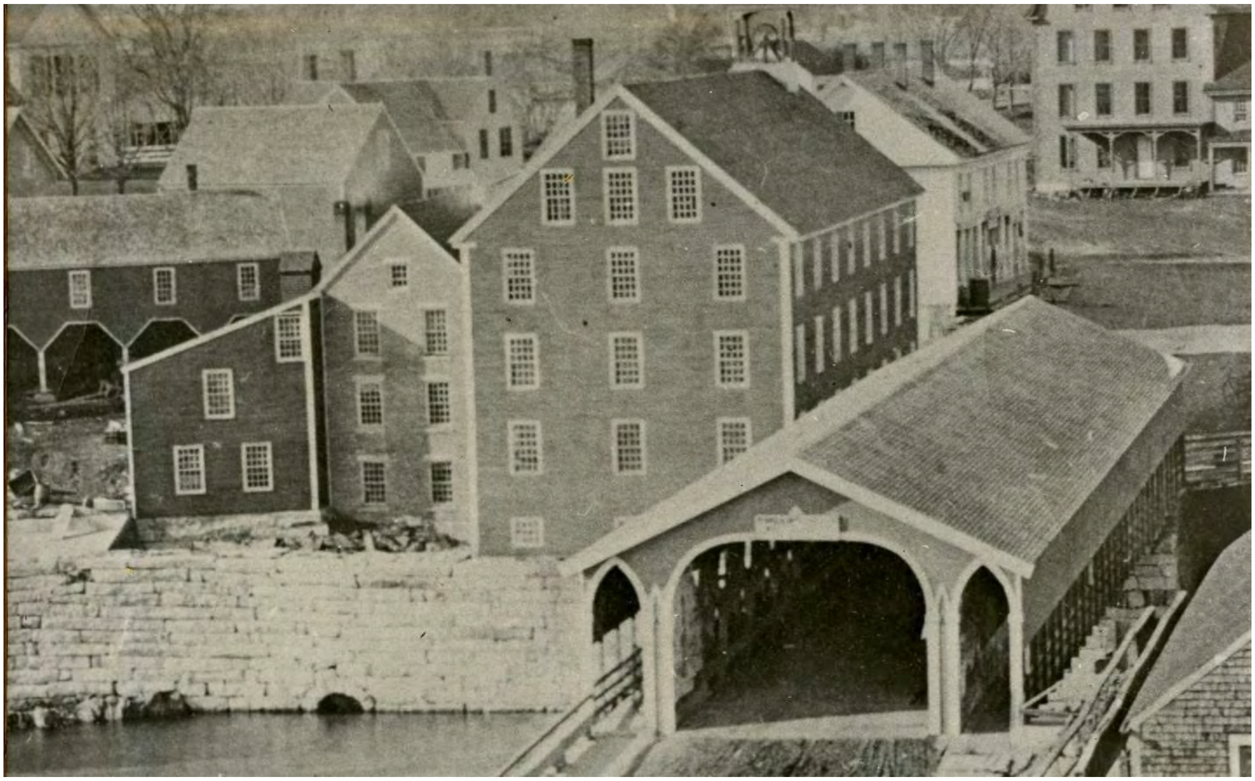

Figure 2. Image showing the original three-story mill at the Mayo Mill site, along with the 19th century era covered bridge. Source: Dover-Foxcroft Historical Society.

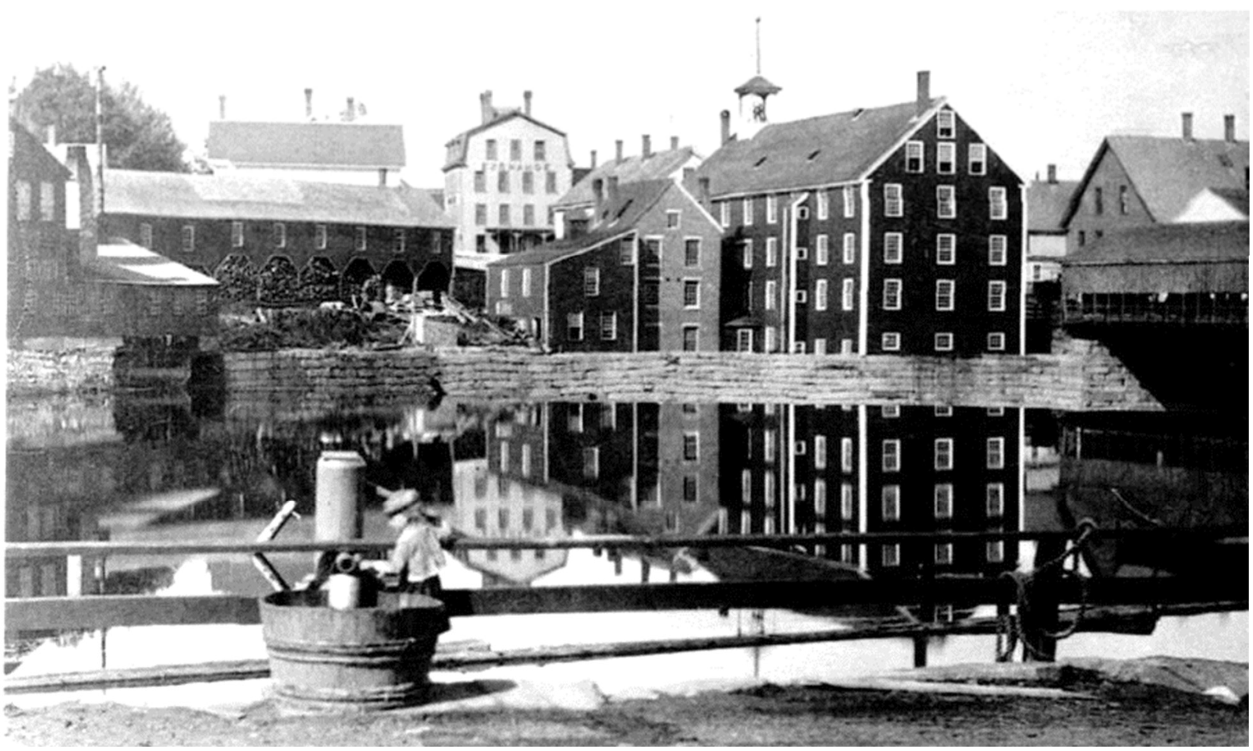

Figure 3. Image showing the original three-story mill at the Mayo Mill site, public water pump on the Dover side of the river. The water pump drew water from the headpond area, and was an important source of water for residents that did not have individual wells. Source: Dover-Foxcroft Historical Society.

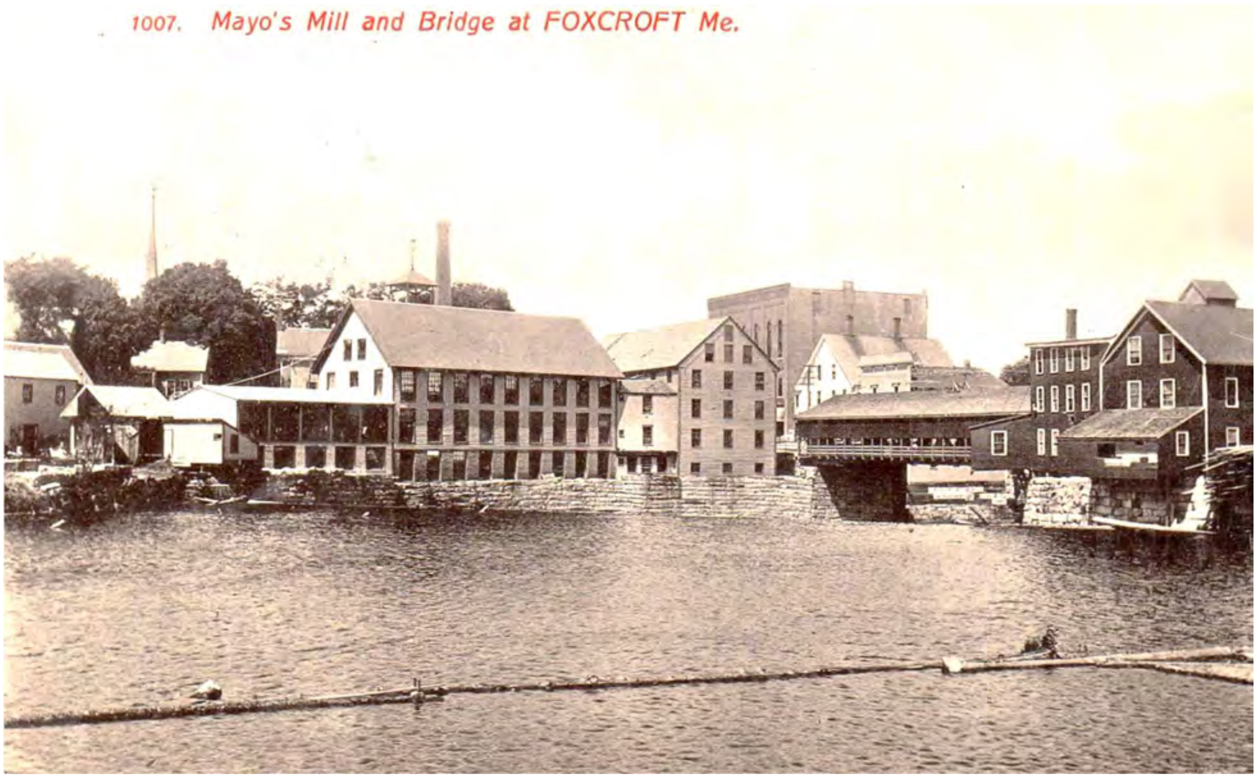

Figure 4. Image showing the second mill constructed at the site in 1883, and mill across the river. Source: Dover-Foxcroft Historical Society.

Figure 5. Image showing the original two mill buildings, and the first concrete structure constructed in 1908. Source: Dover-Foxcroft Historical Society.

Figure 6. 1911 image showing the newly constructed arch bridge. Source: Dover-Foxcroft Historical Society.

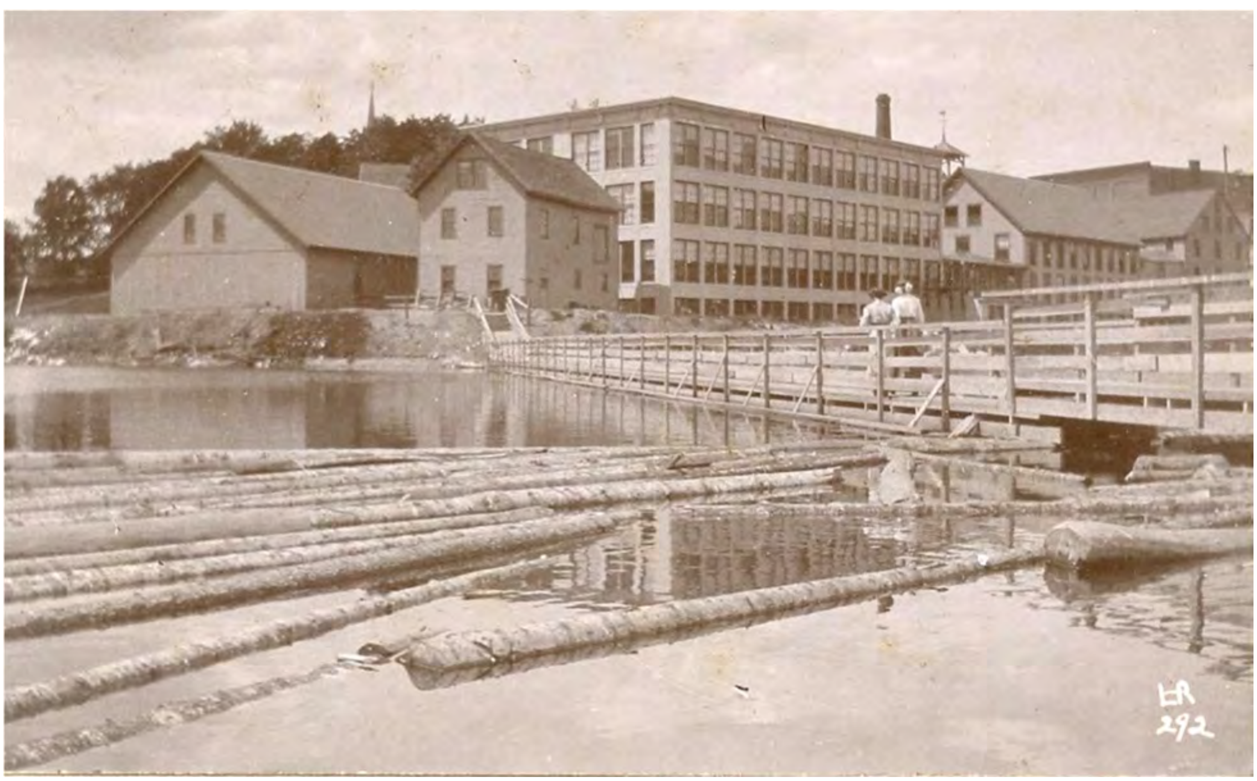

Figure 7. 1911 image showing the floating bridge that was constructed for pedestrians while the Main Street bridge was being replaced. Source: Dover-Foxcroft Historical Society.

Figure 8. 1911 image showing the floating bridge that was constructed for pedestrians while the Main Street bridge was being replaced. Source: Dover-Foxcroft Historical Society.

Figure 9. 1918/19-era image showing the 1916 addition to the concrete mill building. The concrete dam had not yet been constructed in this photo. Source: Dover-Foxcroft Historical Society.

Figure 10. Excerpt from 1906 Sanborn fire insurance map showing the mills that utilized the river at the site. The Thayer & Clark sawmill was previously owned by Gilman. Source: Dover-Foxcroft Historical Society.

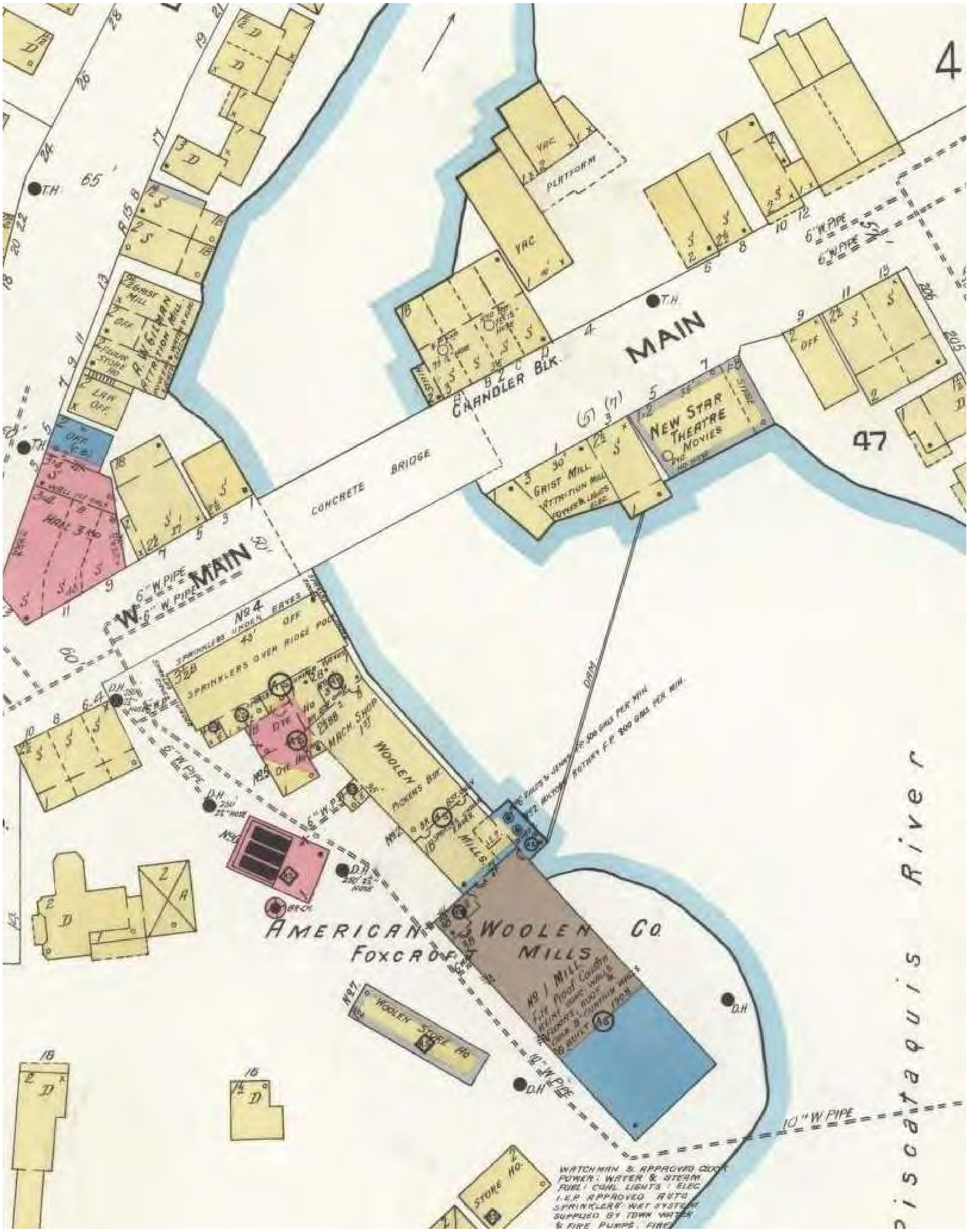

Figure 11. Excerpt from 1923 Sanborn fire insurance map showing the mills that utilized the river at the site. The New Star Theatre is shown in the location of the former second channel exiting the headpond. The Star Theatre is shown on the 1911 map at the location of the Chandler Block on this map. Source: Dover-Foxcroft Historical Society.

Figure 12. Late 1800s photo of Mayo Mill Dam showing original timber crib construction and bedrock outcrops used to anchor the dam.

Figure 13. Pre-1883 photo showing the wood planking on the upstream face of the dam. Source: Dover-Foxcroft Historical Society.

Figure 14. Pre-1883 photo showing the wood planking being replaced on the upstream face of the dam. Source: Dover-Foxcroft Historical Society.

Figure 15. 1870s photo showing high flow over the dam and the foundry which was an early user of the dam. Source: Dover-Foxcroft Historical Society.

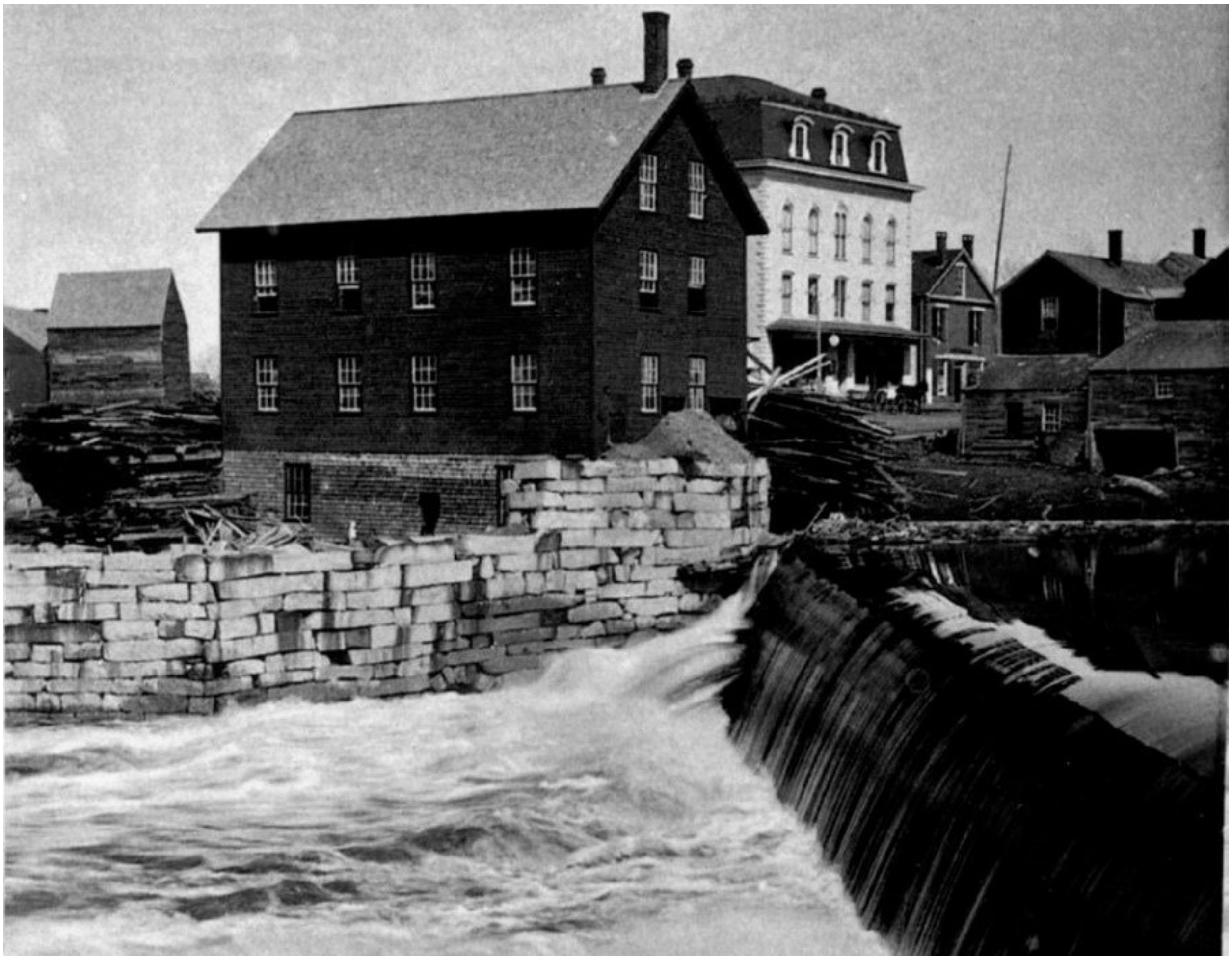

Figure 16. 1800s view of the Dover side of the dam, with the Masonic Hall in the background. Source: Dover-Foxcroft Historical Society.

Figure 17. Collage of late 1800s photos showing the dam, mill, foundry and South Street under differing conditions. Source: Dover-Foxcroft Historical Society.

Figure 18. Late 1800s photo showing tangled logs being extracted from the log sluice. Source: Dover-Foxcroft Historical Society.

Figure 19. 1940-era photo showing the original concrete dam and Main Street retaining wall, along with a timber retaining wall along South Street. Source: Dover-Foxcroft Historical Society.

Figure 20. Post-1920 era photo showing the original concrete dam and pool & weir fishway. Source: Dover-Foxcroft Historical Society.

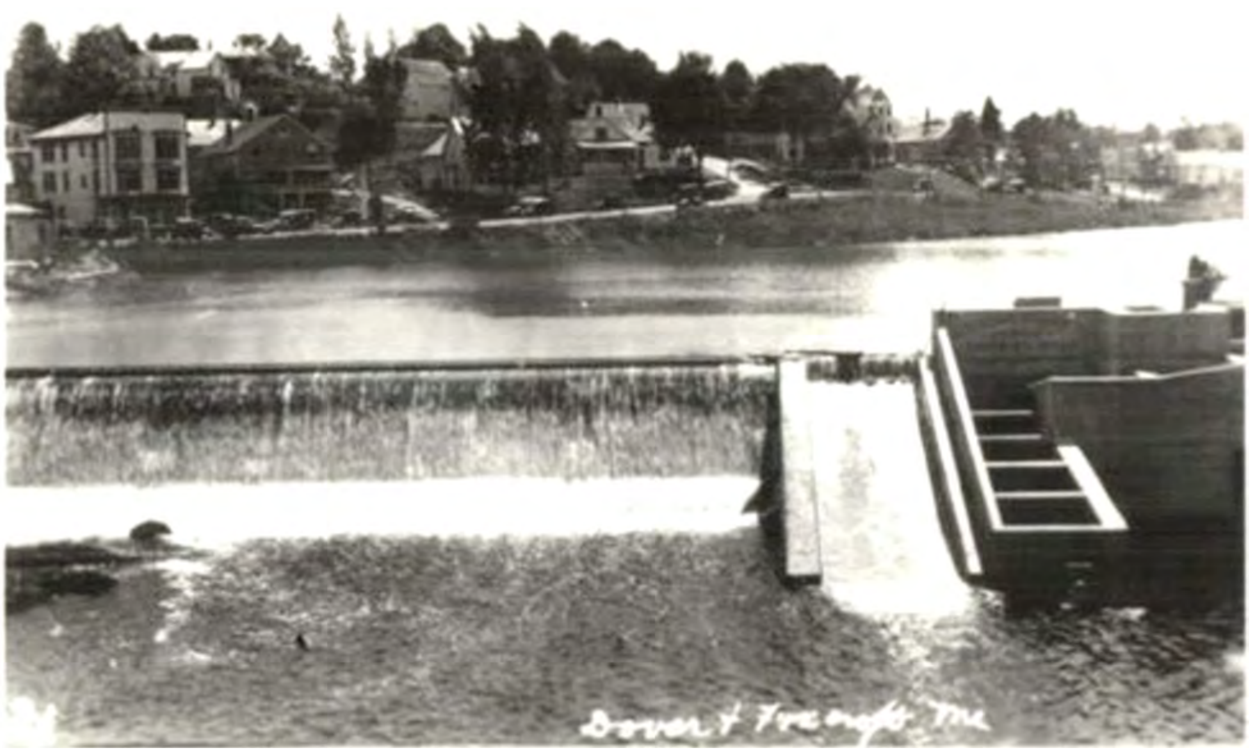

Figure 21. Post-1920 era photo showing the original concrete dam and pool & weir fishway. Source: Dover-Foxcroft Historical Society.

Figure 22. Mayo Mill Dam in June 2022. The dam was reconstructed in 1982, including a new fishway in place of the original fishway.

Figure 23. 1920 inscription in 2022, modified in 1982 with construction of the Denil fishway.

3. Site Context & Watershed Description

The study area for this project extends from approximately 1,000 feet downstream of the Mayo Mill Dam to the upstream end of the impoundment at the former Waterworks Dam, approximately 1.7 miles upstream of Mayo Mill dam. The dam spans the Piscataquis River approximately 150 feet upstream of the East Main Street (Route 15) bridge.

Following review of available background information, Inter-Fluve conducted site investigations in November of 2022. The investigations included a survey of the river channel and selected adjacent infrastructure, a geomorphic assessment of the river channel in the study reach, and measurements and sampling of accumulated sediment in the impoundment area. Additional field investigations were completed in summer 2023, including dam structure condition assessment, dam stability analysis, and water level monitoring. The following paragraphs provide an overview of the landscape context, and the remaining sections of the report detail the current conditions of the study area.

At Mayo Mill Dam, the river drains a 345-square-mile watershed (Figure 24). Elevations within the watershed range from 320 to 2,622 feet. The watershed receives 44 inches of precipitation annually, on average (PRISM 2014) and is predominantly forested (84 percent of watershed area). The Piscataquis River through the study area is classified as a Class B water by Maine Department of Environmental Protection.

Through the project area, the Piscataquis River is underlain by erodible mudstone and low-grade metamorphic rock of the Silurian-age Sangerville Formation, which are expressed at the surface at the upper end of the impoundment and downstream of the dam, where bedrock spans the channel and bounds the gorge downstream of the Main Street Bridge. Historical bedrock exposures at Dover-Foxcroft influenced the locations of Mayo Mill and Brown's Mill dams (Figure 12 and Figure 25).

The watershed is a heavily glaciated landscape, still bearing the marks of the Labrador ice sheet that flowed over the region from approximately 75,000 to 15,000 years ago (Caldwell, 1998). The erosive force of the ice sheet accounts for the molded bedrock and the coverage of glacial till throughout the watershed. Isostatic rebound of the landscape following the retreat of the ice sheet likely accounts for the incised nature of the Piscataquis through the project reach. With the weight of the overlying ice sheet removed, the post-glacial landscape rebounded. Where ice had been thicker (north and inland), the rate and amount of rebound was greater. The resulting disequilibrium initiated a wave of incision by rivers across the region. Through the project area, particularly where erodible mudstone underlies the channel, the Piscataquis River occupies a narrow and deep valley that was formed during this period of rebound and incision. Post-glacial incision explains the long, narrow impoundment upstream of the Mayo Mill Dam.

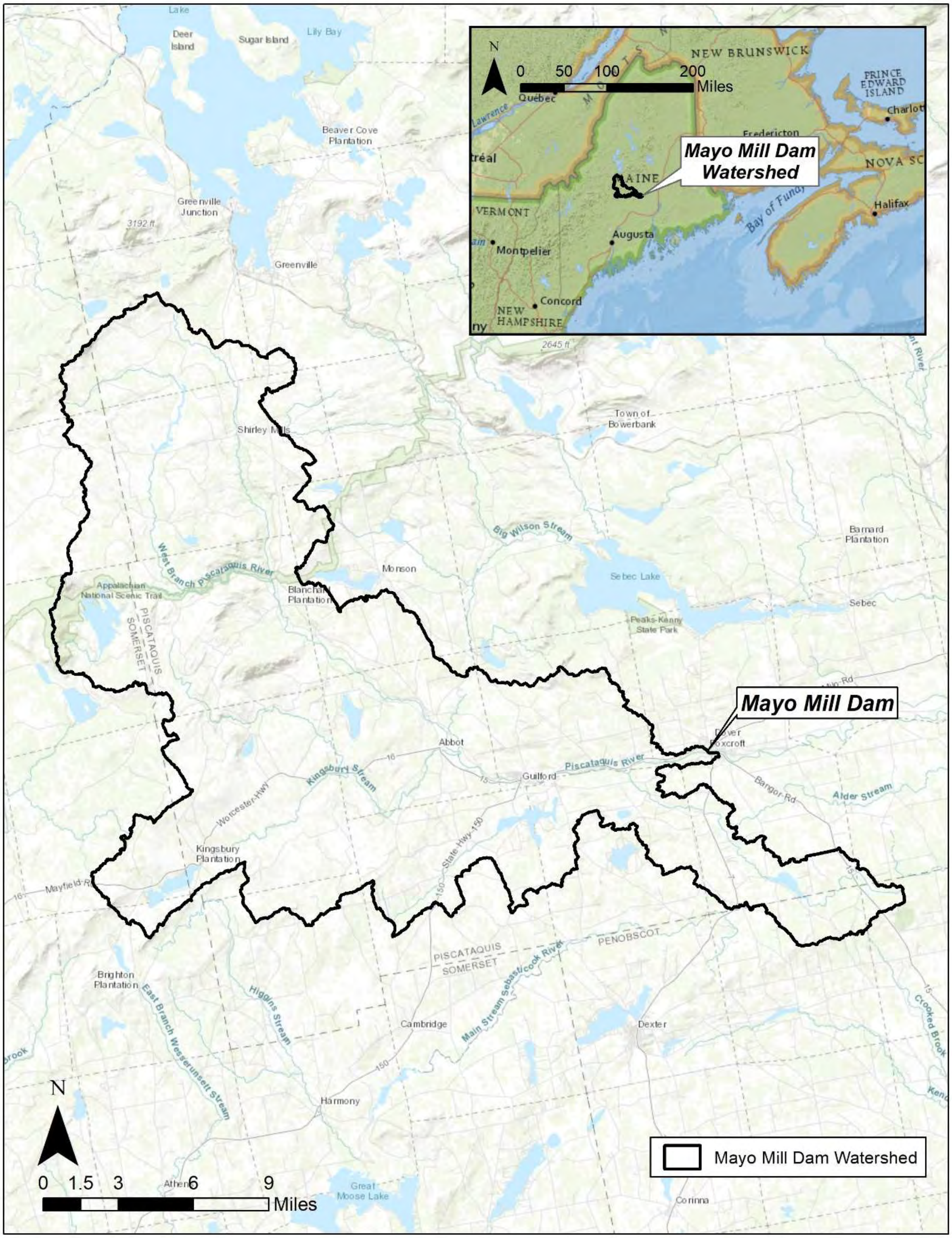

Figure 24. Topographic map with site location and outline of the upstream watershed.

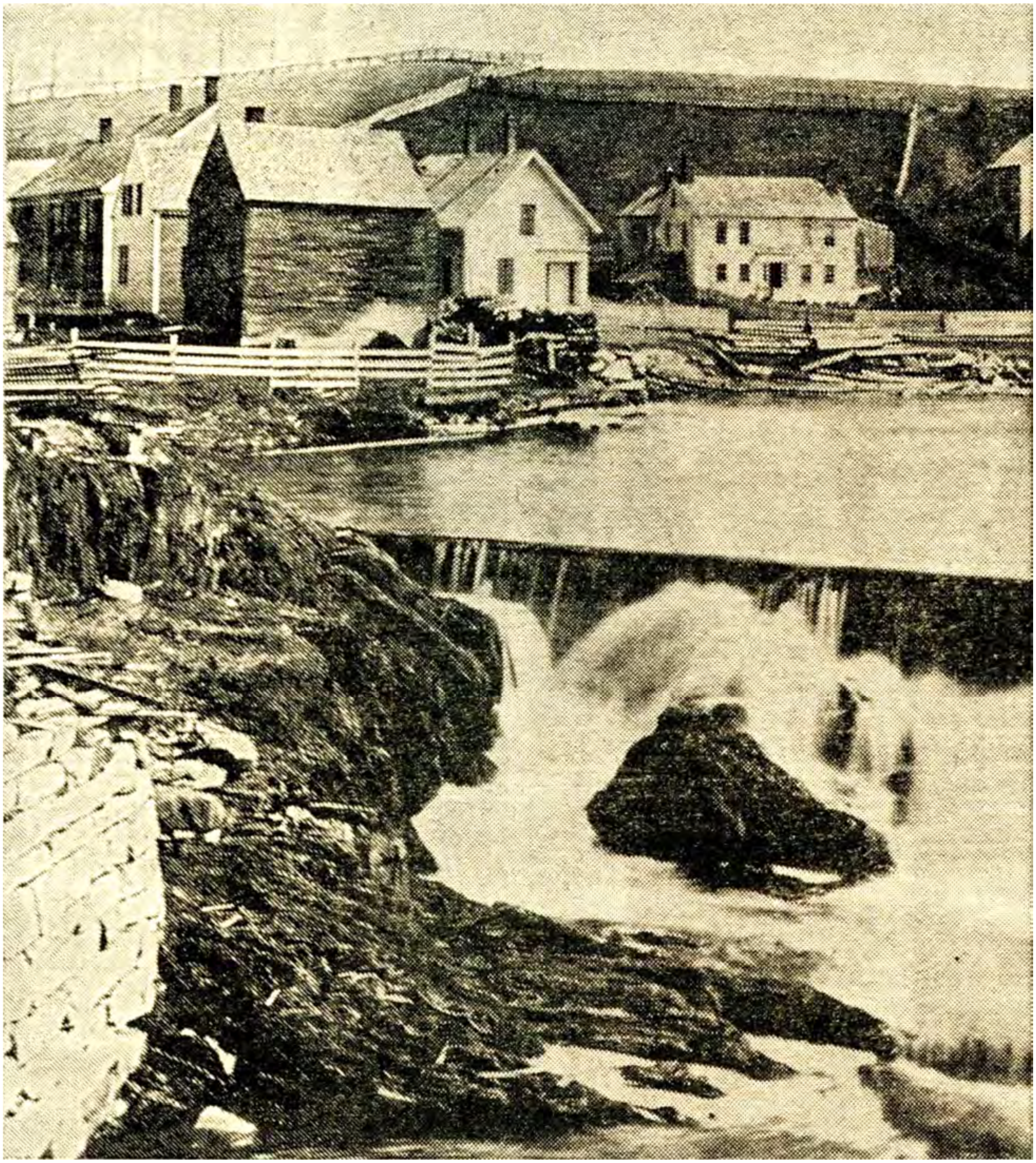

Figure 25. Circa-1860 photograph showing bedrock outcrop near south end of the original dam. Source: Dover-Foxcroft Historical Society.

4. Dam and Powerhouse Facilities

The Mayo Mill Dam (MEMA File #731; State ID #775, USACE ID #00157, FERC 05912), also known as the Moosehead Dam, is a low hazard concrete gravity structure with current hydraulic height of approximately 13 feet. The dam is a run-of-river dam, in that it passes the flow as it arrives from the upstream river. The dam does not provide flood storage or flood attenuation capabilities.

The concrete structure that bolstered the original early 1800s timber crib dam was constructed in 1919-20 by the American Woolens Company and was reconstructed in 1982 by Moosehead Manufacturing (Figure 12 to Figure 22). The hazard classification of low established by the Maine Emergency Management Agency (MEMA) Dam Safety Office in 2002 pertains to the estimated risk and vulnerability to human safety and associated resources downstream of the dam if it were to fail. The hazard rating does not specifically pertain to the present condition or stability of the dam.

4.1 DAM AND FISHWAY CONFIGURATION

The dam includes two spillway sections for a combined spillway length of 145 feet, a 12-foot-wide log sluice, and a 40-foot-wide central non-flood non-overflow section that includes the fishway hydraulic inlet head gate (Figure 26). The non-flood non-overflow section overtops during 2-year return period and larger floods, such as the recent May 1, 2023 peak flow event which had an approximate return period of 3 years.

The powerhouse that includes the turbine wheelhouse and generation equipment is located at the left (west) end of the spillway, between the dam and the mill buildings (Figure 26). A decommissioned historical penstock inlet is located at the far right (east) end of the spillway. Beyond the right end of the spillway is a concrete retaining wall that connects to the East Main Street bridge abutment.

Figure 26. September 2019 aerial photo during drawdown showing features of the dam. Source: Webber Surveying.

4.2 DAM CONDITION

For the purposes of the present report, the Maine Emergency Management Agency Dam Safety Office File for the dam (#731) was reviewed. Notes within the file extend back to the 1980s. Among the file contents, in 1992 the Town contacted the dam safety office to communicate plans to draw down the dam to perform maintenance on the dam spillway face and to inspect the toe of the dam for leakage beneath the dam spillway. The State dam safety engineer subsequently visited the site in 2002 and 2009 to perform inspections (MEMA Dam Safety 2023).

The 2009 inspection was completed in response to a request received from the director of the Piscataquis County Emergency Management Agency. The results of the inspection suggested that the dam was in a degrading condition, with incremental failing conditions in selected locations along the spillway. Spalling of the concrete on the spillway was attributed to the age of the concrete. Recommendations following the inspection included draining the head pond if possible. Failing that, the dam safety engineer recommended regular monitoring, and keeping people away from the downstream river bank for at least a mile (MEMA Dam Safety 2023).

Spalling on the dam spillway was further noted in 2015, in response to a citizen report of a perceived hole having developed on the dam face, and fear of eminent dam failure. The citizen report focused on what appeared to be a jet of water emerging from the downstream spillway face. The State dam safety engineer reviewed the report and concluded that the jet of water resulted from water over the spillway deflecting off a surficial cavity of degraded and spalled concrete. Flow over this cavity may give the appearance of a water jet through a hole, but was in fact a surficial defect attributable to the aging and degrading concrete condition. It was concluded that the defect did not pose an imminent threat to dam stability (MEMA Dam Safety 2023). This surficial flow pattern can still be observed today.

An inspection of the Mayo Mill Dam was conducted by FERC Dam Safety personnel on August 3, 2023. FERC identified a number of issues with the dam, which are listed below (verbatim):

- A section of the powerhouse roof collapsed. Include a plan and schedule to replace the roof.
- Significant concrete deterioration was noted at the upstream face and left wall of the sluicegate structure and upstream face of the fish passage structure. Additionally, concrete deterioration has progressed at the left and right log sluice walls, and seepage through the walls was evident. You must repair these structures.
- Repair of the masonry at the substructure of the powerhouse was previously requested by our October 12, 2018 letter. This area must still be repaired.
- The projects' Public Safety Plan (PSP) dated May 20, 1993, is over 30 years old. You must re-evaluate the project's public safety features and submit an updated PSP.
- A Dam Safety Surveillance Monitoring Plan (DSSMP) and a Dam Safety Surveillance Monitoring Report (DSSMR) have not yet been submitted for the project.

Following the FERC inspection, a detailed inspection of the dam and powerhouse structure, along with a stability analysis of the dam, were conducted by Gomez and Sullivan Engineers (Gomez and Sullivan) on August 29, 2023. The dam/powerhouse inspection and dam stability analysis report is included in this report as Appendix B. Gomez and Sullivan found many of the same issue documented by FERC, but included the following additional issues (verbatim):

Dam

- Seepage through the right abutment.
- Loss of approximately 10 feet of the concrete apron below the right side of the dam.
- Erosion of bedrock along the toe of the dam of up to 9 feet, but no significant undercutting.
- Loss of caulking/sealant in the joints between concrete monoliths.

- On the left abutment wall, which also serves as the powerhouse foundation wall, individual stones were missing.

Powerhouse Structure

- A section of the powerhouse roof collapsed.
- Roof slab and beams are spalling in several areas exposing corroded rebar.
- Steel I-beams supporting the generator floor have varying degrees of web and flange corrosion.
- Generator floor timber beam has marginal end support.
- Individual wood planks are missing from the turbine floor and some planks show signs of rot.
- Vertical guides (I-Beams) for the upstream bulkhead have significant corrosion of the web and flanges.
- Joints in the stone foundation wall show signs of deterioration and mortar loss.
- Joint seepage was observed through the left and right stone masonry foundation walls, at the upstream end of the powerhouse.

Figure 27. Aerial Image of Dam with Deficiencies Labeled (from Gomez and Sullivan, 2023).

The results of the dam stability analysis completed by Gomez and Sullivan show that the dam did not meet FERC dam safety criteria for some of the loading cases evaluated. The stability analysis evaluated the forces on the dam for four different loading cases; normal water level, winter water level with an ice load of 5,000 pounds per linear foot, a spillway design flood where water levels are above the spillway crest, and earthquake conditions. The calculated Sliding Safety Factor (SSF) did not meet FERC standards under the spillway design flood scenario. Additionally, the calculated location of resultant force in the base of the dam did not meet FERC standards in the winter pool plus ice case or the spillway design flood case.

Based on the results of their inspection and stability analysis, Gomez and Sullivan developed an Opinion of Probable Construction Costs for remedial measures required to address the identified deficiencies. The estimated cost to address the dam and powerhouse building deficiencies, including recommended rock anchors to address the dam stability, is $2,030,000 to $2,465,000.

4.3 POWER GENERATION

Hydroelectric power generation at the site has been authorized since the early 1980s by the Federal Energy Regulatory Commission (FERC). In late 1981, the Town of Dover-Foxcroft, which owns the dam and powerhouse, leased the hydroelectric facilities to Moosehead Manufacturing. Moosehead was issued an exemption by FERC in summer 1982 to operation the Moosehead Hydroelectric Project (Project) with authorized generation capacity of 300 kilowatts (kw).

To continue generation under the license exemption, Moosehead Manufacturing was required to comply with certain conditions placed on the exemption by Maine Department of Environmental Protection (MDEP), Atlantic Sea Run Salmon Commission (ASRSC – now Maine Department of Marine Resources), United States Environmental Protection Agency (USEPA), and United States Fish and Wildlife Service (USFWS).

The MDEP conditions included maintaining a minimum outflow of 20 cfs, or the actual inflow, whichever is less. This requirement was based on dilution of discharge from sewer pipes that may have been permitted to discharge to the river at that time. MDEP also required maintaining the water levels to not expose any pipes discharging waste into the river. Presently, there is one discharge location registered with MDEP in the impoundment area, but it was classified as inactive by MDEP as of 2020. ASRSC conditions included maintaining fish passage including a minimum flow of 40 cfs through the fishway, while USEPA conditions included maintaining a minimum flow of 20 cfs (the 7Q10[1]), or the actual inflow, whichever is less. Lastly, the USFWS conditions included operating the facility as run-of-river and maintaining a flow of 40 cfs, or the actual inflow, whichever is less, through the fishway during the migratory fish passage season.

Concurrent with the closure of the Moosehead factory in 2007, the hydropower facility had become inoperable, a condition which continues today. The town assumed operating responsibility and ownership of the hydroelectric facility in 2010 from the previous lease holder. In 2014, the town subsequently leased the Project to Mayo Mill, LLC who proposed to rehabilitate and re-energize the

[1] The lowest continuous seven-day period of flow over a 10 year period, on average.

facility, and improve the existing fish passage and protection facilities to meet requirements. Because the Piscataquis River in the study area was designated as critical habitat for the endangered Atlantic Salmon by this time (finalized in 2009), any work would be subject to the provisions of the Endangered Species Act. The State of Maine fishery agencies also completed a restoration plan for the Penobscot River for all native sea-run fish by then (finalized in 2008). A series of communications from FERC were received in the intervening years seeking resolution of the fate of the facility, and FERC conducted periodic safety inspections on a 5-year cycle, with the last available inspection report from 2018 rpior to that completed in August 2023.

In November 2020, the Town filed an Application for Non-Capacity Related Amendment that was developed by Natel Energy under contract to the Town (Town of Dover-Foxcroft 2020). The proposed facility included a single 300 kilowatt generating unit with an operating range of 100 to 300 cfs, under a design head of 14 feet and an estimated annual generation of 1,361 megawatt-hours/year. Comments on the amendment were filed by numerous groups, and the USFWS, National Marine Fisheries Service (NMFS), and Maine Department of Marine Resources (MDMR) all filed terms and conditions.

Subsequently, in November 2021, the Town indicated to FERC it may partner with a new developer for the project and that it may seek to modify its application. One year later, in November 2022, the Town notified FERC that it had partnered with the Atlantic Salmon Federation and The Nature Conservancy to develop a plan for revitalization of the site. Finally, in December, 2022, the Town officially withdraw its amendment application. In response, FERC requested a timeline for submittal of final disposition of the facility by December 31, 2023.

4.4 FISHWAY DESCRIPTION

The original pool and weir upstream fishway constructed in 1920 was replaced with a Denil fishway during the 1982 dam reconstruction (Figure 20 to Figure 22). The fishway is a standard 4-foot-wide Denil design with three sloping Denil segments that switchback twice between the fishway entrance in the tailwater and the fishway exit through the headgate into the head pond. The fishway slope is 6 feet horizontal to 1 foot vertical (6:1). Based on field reviews completed for this study in 2022-23, overall condition to the fishway is fair to poor, with degrading concrete condition, degraded and partially-repaired head gate, and leakage into the fishway through voids beneath concrete side walls (Figure 28).

The fishway does not meet current Denil fishway design standards (USFWS 2019). The turning pools do not meet current standards for resting pools, and entrance and exit channel lengths are shorter than current typical designs. In the current operational configuration, attraction to the fishway entrance appears poor to very poor, with false attraction signals represented by the two spillways and the log sluice. In particular, discharge from the left spillway and log sluice converge around the front of the fishway entrance, creating a hydraulic shadow in front of the entrance location during the upstream migration period. The current operation does not include the powerhouse outflow present at the time of fishway design and installation, which would substantially alter the flow patterns in the vicinity of the fishway entrance (Figure 29).

During the upstream fish passage season for Atlantic salmon, the fishway is estimated to convey less than 1 percent to 3 percent of the total flow during the upstream fish passage season, depending on flow magnitude. This compares to the current design standard of five percent to ten percent of total station capacity when in active operation (USFWS 2019). Under current design guidelines, American shad are thought to be discouraged from ascending 180-degree switchback designs such as found at the site. In addition, 6:1 Denil designs are considered viable for salmonids only. For shad or river herring, the guidelines recommend at a minimum the more moderately sloping 8:1 design, and preferably the 10:1 design due the nature of their swimming abilities (USFWS 2019). Lastly, Denil fishways are estimated to provide poor passage conditions for American eel and sea lamprey who are also among the target native sea-run fish species population. Estimated fishway effectiveness is further discussed in Section 9 of the report.

Figure 28. May 2023 photo showing condition of spillways and fishway prior to being opened for the year, including leakage at the base of the log sluice into the fishway.

Figure 29. June 2022 aerial photo showing flow patterns over spillways and log sluice, in relation to fishway entrance.

6. River Channel and Impoundment

The Mayo Mill Dam spans the Piscataquis River in downtown Dover-Foxcroft 150 feet upstream of the East Maine Street (Route 15) bridge, and 3,300 feet upstream of the Brown's Mill Dam. The impounded reach (impoundment) behind the dam extends 1.7 miles upstream to the former Waterworks Dam (Figure 30 to Figure 32). The river channel falls 17 feet from the riffle just downstream of the Waterworks Dam (head of the impoundment) to a location just downstream of the East Main Street bridge (Figure 30), for an overall average channel gradient of 0.0019 feet/feet (0.19 %). The entire river reach surrounding the study area is designated critical habitat for ESA-listed Atlantic salmon, discussed in more detail in Sections 9 and 11 of the report.

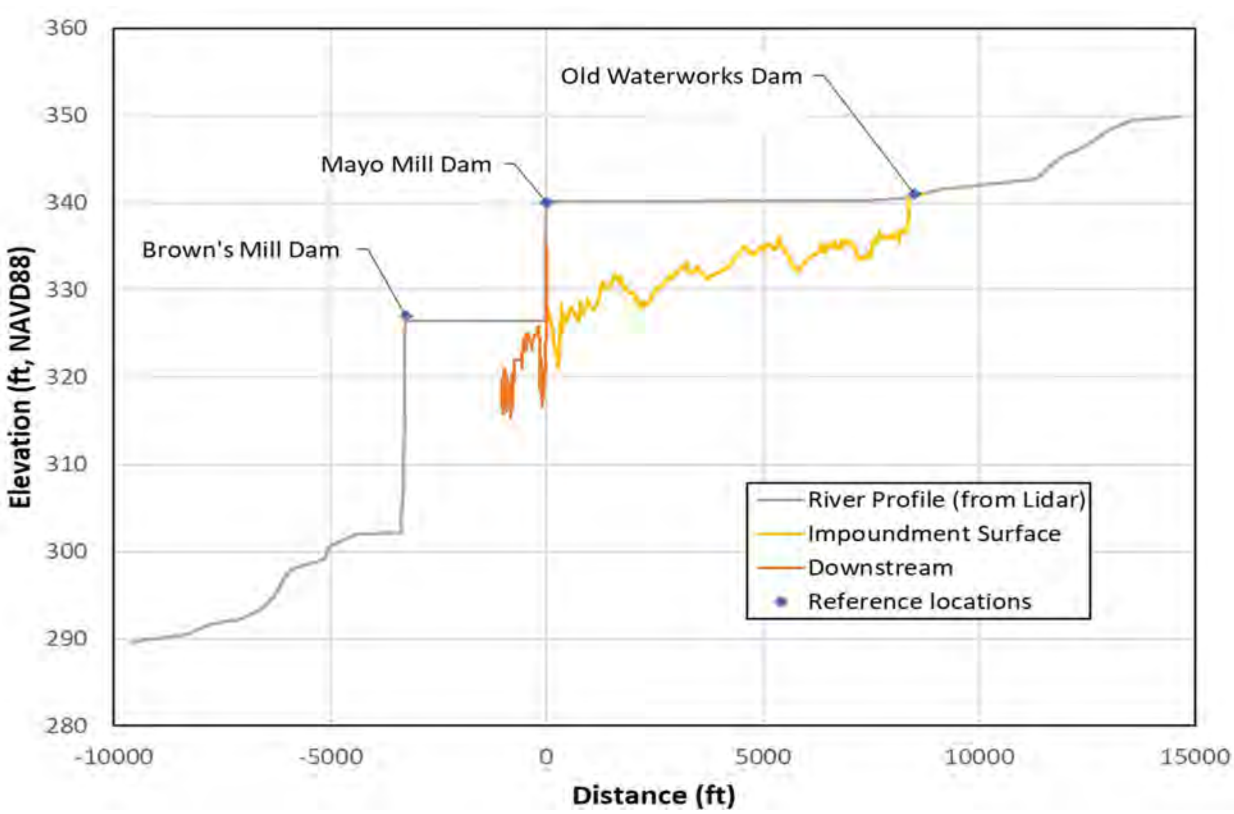

Figure 30. Lidar elevation profile of the Piscataquis River through the project area, with bathymetry surface shown where surveyed. Selected points and their elevations are noted.

Figure 31. June 2022 view looking upstream at Mayo Mill Dam and impoundment.

Figure 32. June 2022 view looking downstream at Waterworks Dam location and the upper Mayo Mill Dam impoundment.

6.1 RIVER CHANNEL CONDITIONS

With the exception of a short segment of free-flowing river channel that stretches 200 feet downstream of the East Main Street bridge (Figure 33), the entire 2.25-mile reach of the river from Brown's Mill Dam to the former Waterworks dam is impounded by Brown's Mill and Mayo Mill dams. Beyond those points, the free-flowing river reaches upstream of the Waterworks Dam or downstream of Brown's Mill Dam provide reasonable examples of how the impounded reach may appear in a free-flowing condition (Figure 34). The Piscataquis is not a meandering river; instead, it is moderately-laterally confined by legacy river terraces resulting from channel incision that occurred in conjunction with the post-glacial landscape rebound described in Section 3.

The channel conditions in the upstream reach are fairly consistent over the 8-mile distance to Guilford, and also in the downstream reach flowing towards Howland. The channel is a cobble- and boulder-based plane bed channel, with intermittent pools localized around features that create local scour, such as large boulders left behind as the glaciers retreated, and bedrock outcrops.

While the upstream river channel exhibits naturalized, recovering conditions, it is also substantially altered from its native, historical condition that existed prior to European settlement of the area. Large wood habitat in the form of logs and rootwads that fall into the river would historically have also been very pervasive morphologic and habitat features in the Piscataquis River. Large wood features would have provided shelter for fish and other animals and created pools and bars through local scouring, but are nearly completely absent today.

The lack of large wood and similar diverse, complex instream habitats and overall channel simplification are attributable to an array of impacts described below. In addition, the historically-impacted riparian corridor which supported these river processes presently lacks the mature forests that once existed, but is recovering. Primary impacts occurred as a result of deforestation and extensive timber harvest across the watershed, manipulation to support communities and industry, such as dam and road construction, and localized channelization and dredging, and in particular as a result of log drives to support historical forestry practices (Figure 35).

The extensive use of the Piscataquis for log driving caused a lasting, profound simplification of the river channel and the habitat within, a pattern common throughout Maine's forested landscape. In addition to removing the large wood habitat from the river channel, log drives had a profound impact on eroding gravels and fine sediment that would have historically been present in greater quantities along with the coarse cobble and boulders.

At Dover-Foxcroft, the logs delivered down the river were stored in the impoundment area and fed from the headpond through the Gilman sawmill located north of East Main Street (Geller 2020). The logs were fed beneath East Maine Street under a second bridge located to the east of the current bridge which is shown on the historical fire insurance maps (Figure 10).

Despite the historical impacts to the river, conditions are restoring along the Piscataquis River. This is the result of significant efforts to reduce fragmentation in the watershed due to road crossings and unused dams, and significant strides to recover its pristine water quality. Through the era of industrialization, water quality degraded substantially due to uncontrolled effluent and waste releases to the river. However, the federal Clean Water Act addressed point source pollution, and potential water quality impacts are controlled more effectively through regulation. In addition, enhanced environmental protections, improved forestry practices, and recovering forest cover all have contributed to the health of the watershed and the river. The river reach that includes Dover-Foxcroft was upgraded from a Class C Water to a Class B Water in 1999 by Maine DEP (Town of Dover-Foxcroft 2020).

Figure 33. June 2022 view looking downstream at short segment of free-flowing river downstream of Mayo Mill Dam before flowing into Brown's Mill Dam impoundment.

Figure 34. June 2022 view looking upstream from Waterworks Dam at free-flowing river through former Waterworks Dam impoundment and river channel towards Guilford.

Figure 35. Late 1800s to early 1900s view looking downstream towards Foxcroft Academy from the former railroad bridge (now the Four Seasons Adventure Trail). Academy Island is seen in the center of the frame. The impoundment is full of logs being stored for processing at the Dover saw mill. Source: Dover-Foxcroft Historical Society.

Figure 36. April 2023 view looking downstream towards Foxcroft Academy from the former railroad bridge (now the Four Seasons Adventure Trail). Academy Island is seen in the center of the frame.

6.2 MAYO MILL IMPOUNDMENT CONDITIONS

The Mayo Mill Dam impoundment reach extends from the dam to the riffle immediately downstream of the Waterworks Dam site (Figure 31 and Figure 32). In contrast to the upstream and downstream free-flowing river reaches, the impounded reach is wider with slower currents and characteristics similar to a pond or flowage. In general, the impoundment supports a range of flatwater-focused activities such as paddling and fishing. In the late summer months, the impoundment likely causes water temperatures to rise and dissolved oxygen levels to fall, and supports primarily a warmwater resident fish population. The impoundment was assessed during the November 2022 field investigation and through subsequent analyses, summarized in the following paragraphs (See also Appendix A – Project Basemap).

The impoundment can be characterized in four primary zones, according to varying attributes along its length (Figure 37). The first zone (Zone 1) is the headpond area immediately upstream of the dam, extending to the first major bend in the river at the southeast corner of The Mill, and the typical general vicinity of the safety buoy. Zone 1 is bracketed by The Mill on the west side, and the South Street commercial properties on the opposite bank (Figure 38). This area was historically utilized for log storage and other functions (Figure 39 and Figure 40), in addition to controlling the river for power generation.

Zone 2 includes the area from the safety buoy location to a point just west of the gazebo and basketball court at the Riverfront Park, and represents the widest area of the impoundment. This zone also includes the historical Cove area, the Piscataquis County Chamber of Commerce building, and the MDIFW boat ramp (Figure 41). Water velocities are slowest in this zone, which also provides the primary access to the river for the public.

Zone 3 extends from the west end of the Riverfront Park to the upstream end of Academy Island. This moderately-wide zone includes several residences on the north bank in the downstream half, transitioning to a vegetated riparian zone in the upstream half, as well as along the south bank. Along this zone, there are selected areas of floodplain and wetland alcoves along the south bank (Figure 42). Water velocities are modestly higher than the downstream reach.

Upstream of Academy Island, the impoundment narrows substantially through Zone 4. The impoundment conditions take on a notably distinct character through this zone, with steepening, bluff-like banks, greater water depths, and exposed bedrock outcrops in selected areas leading to the Four Seasons Adventure Trail bridge and the Waterworks dam site. This zone likely had a canyon- or gorge-like character prior to impoundment (Figure 43). In this zone, water velocities are greatest of all of the zones, in particular during the higher flow spring months.

Based on the bathymetric survey performed in November of 2022, a composite bathymetric and topographic terrain map was developed for the impoundment, for use in project evaluations. Several improvements and infrastructure features are located along the impoundment, which are catalogued in Section 7. In terms of state- and federally-listed fish and wildlife habitat, the impoundment falls within the designated critical habitat for Atlantic salmon, and is a focus area in the strategic plan for restoration of diadromous fishes to the Penobscot River (MDMR and MDIFW

2008; discussed in Sections 9 and 11). There are no State of Maine-designated wading bird or waterfowl, wetland, or rare plant habitats within the impoundment area.

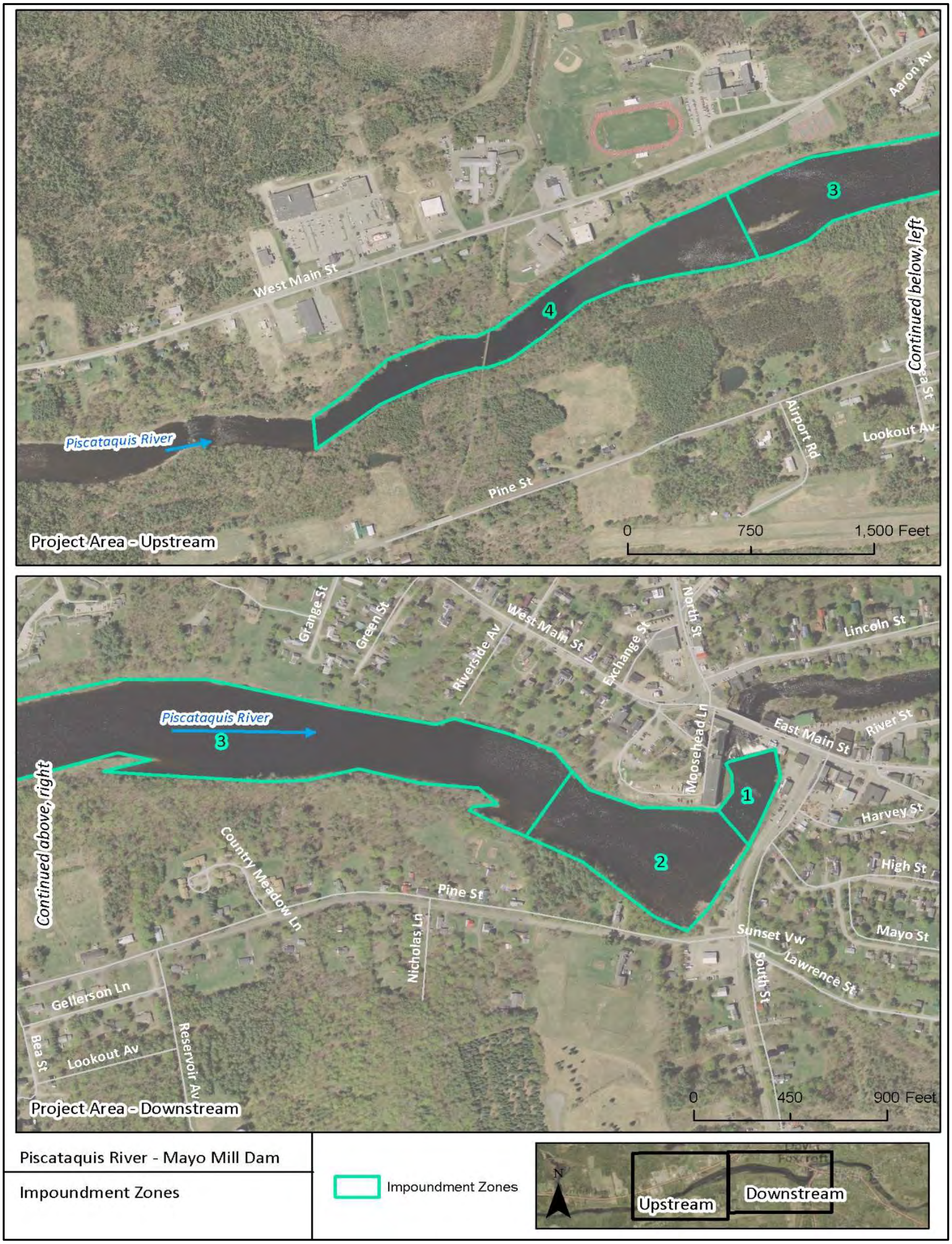

Figure 37. Mayo Mill impoundment zones.

Figure 38. June 2022 view looking upstream at impoundment Zone 1.

Figure 39. Late 1800s image showing saw logs ponded in the head pond area. Source: Dover-Foxcroft Historical Society.

Figure 40. 1910-era image showing ice harvest in the head pond area. Source: Dover-Foxcroft Historical Society.

Figure 41. June 2022 view looking upstream at impoundment Zone 2.

Figure 42. June 2022 view looking upstream at impoundment Zone 3.

Figure 43. June 2022 view looking upstream at impoundment Zone 4.

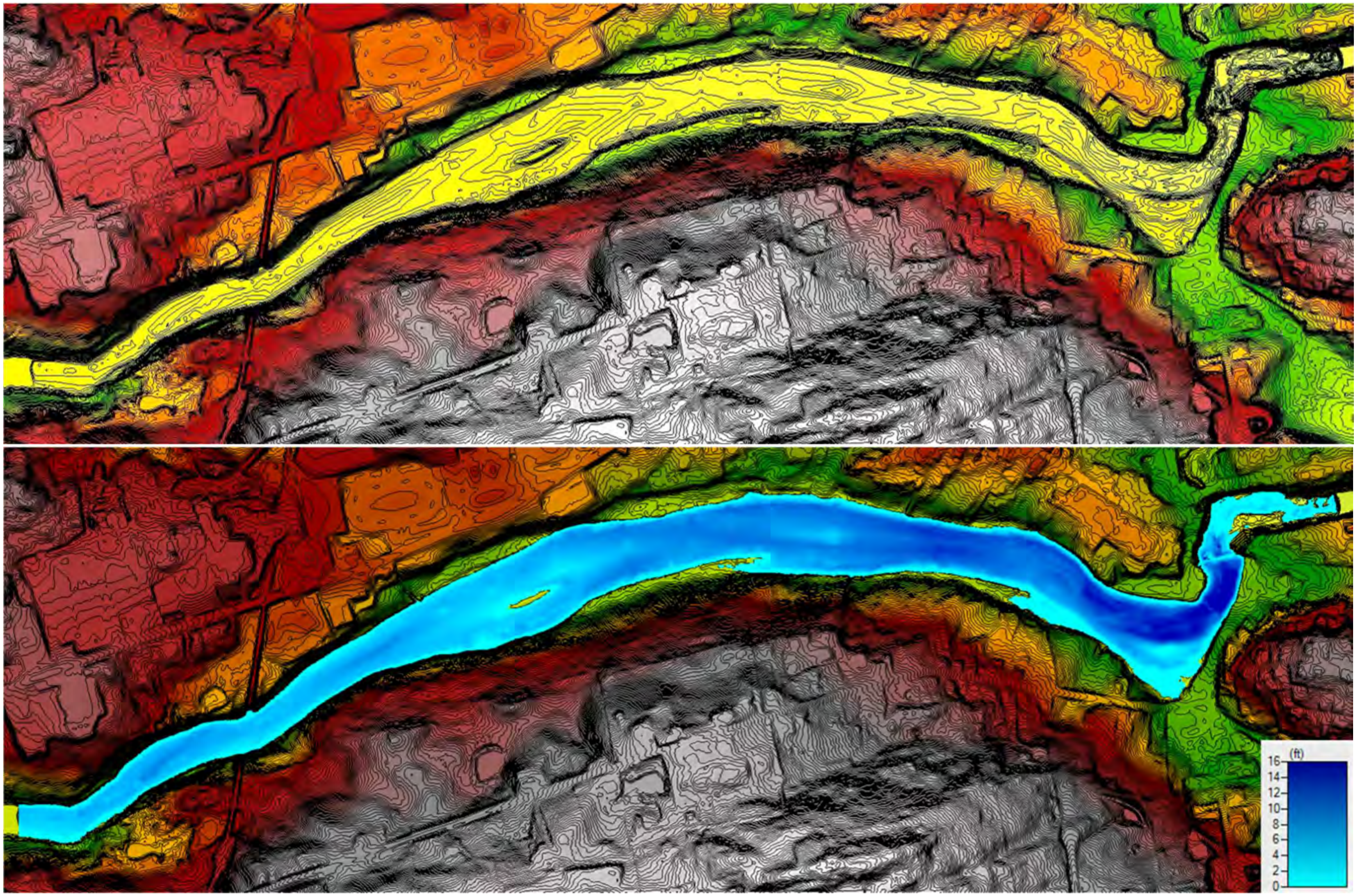

Figure 44. Bathymetric and topographic terrain map (top) along with water depth (bottom) at time of survey in November 2022.

6.2.1 Impounded Sediment

Dams create backwater environments, known as impoundments, that are wider, deeper, and lower gradient than the river is upstream of the impoundment or downstream of the dam. Flow velocity is reduced, which reduces the sediment transport capacity of the river. As a result, a portion of sediment that is transported into an impoundment is deposited and trapped, resulting in sediment accumulation over time. Management of impounded sediment is an important consideration when contemplating dam management activities, in which the quantity and composition of impounded sediment are key factors.

Generally, downstream transport of sediment is a natural process, that is important for sustaining rivers and floodplains, estuaries, and coastal areas. In some instances, passive release of accumulated sediment associated with dam modification or removal may be planned when the net benefit to the downstream river facilitates restoration while avoiding risks. In other instances, a passive release of sediment can impact sensitive aquatic habitat or accumulate in downstream depositional areas where it would be viewed problematically. Additionally, sediment impounded behind a dam can potentially bear the legacy of contamination from past or present upstream land or industrial uses, including urban runoff.

The November 2022 site investigation included a depth-of-refusal (DOR) survey in the impoundment, excluding the area between the location of the safety buoy and the dam due to navigation safety concerns at the time. Additional DOR survey was completed in August 2023, including survey of the area between the safety buoy and the dam. The DOR survey entailed surveying the surface of the impounded sediment and probing through this layer and surveying the ledge or coarse sediment that made up the pre-dam ground or riverbed surface (Figure 45). These survey points are used to estimate the volume of sediment trapped behind the dam and also provide clues to what the site may look like if the dam were not in place.

Based on the industrial legacy of the river and the urban setting, samples of the accumulated sediment behind the dam were also collected to screen for the presence of potential pollutants.

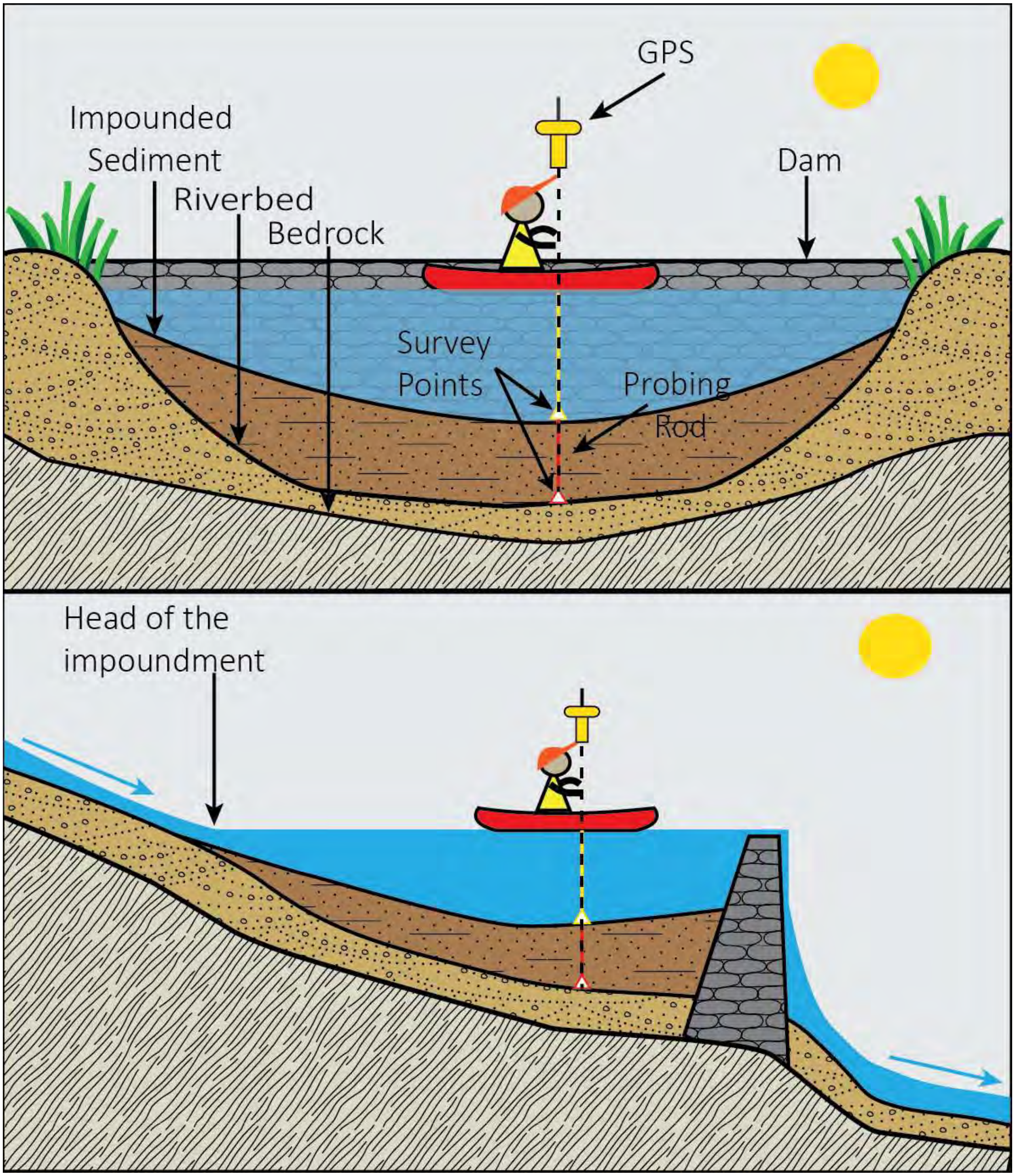

Figure 45. Schematic depiction of an impounded sediment survey. The upper frame shows the impoundment in cross section and the lower frame shows the impoundment in profile. This process of collecting a pair of points- one at the top of the impounded sediment and one at the pre-dam riverbed- is carried out throughout the impoundment.

6.2.1.1 Sediment Quantity

Based on the DOR survey, the estimated volume of accumulated sediment within the present impoundment is approximately 57,000 to 74,000 cubic yards. The range in the estimate reflects the uncertainty in the standard methods utilized to collect the measurements and generate the estimate. As such, the lower end of the represented range is based on calculated volumes over the zones indicated using the average thicknesses indicated, rounded up to the nearest 1,000. The upper end of the range represents an approximate 30% increase in volume to conservatively account for uncertainty. Overall, only a portion of the accumulated sediment would be expected to erode passively under varying dam modification scenarios. The sediment that would remain would be expected to revegetate to a natural condition within one to two growing seasons. Overall, measured sediment thickness ranged from zero feet to six feet, with an average thickness of 0.8 feet across all of the measurements taken.

The distributions of accumulated sediment can be broadly characterized within four distinct zones, shown in Figure 46. Zone 1 is the area between the dam and the safety buoy location which was measured in August 2023. There is limited sediment accumulation in this zone, with most notable deposits along the river left margin area of the impoundment. The bed of the impoundment in this area is rocky, with some sediment accumulation and drowned woody debris (Figure 47). Zone 2 represents the widest area of the impoundment. A similar pattern was observed in this area, but with notable sedimentation in the Cove area by the MDIFW boat ramp. In contrast to the upstream zones, accumulated sediment was found more consistently in the center of the impoundment in this zone. However, the sediment was not continuous across the impoundment bottom. This is likely due to the more substantial velocities through the center of the impoundment during high flow events, as compared to the shoreline areas.

Further upstream, in Zone 3 sediment was found with increasing scarcity in the upstream direction, inconsistently distributed across the impoundment bottom, with more consistent deposits along the impoundment margins. Zone 4 represents the narrowest zone, with negligible accumulated sediment was found in this zone. **Error! Reference source not found.** summarizes the estimated sediment volumes across the four zones.

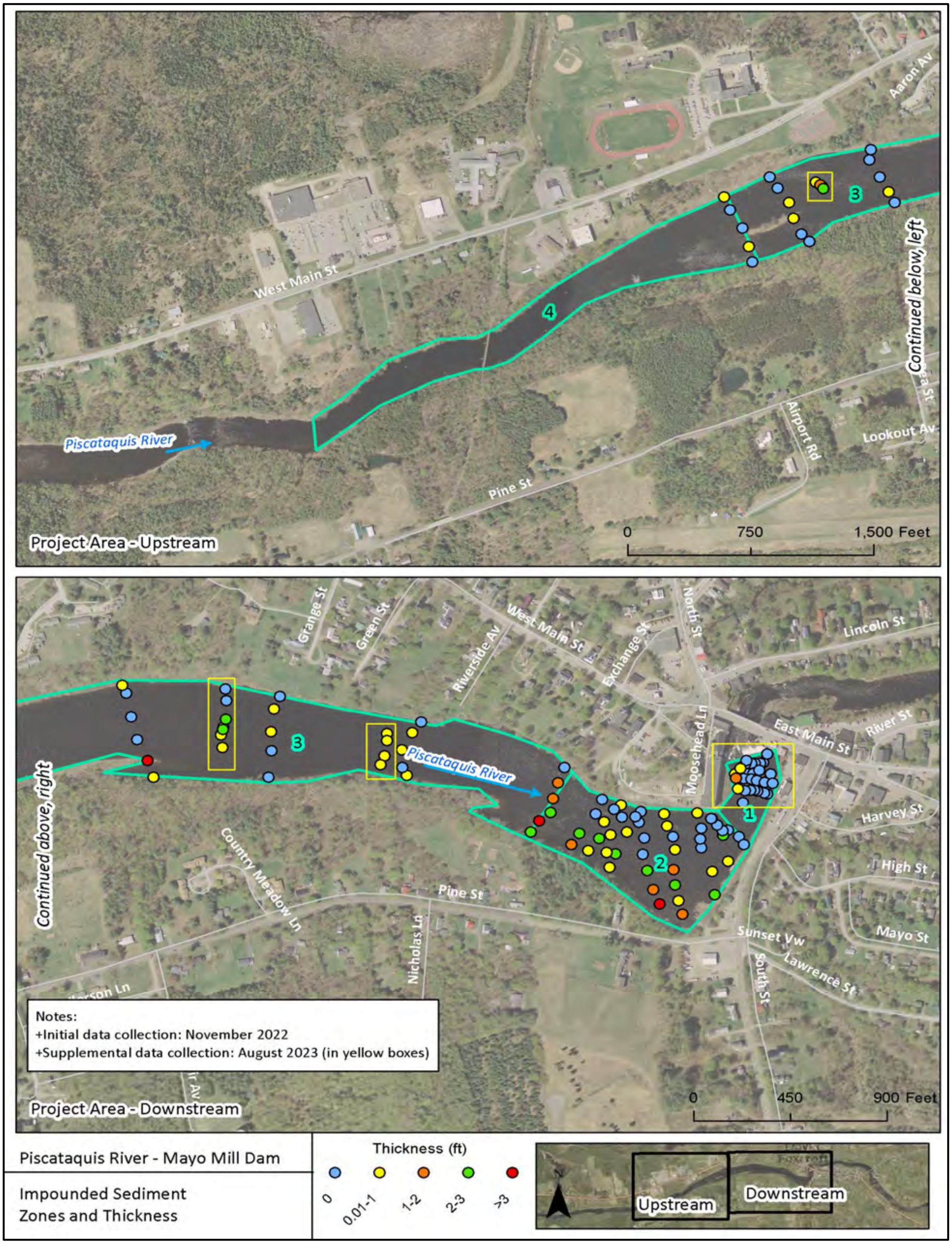

Figure 46. Sediment zones in the impoundment, with accumulated sediment thickness measurements indicated.

Figure 47. September 2019 aerial photo during drawdown showing sediment conditions in Zone 1. Source: Webber Surveying.

Table 1. Details of impoundment zones and distribution of estimated accumulated sediment. Lower end of represented range based on calculated volumes over the zones using the average thicknesses indicated, rounded up to nearest 1,000. Upper end of range represents approximate 30% increase in volume to conservatively account for uncertainty.

Zone	Proportion of Impoundment Area (%)	Sediment Volume Estimate (CY)	Proportion of Accumulated Sediment (%)	Average Measured Sediment Thickness (ft)
1	3	0 – 1,000	0.6	0.1
2	15	18,000 – 23,000	31.3	1.2
3	54	39,000 – 50,000	68.1	0.7
4	28	----	<1	0
Total		57,000 – 74,000		

6.2.1.2 Sediment Quality

Sediment samples were collected from the impoundment (4 samples), as well as background samples from the adjacent free-flowing reaches of the river upstream of the impoundment and downstream of the dam (Figure 48). In addition, a pooled sample from the impoundment was tested for the presence of pesticides and herbicides. The purpose of the sediment sampling and testing is to provide an initial screening of accumulated sediment quality. Additional sampling and screening may be required in future project phases.

Samples were analyzed by Absolute Resource Associates, a testing laboratory in Portsmouth, NH. Results of the testing were screened against 1) ecological criteria that are typically used to evaluate accumulated sediment in impoundments in New England, and 2) State of Maine human exposure criteria more typically used in construction or development settings.

The ecological criteria are defined by the consensus-based sediment quality guidelines developed by NOAA (MacDonald et al. 2000), which set thresholds for concentrations of pollutants that might result in possible effects (FTEC) and probable effects (FPEC) to organisms living in freshwater ecosystems. The human exposure criteria are part of the Maine DEP's remedial action guidelines (ME-DEP-RAGs) for various levels of human exposure, in this case construction worker and park user (Maine DEP 2018a). These criteria are typically used to inform the determination of whether sediment is clean enough to allow it to pass downstream, to reuse the sediment on a project site, or whether it is advisable to remove the sediment from the project location and prevent further exposure.

Selected samples results exceeded the ecological criteria threshold and probable effects screening levels, predominantly for metals and semi-volatile organic compounds (SVOCs). When the analyzed samples are compared to human health screening criteria from the ME-DEP-RAGs for construction workers and park users, there were no exceedances. Summaries of detections and screening results are shown in Table 2 and Table 3. Note that a much more extensive list of analytes was screened, but only those analytes which had at least one detection are included in the summary tables. The full list of analytes screening and testing results (all of the non-detections) are available upon request.

In general, the highest concentrations of analytes were found in the sample collected adjacent to the Riverside Park (Mayo-1). Overall, the comparison samples taken from upstream and downstream of the impoundment are reasonably similar to the samples taken from the impoundment. However, in selected instances results for the samples in the impoundment are one- to two-times higher than the background samples, in particular for the sample near Riverside Park (Mayo-1) sample. In these instances, selected sample concentrations are still below the ecological criteria in some cases, whereas in other selected cases the increased concentrations cause the sample to exceed the next higher screening criteria.

The metals detected are consistent with those found in other impoundments regionally. Arsenic is naturally occurring throughout New England, and has historically been used as an insecticide and wood preservative. The remaining metals are common pollutants related to a range of industrial applications, including leather tanning, metal plating, and wood treatment. The SVOCs detected are associated with the incomplete combustion of organic material. They can be released into the environment through various anthropogenic activities, including industrial processes, vehicle emissions, and other combustion of organic materials and fossil fuels.

While there are a range of compounds and constituents found in the accumulated sediment, the sediment quality is not unlike that found in many impoundments along rivers throughout New England. Sediment management will be a project component requiring coordination and project resources, yet successful sediment management is achievable while limiting impacts to local residents, river users, and fish and wildlife. There is an extensive track record of sediment management at many similar sites across the region that have resulted in highly successful river restoration.

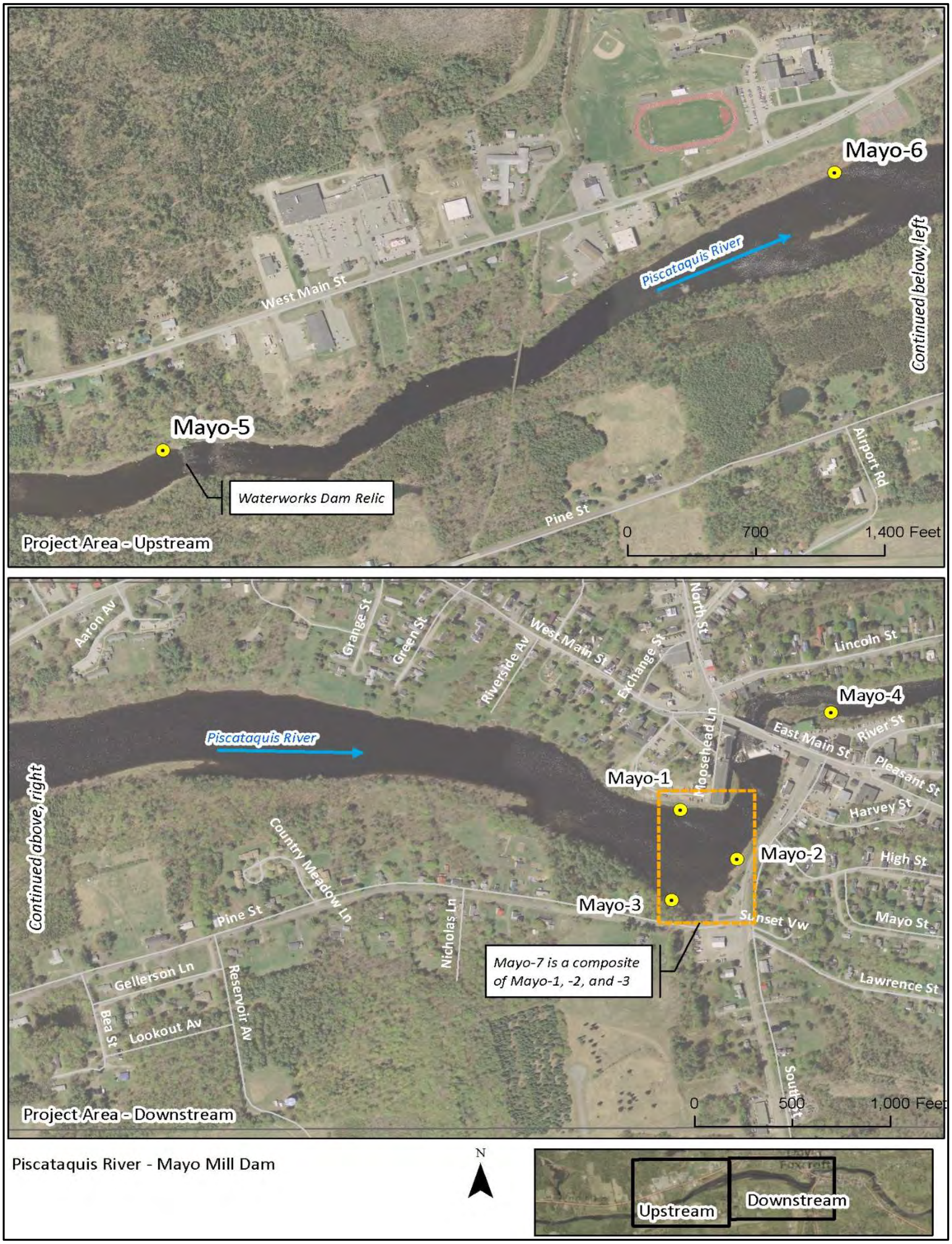

Figure 48. Overview of sediment sample locations. Mayo-4 is a background sample from the free-flowing reach downstream of the dam. Mayo-5 is a background sample from the free-flowing reach upstream of the impoundment.

Table 2. Summary of sediment compound detections and screening level exceedances – NOAA Freshwater Probable Effects Concentrations (FPEC) and Freshwater Threshold Effects Concentrations (FTEC). Results exceeding criteria are color-coded to the exceeded criteria. Mayo-7 is a pooled sample of Mayo-1,2,3 to test for presence of herbicides and pesticides in the impoundment. Note that only those analytes which had at least one detection are included in the summary table, compared to a much more extensive list of analytes that were screened.

				Downstream	Impoundment					Upstream
			LOCATION	MAYO-4	MAYO-1	MAYO-2	MAYO-3	MAYO-6	MAYO-7	MAYO-5
			SAMPLING DATE	11/21/22	11/21/22	11/21/22	11/21/22	11/21/22	11/21/22	11/21/22
	NOAA FPEC	NOAA FTEC	Units							
Total Metals										
Arsenic	33	9.79	ug/g	**7.5**	**7.7**	**8**	**17**	**7.4**	--	**7.1**
Chromium	111	43.4	ug/g	**17**	**47**	**22**	**27**	**26**	--	**19**
Copper	149	31.6	ug/g	**11**	**18**	**14**	**13**	**11**	--	**8.2**
Lead	128	35.8	ug/g	**13**	**38**	**17**	**10**	**18**	--	**10**
Nickel	48.6	22.7	ug/g	**20**	**22**	**17**	**35**	**18**	--	**18**
Zinc	459	121	ug/g	**51**	**81**	**64**	**41**	**57**	--	**49**
Polychlorinated Biphenyls				No Detections						
Semivolatile Organics										
anthracene	0.845	0.0572	ug/g	ND*	**0.38**	ND*	ND*	ND*	--	ND*
benzo(a)anthracene	1.05	0.108	ug/g	**0.14**	**1.1**	**0.17**	ND	**0.16**	--	**0.11**
benzo(a)pyrene	1.45	0.15	ug/g	**0.17**	**0.93**	**0.2**	ND	**0.17**	--	**0.12**
benzo(b)fluoranthene	--	--	ug/g	**0.13**	**0.71**	**0.13**	ND	**0.13**	--	**0.089**
benzo(g,h,i)perylene	--	--	ug/g	**0.15**	**0.67**	**0.14**	ND	**0.13**	--	**0.087**
benzo(k)fluoranthene	--	--	ug/g	**0.095**	**0.83**	**0.15**	ND	**0.14**	--	**0.094**
chrysene	1.29	0.166	ug/g	**0.16**	**1.0**	**0.18**	ND	**0.2**	--	**0.12**
dibenzo(a,h)anthracene	--	0.033	ug/g	ND*	**0.23**	ND*	ND*	ND*	--	ND*
fluoranthene	2.23	0.423	ug/g	**0.2**	**2.1**	**0.33**	ND	**0.32**	--	**0.16**
indeno(1,2,3-cd)pyrene	--	--	ug/g	**0.13**	**0.59**	**0.12**	ND	**0.11**	--	< 0.077
phenanthrene	1.17	0.204	ug/g	**0.12**	**1.9**	**0.12**	ND	**0.22**	--	**0.078**
pyrene	1.52	0.195	ug/g	**0.27**	**2.4**	**0.37**	ND	**0.42**	--	**0.22**
Volatile Organics				No Detections						
Pesticides				No Detections						
Herbicides				No Detections						
Total Organic Carbon			ug/g	**30,000**	**37,000**	**8,500**	**14,000**	**14,000**	--	**37,000**

ND : Analyte was not detected in sample above the reporting limit.
ND* : Analyte was not detected in sample above the reporting limit, but the reporting limit was higher than the FTEC screening level
NOAA-FPEC: NOAA Freshwater Sediment Probable Effect Concentration (PEC) SQuiRTs Criteria per 2008 Screening Quick Reference Tables.
NOAA-FTEC: NOAA Freshwater Sediment Threshold Effect Concentration (TEC) SQuiRTs Criteria per 2008 Screening Quick Reference Tables.

Table 3. Summary of sediment compound detections and screening level exceedances – Maine DEP Remedial Action Guidelines (RAGS) Excavation Worker and Park User Thresholds. Results exceeding criteria are color-coded to the exceeded criteria. Mayo-7 is a pooled sample of Mayo-1,2,3 to test for presence of herbicides and pesticides in the impoundment. Note that only those analytes which had at least one detection are included in the summary table, compared to a much more extensive list of analytes that were screened.

				Downstream	Impoundment					Upstream
	LOCATION			MAYO-4	MAYO-1	MAYO-2	MAYO-3	MAYO-6	MAYO-7	MAYO-5
	SAMPLING DATE			11/21/22	11/21/22	11/21/22	11/21/22	11/21/22	11/21/22	11/21/22
	Excavation Worker	Park User	Units							
Total Metals										
Arsenic	54	26	ug/g	**7.5**	**7.7**	**8**	**17**	**7.4**	--	**7.1**
Chromium	--	--	ug/g	**17**	**47**	**22**	**27**	**26**	--	**19**
Copper	3,400	12,000	ug/g	**11**	**18**	**14**	**13**	**11**	--	**8.2**
Lead	450	290	ug/g	**13**	**38**	**17**	**10**	**18**	--	**10**
Nickel	990	6,100	ug/g	**20**	**22**	**17**	**35**	**18**	--	**18**
Zinc	100,000	91,000	ug/g	**51**	**81**	**64**	**41**	**57**	--	**49**
Polychlorinated Biphenyls				No Detections						
Semivolatile Organics										
anthracene	100,000	70,000	ug/g	ND	**0.38**	ND	ND	ND	--	ND
benzo(a)anthracene	1,700	45	ug/g	**0.14**	**1.1**	**0.17**	ND	**0.16**	--	**0.11**
benzo(a)pyrene	10	5	ug/g	**0.17**	**0.93**	**0.2**	ND	**0.17**	--	**0.12**
benzo(b)fluoranthene	1,700	45	ug/g	**0.13**	**0.71**	**0.13**	ND	**0.13**	--	**0.089**
benzo(g,h,i)perylene	72,000	7,000	ug/g	**0.15**	**0.67**	**0.14**	ND	**0.13**	--	**0.087**
benzo(k)fluoranthene	17,000	450	ug/g	**0.095**	**0.83**	**0.15**	ND	**0.14**	--	**0.094**
chrysene	100,000	4,500	ug/g	**0.16**	**1.0**	**0.18**	ND	**0.2**	--	**0.12**
dibenzo(a,h)anthracene	170	5	ug/g	ND	**0.23**	ND	ND	ND	--	ND
fluoranthene	24,000	9,300	ug/g	**0.2**	**2.1**	**0.33**	ND	**0.32**	--	**0.16**
indeno(1,2,3-cd)pyrene	1,700	45	ug/g	**0.13**	**0.59**	**0.12**	ND	**0.11**	--	ND
phenanthrene	72,000	7,000	ug/g	**0.12**	**1.9**	**0.12**	ND	**0.22**	--	**0.078**
pyrene	72,000	7,000	ug/g	**0.27**	**2.4**	**0.37**	ND	**0.42**	--	**0.22**
Volatile Organics				No Detections						
Pesticides				No Detections						
Herbicides				No Detections						
Total Organic Carbon			ug/g	**30,000**	**37,000**	**8,500**	**14,000**	**14,000**	--	**37,000**

ND : Analyte was not detected in sample above the reporting limit.
ME-RAGS-ME: Maine Excavation/Construction Worker Remedial Action Guidelines (RAGs) Criteria per Maine DEP RAGs dated October 19, 2018.
ME-RAGS-MP: Maine Park User Remedial Action Guidelines (RAGs) Criteria per Maine DEP RAGs dated October 19, 2018.

7. Adjacent Features and Infrastructure

Desktop research, field visits conducted by the project team, and inquiries with project stakeholders have identified several infrastructure features in the vicinity of Mayo Mill Dam and the associated impoundment. Figure 49 illustrates the locations of these features. Table 9 summarizes the features identified at this stage of the project and indicates evaluation notes and status. Proposed project alternatives may have direct and indirect impacts to these features. These potential impacts will be evaluated for each identified alternative during the feasibility evaluation phase.

Of particular note, the East Main Street bridge (MDOT # 2293) was constructed in 1912, and rebuilt and widened in 1988. This followed some damage that was incurred in the 1987 flood, in particular to the retaining wall to the east of the bridge. The most recent MEDOT inspection (09/2022) reported fair condition, with many locations with minor to moderate concrete spalling, areas of exposed rebar, cracks and deep spalls at construction joints (MEDOT 2022). The bridge is founded on exposed ledge. The bridge is in the MEDOT 2023-25 work plan for preliminary design study for replacement. There have been recent anecdotal reports of a concrete panel detachment on the underside of the bridge.

Additionally, a combined sewer overflow pipe outfall (MDEP ME0100501, ID 018-153) is located in the river bed off the end of Green Street, approximately 2,100 feet upstream of the dam. According to the 2020 MDEP online database, this outfall is listed as inactive. There is also a dry hydrant located at Riverside Park, approximately 800 feet upstream of the dam. This hydrant was installed in 2019 as a replacement for the historical dry hydrant that was dedicated to the former mill. The hydrant is now used primarily for training, as the redeveloped mill is connected to the municipal water system, with a sprinkler system for fire suppression.

Lastly, of note is FAA-registered Riverside Sea Plane Base (FAA ME85). The private sea plane base coordinates are located in the impoundment area, approximately 1,500 upstream of the dam. The registered water runway dimensions are 3600 feet by 300 ft. The seaplane base is discussed in more detail in Section 1.

Figure 49. Locations of adjacent features and low-lying infrastructure.

Table 4. Identified Features and Infrastructure near Mayo Mill Dam and Impoundment.

Feature	Location	Summary
East Main Street Bridge MEDOT # 2293	Crosses river approximately 150 feet downstream of dam	Constructed 1912, rebuilt/widened in 1988. Most recent MEDOT inspection (09/2022) reported fair condition, many locations with minor to moderate concrete spalling, areas of exposed rebar, cracks and deep spalls at construction joints. Founded on exposed ledge. In MEDOT 2023-25 work plan for replacement preliminary design study. Anecdotal reports of concrete panel detachment on underside of bridge.
Mill Masonry Retaining Wall	River Left, extends 140 feet downstream of powerhouse to left bridge abutment, and behind powerhouse in upstream direction to overbank area	Stacked masonry retaining wall forms foundation for the restored and redeveloped Mayo Mill facility
Concrete Retaining Wall	River Right, extends 100 feet downstream of right abutment of dam to right abutment of bridge, and 70 feet upstream of dam to a location integral with Robinson Oil garage building foundation (former service station)	Retains fill at former service station location between East Main Street and river. Sustained major damage in 1987 flood. Rebuilt with FEMA funding. Garage building on lot owned by Robinson Oil.
Storm Drain	River Right, 75 feet downstream of dam, protrude from retaining wall elevated above river level	Conveys storm drainage from Main Street to the river.
Unused Dry hydrant	River Right, 100 feet upstream of dam, near redemption center.	Disused dry hydrant on parcel owned by Maine DOT, no longer in use.
Seasonal Dock	River Right, approximately 600 feet upstream of dam	Seasonal dock location along Town-owned property, fair to degrading condition.
MDIFW Hand-Carry Boat Launch	River Right, approximately 900 feet upstream of dam	Provides access for flatwater paddling and hand-carry boat access in an area of the impoundment known as “The Cove”. Surrounded by fairly extensive emergent and submerged aquatic vegetation, and notable sedimentation.
Storm Drain	River Right, approximately 1,000 feet upstream of dam	Storm drain conveys road drainage to river in cover area. outlet located along stone/vegetated bank, invert above typical impoundment water surface elevation.
Buried Geothermal System	River Left, extends from approximately 350 feet to 700 feet upstream of dam	Provides energy to redeveloped mill complex. Buried with boxes at surface grade. Does not depend on river.
Mill Parking Lot	River Left, extends from approximately 350 feet to 700 feet upstream of dam	Mill building parking lot, located at the end of Moosehead Lane. The parking lot appears to be within the FEMA 100-year floodplain. Storm drainage via surface runoff.
Seasonal Dock	River Left, approximately 750 feet upstream of dam	Seasonal dock along waterfront park area, posted as sea plane dock in summer 2022. On parcel owned by Mayo Mill Holdings LLC.
Dry Hydrant	River Left, approximately 800 feet upstream of dam	Town-owned dry hydrant installed 2019, 10-inch diameter steel pipe. Strainer elevation unknown, not visible during field visits to date. Replaced prior hydrant historically dedicated to mill facility. Used for training purposes. Fire protection for mill is sprinkler system connected to municipal fire protection hydrant system. On parcel owned by Mayo Mill Holdings LLC.
Sanitary Sewer Pump Station	River Left, approximately 1,000 feet upstream of dam	Former pump station location atop high bank near Town-owned park gazebo, connected to pressurized sewer system, but replaced by new pump station installed directly across Moosehead Lane in 2013. Does not interact with the river. Former and current pump stations appear to be outside FEMA 100-year floodplain. Associated buried sewer line runs along north side of mill parking lot from the mill facility to the pump station. The sewer line appears to be within the FEMA 100-year floodplain.
Float Plane Base Station	In River, base coordinates approximately 1,500 feet upstream of dam	Riverside sea plane base (private), FAA Identifier ME85, water runway dimensions 3600 feet x 300 ft.
Seasonal Dock	River Left, approximately 1.900 feet upstream of dam	Private seasonal dock along, appears intermittent year to year. Past aerial images show sea plane at this location.
Storm Drain	River Left, approximately 2,100 feet upstream of dam, near end of Green Street	12-inch diameter storm drain, conveys stormwater from Green Street. Outlets onto stone bank, pipe invert elevation approximately 5 feet above typical impoundment level
Sewer Overflow Discharge Pipe	River Left, approximately 2,100 feet upstream of dam, near end of Green Street	Sewer overflow pipe, outlet location below water, not observable during field visits to date. Infrequent use. Inactive ass of 2020 per Maine DEP.
Former Rail Trestle Bridge	Crosses river approximately 6,800 feet upstream of dam	Converted rail to trail bridge conveys Four Season Adventure Trail & ITS Snowmobile Trail, two masonry stone piers, bridge deck high above the river.
Former Waterworks Dam	Spans river approximately 8,800 feet upstream of dam	Former Waterworks dam site, river left abutment still present at the location, portions of the crib dam are still present in the river bed below water surface. At typical water levels, the site forms a riffle which marks the upstream end of the Mayo Mill Dam impoundment. Town-owned property.

8. Piscataquis River Flow Patterns

As part of this project, Inter-Fluve evaluated the hydrologic characteristics of the Piscataquis River and the contributing watershed, and the associated flow patterns near Mayo Mill Dam.

8.1 FLOODING PATTERNS

Nestled along the river, Dover-Foxcroft has experienced notable floods periodically through its history. Table 5 lists the ten largest floods that have occurred since the United States Geological Survey (USGS) started recording river discharges at Dover-Foxcroft in 1903. Figure 50 compares these peak flows to the estimated peak flood recurrence intervals estimated for the site (see Section 8.3). The 1987 flood, estimated as a greater than 1 in 200-year event, resulted in particularly dramatic conditions through the Town and extensive damage. Photographs of several of these historical floods are found in Figure 51 to Figure 61.

Table 5. Largest Piscataquis River flood flows at Dover-Foxcroft, ME since 1903. All flows given in cubic feet per second.

Date	Flood Peak (cfs)
4/1/1987	37,300
11/4/1966	22,800
4/29/1923	21,500
3/20/1936	19,300
4/28/1979	19,300
12/22/1973	19,200
4/18/1983	18,800
9/29/1909	17,400
11/27/1950	17,400
12/26/2020	15,300

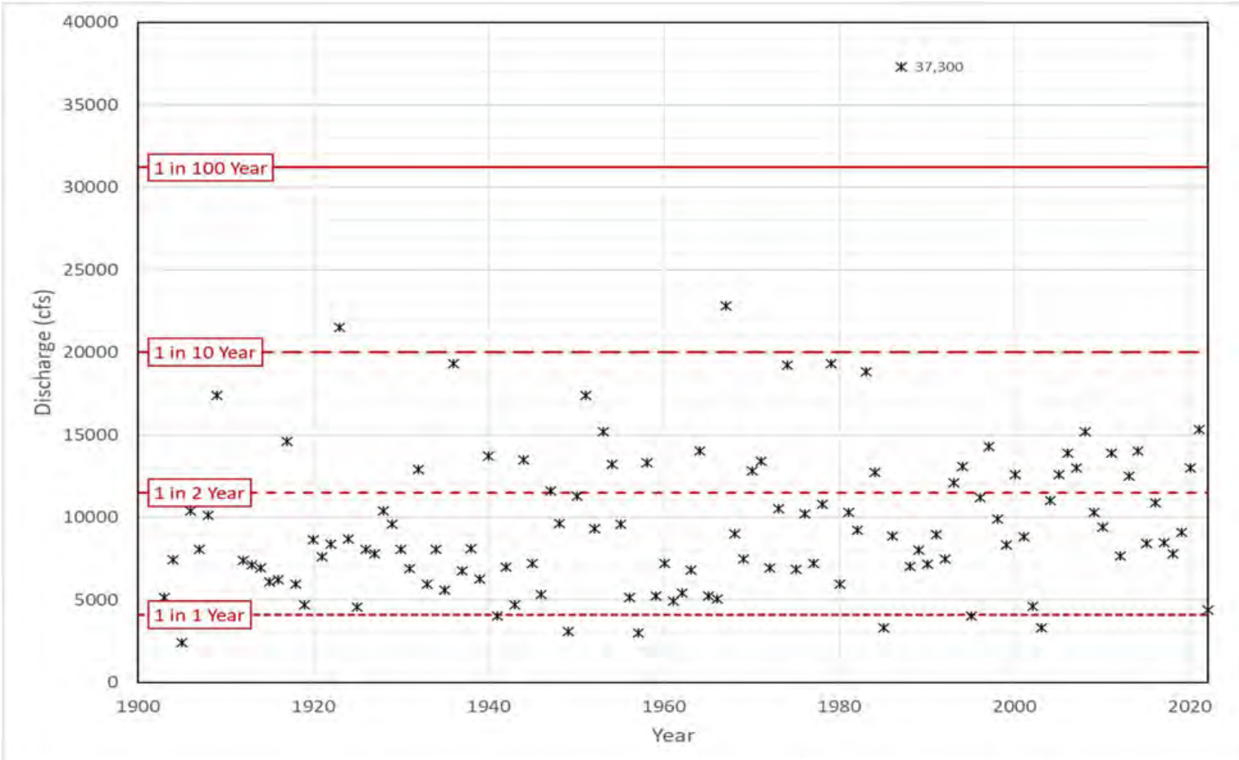

Figure 50. Annual peak floods at USGS station Piscataquis River at Dover-Foxcroft (01031500), compared to estimated flood recurrence interval magnitudes (see Section 8.3).

Figure 51. Ice-damming during flood circa 1900. Photo courtesy of Dover-Foxcroft Historical Society.

Figure 52. Winter flood circa 1900. Photo courtesy of Dover-Foxcroft Historical Society.

Figure 53. Flood conditions during the 1909 flood, estimated at between a 5- and 10-year peak flood event. Photo courtesy of Dover-Foxcroft Historical Society.

Figure* 54*. Flood conditions during the 1936 flood, estimated as an approximate 10-year peak flood event. Photo courtesy of Dover-Foxcroft Historical Society.

Figure 55. Flood conditions during the 1936 flood, estimated as an approximate 10-year peak flood event. Photo courtesy of Dover-Foxcroft Historical Society.

Figure 56. Flood conditions during the 1950 flood, estimated at between a 5- and 10-year peak flood event. Photo courtesy of Dover-Foxcroft Historical Society.

Figure 57. Flood conditions along South Street (left) and downstream of the Main Street bridge (right) during the 1966 flood, an approximate 20-year peak flood event. Photos courtesy of Dover-Foxcroft Historical Society.

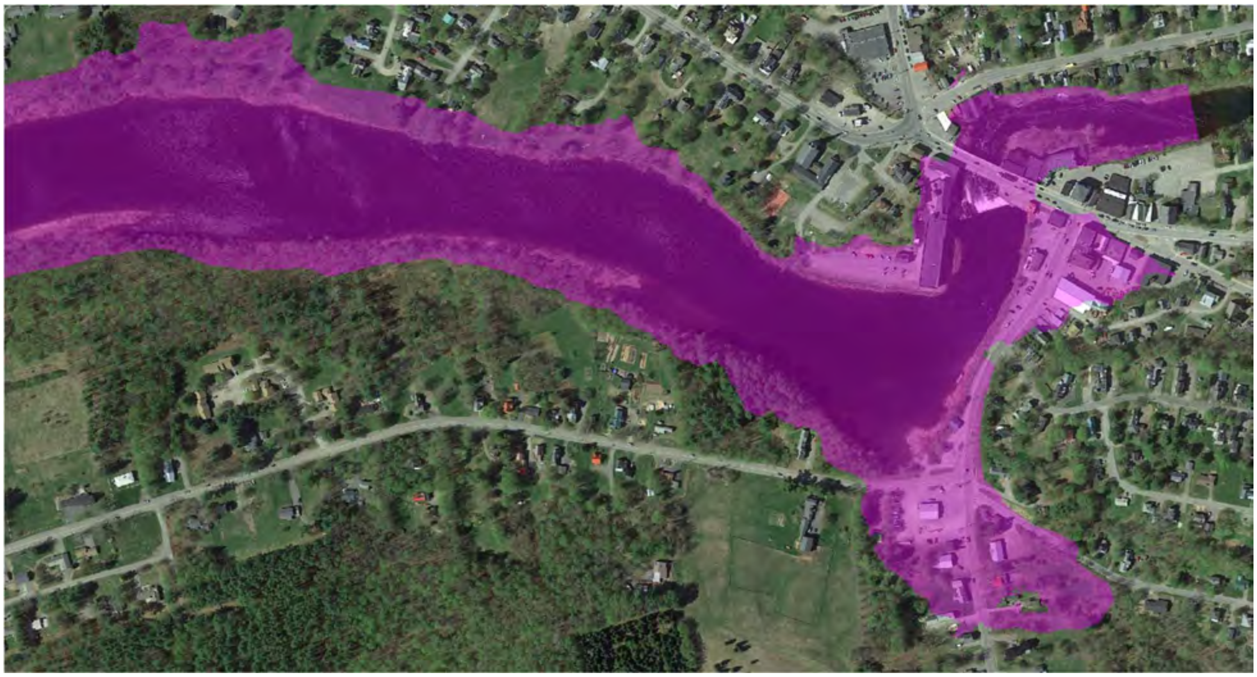

Figure 58. Simulated flood extent during the 1987 flood, estimated as an approximate 200-year peak flood event.

Figure 59. Flood conditions along South Street during the 1987 flood, an approximate 200-year peak flood event. Photo courtesy of Dover-Foxcroft Historical Society.

Figure 60. Flood conditions April 14, 2020, estimated as an approximate 3-year peak flood event. Photo courtesy Piscataquis County Emergency Management Agency.

Figure 61. Flood conditions April 14, 2020, estimated as an approximate 3-year peak flood event. Photo courtesy Piscataquis County Emergency Management Agency.

8.2 REGULATORY FLOODPLAIN AND FLOODWAY

Due to the hazards that these periodic floods present, the Federal Emergency Management Agency (FEMA) established a regulatory floodplain along the river to limit development, reduce damage, and protect the public in these flood prone areas. The Project Site is represented on FEMA Flood Insurance Rate Map (FIRM) Panel 230116 0010 B [2]. Portions of the Project Site and the adjacent downtown areas are located in the Regulatory Floodplain (the 100-year floodplain; Zone AE) and the Regulatory Floodway. In addition, the 500-year floodplain (and 100-year flood at depths less than 1 foot; Zone X) is shown to extend overland from the Piscataquis River to the neighboring Fox Brook, re-entering the Piscataquis River downstream of Brown's Mill Dam (Figure 62).

The Flood Insurance Study (FIS) for the Town of Dover-Foxcroft[3] indicates that the Soil Conservation Service (now the NRCS) performed detailed hydrologic and hydraulic analysis of the Piscataquis River in December 1990. The FIS indicates that the regulatory flood elevation downstream and upstream of the Main Street bridge is 344.0 feet and 347.0 feet (NGVD 1929), respectively. The regulatory flood elevation immediately upstream of the dam and at the upstream end of the impoundment is 356.0 feet and 360.0 feet (NGVD 1929), respectively. To convert these elevations to the NAVD 1988 vertical datum used for the current study[4], 0.576 feet would be subtracted from the regulatory flood elevations reported in the FIS.

Mayo Mill Dam has a direct impact on flood profiles upstream of the dam. The flood profile published in the effective FIS indicates that the dam raises the profile of the 100-year flood by up to 9 feet (Figure 63). The hydraulic evaluation prepared as part of this work and published in this report (Section 0) indicates that the impact of the dam extends upstream approximately 1.7 miles to the former Waterworks Dam location. The increase in the flood water surface elevation attributed to the dam is also responsible for the flood bypass flow pattern described above, where floodwaters from extreme events are predicted to travel overland to Fox Brook, and back to the river downstream of Brown's Mill.

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[2] FEMA FIS, 1993a. Flood Rate Map, Town of Dover-Foxcroft, Maine, Piscataquis County. August 16, 1993. Panel 2301160010B.

[3] FEMA FIS, 1993b. Flood Insurance Study, Town of Dover-Foxcroft, Maine, Piscataquis County. Community Number 230116. April 2, 1993.

[4] The conversion between the NGVD 29 datum and the NAVD 88 datum at the project site is *NAVD88 (feet) = NGVD29 (feet) - 0.58 (feet);* https://www.ngs.noaa.gov/NCAT/

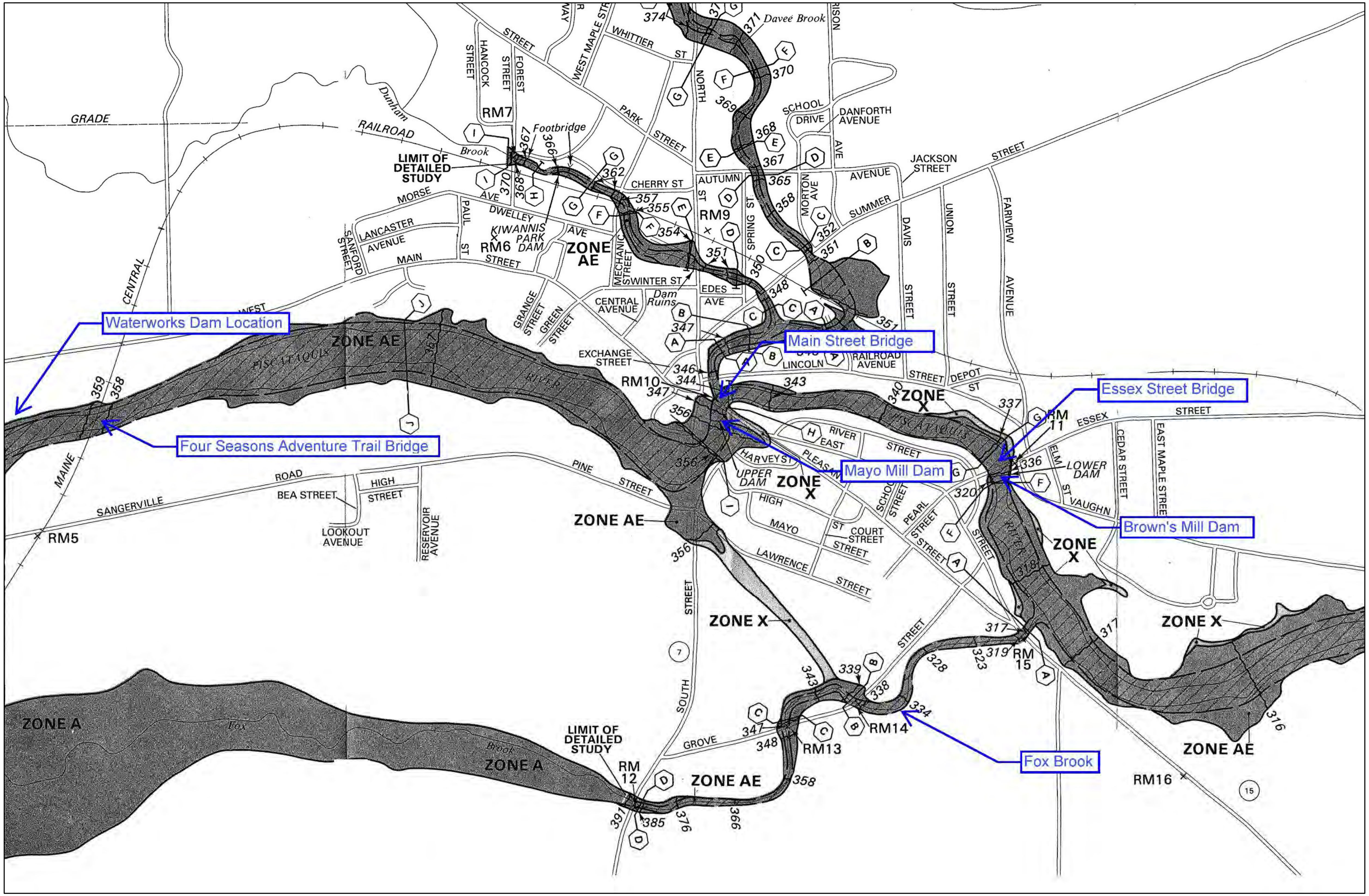

Figure 62. Excerpt from Flood Insurance Rate Map, Panel 2301160010B.

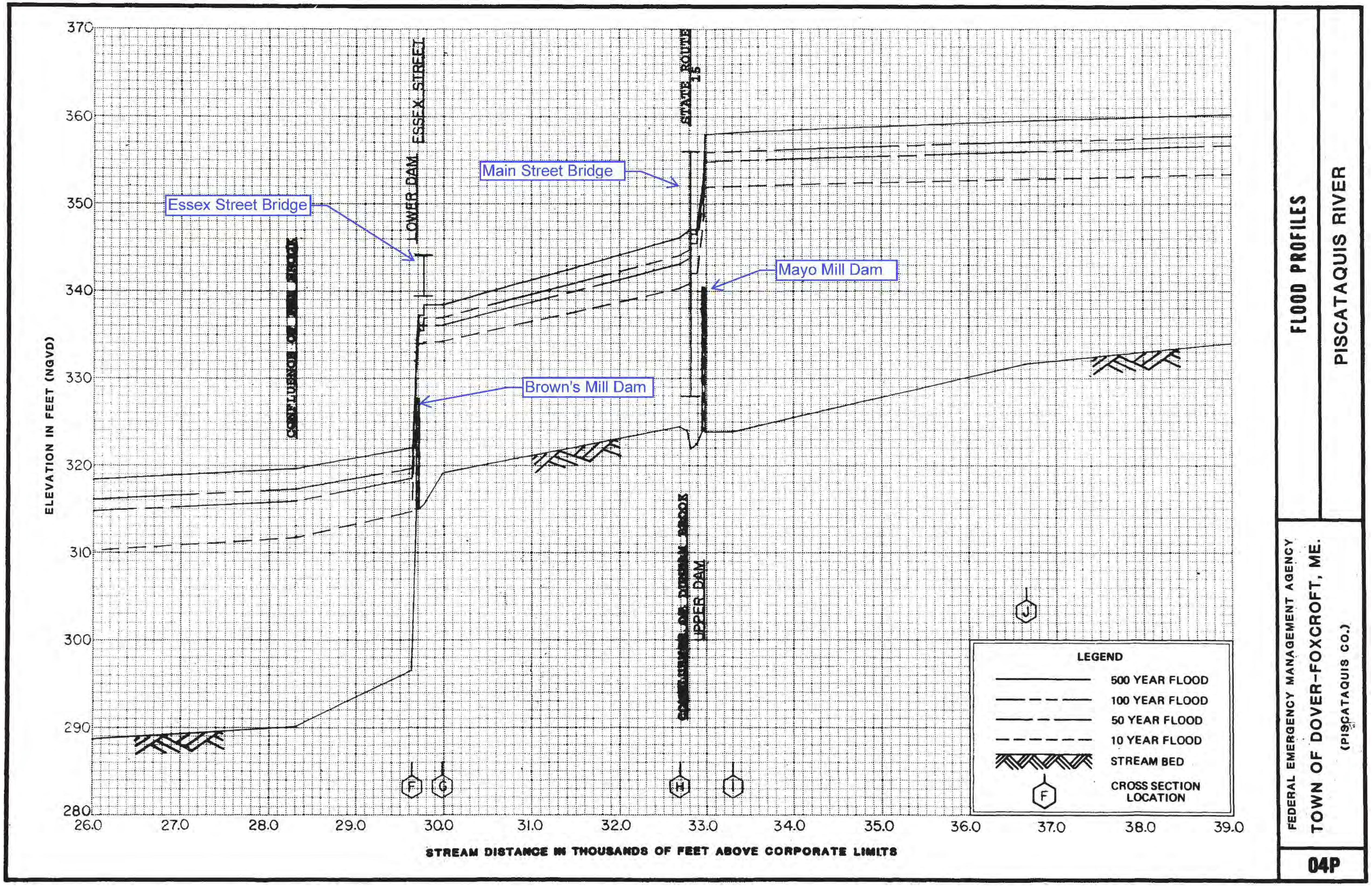

Figure 63. Flood Profile from the FEMA FIS.

8.3 HYDROLOGIC ANALYSIS

Inter-Fluve performed a hydrologic analysis to estimate peak flood flows and typical seasonal flows for the Piscataquis River at Dover-Foxcroft, Maine. The estimated flows are used in the hydraulic analysis to inform the project designs. Inter-Fluve also reviewed hydrologic evaluations published in flood insurance studies and compared the results of the historical evaluations to our estimates. The data, methods, and results are described below.

8.3.1 Data

The hydrologic analyses presented in this document are based on the following data and assumptions.

Watershed Characteristics

Inter-Fluve used the web-based software application, USGS Streamstats, to determine the characteristics of the contributing watershed. The contributing watershed to the Project Site is approximately 345 square miles. The proportion of the contributing watershed that is occupied by water, as indicated by the National Wetlands Inventory[5], is 10.2%.

Water Level Monitoring

Inter-Fluve deployed three water level monitoring devices (HOBO Water Level Data Logger) within the project area; 1) installed approximately 1.25 miles upstream of the dam at the rail trestle bridge, 2) on the upstream face of the dam, and 3) directly downstream of the dam. Figure 64 shows water level data collected from May 19th to August 23rd, 2023 at the three discrete monitoring locations.

The average water level difference between the upstream side of the dam and just downstream of the dam, representing the hydraulic height created by the existing dam, is 12.3 feet. The average water level difference between the upstream side of the dam and the rail trestle bridge (1.25 miles upstream) is 0.5 feet. The relatively small rise in water level observed for over a mile upstream of the dam highlights the extent of the dam impoundment.

[5] STORAGE is the percentage of storage (combined water bodies and wetlands).

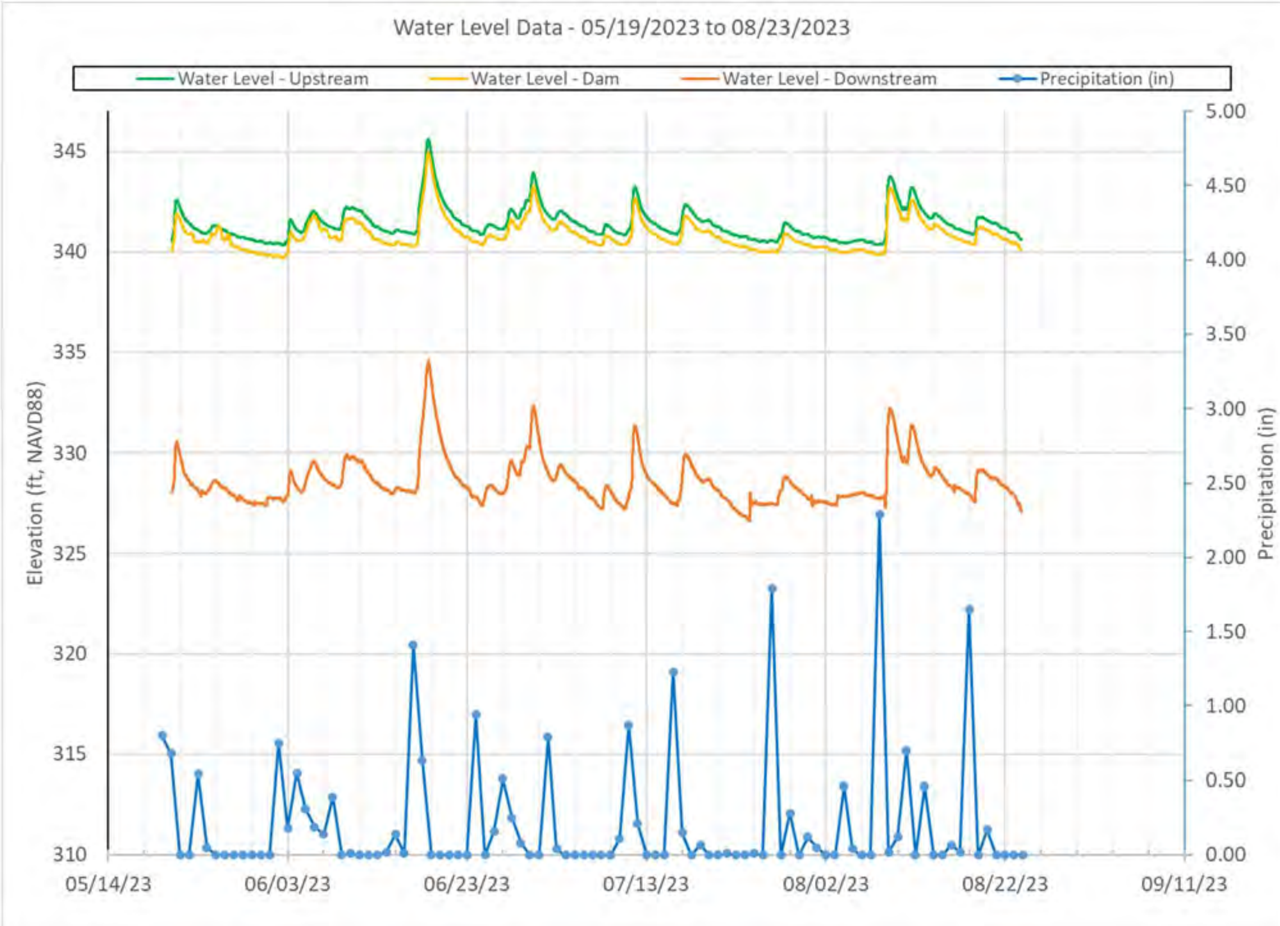

Figure 64. Water level monitoring data collected from May 15, 2023 to August 23, 2023 at three locations along the Piscataquis River. Precipitation data for Dover-Foxcroft was obtained from wunderground.com on 9/20/2023 (weather station ID: KMEDOVER 14).

USGS Streamgage

The USGS maintains a streamgage on the Piscataquis River at Dover-Foxcroft (01031500)[6]. The USGS gage is located approximately 5 miles upstream of the Project Site. The contributing watershed to the gage is approximately 298 square miles. Inter-Fluve used the flow record at the Dover-Foxcroft gage to inform the statistical analysis of streamflow at the Project Site.

The flow record begins on October 1, 1902 and continues through the present day (Figure 65). The flood of record at this gage (average daily peak 31,700 cfs, instantaneous peak 37,300 cfs) was recorded in April 1987. The conditions that led to the flood event were summarized by the National Weather Service and reported in ENSR (2007):

[6] https://waterdata.usgs.gov/monitoring-location/01031500/#parameterCode=00065&period=P7D

> *"Approximately 3 inches of rain fell between March 31 and April 1. The rainfall was accompanied by warm temperatures and melting snowpack. Three days later, the river basin received an additional two inches of rain… The estimated return period of this flow on the Piscataquis River at Dover-Foxcroft was greater than 500 years."*

The flow record indicates that annual peak flows are increasing over time (Figure 66). This finding is consistent with observations across the New England region and with the predictions for the region with respect to climate change.

Flow Scaling Factor

The contributing watershed to the Project Site is larger than the contributing area to the USGS streamgage. Therefore, it is necessary to adjust flow estimates made using the streamgage data to be applicable to the Project Site.

For this work, Inter-Fluve used a simple drainage-area-ratio scaling method to adjust the flow estimates for the gaged site to the Project Site.

$$Scale\ Factor = \frac{A_u}{A_g} = 1.16$$

Where:

the contributing area to the ungaged site (the Project Site) is: $A_u = 345\ square\ miles$

And the contributing area to the gaged site (Dover-Foxcroft) is: $A_g = 298\ square\ miles$

FEMA Flood Study

Inter-Fluve reviewed the effective Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for the Piscataquis River, published in the April 2, 1993 FIS report (FEMA 1993b). The FIS report indicates that the historical hydrologic analysis was performed by the U.S. Department of Agriculture Soil Conservation Service in December, 1990 using a combination of methods including an SCS TR-20 rainfall/runoff model and a Log-Pearson Type III (LP3) analysis of the streamgage record at Dover-Foxcroft. The results of the FEMA analysis are summarized in Table 6.

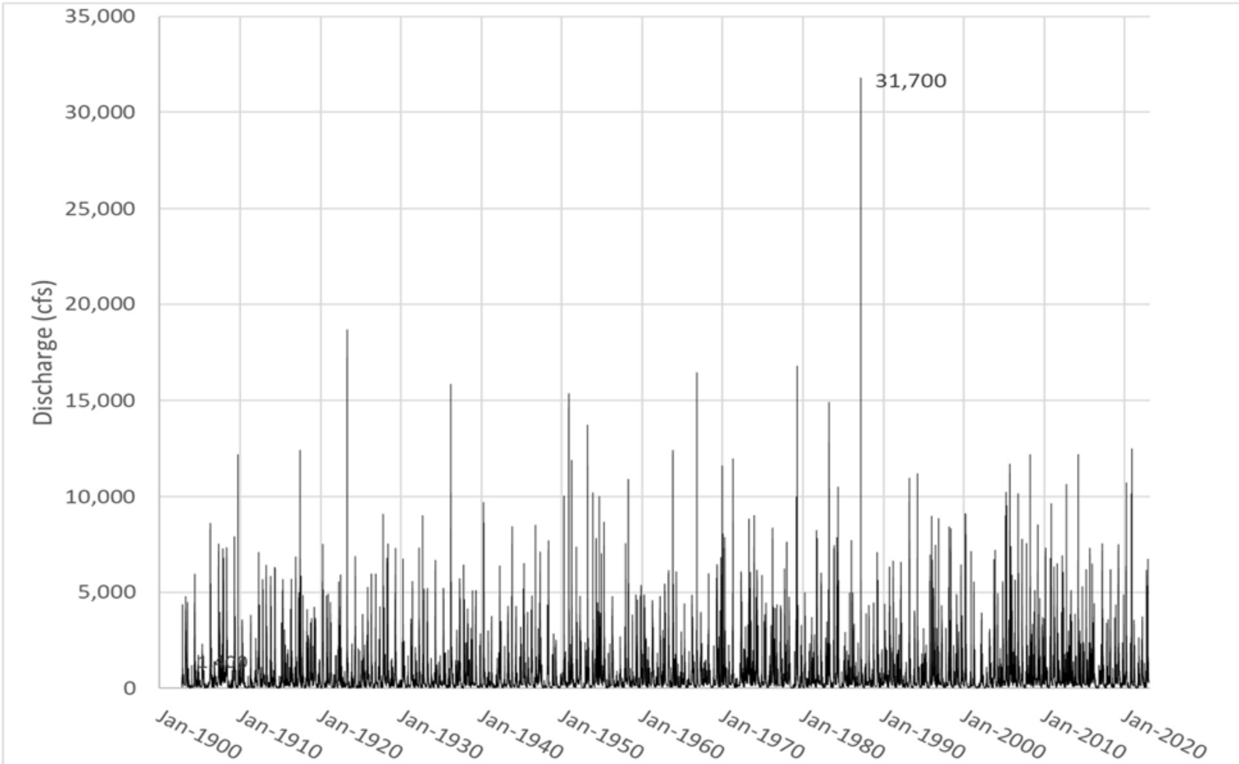

Figure 65. Daily Discharge at the USGS Gage on the Piscataquis River at Dover Foxcroft (0103150). From January 1902 to present.

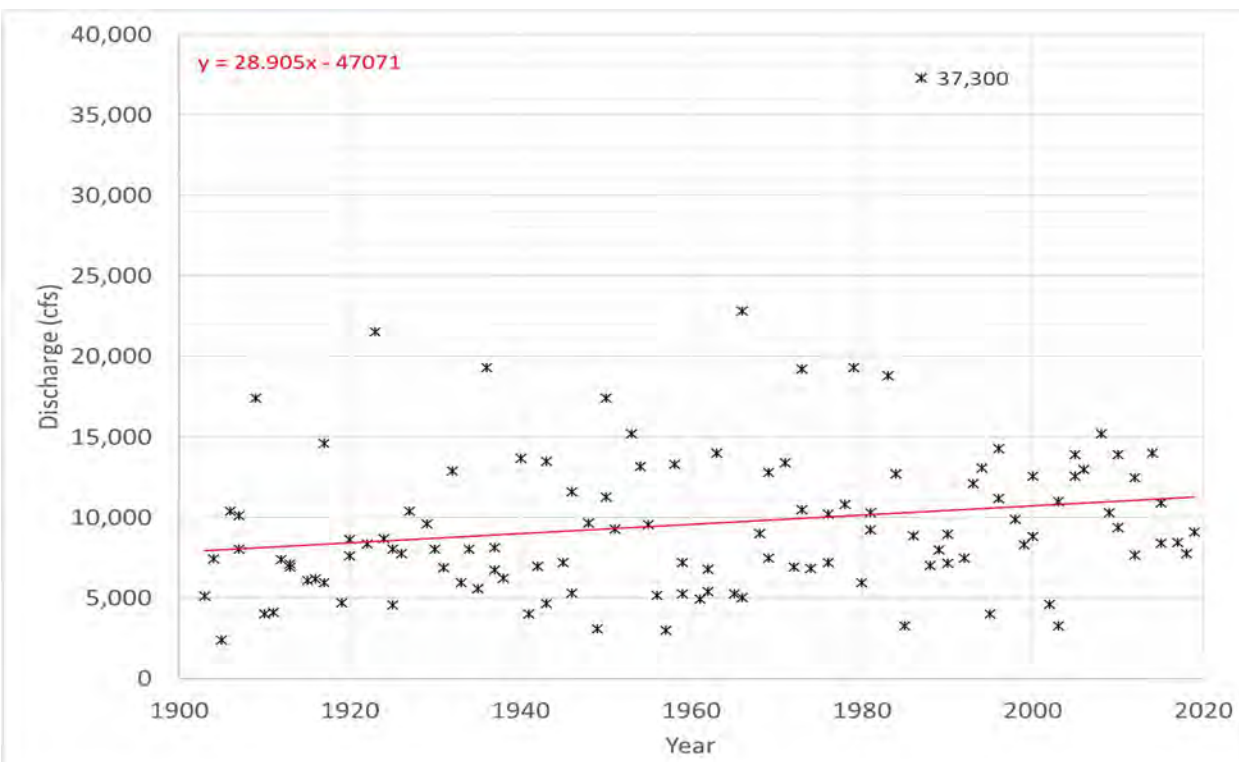

Figure 66. Peak Annual Discharge at the USGS Gage 01031500, Piscataquis River at Dover Foxcroft. From 1902 to present.

8.3.2 Peak Flood Flow Statistics

Inter-Fluve used several methods to evaluate the peak flood flow statistics for the Piscataquis River at the Project Site including (1) a statistical analysis of streamflow measurements (a gage record analysis), (2) a statistical analysis of watershed characteristics (a regional regression analysis) and, (3) a weighted combination of the gage record and regional regression analyses.

Gage Record Analysis

Inter-Fluve performed a statistical analysis of stream gage records by applying the methods described in USGS Water Resources Bulletins 17B (USGS 1981) and 17C (USGS 2019) to the data collected at the USGS streamgage at Dover-Foxcroft. These methods use the historical record of peak annual flows to estimate a frequency-discharge relationship for high-flow events.

The statistical methods described in Bulletins 17B and 17C are applicable to datasets that are stationary – that is, datasets that do not exhibit trends in time. The work of Collins (2009, 2014, 2018), and Walter (2010) indicate that streamflow data in New England appears to exhibit trends in time.

For this study area, work by Collins indicates a statistically significant increasing trend in peak annual floods. The work by Collins indicates an observable step-increase in peak annual floods around 1970 that may be related to conditions in the Atlantic Ocean (the North Atlantic Oscillation). To evaluate the impact of the trend on the estimates, Inter-Fluve performed the gage record analysis on two periods of time including (1) the full period of record and (2) the record post-1970. Figure 67 compares the frequency-discharge relationship for high-flow events for the full period of record at the gaged site to the same relationship for a period post-1970.

The results of this analysis indicate that, for events more frequent than the 500-year return period event, use of the truncated period of record (post-1970) will result in higher estimates for peak flood flows. Furthermore, results indicate that flow estimates made using the truncated period of record lie outside the 90% confidence interval for events more frequent than the 8-year return period event. This is a significant finding that indicates that flow conditions during the most recent 50± years of record are significantly different (higher) than flow conditions during the early period of record.

Table 6 and Figure 68 present the flow estimates advanced for use in the hydraulic model. For events more frequent than the 500-year return period event, we have selected flow estimates based on the truncated period of record. For the 500-year return period event, we have selected the flow estimate based on the full period of record. For comparison, Table 6 and Figure 68 also summarize the discharge-frequency relationship published in the FEMA FIS.

Regional Regression Analysis

Inter-Fluve used USGS Streamstats tool to implement the most recent regional regression equation method for estimating the flood discharge frequency relationship for the Piscataquis River at the Project Site (Lombard and Hodgkins 2020). Results indicate that the regional regression equation method predicts lower peak flood flows for a given frequency than the gage record analysis. These flow estimates are reported in Table 6 and Figure 68, but are not advanced for use in subsequent work.

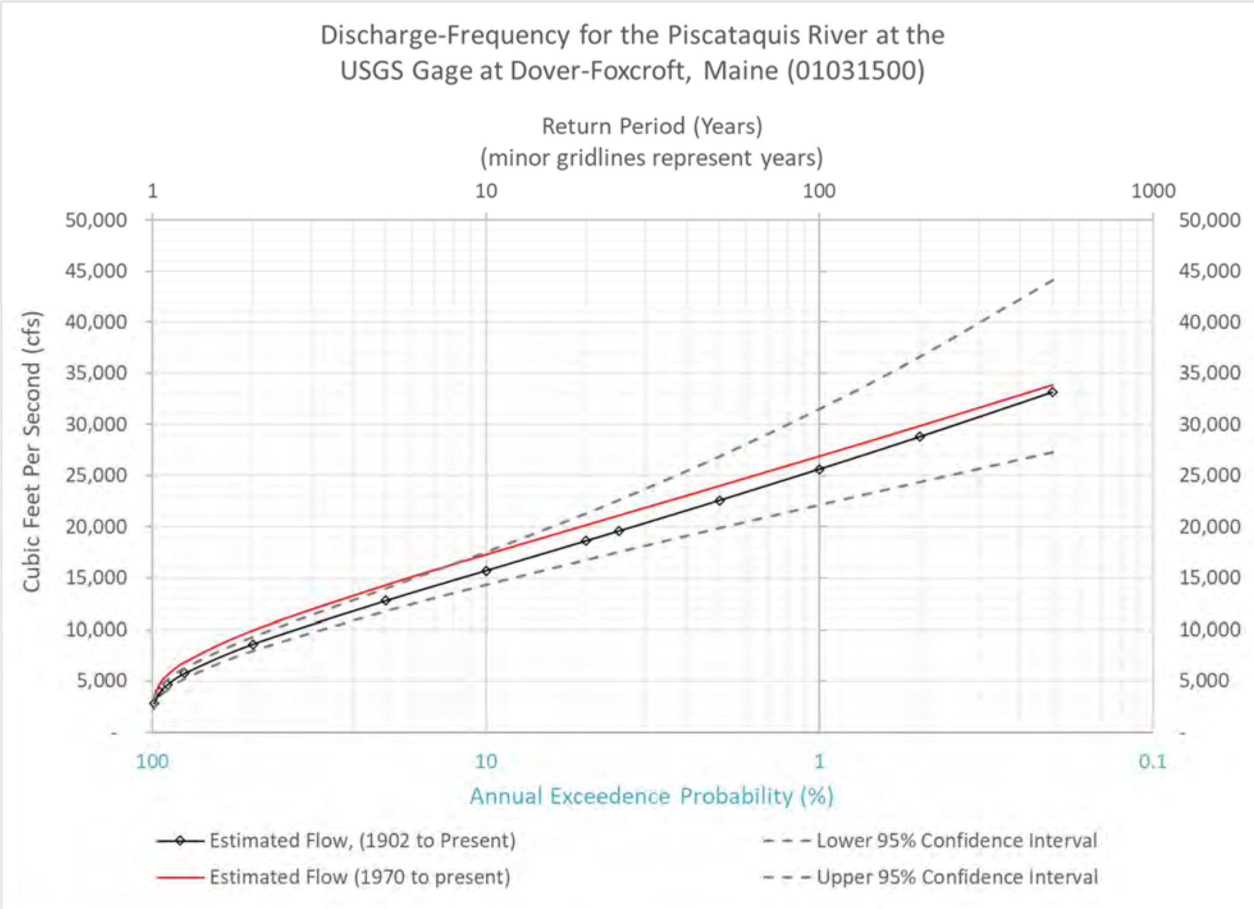

Figure 67. Discharge-Frequency Relationship at the USGS Gage at Dover-Foxcroft. Compare 1902 to present and 1970 to present.

Weighted Analysis

The USGS Regional regression equation method provides guidance for an alternative method for estimating discharge-frequency relationships for ungaged sites on gaged rivers and streams. The alternative method combines the results of the gage record analysis and the regional regression analysis based on proximity to the streamgage and similarity of watershed characteristics.

Results indicate that the weighted analysis predicts higher peak flood flows for a given frequency that the simple regional regression analysis; however, as expected, it predicts lower flood flows than the gage record analysis. These flow estimates are reported in Table 6 and Figure 68, but are not advanced for use in subsequent work.

8.3.3 Summary - Peak Flood Flow Statistics Results and Peak Design Flow Selection

Based on the above range of analyses, peak flood flow estimates were determined, and design flows were selected. Table 6 and Figure 68 summarize the results of the analysis to estimate relationship between flood discharge and frequency of the Piscataquis River at the Project Site in tabular and graphical format, respectively. Discharge estimates in bold-faced text have been advanced for use in subsequent work.

Table 6. Discharge Frequency Relationship for Peak Flood Flows. Piscataquis River at the Mayo Dam, Dover-Foxcroft, ME. All flows given in cubic feet per second. Discharge estimates in bold-faced text have been advanced for use in subsequent work.

Return Period	*Annual Exceedance Probability*	*Log-Pearson Type III Analysis (1970 – present)*			*Regional Regression Analysis*	*Weighted Analysis*	*FEMA FIS At State Route 15 (1993)*
		Estimated Peak Flood Flow	*Confidence Interval (Exceedance Probability)*				
Years	*%*		*5%*	*95%*	*(2020)*		
1	100	**4,100**	4,900	3,000			
2	50	**11,500**	12,800	9,300	7,400	9,600	
5	20	**16,600**	18,900	14,800	10,100	13,600	
10	10	**20,000**	23,500	17,700	12,000	16,200	19,900
20	5	**23,400**	28,300	20,400			
25	4	**24,500**	30,000	21,200	14,400	19,800	
50	2	**27,800**	35,500	23,700	16,200	22,400	29,100
100	1	**31,200**	41,400	26,000	18,000	25,000	32,700
200	0.5	**34,600**	48,000	28,300	19,400	27,600	
500[A]	0.2	**38,500**	57,600	31,100	21,400	30,500	40,800

A. The flow estimate associated with the Log-Pearson Type III, 500-year event is based on the full period of record at the gage.

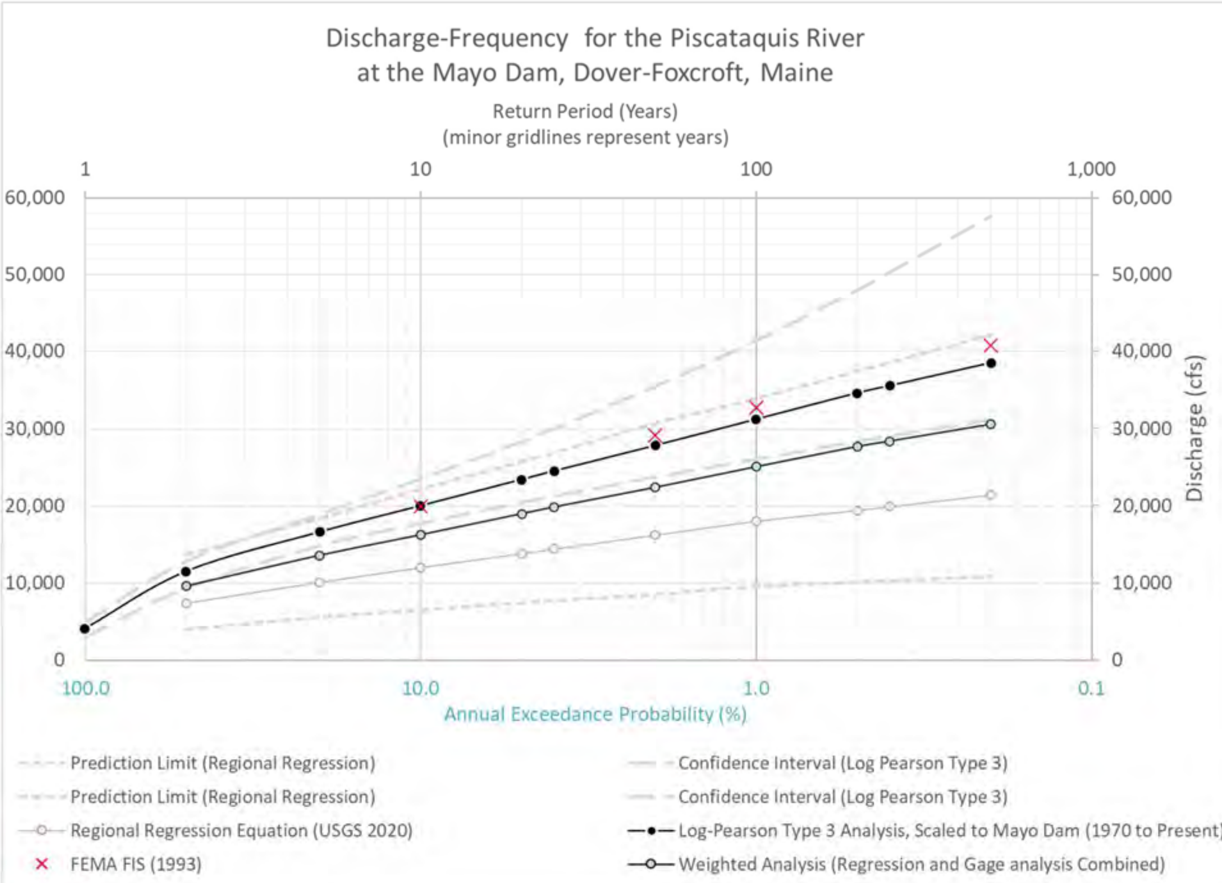

Figure 68. Discharge Frequency Relationship. Piscataquis River at the Mayo Dam, Dover-Foxcroft, ME.

8.3.4 Summary - Monthly Flow Statistics

In addition to the peak flood flow estimates, more typical flow estimates were determined for non-flood periods. Inter-Fluve performed a statistical analysis on the daily flow record at the USGS gage to evaluate the discharge-frequency relationship for flows on a monthly basis. Table 7and Figure 69 present the results of this analysis. The gage analysis results have been adjusted using the flow scaling factor described in Section 8.3.1 of this report to represent flows at the Project Site in Dover-Foxcroft. Inter-Fluve has selected the design flows summarized in Table 7 for use in subsequent habitat continuity and fish passage design analyses, and to inform construction planning.

Table 7. Monthly Flows. Piscataquis River at the Mayo Dam, Dover-Foxcroft, ME. All flows given in cubic feet per second.

Month	*95% Exceedance Probability*	*50% Exceedance Probability*	*5% Exceedance Probability*
January	90	250	1,040
February	70	210	880
March	90	350	2,530
April	450	1,970	5,850
May	260	980	4,050
June	90	340	1,740
July	40	150	950
August	30	100	740
September	20	90	690
October	30	200	1,880
November	50	510	2,470
December	80	400	2,090

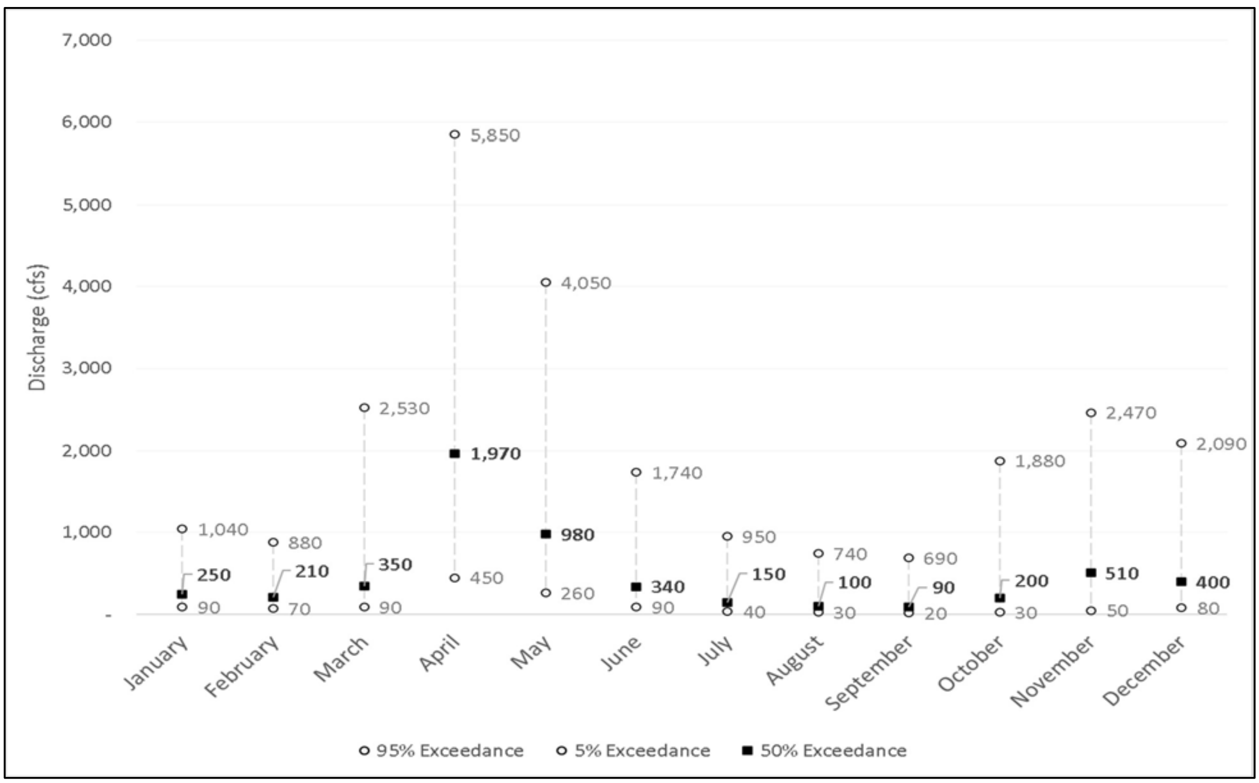

Figure 69. Monthly Flow Statistics at Dover-Foxcroft, Maine. Median, 5% exceedance, and 95% exceedance Flow.

8.4 CLIMATE CHANGE AND RESILIENCE CONSIDERATIONS

Climate models are forecasting that climate change due to greenhouse gas emissions is likely to have substantial impacts to Maine's rivers and streams. Climate models predict changes to temperature and water distribution. The changes will affect seasonal patterns, the frequency and severity of extreme weather events, and the resident flora and fauna that have adapted to historic climate conditions.

Since 1895, the average annual air temperature of inland Maine has increased by an average of 3.2 °, the growing season has lengthened by approximately 2 weeks, and annual precipitation has increased by 5.8 inches (Fernandez et al. 2020). In Maine, the increase in temperature is primarily associated with warmer winters that result in decreased snowpack.

In general, increasing temperatures cause an increase in hydrologic variability in watersheds: evaporation increases, precipitation and drought events intensify, winter rainfall increases and, consequently, winter snowpack decreases. The snowmelt that does occur, occurs earlier in the year (MCC STS 2020).

In the northeastern U.S., annual and extreme precipitation have increased by 7% and 41% since the early 1900s, respectively. Analysis of the precipitation data reveals that the rate of change has accelerated with an inflection point in the late 1990s to early 2000s. During this period, the quantity and severity of extreme coastal events increased (Huang et al. 2017). This finding is consistent with the results of a local study summarized in Figure 70 (Runkle et al. 2017), which indicated that between 1961 and 2008 there was an approximately 15 to 20% increase in magnitude of an estimated 24-hour 100-year precipitation event in Piscataquis County.

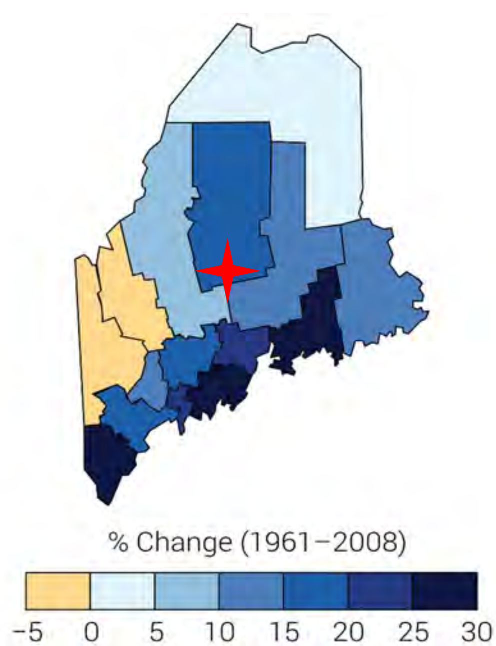

***Figure* 70. Change in the magnitude of the 24-hr, 100-yr precipitation event by county in Maine. Reprint from Runkle et al. 2017. Red star indicates location of Dover-Foxcroft.**

Changes in precipitation totals and the distribution in space and time will also affect vegetation and soil conditions. The changes are anticipated to adversely affect Maine forests by increasing drought stress. Because vegetation is a critical element of the hydrologic cycle, the changes to vegetation will result in additional changes to water distribution in any given region.

8.4.1 Impacts on Streamflow

Streamflow in Maine's rivers, including the Piscataquis, follow a seasonal pattern. In general, the highest magnitude of flows occurs in the spring during the snowmelt period and rainy season, the lowest flows occur during late summer dry season. Flow typically increases again in autumn during the rainy season. The occasional late-summer post-tropical storm contributes to the autumn flows.

Climate change is leading to shifts in timing, magnitude, and frequency of streamflow. Researchers have observed increases in March flows and decreases in May flows in New England throughout the 1900s. This pronounced change is attributed to the snowpack melting earlier in the season (Hodgkins and Dudley 2005). Ice patterns in the Piscataquis have also been shown to reflect climate change patterns, including thickness decreases and earlier ice-out (Huntington, Hodgkins, and Dudley 2003)

At this time, researchers have not observed substantial changes to the magnitudes of summer low flows and levels of groundwater (Hodgkins et al., 2017; Dudley et al., 2019). However, researchers have observed that the duration of low flows may be increasing (MCC STS 2020).

The frequency of moderate flood events is increasing in Maine. The peak flows of the statistical events typically referred to as the 2- and 10-year floods are increasing. At this time, the increase appears to be attributable to increases in precipitation during typical thunderstorm and/or post-tropical storm events (MCC STS 2020).

The peak discharge of the annual flood, which often occurs during the snowmelt season, increased by 19% between 1966 and 2015 (Dudley et al. 2018). It is unclear whether the magnitude of the annual flood will continue to increase in tandem with precipitation, or if the annual flood will plateau or decrease as a result of decreased snowpack (Hodgkins and Dudley 2013).

At this time, it is difficult to evaluate trends for larger, less frequent floods (.e.g, the 100-year flood). Firstly, very few data records include 100 years of data. Secondly, the events that cause these floods are influenced by many different global processes.

Predictions for future large floods events indicate that the magnitude and frequency of the events may increase or decrease depending on which climate processes dominate (MCC STS 2020, Hodgkins and Dudley 2013). Decreases in major floods could result from the decoupling of historical contributing factors to these types of events. Similarly, increases in major floods could result from an increased likelihood of coincidental occurrence of contributing factors possibly coupled with increased potential for rain on snow events.

8.4.2 Implications for Flooding Patterns

Hydraulic modeling results discussed later in this report demonstrate that even small flood events interface with existing infrastructure and private property along the Piscataquis River. Preliminary model results indicate that the Mill Street parking lot begins to flood during the 2-year event, South Street begins to flood during the 10-year event, and overland flow bypasses the dam entirely during the 50-year event. These events are likely to occur more frequently in future years (MCC STS 2020), increasing strain on infrastructure near the river.

8.4.3 Implications for Fish Migration and Habitat

Climate change may impact fish passage in several ways. Shifts in peak spring flows to earlier months may lead to relatively lower flows during the principal fish migration period in May and June, or may lead to shifts in the timing of fish migration due to collateral effects, including shifts in seasonal water temperatures. Hydrologic intensification may result in more frequent flood conditions or low flow conditions, so that flow is more varied, with greater chance of typical conditions near the extremes of monthly flow distributions predicted for the watershed. Increasing floods may also flush aquatic insects and other food sources from streams (MCC SCS, 2020). Earlier spring thaw and increased runoff from extreme precipitation events, along with increasing air temperatures, are leading to warming trends in Maine's lakes and rivers, which increase thermal stress on coldwater fishes such as the Atlantic salmon and Eastern brook trout, and will contribute to water quality issues detrimental to fish (MCC SRS, 2020). These shifts may directly affect fish passage potential, habitat availability, and habitat quality, and in turn, viability of the the native fish populations.

8.4.4 Climate Change Predictions for the Piscataquis River at Dover Foxcroft

Neither Maine nor the bordering states of New Hampshire or Massachusetts have adopted recommendations for adjusting flow estimates such as reported in Section 8.3 t predict future flow conditions. Further afield, New York and Vermont have adopted practices where peak flow estimates are escalated by 20 to 25 percent for consideration alongside peak flow estimates determined by standard of practice statistical methods, such as those reported in Section 8.3.

At this time, there are no specific New England regional analyses that downsample, calibrate, and validate climate predictions produced by global models. With the support of the U.S. Forest Service (USFS)[7], researchers (Wegner et al. 2010*)* have established a methodology to use national datasets to produce forecasts for the Pacific Northwest region. The researchers applied their methodology to the national dataset, and calibrated and validated their model specific to their region of interest (Pacific Northwest). Results are available for New England; however, since their model has not been calibrated and validated for New England, it has not been determined whether or not the results are applicable for Maine. Future work (by others) may provide insight with respect to the applicability of this dataset.

[7] https://data.fs.usda.gov/geodata/edw/datasets.php?xmlKeyword=edw

However, given the data and analyses discussed above, a few key points regarding future trends in the Piscataquis River watershed include the following:

- Researchers have observed increases in March flows and decreases in May flows in New England throughout the 1900s. This pronounced change is attributed to the snowpack melting earlier in the season (Hodgkins and Dudley, 2005).
- Small to moderate flood events interface with existing infrastructure and private property along the Piscataquis River. These events are likely to occur more frequently in future years (MCC STS 2020),
- These shifts may directly affect fish passage potential, habitat availability, and habitat quality and in turn, viability of the populations.
- Changes in precipitation totals and the distribution in space and time will also affect vegetation and soil conditions. The changes are anticipated to adversely affect Maine forests by increasing drought stress. Because vegetation is a critical element of the hydrologic cycle, the changes to vegetation will result in additional changes to water distribution in any given region.
- However, the drainage area above Dover-Foxcroft is at a higher elevation, is predominantly forested with limited development, forested, and based on emerging analyses such as stream temperature models – these trends point to greater resilience in the watershed.

As climate change science is rapidly emerging, additional considerations will continue to be evaluated for the final baseline conditions summary to be delivered in September 2023.

8.5 HYDRAULIC ANALYSIS

Inter-Fluve developed a hydraulic model of the Piscataquis River at Dover-Foxcroft to represent current conditions and to understand flood levels, erosion forces, and water levels in the impoundment area.

8.5.1 Methods

As part of this work, Inter-Fluve developed a 1-dimensional, steady-flow hydraulic model of the study area using U.S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System (HEC-RAS) software version 6.3.1.

8.5.2 Data

Inter-Fluve used data from sources identified in Table 8 to build the hydraulic model of the study area.

Table 8. Data Used to Populate the Hydraulic Model

Data Type	Source
Flow	Hydrologic Analysis (Section 8.3)
Topography	Field Survey by Inter-Fluve in (See Section 5). Supplemented with: Survey and structure from motion photogrammetry courtesy of Webber Surveying, 2019. Field Survey of Monument Square and Moosehead Lane by Perry Land Surveying, 2021 & 2022. 2015 LiDAR Data USGS Maine & Massachusetts QL1, QL2[8] Vertical accuracy 8.1cm, horizontal accuracy 100 cm (not tested). Data relevant to the study area collected November, 2015.
Bathymetry	Field survey by Inter-Fluve (See Section 5)

Model Domain

Inter-Fluve developed a hydraulic model of the Piscataquis River from a downstream limit located approximately 975 feet downstream of the Mayo Mill Dam to an upstream limit located approximately 1,950 feet upstream of the Newport/Dover-Foxcroft Rail Trail Bridge (Figure 71).

Geometry

Inter-Fluve developed the model geometry in an ESRI ArcGIS environment using the GeoRAS tools to locate the river centerline and to sample the cross-section geometry from the composite topographic/bathymetric surface.

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[8] https://noaa-nos-coastal-lidar-pds.s3.amazonaws.com/laz/geoid18/5087/supplemental/Maine_QL2_LiDAR_Overall_FOCUS_Report.pdf

With respect to structures:

- The Mayo Mill Dam is simulated as an Inline Structure at River Station 33600.
- The East Main Street Bridge is simulated as a bridge at River Station 33386. The high and low chords of the opening are defined in the Deck/Roadway editor.
- The Four Seasons Rail Trail Bridge is simulated as a bridge with two piers at River Station 40500. The high and low chords of the opening are defined in the Deck/Roadway editor and the piers are defined in the Pier editor.

Boundary Conditions

Both the upstream and downstream boundary condition are set to reflect the normal depth at a slope of 0.001 feet per foot, estimated from site observations and measurements.

Expansion/Contraction

The expansion and contraction coefficients are set to typical values of 0.3 and 0.1, respectively. Expansion and contraction coefficients for the two bridges within the model domain were set to 0.5 and 0.3, respectively.

Manning's "n"

Channel and floodplain hydraulic roughness values (Manning's "n") were assigned based on field observations, and through consideration of published reference methods (Arcement & Schneider 1989). Channel roughness values were adjusted based on comparison of simulation results to measured water surface elevations at the time of survey.

Table 9. Manning's "n" Values Used in the Hydraulic Model

Location	Value	Description
Channel	0.04 – 0.045	Typical channel through the impoundment reach, depth is high relative to bed substrate size (gravel, cobble and sand, uniform, limited obstructions)
Channel	0.05	Typical channel downstream of the dam, depth is lower relative to bed substrate size (gravel, cobble and small boulders), some obstructions
Mid-Channel and Overbanks	0.10	Typical overbank

8.5.3 Results

Figure 72 and Figure 73 summarize selected model results for the existing condition hydraulic model, which forms the basis of comparison for the performance of hydraulic design features. Figure 72 illustrates the water surface profiles for selected flood events. Figure 73 illustrates the footprint of inundation for the 100-year flood as compared to the FEMA FIS Floodplain for the Piscataquis River.

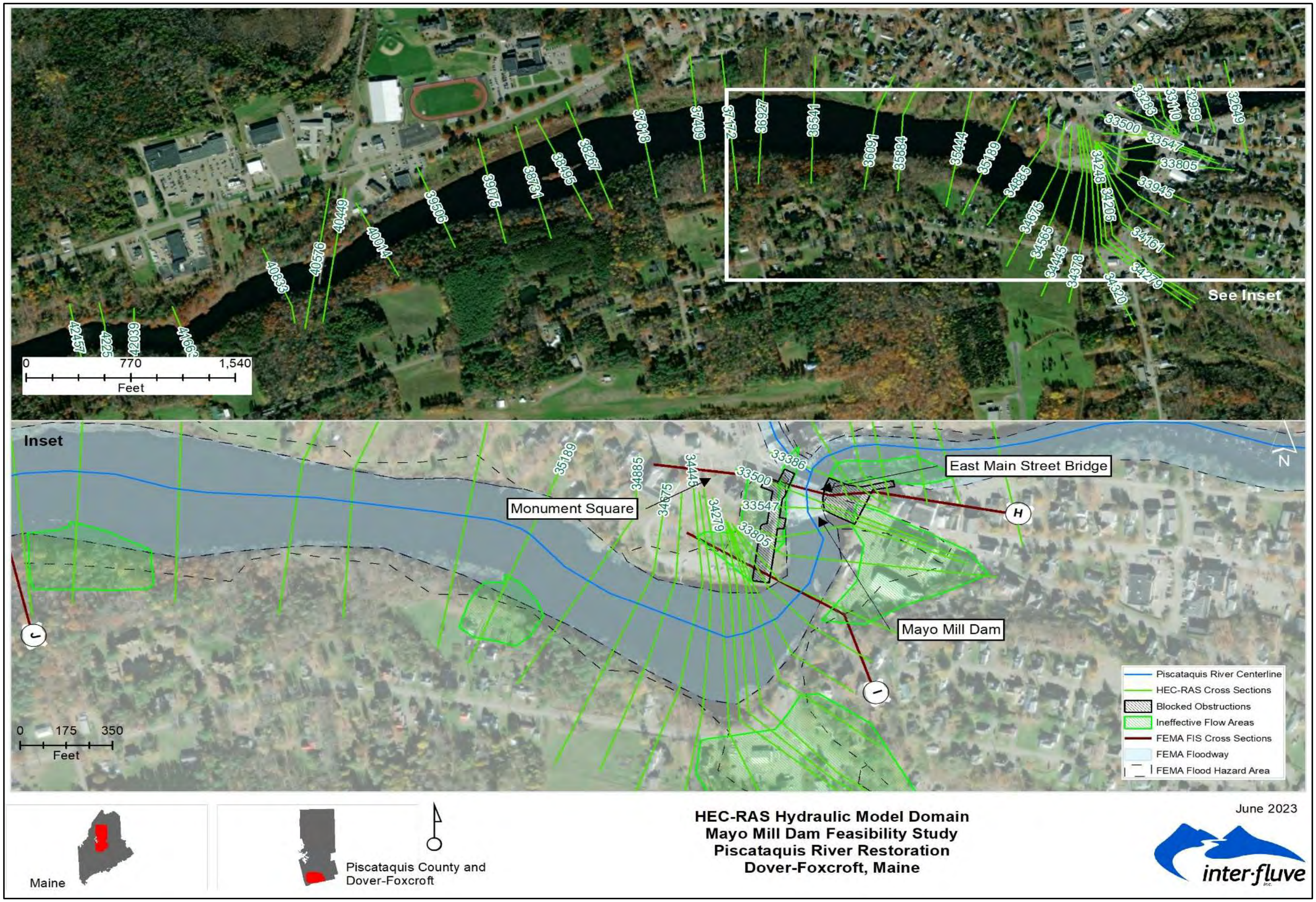

Figure 71. HEC-RAS Model Domain.

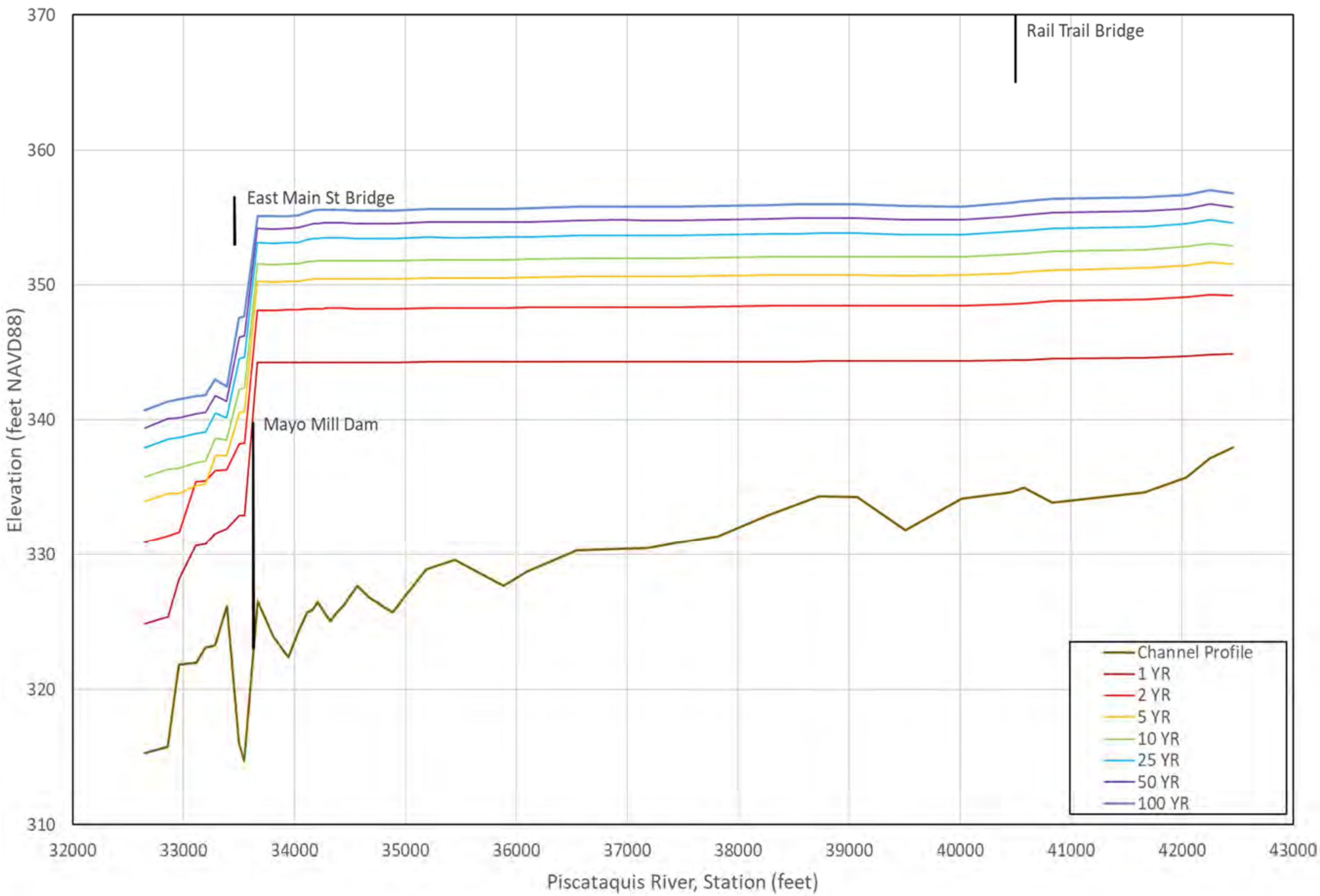

Figure 72. Existing Condition Hydraulic Model Results. Flood Profiles.

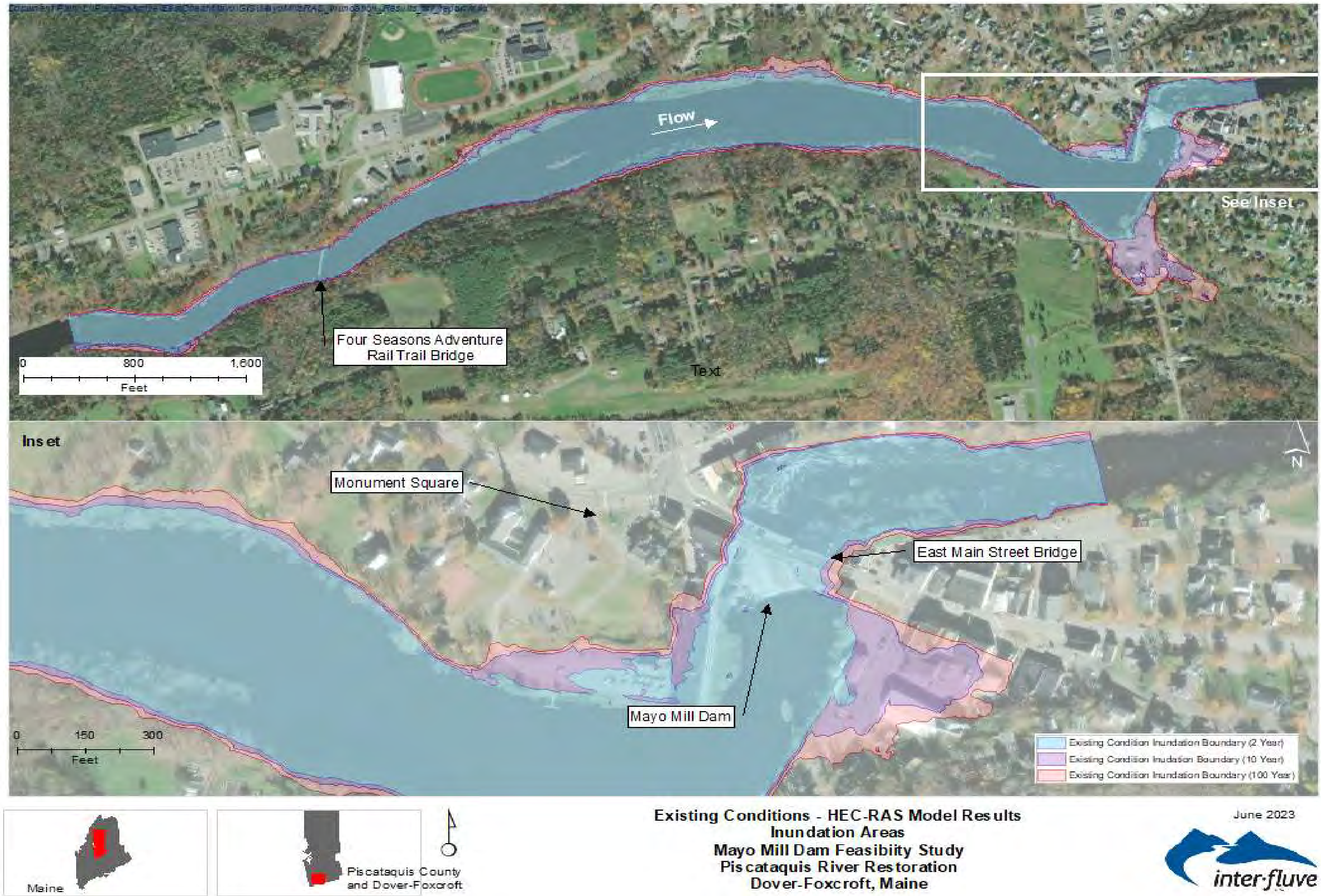

Figure 73. Simulated Two-, Ten-, and 100-Year Event Inundation Footprints.

9. Ecological Resources

The Piscataquis River is a major tributary to the Penobscot River and the focal point of a regionally important 1,459 square mile watershed which provides habitat for a diverse assemblage of native flora and fauna. The 62-mile-long river has been afforded federal and state protections to maintain water quality and habitat to support a diverse community of aquatic and terrestrial species. Much of the Piscataquis River is designated an outstanding river segment, and as such is afforded special protection under the Natural Resources Protection Act (NRPA)[9].

The reach of the river that flows through the project area lies along the northern extent of the central Maine embayment region of the Acadian plains and hills ecoregion (Griffith et al. 2009). This ecoregion consists of rolling plains and hills with a diversity of geology and moderate climate. This transition zone represents the northern range limit of many plant species, contributing to the diversity of habitats encountered in this region.

Within the Mayo Mill project area, the hydrology of the Piscataquis River is controlled by the Mayo Mill dam which impacts the stream habitat present. The upstream extent of the project area corresponds with the upstream end of the 60-acre impoundment formed by the dam. The project area extends downstream through the Main Street bridge, where the river becomes backwatered by the Brown's Mill dam. Dunham Brook, which has been identified as a cold-water refuge, enters the Piscataquis River just downstream of the project area, after flowing approximately 4.5 miles from Dunham Pond.

9.1.1 Fisheries

Inventories of fish species present in the Penobscot River basin were conducted in 1983 and 2011. The results of these inventories as summarized in the 2020 biological assessment (R2 Resource Consultants 2020) is presented in Table 10. Many, but not all, of these species are also present within the direct project area, either year-round and at all life-stages as resident populations, or during parts of their migratory life history.

[9] Maine Bureau of Land and Water Quality and Maine Department of Environmental Protection, "Natural Resources Protection Act and 35-A M.R.S.A. § 3452 2015" (2015). Land and Water Quality Documents. 15. https://digitalmaine.com/lwq_docs/15

Table 10. Fishes of the Penobscot River basin as described by Baum (1983) and Kiraly et. al (2014).

Common name	Scientific name	Habitat*	Status	Source(s)
Alewife	*Alosa pseudoharengus*	D	Native	Baum 1983, Kiraly et. al 2014
American Eel	*Anguilla rostrata*	D	Native	Baum 1983, Kiraly et. al 2014
American Shad	*Alosa sapidissima*	D	Native	Baum 1983, Kiraly et. al 2014
Arctic Char	*Salvelinus alpinus*	F	Native	Baum 1983
Atlantic Salmon	*Salmo salar*	D	Native	Baum 1983, Kiraly et. al 2014
Atlantic Sturgeon	*Acipenser oxyrinchus*	D	Native	Baum 1983, Kiraly et. al 2014
Atlantic Tomcod	*Microgadus tomcod*	D	Native	Baum 1983
Banded Killifish	*Fundulus diaphanus*	M,F	Native	Baum 1983, Kiraly et. al 2014
Black Crappie	*Pomoxis nigromaculatus*	F	Introduced	Baum 1983, Kiraly et. al 2014
Blacknose Shiner	*Notropis heterolepis*	F	Native	Kiraly et. al 2014
Blueback Herring	*Alosa aestivalis*	D	Native	Baum 1983, Kiraly et. al 2014
Bridle Shiner	*Notropis bifrenatus*	F	Native	Baum 1983
Brook Stickleback	*Culaea inconstans*	F	Native	Baum 1983
Brook Trout	*Salvelinus fontinalis*	D	Native	Baum 1983, Kiraly et. al 2014
Brown Bullhead	*Ameiurus nebulosus*	F	Native	Baum 1983, Kiraly et. al 2014
Brown Trout	*Salmo trutta*	F	Introduced	Baum 1983
Burbot	*Lota lota*	F	Native	Baum 1983, Kiraly et. al 2014
Chain Pickerel	*Esox niger*	F	Native	Baum 1983, Kiraly et. al 2014
Common Shiner	*Luxilus cornutus*	F	Native	Baum 1983, Kiraly et. al 2014
Creek Chub	*Semotilus atromaculatus*	F	Native	Baum 1983, Kiraly et. al 2014
Creek Chubsucker	*Erimyzon oblongus*	F	Native	Baum 1983
Eastern Blacknose Dace	*Rhinichthys atratulus*	F	Native	Baum 1983, Kiraly et. al 2014
Eastern Silvery Minnow	*Hybognathus regius*	F	Introduced	Kiraly et. al 2014
Emerald Shiner	*Notropis atherinoides*	F	Introduced	Baum 1983
Fallfish	*Semotilus corporalis*	F	Native	Baum 1983, Kiraly et. al 2014
Fathead Minnow	*Pimphales promelas*	F	Native	Baum 1983
Finescale Dace	*Phoxinus neogaeus*	F	Native	Baum 1983, Kiraly et. al 2014
Fourspine Stickleback	*Apeltes quadracus*	M,F	Native	Baum 1983
Golden Shiner	*Notemigonus crysoleucas*	F	Native	Baum 1983, Kiraly et. al 2014
Green Sunfish	*Lepomis cyanellus*	F	Introduced	Baum 1983
Lake Trout	*Salvelinus namaycush*	F	Native	Baum 1983
Lake Whitefish	*Coregonus clupeaformis*	F	Native	Baum 1983
Largemouth Bass	*Micropterus salmoides*	F	Introduced	Baum 1983, Kiraly et. al 2014
Longnose Dace	*Rhinichthys cataractae*	F	Native	Baum 1983
Longnose Sucker	*Catostomus catostomus*	F	Native	Baum 1983, Kiraly et. al 2014
Mummichog	*Fundulus heteroclitus*	M,F	Native	Baum 1983, Kiraly et. al 2014
Ninespine Stickleback	*Pungitius pungitius*	M,F	Native	Baum 1983, Kiraly et. al 2014
Northern Pike	*Esox lucius*	F	Introduced	Baum 1983
Northern Redbelly Dace	*Phoxinus eos*	F	Native	Baum 1983, Kiraly et. al 2014
Pearl Dace	*Margariscus margarita*	F	Native	Baum 1983
Pumpkinseed	*Lepomis gibbosus*	F	Native	Baum 1983, Kiraly et. al 2014
Rainbow Smelt	*Osmerus mordax*	D	Native	Baum 1983
Redbreast Sunfish	*Lepomis auritus*	F	Native	Baum 1983, Kiraly et. al 2014
Sea Lamprey	*Petromyzon marinus*	D	Native	Baum 1983, Kiraly et. al 2014
Shortnose Sturgeon	*Acipenser brevirostrum*	D	Native	Baum 1983, Kiraly et. al 2014
Slimy Sculpin	*Cottus cognatus*	F	Native	Baum 1983, Kiraly et. al 2014
Smallmouth Bass	*Micropterus dolomieui*	F	Introduced	Baum 1983, Kiraly et. al 2014
Striped Bass	*Morone saxatilis*	D	Native	Baum 1983, Kiraly et. al 2014
Threespine Stickleback	*Gasterosteus aculeatus*	M,F	Native	Baum 1983, Kiraly et. al 2014
White Perch	*Morone americana*	F	Native	Baum 1983, Kiraly et. al 2014
White Sucker	*Catostomus commersonii*	F	Native	Baum 1983, Kiraly et. al 2014
Yellow Perch	*Perca flavescens*	F	Native	Baum 1983, Kiraly et. al 2014

* D = Diadromous, F= Freshwater, M = Marine

Diadromous species of particular interest within the project area include American eel (*Anguilla rostrata*), sea lamprey (*Petromyzon marinus*) and Atlantic salmon (*Salmo salar*). All three of these species have been observed upstream of Mayo Mill dam, and sea lamprey have been documented spawning within the impoundment (USFWS 2020). Additionally, alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*) and American shad (*Alosa sapidissima*) are the focus of restoration efforts elsewhere within the Penobscot River basin. Though these species are currently excluded from the project area, the Piscataquis River was an important part of the historical ranges of all three of these species and the possibility of their return to this reach in the future remains (MDMR and MDIFW 2008). For the purpose of long-term planning, these species will be included in the list of target species for the project and migration timing, and swimming ability and other passage considerations for all six diadromous species will be evaluated for the alternatives presented. Figure 74 depicts months of the year when these fish species are likely present in the Piscataquis River, and at which life stages.

Eastern brook trout (*Salvelinus fontinalis*) and smallmouth bass are important resident species which provide a sport fishery in the area. Brook trout are stocked in the vicinity of the project area by Maine Department of Inland Fisheries & Wildlife (IFW) in both Dunham Brook and in the Piscataquis River between Mayo Mill Dam and Guilford Dam (MDIFW 2023).

The fishway at Brown's Mill dam includes a barrier which is passable by Atlantic salmon, but other species which do not match the swimming and jumping ability of salmonids are unable to navigate. This barrier is important to the management of the fisheries in the Piscataquis River as it prevents undesirable, non-native species including northern pike and black crappie from expanding their range further upstream, and will remain in place until the conditions laid out are in the Penobscot River Invasive Species Barrier Agreement (MDIFW and MDMR 2009) are reached.

While Atlantic salmon currently utilize habitat within the project area, both upstream and downstream migrations are impeded by dams on the Penobscot and Piscataquis Rivers. Milford Dam (located on the Penobscot River), Brown's Mill Dam, Mayo Mill Dam and Guilford Dam (located on the Piscataquis River 8.4 miles upstream of the project site) are all categorized as potential barriers[10], indicating that they allow passage of some but not all species at some range of flows.

Estimates of upstream passage for Atlantic salmon at Mayo Mill dam, based on data collected from 2002 to 2004, ranged from 66.7 to 85.7 percent success, though it should be noted that the hydroelectric station was operating at that time and that the sample sizes were very small due to the small population size. Survival estimates for downstream migrating smolts, based on data collected from 2010 to 2018, ranged from 96.7 to 99.8 percent survival (NOAA Fisheries 2021).

In addition to creating passage constraints which lead to passage delays and associated delayed mortality, the impoundments formed by these dams reduce potential critical rearing and spawning

[10] U.S. Fish and Wildlife Service and Maine Department of Environmental Protection. Maine Stream Habitat Viewer. https://www.maine.gov/dmr/programs/maine-coastal-program/habitat-restoration-tools/habitat-restoration-and-tools-maine-stream-habitat-viewer. Accessed May 16, 2023.

habitat availability. The impoundments also create habitat conditions that favor invasive species over native fish. Mortality of juvenile salmonids is typically high in impoundments. Water temperatures are generally elevated in these environments, due to increased solar gain and decreased hyporheic exchange. This increases the risk of water temperatures rising above critical thresholds for cold-water species such as salmonids during the warmest parts of the year. Predation by warm-water species such as bass, which flourish in these environments, can also have a large negative effect on salmonid populations in the vicinity of dams.

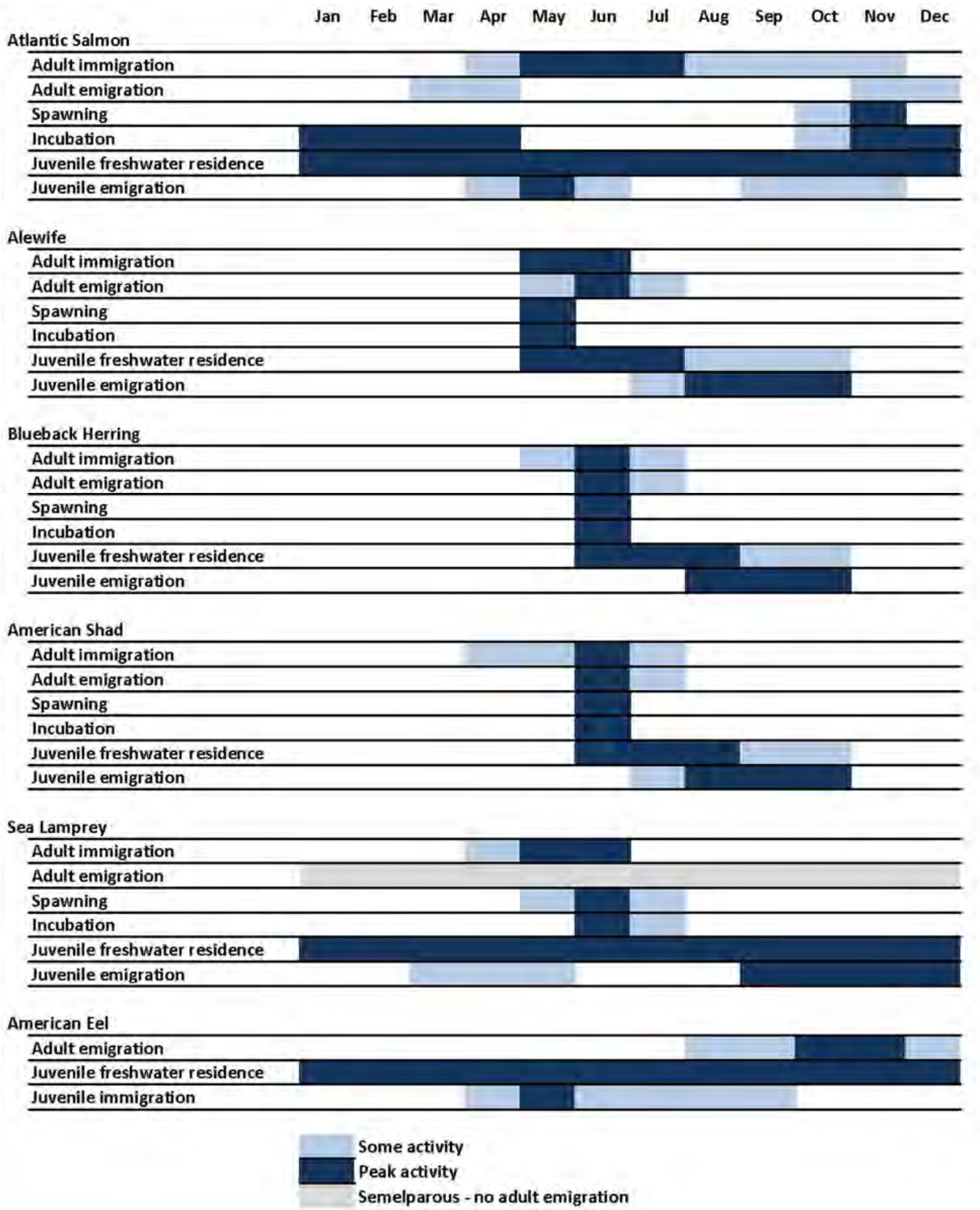

Figure 74. Generalized life history of diadromous fish in the Piscataquis River, Maine, adapted from Saunders et al. (2006), NOAA Fisheries (2023), and MDMR (2023).

Atlantic Salmon

The Gulf of Maine Distinct Population Segment (DPS) of Atlantic salmon was first listed as endangered under the Endangered Species Act (ESA) on November 17, 2000 by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS)[11]. On June 19, 2009 the critical habitat designation for this population was finalized and includes the Piscataquis River within the project area[12]. The recovery plan for the Gulf of Maine DPS (first published in 2005 and updated in 2018; USFWS and NMFS 2018) divides the population into three Salmon Habitat Recovery Units (SHRUs). The project area is within the Penobscot Bay SHRU. The ESA recovery plan lists dams as the top significant threat to the recovery of Atlantic Salmon in Maine. The following paragraphs include a general description of the life history of Atlantic Salmon, however it is important to note that most dams significantly alter these patterns including the impediment of their migratory pathways at all life stages.

Atlantic salmon exhibit an anadromous life history strategy, living a large portion of their lives in the northern Atlantic Ocean after completing a long migration from their natal rivers. After spending one to three years in freshwater and an additional one to three years in the ocean, individuals migrate inland to spawn. The majority of adults spawn only once, though some exhibit iteroparity, meaning that they are capable of repeating this migration and spawning again in subsequent years.

While all individuals within a population follow this general life-history strategy, there is a great deal of variation in the length of time individuals spends in each phase. This diversity is due to both environmental and genetic factors and is the subject of current research.

In the Piscataquis River the adult upstream migration begins in spring, with the number of individuals entering the river per day peaking in June (Fay et al. 2006). Upstream migration drops off in the summer, corresponding to an increase in water temperature though migration can continue to a lesser extent during this period, punctuated by periods of suitable conditions resulting from storm events. A second pulse of individuals enters the river as temperatures drop in the fall.

While residing in the river prior to spawning, adults do not feed, and those that migrate in early spring spend nearly five months in the river before spawning. They seek cool water refuge (e.g., deep pools, springs, and mouths of smaller tributaries) in natal stream reaches during the summer months and await cooler temperatures to spawn (Baum and Quinn, 1993).

After reaching spawning grounds, adult salmon build redds in the streambed in areas with suitable water depth, velocity and substrate. Spawning occurs in late October and November and is closely correlated to water temperatures between 7.2°C – 10.0°C (Fay 2006). After spawning, the majority of individuals, now referred to as kelts, migrate downstream and back to the ocean. This pulse of fish migrates downstream in November and December. Other individuals overwinter in freshwater and

[11] Endangered and Threatened Species; Final Endangered Status for a Distinct Population Segment of Anadromous Atlantic Salmon (*Salmo salar).* 65 FR 223 (November 17, 2000).
[12] Endangered and Threatened Species; Designation of Critical Habitat for Atlantic Salmon (*Salmo salar)* Gulf of Maine Distinct Population Segment*.* 74 FR 2933 (June 19, 2009).

migrate downstream in April and May. This timing trait is associated with individuals likely to repeat the spawning migration (Mobley et al. 2021).

Fertilized eggs remain in the redds throughout the winter and hatch in late March and April. Fry emerge in mid-May and rapidly enter the parr life stage. Most individuals remain in freshwater in the parr stage for two years, though some will emigrate as smolts after one year, and some remain in this freshwater phase rearing for three years (Fay 2006). Based on observations and studies in other rivers, juveniles will typically rear within a few kilometers of the redd that the parr originates from. Additionally, some parr will migrate downstream prior to smoltification, remaining in freshwater lower in the watershed for a period of time prior to being the marine phase of their life history (MDMR 2023).

Migrating smolts travel downstream cued by various factors, and enter the ocean two to three weeks after beginning their migration. This migration period occurs between May and September, at which time the smolts outgrow the upstream habitat and travel downstream for larger substrate. The migration of smolts peaks in early-May and corresponds to rising water temperatures reaching 10.0°C (Kleinschmidt 2015). A summary of Atlantic salmon life history timing in the Piscataquis River is presented in Figure 75 and maps depicting the location of redds surveyed in 2009 and 2011 in the Penobscot and Piscataquis Rivers is presented in Figure 76.

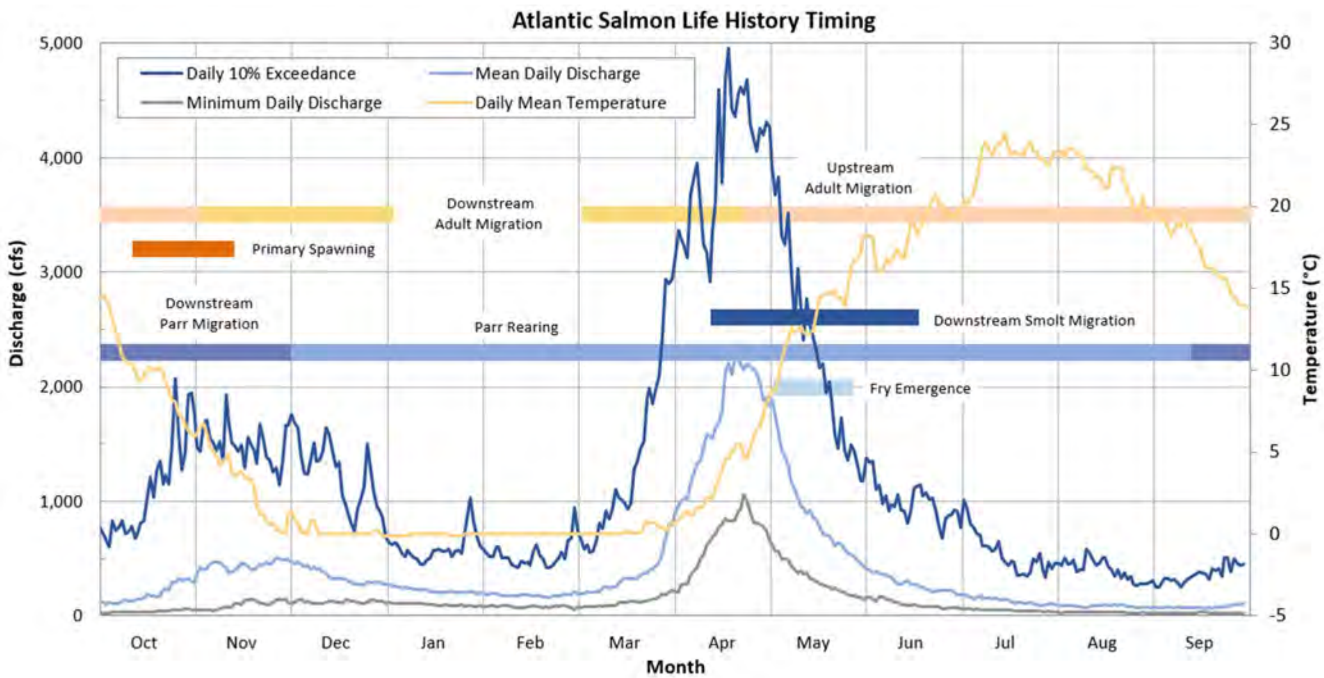

Figure 75. Atlantic salmon life history timing as a function of stream flow and water temperature. Daily flow and temperature statistics at the USGS Gage on the Piscataquis River at Dover Foxcroft (0103150)[13] from January 1902 to present.

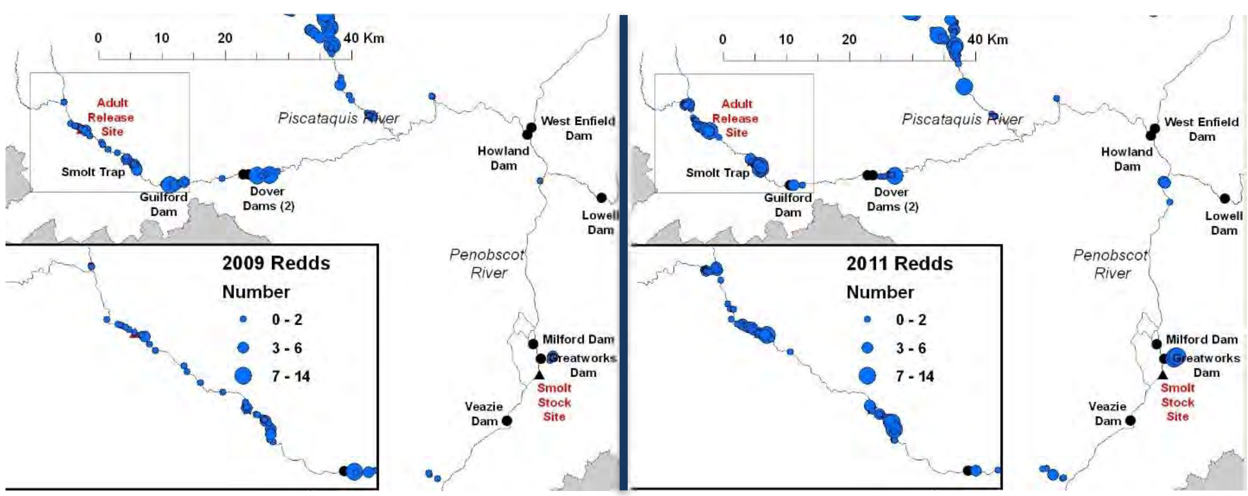

Figure 76. Location of Atlantic salmon redds in the Penobscot and Piscataquis Rivers, as surveyed by Maine Department of Marine Resources (DMR) in 2009 and 2011 (reported in Kleinschmidt 2015).

[13] Surface Water data for USA: USGS Surface-Water Daily Statistics, https://waterdata.usgs.gov/nwis/dvstat?

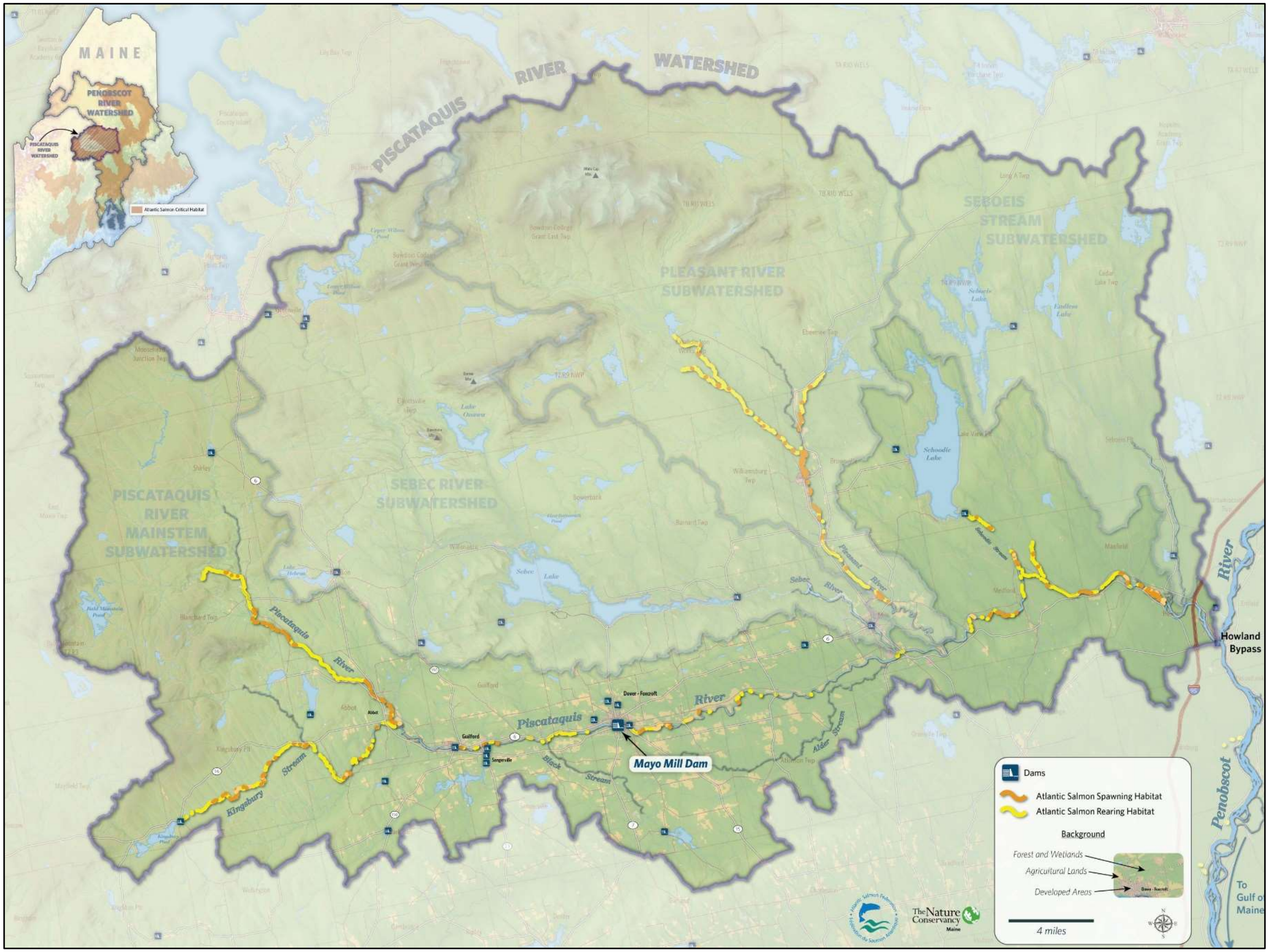

Figure 77. Locations of Atlantic salmon spawning (orange lines) and rearing habitat (yellow lines) mapped by MDMR. Map by TNC and ASF.

9.1.2 Other Aquatic Species of Interest

Freshwater Mussels

Freshwater mussel populations are in decline nationwide due to a range of factors including habitat loss, dredging and sedimentation of aquatic environments, overharvest, and competition from invasive species such as zebra mussels. The cumulative effect of these factors has contributed to dramatic declines in mussel populations, resulting in nearly a quarter of all species currently found in the United States being listed under the Endangered Species Act (Swartz 2007).

Ten species of freshwater mussels exist in Maine. None of these species are federally listed, but three species are listed as threatened under the Maine Endangered Species Act (MESA)[14]. The yellow lampmussel (*Lampsilis cariosa)* and tidewater mucket (*Leptodea ochracea*) were listed under MESA in 1997. The brook floater (*Alasmidonta varicosa*) was added in 2007. None of the listed mussel species has been documented in the mainstem of the Piscataquis River, though both the brook floater and yellow lampmussel have been documented elsewhere in the watershed and tidewater mucket populations have been documented in lakes in Piscataquis County (Nedeau et al. 2000). Surveys of these species have been limited and while their presence has not been documented within the project area, presence of the yellow lampmussel and brook floater is possible.

The preferred habitat of yellow lampmussels include medium to large rivers, though populations can also be found in lakes, ponds and impoundments. Tidewater mucket prefer coastal lakes, ponds and slow-moving rivers including impoundments. Brook floaters reside in moderate gradient rivers and streams of all sizes.

Freshwater mussels play an important role in fluvial and lacustrine environments. As filter-feeders who live in colonies (known as beds), they can have a large impact on water quality, nutrient cycling and the structure of the benthic environment. Dispersal and colonization of new habitats occurs during a parasitic phase of the mussel's life-history, which requires specific fish or amphibian species as hosts. Mussel larvae (known as glochidia) attach to the gills of a host and remain there for a period of time before releasing and burrowing into the stream or lake bed, and remain in that vicinity for the rest of their lives. The health of mussel populations is therefore closely linked to that of their host species.

Six species of freshwater mussels have been documented in the mainstem of the Piscataquis River. A list of these species and their corresponding fish hosts as summarized in the 2020 biological assessment (R2 Resource Consultants 2020) is presented in Table 11. An additional species which is currently present in Maine but not in the Piscataquis basin is the alewife floater (*Anodonta implicata*). The range of this species is expected to increase as the removal of dams opens up additional habitat to its host species (alewives, American shad and blueback herring).

[14] Maine Endangered Species Act (12 M.R.S. §12801 - §12809)

Table 11. Mussel species documented in the mainstem Piscataquis River and their corresponding fish hosts as of September 2023.

Mussel Species		Fish Hosts
Common name	**Scientific name**	
Eastern Pearlshell	*Margaritifera margaritifera*	Brook Trout, Atlantic Salmon, Brown Trout, Rainbow Trout
Triangle Floater	*Alasmidonta undulata*	Common Shiner, Blacknose Dace, Longnose Dace, White Sucker, Pumpkinseed Sunfish, Fallfish, Largemouth Bass, Slimy Sculpin
Creeper	*Strophitus undulatus*	Largemouth Bass, Creek Chub, Fallfish, Fathead Minnow, Golden Shiner, Common Shiner, Slimy Sculpin, Bluegill, Longnose Dace, Yellow Perch
Eastern Floater	*Pyganodon cataracta*	Common Carp, Bluegill, Pumpkinseed, Yellow Perch, Three-Spined Stickleback, White Sucker
Eastern Elliptio	*Elliptio complanata*	Yellow Perch, Banded Killifish, Largemouth Bass
Eastern Lampmussel	*Lampsilis radiata radiata*	Yellow Perch, Largemouth Bass, Smallmouth Bass, Black Crappie, Pumpkinseed Sunfish
Yellow Lampmussel †	*Lampsilis cariosa*	Yellow Perch, White Perch
Brook Floater †	*Alasmidonta varicosa*	Longnose Dace, Blacknose Dace, Golden Shiner, Pumpkinseed Sunfish, Slimy Sculpin, Yellow Perch

† Species not documented in the mainstem of the Piscataquis River, however have been documented in nearby waterbodies and have the potential to be present based on habitat requirements.

9.1.3 Terrestrial species

Northern Long-eared Bat

The northern long-eared bat (*Myotis septentrionalis*) was first listed as threatened under the Endangered Species Act (ESA) on April 2, 2015 by the U.S. Fish and Wildlife Service (USFWS)[15]. This species was reclassified as endangered on November 30, 2022[16], primarily due to the threat of white-nose syndrome which has caused severe declines in the northern long-eared bat populations. Northern long-eared bats are also listed as endangered under Maine's Endangered Species Act (MESA)[17].

In the summer, northern long-eared bats can live alone or in colonies. They roost in trees from early June through July, hiding in crevices, cavities or underneath the bark of both living and dead trees.

[15] Endangered and Threatened Wildlife and Plants; Threatened Species Status for the Northern Long-Eared Bat with 4(d) Rule. 80 FR 17973 (April 2, 2015).
[16] Endangered and Threatened Wildlife and Plants; Endangered Species Status for Northern Long-Eared Bat. 87 FR 73488 (November 30, 2022).
[17] Maine Endangered Species Act (12 M.R.S. §12801 - §12809)

Individuals could be present in trees along the riparian area surrounding the project area during these months.

In the winter these bats seek mines or caves with constant temperatures, high humidity and no air currents in which to hibernate. White-nose syndrome is a fungal disease which has infiltrated the majority of hibernacula used by northern long-eared bats causing mass die-offs during the winter season. This acute threat has been identified in Piscataquis County.

Monarch Butterfly

The Monarch Butterfly (*Danaus plexippus*) is currently listed as a candidate species under review by USFWS, which has no protection under the ESA but is being considered for inclusion. The Monarch Butterfly was identified as a species with the potential to be within the project area, therefore impacts to this species should be minimized to the maximum extent practicable.

9.1.4 Plant Communities

The river corridor in the immediate vicinity of the Mayo Mill dam is occupied by homes and businesses in the downtown area of Dover-Foxcroft. Upstream of the dam, the banks and floodplain adjacent to the impoundment contain areas of riparian forest, meadows and wetlands, as well as adjacent homes and commercial development.

Wetlands

The project site contains a three small (> 2 acre) mapped wetlands adjacent to the river channel. These wetlands are classified as PSS1C/ PSS1E (i.e., palustrine, scrub-shrub, broad-leaved deciduous and either seasonally flooded or saturated) by the NWI[18].

Garber's sedge

A rare herbaceous plant known as Garber's sedge (*Carex garberi)* has been mapped in within the project area, downstream of the Mayo Mill dam[19]. This sedge is a species of special concern in Maine, ranked as S2, or imperiled, by the Maine Natural Areas Program (MNAP 2021). The distribution of this species is limited to seasonally inundated areas along the margins of rivers with either calcareous ledges and or sand/gravel bars as the substrate; and areas associated with the location of riverside seeps Brumback et al. 2021). These conditions often occur downstream of dams, and a majority of the limited number of mapped occurrences in New England occur downstream of dams. These plant communities are also associated with areas impacted by ice scour which prevents the establishment of competing woody vegetation. Changes to flood regimes associated with dams have been linked to a reduction in habitat for Garber's sedge as the moderation of flows reduces instances of vegetation stripping from riverbanks. Removal of dams could negatively affect populations of Garber's sedge currently located downstream of the dam, but could also result in habitat gain in formerly impounded areas.

[18] The National Wetlands Inventory (NWI) - Version 2, Surface Waters and Wetlands Inventory.
[19] Maine Department of Inland Fisheries & Wildlife, Beginning with Habitat. BwH Map Viewer. https://webapps2.cgis-solutions.com/beginningwithhabitat/mapviewer/. Accessed May 16,2023.

10. Recreational Resources

The project area presently offers a variety of recreational access points and opportunities for the public (Figure 1).

10.1 RIVER ACCESS

There are two primary public access points to the river in the impoundment area near the historic downtown. The first access point is from the Town-owned parcel along South Street and Pine Street that includes both a seasonal dock and an MDIFW boat launch, located on either side of the Piscataquis County Chamber of Commerce building. The MDIFW boat launch may have been originally developed for trailer access, but based on current conditions is predominantly suited for hand-carry boat launching. The MDIFW launch access the river in an area known as "The Cove", which has been the setting for several historical vignettes, such as the bathing of the elephants when the circus would come to town.

The second access point is from the Riverfront Park along Moosehead Lane and the parking for the mill complex. The park spans parcels owned by both Mayo Mill Holdings LLC and the Town, and includes a seasonal dock, a short walking trail, stone benches, and park landscaping in the narrow greenspace between the parking area and the river. Further upstream, the public may also periodically access the river from informal access points along the Foxcroft Academy parcel behind the tennis courts, or beneath the Four Seasons Adventure Trail bridge.

Although these access points and assets provide assets to the public and offer selected pedestrian opportunities for walking, scenic viewing, and historical appreciation, the Town hopes to enhance these opportunities in the future, particularly in the downtown area. The Town has been progressing in this way for some time, starting with preparation of the 2003 Downtown Revitalization Plan (WBRC 2003). The revitalization plan included a master plan for the South Street/Pine Street corridor which among other improvements enhanced greenspace and pedestrian connectivity between the boat ramp area and Main Street. Subsequent efforts by the Town in conjunction with Maine DOT seek to further develop the connectivity and gateway along South Street to Main Street and across the river to the Mill and Riverfront Park area. These efforts are described in more detail in the following sections.

10.2 RECREATIONAL USES

Recreational opportunities on the river itself focus primarily on the impoundment area upstream of the dam, although whitewater kayakers are occasionally seen in the river downstream of the Main Street bridge during higher flow conditions in the spring. In addition, the annual Kiwanis Piscataquis River Race runs from Guilford to Dover-Foxcroft each April. The finish line for the race is located at the Foxcroft Academy riverfront near the tennis courts.

The impoundment offers predominantly flatwater paddling opportunities, along with swimming and recreational sport fishing for resident game fish. Each year, MDIFW stocks Eastern brook trout at Brown's Mill and often near the Chamber of Commerce building in late spring, and finds they often disperse by mid-July as temperatures rise and they face predation from smallmouth bass (MDIFW 2023). As temperatures rise in the impoundment through the summer, fish presence reverts to warmwater fish such as bass.

Lastly, in conjunction with the FAA-registered private sea plane base located in the impoundment area, sea planes may periodically use the impoundment for landings and takeoffs, utilizing seasonal docks in three identified potential locations along the river. Seaplane usage is limited to those times when river flow and water levels allow. Anecdotal reports suggest that there are times in the late summer when levels become too low for use by the planes. In recent years, an annual fly-in has occurred Chase Memorial Field airport in Dover-Foxcroft. In conjunction with that event, limited numbers of sea planes have utilized the Riverside sea plane base, transferring to the airport via shuttle.

11. Property Ownership and Land Use Zoning

Patterns in property ownership, land use, and zoning were preliminarily reviewed to provide context to the existing conditions in the study area.

11.1 PROPERTY OWNERSHIP

Property ownership in the study area and along the river includes a mix of private and public ownership (Figure 78). Along South Street from Pine Street to Maine Street, approximately ¾ of the length is publicly owned by the Town and Maine DOT, with the remaining frontage owned by the redemption center. Along the river side of Main Street, with the exception of the Maine DOT corner lot, the parcels are privately held, including the Mill parcel owned by Mayo Mill Holdings, LLC. Moving upstream along the north bank, the parcel containing the dam and powerhouse is owned by the Town, while the Riverfront Park area includes a mix of Town and Mayo Mill Holdings ownership.

Extending further upstream along the north side of the river from Riverview Park, the properties are privately held all of the way to the Four Seasons Adventure Trail, with selected sizable parcels owned by Foxcroft Academy and the Riverview Apartments. Upstream of the trail to the former Waterworks Dam and the head of the impoundment, ownership of the north bank is split between private and public (Town, Dover & Foxcroft Water District). Across the river, the south bank at the Waterworks Dam site falls in Sangerville. The properties along the south bank extending from the municipal boundary (approximately 1,000 feet downstream of the Waterworks Dam) to the Town property at the corner of Pine Street and South Street are all privately owned.

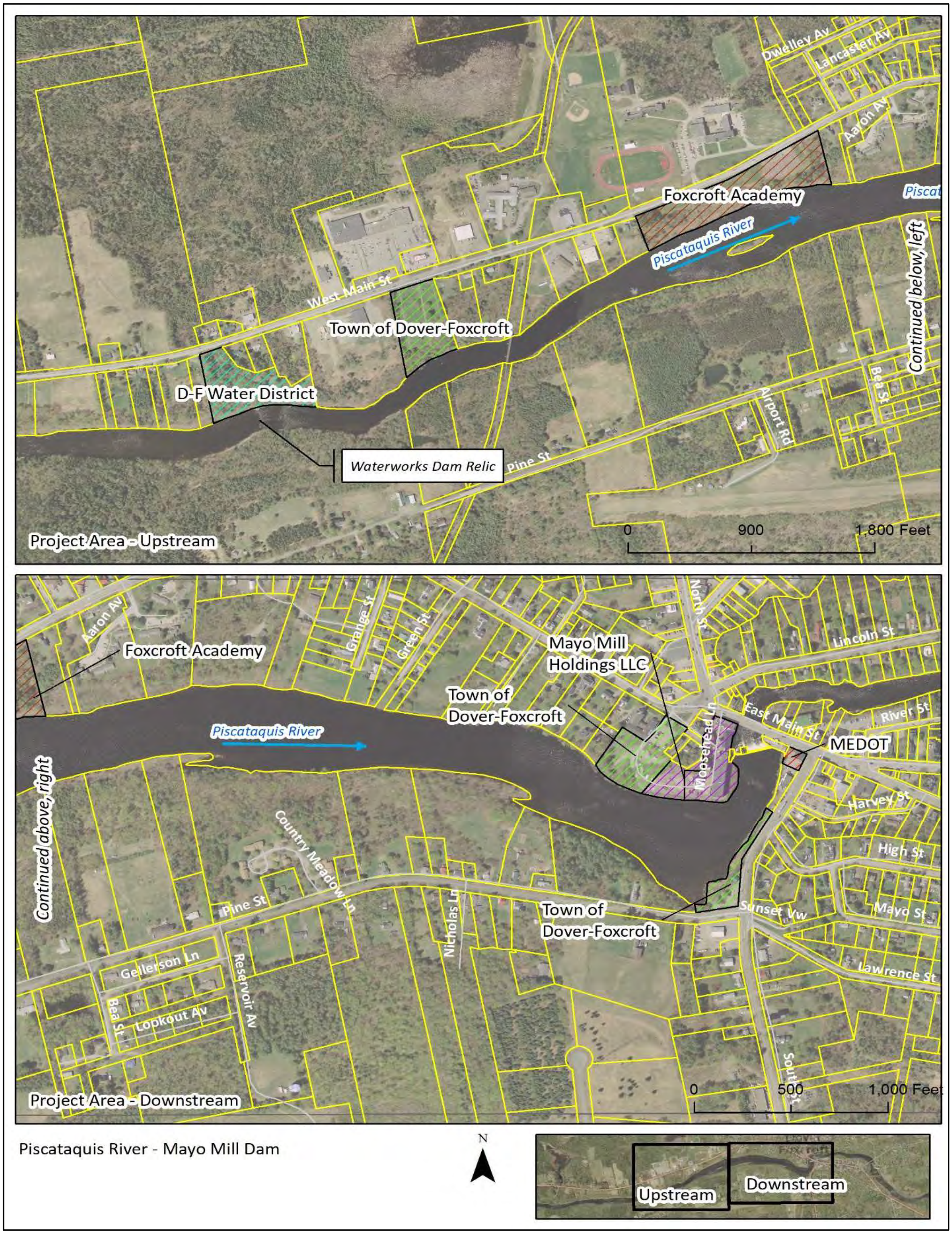

Figure 78. Parcels along the impoundment, with select property owners noted.

11.2 LAND USE AND SHORELAND ZONING

Land use zoning in the study area is defined by the Town's Land Use and Shoreland Ordinances (Figure 79). The majority of the study area falls into the Village and Downtown land use districts, with areas towards the upper end of the impoundment falling into the Commercial and Rural Residential land use districts. A selected portion of the Downtown district also falls into the Historic district, which is an overlay district designed to encourage long-term preservation of properties listed on the National Register of Historic Places found within the district. The Historic district surrounds the national historic districts described in Section 2 of the report. The characteristics of each of the districts is briefly described in **Error! Reference source not found.**.

With respect to the Shoreland Ordinance, the 250-foot buffer on either side of the river falls in the General Development zones in the downtown area and the Limited Commercial zone in the upper impoundment along West Main Street (Figure 79). The middle stretch of the impoundment falls into the Limited Residential zones.

Table 12. General description of designated purposes of Land Use and Shoreland Zoning Districts found in the study area. Descriptions from 2016 Dover-Foxcroft Comprehensive Plan (Town of Dover-Foxcroft 2016) and the Shoreland Zoning Ordinance (Town of Dover-Foxcroft 2019).

Zone	Description
Land Use Ordinance Districts	
Village	Provide area for future growth; provide for expansion of limited commercial uses, high-density residential uses.
Downtown	Include existing commercial development while providing for expansion of commercial uses.
Commercial	Encourage development of commercial uses.
Rural Residential	Encompass existing residential while maintaining rural character, protecting agriculture and forestry, provide open spaces, provide for residential growth, encourage medium-density development.
Shoreland Zone Ordinance Districts	
General Development	Areas devoted to intensive commercial, industrial or recreational activities, or a mix of such activities
Limited Commercial	Areas of mixed, light commercial and residential uses, which should not be developed as intensively as the General Development Districts
Limited Residential	Areas suitable for residential and recreational development, including areas other than those in the Resource Protection District or Stream Protection District, and areas which are used less intensively than those in the Limited Commercial District or the General Development Districts.

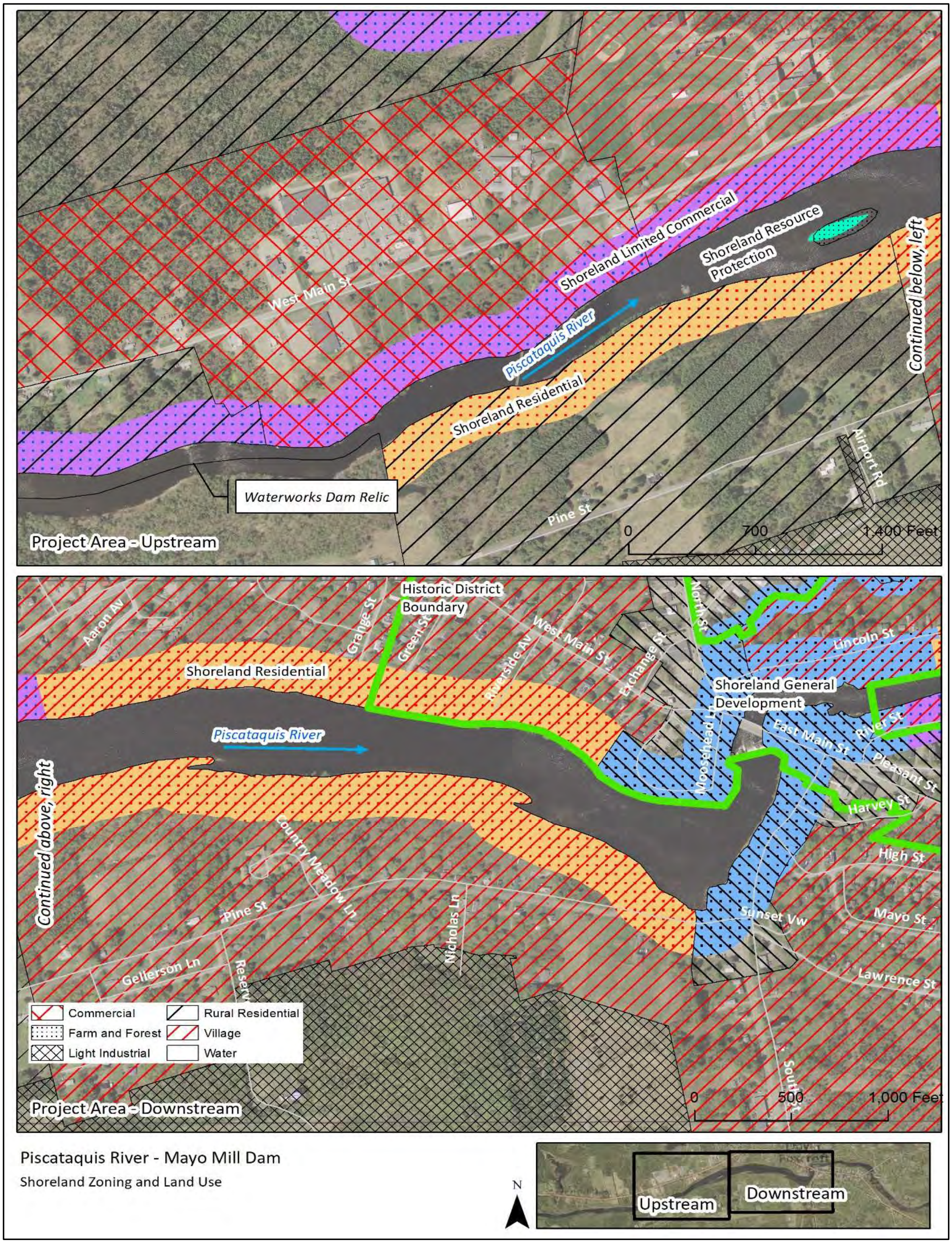

Figure 79. Land Use and Shoreland Zone districts. The Historic District overlay is shown with the heavy green boundary.

11.3 FLOODPLAIN MANAGEMENT ORDINANCE, RESOURCE PROTECTION, AND DESIGNATED CRITICAL HABITAT

In addition to the community zoning considerations described above, two additional designations have special relevance to the river. Dover-Foxcroft participates in the federal flood insurance program, which requires a Town Floodplain Management Ordinance. The ordinance allows landowners in FEMA-mapped 100-year floodplain to obtain federal flood insurance. A permit is required for any construction or other development within the designated flood area. Although development in the floodplain is discouraged and closely regulated, if permitted, must follow certain development standards (Town of Dover-Foxcroft 2016).

Lastly, the Piscataquis River through the study area is protected by the federal Clean Water Act and Maine's Natural Resource Protection Act. The river is also protected as Designated Critical Habitat for Atlantic Salmon, listed as endangered under the federal Endangered Species Act. Development activities or modifications within the river are closely regulated, and will require consultation under the Endangered Species Act.

12. Concurrent Community Planning and Revitalization Initiatives

The Town of Dover-Foxcroft has been proactively pursuing downtown revitalization adjacent to and within the study area for two decades. This commenced with the 2003 Downtown Revitalization Plan (WBRC 2003). The Revitalization Plan was the result of a community-based process that established core initiatives and visioning that highlight potential enhancement of the gateway to the community along South Street, and connectivity along the river in the historical downtown area (Figure 80).

After the Town acquired the Mayo Mill in 2007 following its closure, a community-visioning process put in place the groundwork that facilitated the mill redevelopment. Accomplished through a community-supported private-public partnership, the modified mill complex supports mixed use with innovative energy sources, the first of its kind in the region. The Mayo Mill now is an economic hub for several businesses including a boutique hotel and a café, and is also home for many community members with 22 residential apartments, and a data center – the routing hub for newly expanded broadband internet access in this part of rural Maine. The redevelopment has led to a resurgence of vitality into the downtown and is a testament to the community's ability to create and execute a vision.

Community planning for further revitalization has continued through completion of the 2016 Comprehensive Plan (Town of Dover-Foxcroft 2016) and the 2020 Urban Area Transportation Study (Gorrill Palmer 2020) in partnership with Maine DOT. These efforts have led to the current range of ongoing revitalization initiatives, which include revitalization of Monument Square and Union Square, the historical town centers for Foxcroft and Dover, respectively. Concurrent with and supporting these planning efforts, the Town's Climate Action Advisory Committee is evaluating and developing recommendations to support community resiliency in the face of changing climate.

At the same time, Maine DOT (2023) has initiated engineering studies and design activities for replacement of the East Main Street bridge and the Essex Street bridge (located 3,000 feet downstream). Lastly, the Town has recently commenced another partnership with Maine DOT for a Villages planning and revitalization project, which is designed to tie together all of these ongoing and concurrent initiatives. All of these activities provide an unequivocal opportunity for the long-term planning and management for Mayo Mill Dam and the Piscataquis River to both support and also leverage the support of the Town's initiative and motivation to result in a revitalized, resilient, and sustainable community landscape for the future.

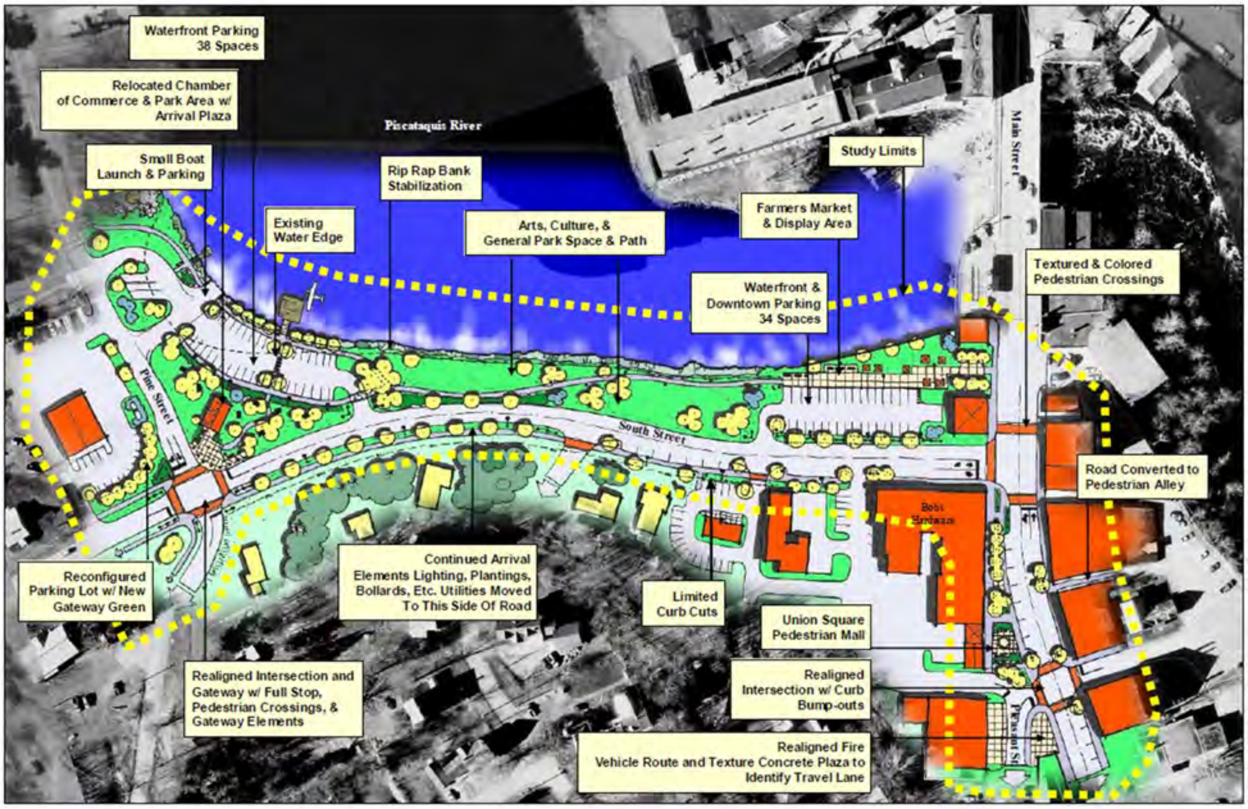

Figure 80. 2003 Dover-Foxcroft Downtown Revitalization Phase I Master Plan (WBRC 2003).

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Wenger, S. J., C. H. Luce, A. F. Hamlet, D. J. Isaak, and H. M. Neville (2010), Macroscale hydrologic modeling of ecologically relevant flow metrics, Water Resour. Res., 46, W09513, doi:10.1029/2009WR008839.

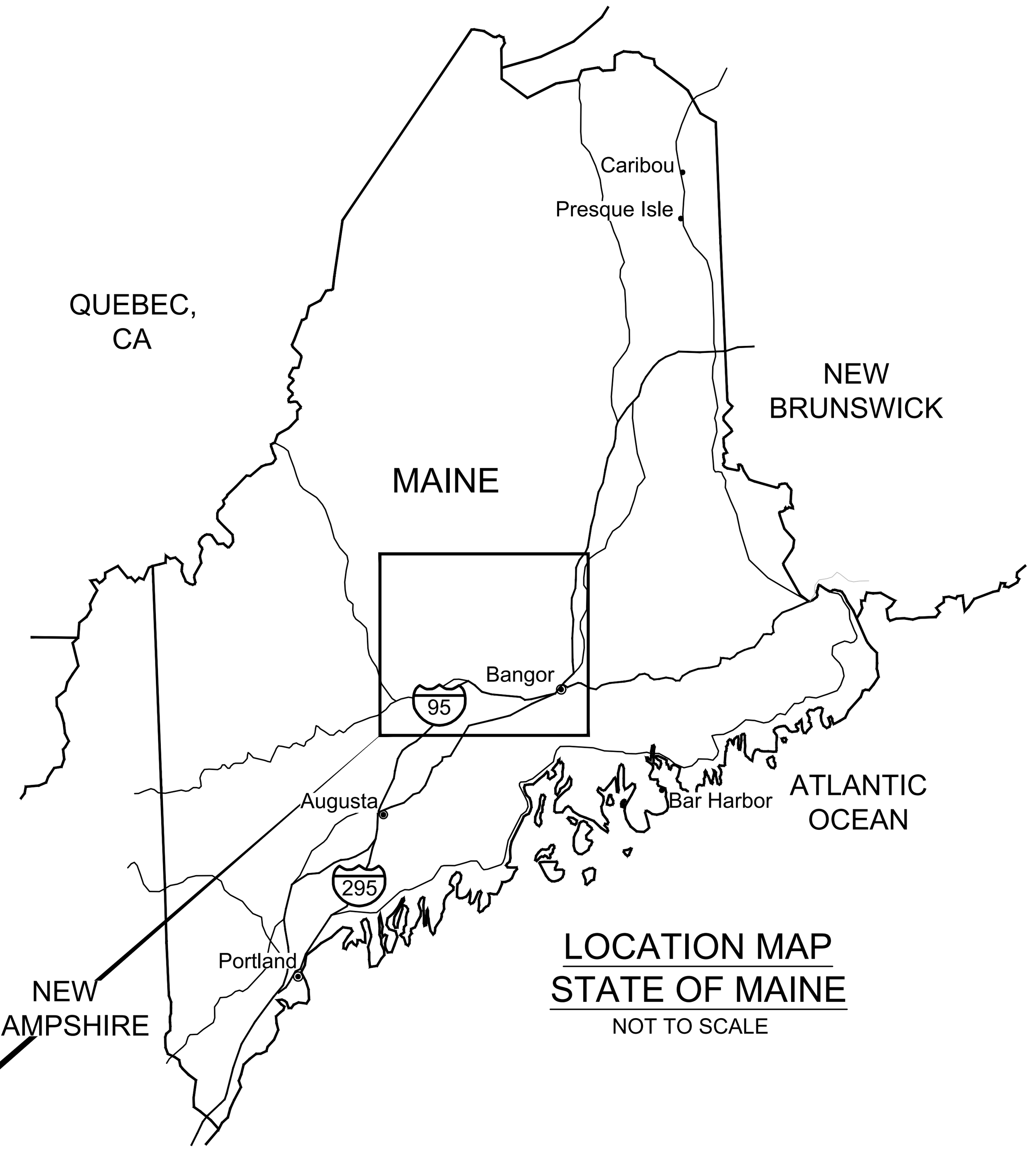
Appendix A - Project Basemap

MAYO MILL DAM FEASIBILITY STUDY

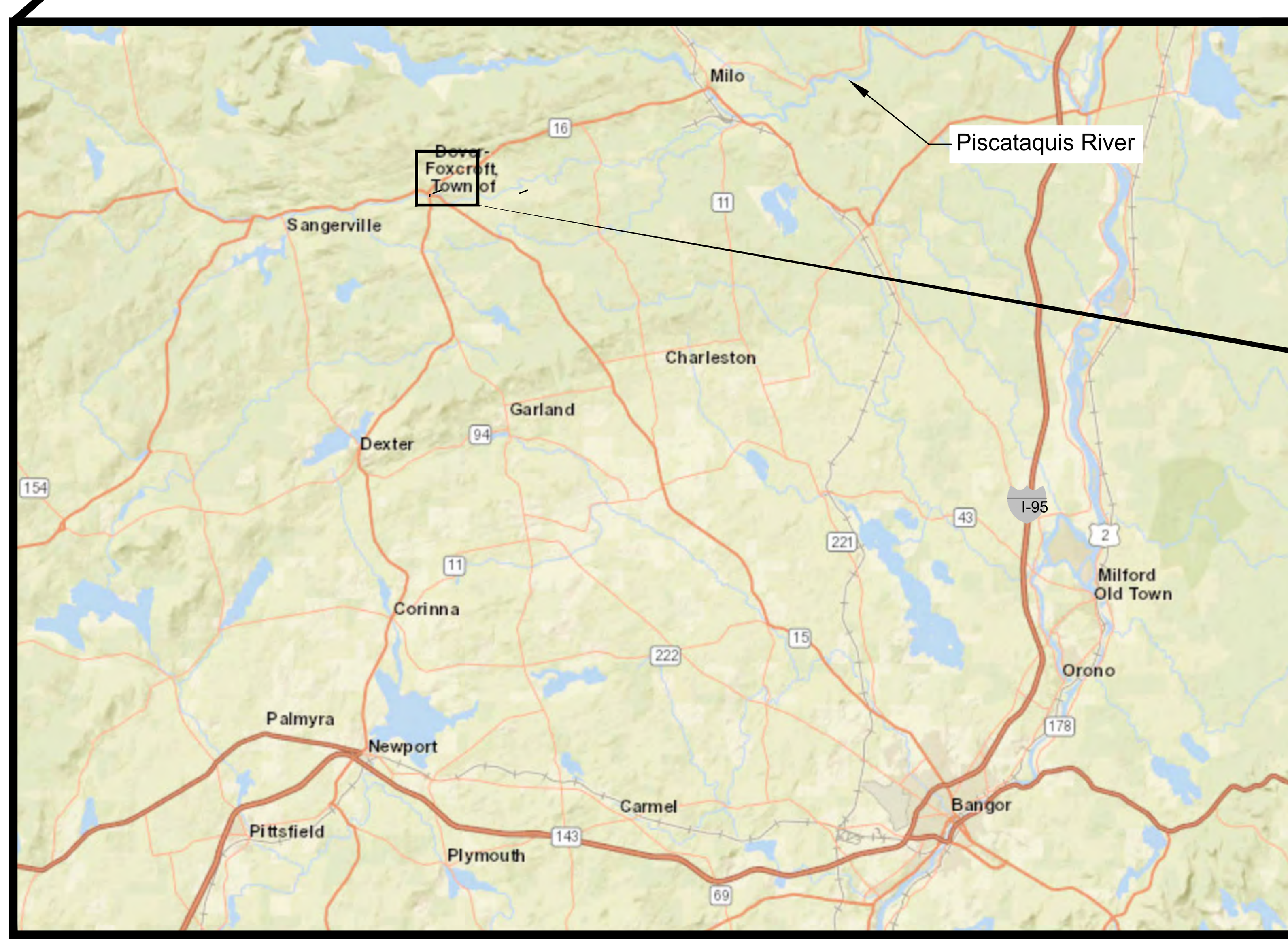
PISCATAQUIS RIVER, DOVER-FOXCROFT, ME

PROJECT BASEMAP

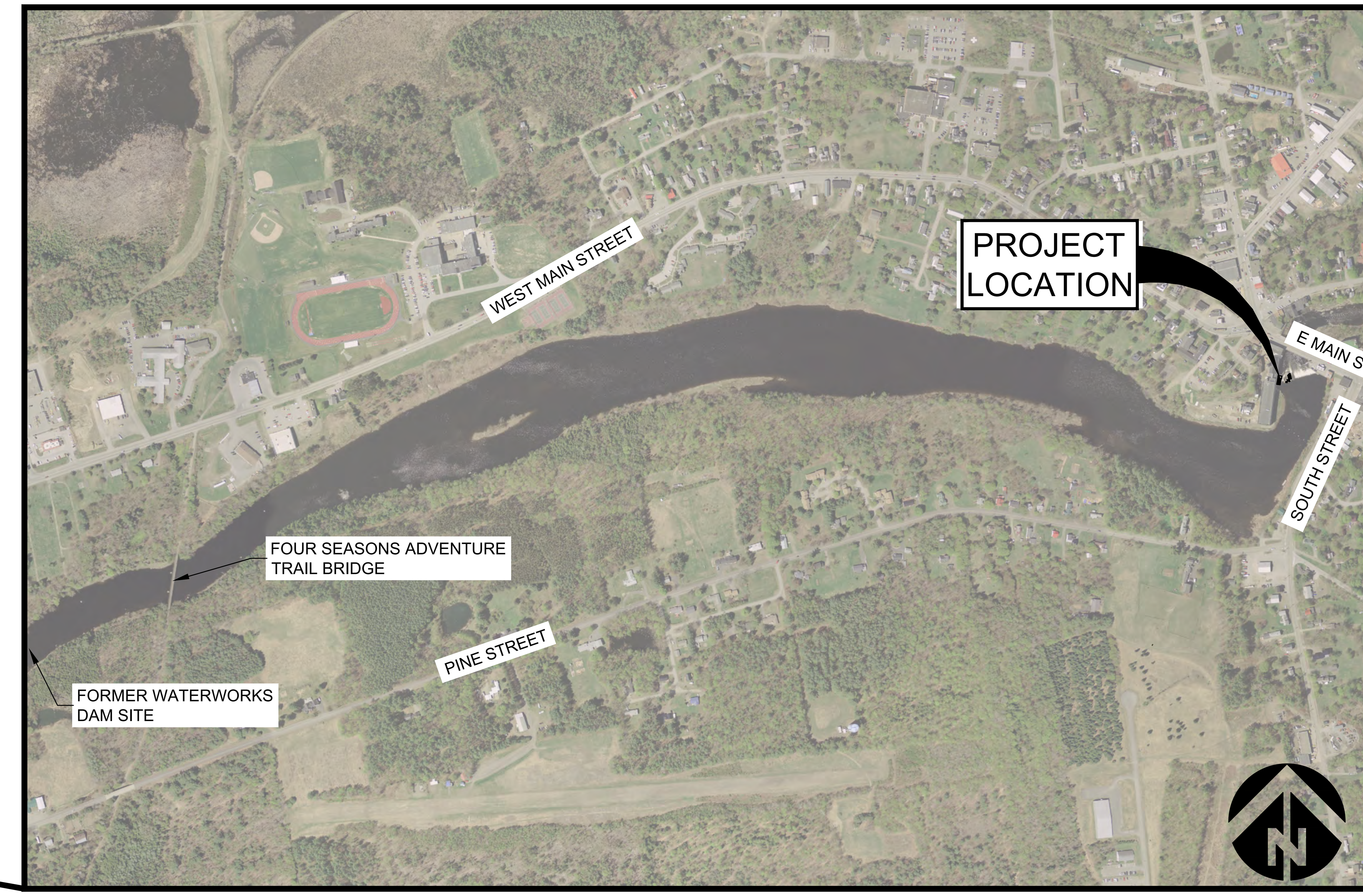
October 2023



LOCATION MAP
STATE OF MAINE
NOT TO SCALE



VICINITY MAP
1" = 30,000'



SITE MAP
1" = 500'

SHEET LIST:

1 - COVER SHEET, LOCATION MAP AND SHEET INDEX
2 - PLAN OVERVIEW & SURVEY CONTROL
3 - EXISTING CONDITIONS (1 OF 4)
4 - EXISTING CONDITIONS (2A OF 4) WITH AERIAL PHOTO
5 - EXISTING CONDITIONS (2B OF 4) WITHOUT AERIAL PHOTO
6 - EXISTING CONDITIONS (3 OF 4)
7 - EXISTING CONDITIONS (4 OF 4)

COORDINATES:
LATITUDE N45° 11' 14"
LONGITUDE W69° 13' 54"
DOVER-FOXCROFT, PISCATAQUIS COUNTY, MAINE

WATERBODY: PISCATAQUIS RIVER
TRIBUTARY OF: PENOBSCOT RIVER

NO.	BY	DATE	REVISION DESCRIPTION

KD	MYS	MB
DRAWN	DESIGNED	CHECKED
----	10-31-23	22-05-26
APPROVED	DATE	PROJECT

MAYO MILL FEASIBILITY STUDY
ATLANTIC SALMON FEDERATION
TOWN OF DOVER-FOXCROFT, ME

inter-fluve

265 Main Street, Suite 2 B
PO Box 236
Damariscotta, ME 04543
207.315.7014
www.interfluve.com

COVER SHEET, LOCATION MAP AND SHEET INDEX

SHEET
1 OF 7

NOTES:

1. HORIZONTAL COORDINATES ARE REFERENCED TO MAINE STATE PLANE, EAST ZONE, NAD 83, US SURVEY FEET. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM 1988 (NAVD88), UNITS OF FEET.
2. BATHYMETRIC SURVEY BY INTER-FLUVE NOVEMBER 2022. BATHYMETRIC CONTOURS SHOULD BE CONSIDERED APPROXIMATE.
3. SELECTED TOPOGRAPHIC SURVEY OF NEAR SHORE DAM AREA AND SELECTED FEATURES BY INTER-FLUVE IN NOVEMBER 2022. TOPOGRAPHY AND FEATURE SURVEY IN DAM, SPILLWAY AND SURROUNDING AREA SUPPLEMENTED BY SURVEY AND STRUCTURE FROM MOTION PHOTOGRAMETRY COURTESY OF WEBBER SURVEYING, COLLECTED SEPTEMBER, 2019. TOPOGRAPHIC SURVEY OF MONUMENT SQUARE AND MOOSEHEAD LANE AREAS SUPPLEMENTED BY SURVEY COURTESY OF PLYMOUTH ENGINEERING, COLLECTED BY PERRY LAND SURVEYING IN DECEMBER 2021 AND JUNE 2022.
4. LIDAR DATA OBTAINED FROM USGS VIA MAINE GIS, COLLECTED IN 2015, PROVIDES SUPPLEMENTAL TOPOGRAPHY OUTSIDE THE LIMITS OF THE TOPOGRAPHIC AND BATHYMETRIC SURVEY.
5. FERC PROJECT BOUNDARY PER NATEL 2020. PARCEL LINES, LAND USE BOUNDARIES AND HISTORIC DISTRICT BASED ON PUBLIC SOURCE GIS DATA COURTESY OF LATLONG LOGIC. SEWER AND WATER SUPPLY ALIGNMENTS AND FEATURES COURTESY OF DIRIGO ENGINEERING. ALL OTHER BOUNDARIES AND FEATURES BASED ON STATE OF MAINE GIS MAINE DATABASE OR RELEVANT RESOURCE AGENCY ONLINE SOURCES.
6. PISCATAQUIS RIVER IS FEDERALLY DESIGNATED CRITICAL HABITAT FOR ENDANGERED ATLANTIC SALMON

LEGEND

- EXISTING 1 FT. CONTOUR
- EXISTING 5 FT. CONTOUR
- PARCELS
- RIVER/STREAM
- LAND USE-VILLAGE
- LAND USE-DOWNTOWN
- LAND USE-LIGHT INDUSTRIAL
- LAND USE-RURAL RESIDENTIAL
- LAND USE-COMMERCIAL
- HISTORIC DISTRICT
- OWL — ORDINARY WATER LEVEL
- 100YR — FEMA ZONE AE BOUNDARY
- NATIONAL WETLANDS INVENTORY
- CONSERVED LANDS
- 250 FOOT RIPARIAN BUFFER

0 600 1200

SCALE IN FEET

(AS SHOWN ON 22" X 34" SHEET)

SURVEY CONTROL:

CONTROL	DESCRIPTION	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
101.00	CAPPED REBAR	791823.55	554175.59	377.90
102.00	CAPPED REBAR	795536.90	553615.85	348.44
103.00	MANHOLE	795482.17	553722.00	350.63
104.00	CAPPED REBAR	791970.67	554305.62	377.02
105.00	CAPPED REBAR	796741.38	554069.68	371.48
106.00	NAIL	796652.11	554044.96	368.81
107.00	NAIL	796051.90	553962.65	356.39
108.00	NAIL	796087.52	554000.81	355.81
109.00	NAIL	796115.29	553999.20	356.39

NO.	BY	DATE	REVISION DESCRIPTION

KD	MYS	MB
DRAWN	DESIGNED	CHECKED
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APPROVED	DATE	PROJECT

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PLAN OVERVIEW & SURVEY CONTROL

NOTES:

1. NATIONAL WETLANDS INVENTORY DATA OBTAINED FROM US FISH AND WILDLIFE SERVICE. SOURCE DATA RESOLUTION IS LOW AND LOCATIONS ARE APPROXIMATE.
2. FEMA ZONE AE OBTAINED FROM GEOREFERENCED FIRM MAPS WITH DIGITIZED HAZARD BOUNDARIES IMPORTED INTO THE THE BASEMAP FILE. HAZARD EXTENTS ARE APPROXIMATE.
3. PISCATAQUIS RIVER IS FEDERALLY DESIGNATED CRITICAL HABITAT FOR ENDANGERED ATLANTIC SALMON

LEGEND

- EXISTING 1 FT. CONTOUR
- EXISTING 5 FT. CONTOUR
- PARCELS
- SEWER LINE WITH MANHOLE
- TOWN WATER LINE
- RIVER/STREAM
- ORDINARY WATER LEVEL
- FEMA ZONE AE BOUNDARY
- NATIONAL WETLANDS INVENTORY
- CONSERVED LANDS
- 250 FOOT RIPARIAN BUFFER

0 200 400

SCALE IN FEET

(AS SHOWN ON 22" X 34" SHEET)

NO.	BY	DATE	REVISION DESCRIPTION

KD	MYS	MB
DRAWN	DESIGNED	CHECKED
----	10-31-23	22-05-26
APPROVED	DATE	PROJECT

MAYO MILL FEASIBILITY STUDY
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EXISTING CONDITIONS (1 OF 4)

SHEET
3 OF 7

NOTES:

1. PISCATAQUIS RIVER IS FEDERALLY DESIGNATED CRITICAL HABITAT FOR ENDANGERED ATLANTIC SALMON.
2. FEMA ZONE AE OBTAINED FROM GEOREFERENCED FIRM MAPS WITH DIGITIZED HAZARD BOUNDARIES IMPORTED INTO THE THE BASEMAP FILE. HAZARD EXTENTS ARE APPROXIMATE.

LEGEND

- EXISTING 1 FT. CONTOUR
- EXISTING 5 FT. CONTOUR
- PARCELS
- SEWER LINE WITH MANHOLE
- WATER LINE
- ORDINARY WATER LEVEL
- RIVER/STREAM
- FERC PROJECT BOUNDARY
- FEMA ZONE AE BOUNDARY

0 60 120

SCALE IN FEET

(AS SHOWN ON 22" X 34" SHEET)

NO.	BY	DATE	REVISION DESCRIPTION

KD	MYS	MB
DRAWN	DESIGNED	CHECKED
----	10-31-23	22-05-26
APPROVED	DATE	PROJECT

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EXISTING CONDITIONS (2A OF 4) WITH AERIAL PHOTO

LEGEND

- EXISTING 1 FT. CONTOUR
- EXISTING 5 FT. CONTOUR
- PARCELS
- SEWER LINE WITH MANHOLE
- WATER LINE
- ORDINARY WATER LEVEL
- RIVER/STREAM
- FERC PROJECT BOUNDARY
- FEMA ZONE AE BOUNDARY

0 60 120

SCALE IN FEET

(AS SHOWN ON 22" X 34" SHEET)

NOTES:

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EXISTING CONDITIONS (2B OF 4)
WITHOUT AERIAL PHOTO

NOTES:

1. NATIONAL WETLANDS INVENTORY DATA OBTAINED FROM US FISH AND WILDLIFE SERVICE. SOURCE DATA RESOLUTION IS LOW AND LOCATIONS ARE APPROXIMATE.
2. FEMA ZONE AE OBTAINED FROM GEOREFERENCED FIRM MAPS WITH DIGITIZED HAZARD BOUNDARIES IMPORTED INTO THE THE BASEMAP FILE. HAZARD EXTENTS ARE APPROXIMATE.
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LEGEND

- EXISTING 1 FT. CONTOUR
- EXISTING 5 FT. CONTOUR
- PARCELS
- SEWER LINE WITH MANHOLE
- WATER LINE
- ORDINARY WATER LEVEL
- FEMA ZONE AE BOUNDARY
- NATIONAL WETLANDS INVENTORY
- 250 FOOT RIPARIAN BOUNDARY

0 200 400

SCALE IN FEET

(AS SHOWN ON 22" X 34" SHEET)

NO.	BY	DATE	REVISION DESCRIPTION

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DRAWN	DESIGNED	CHECKED
----	10-31-23	22-05-26
APPROVED	DATE	PROJECT

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EXISTING CONDITIONS (3 OF 4)

SHEET
6 OF 7

NOTES:

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3. PISCATAQUIS RIVER IS FEDERALLY DESIGNATED CRITICAL HABITAT FOR ENDANGERED ATLANTIC SALMON

LEGEND

- EXISTING 1 FT. CONTOUR
- EXISTING 5 FT. CONTOUR
- PARCELS
- SEWER LINE WITH MANHOLE
- WATER LINE
- ORDINARY WATER LEVEL
- FEMA ZONE AE BOUNDARY
- CONSERVED LANDS
- 250 FOOT RIPARIAN BOUNDARY

0 200 400

SCALE IN FEET

(AS SHOWN ON 22" X 34" SHEET)

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EXISTING CONDITIONS (4 OF 4)

Appendix B - Dam/Powerhouse Inspection and Dam Stability Analysis (Gomez and Sullivan Engineers, 2023)

MOOSEHEAD HYDROELECTRIC PROJECT

DAM/POWERHOUSE INSPECTION AND DAM STABILITY ANALYSIS

Piscataquis River, Maine

OCTOBER 2023

Prepared for

Atlantic Salmon Federation

14 Maine St., Ste. 202A
Brunswick, ME 04011

Town of Dover-Foxcroft

48 Morton Ave Suite A
Dover-Foxcroft, ME 04426

Prepared by

GOMEZ AND SULLIVAN ENGINEERS

41 Liberty Hill Road
Henniker, NH 03242

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ASF	Atlantic Salmon Federation
cfs	cubic feet per second
DSSMP	Dam Safety and Surveillance Monitoring Plan
DSSMR	Dam Safety and Surveillance Monitoring Report
FERC	Federal Energy Regulatory Commission
GSE	Gomez and Sullivan Engineers, DPC
NID	National Inventory of Dams
OPCC	Opinion of Probable Construction Cost
pcf	Pounds per cubic foot
PGA	Peak ground acceleration
Project	Moosehead Hydroelectric Project
psi	Pounds per square inch
PSP	Public Safety Plan
SHPO	State Historic Preservation Office
TNC	The Nature Conservancy
Town	Town of Dover-Foxcroft, ME

1.0 Introduction

The Moosehead Hydroelectric Project (Project) is owned and operated by the Town of Dover-Foxcroft, Maine (Town). The Project is licensed with the Federal Energy Regulatory Commission (FERC) and received an exemption from licensing in 1982. The Project consists of a dam, upstream fish passage facility, and powerhouse with inoperable hydroelectric equipment. The Project has not produced hydroelectric power since 2008.

On December 30, 2022, the Town notified FERC that it had partnered with the Atlantic Salmon Federation (ASF) and The Nature Conservancy (TNC) to develop a plan for revitalization of the Project. The Town indicated that it would evaluate hydro and non-hydro concepts to meet the needs of the community and environment. On February 7, 2023, FERC approved the proposal. FERC also indicated that by December 31, 2023, the Town must file an application to surrender the Project or an application requesting an amendment to the exemption.

To help inform the Town on whether to surrender the Project or file an application to amend the exemption, Gomez and Sullivan Engineers, D.P.C (GSE) was contracted by Inter-Fluve to conduct an inspection of the dam and powerhouse structure and to conduct a stability analysis of the dam. Inter-Fluve leads a technical consulting team contracted by ASF, who in turn has a Town-signed agreement to perform the Mayo Mill Dam Feasibility Study on behalf of the Town. The feasibility study is funded by NOAA Fisheries.

Should the Town opt to surrender the Project, it also sought an evaluation of the dam to determine whether to retain or remove it. This report summarizes the findings of our inspections and stability analysis.

Any figures appear at the end of each section.

2.0 Dam and Powerhouse Inspection- Structural Deficiencies

2.1 FERC Dam Inspection

On August 3, 2023, FERC Dam Safety personnel conducted an inspection of the dam and on August 30, 2023, it sent the Town its Dam Safety Inspection Report (see **Appendix A**). **Figure 2.1-1** is a plan map of the dam showing the specific areas of concern as raised by FERC or GSE in their inspections. FERC identified the following major issues in its inspection (verbatim):

- A section of the powerhouse roof collapsed. Include a plan and schedule to replace the roof.
- Significant concrete deterioration was noted at the upstream face and left wall of the sluicegate structure and upstream face of the fish passage structure. Additionally, concrete deterioration has progressed at the left and right log sluice walls, and seepage through the walls was evident. You must repair these structures.
- Repair of the masonry at the substructure of the powerhouse was previously requested by our October 12, 2018 letter. This area must still be repaired.
- The projects' Public Safety Plan (PSP) dated May 20, 1993, is over 30 years old. You must re-evaluate the project's public safety features and submit an updated PSP.
- A Dam Safety Surveillance Monitoring Plan (DSSMP) and a Dam Safety Surveillance Monitoring Report (DSSMR) have not yet been submitted for the project.

The DSSMP provides details on how the Town will monitor and evaluate performance of the dam. The DSSMR is a separate report, filed annually with FERC, that presents an analysis, evaluation, and interpretation of the dam safety surveillance and monitoring data and provides findings on the overall performance of the dam. The PSP and DSSMP are living documents and should be updated if there are changes at the Project. Note that on September 29, 2023, the Town filed a letter with FERC requesting an extension of time until March 31, 2024 to address the above issues, with the exception of the PSP, which it would complete before December 31, 2023.

2.2 Gomez and Sullivan Dam and Powerhouse Building Inspection

On August 24, 2023, GSE conducted a site inspection of the dam and a structural inspection of the powerhouse building. The inspection of the dam revealed similar observations as FERC. However, GSE observed the following additional deficiencies:

- Seepage through the right abutment.
- Loss of approximately 10 feet of the concrete apron below the right side of the dam.
- Erosion of bedrock along the toe of the dam of up to 9 feet, but no significant undercutting.
- Loss of caulking/sealant in the joints between concrete monoliths.
- On the left abutment wall, which also serves as the powerhouse foundation wall, individual stones were missing.

The inspection of the powerhouse building revealed the following deficiencies:

- A section of the powerhouse roof collapsed.
- Roof slab and beams are spalling in several areas exposing corroded rebar.
- Steel I-beams supporting the generator floor have varying degrees of web and flange corrosion.

- Generator floor timber beam has marginal end support.
- Individual wood planks are missing from the turbine floor and some planks show signs of rot.
- Vertical guides (I-Beams) for the upstream bulkhead have significant corrosion of the web and flanges.
- Joints in the stone foundation wall show signs of deterioration and mortar loss.
- Joint seepage was observed through the left and right stone masonry foundation walls, at the upstream end of the powerhouse.

Based on the inspection, remedial measures are needed to address the dam deficiencies and an Opinion of Probable Construction Costs was developed as discussed in Section 4.0 Economics. GSE also developed a potential schedule to address the deficiencies as shown in Table 2.2-1. It should be noted that any updates to the powerhouse would also need to be reviewed for compliance by the Maine State Historic Preservation Office (SHPO), since it is included in the American Woolens/Mayo Mill National Historic District.

Table 2.2-1. Recommended Schedule for Addressing Dam and Powerhouse Structural Deficiencies

Structural Deficiency	< 1 yr	1-3 yrs	3-5 yrs	5-7 yrs
Dam				
Left Abutment Wall- Shore existing building structure from building interior as necessary	x			
Left Abutment Wall- Fill voids with reinforced concrete		x		
Right Abutment Seepage- place new concreate to fill voids, and pressure grout, as required			x	
Concrete Apron- Drill and grout rebar into existing concrete and place new concrete to the original lines			x	
Erosion of Bedrock below Dam- Place concrete and/or heavy riprap to fill void			x	
Concrete Deterioration of Log Sluice Left and Right Walls- Remove all soft and deteriorated concrete. Drill and grout rebars into existing concrete. Place new concrete to the original lines.			x	
Upstream Face of Dam and Left Sluice gate Structure Wall- Remove all soft and deteriorated concrete. Drill and grout rebars into existing concrete. Place new concrete to the original lines.			x	
Concrete Surface Erosion, Crest and Downstream Face of Spillway- Remove any soft or unsound concrete. Drill and grout rebars into existing concrete. Place new concrete to the original lines.				x
Powerhouse Building				
Roof- Shore structure as required. Make roof watertight with tarps or similar to prevent additional damage.	x			
Generator Floor- Provide positive support for timber floor beam on upstream end of Powerhouse	x			
Turbine Floor Deck- Replace missing and damaged floor planks, or close-off area to prevent access	x			
Roof- Repair roof structure and install new roofing system		x		
Stone Wall Foundations- Pressure grout areas of walls with seepage, or place concrete on exterior face of walls. Repoint the walls.		x		
Corroded Structural Steel Framing- Reinforce existing framing if possible or replace individual members.			x	
Spalled Concrete Roof Deck and Beams- Remove deteriorated concrete. Splice-in new reinforcing to make up lost area of steel due to corrosion. Patch with structural epoxy with minimum compressive strength of 4,500 psi.			x	

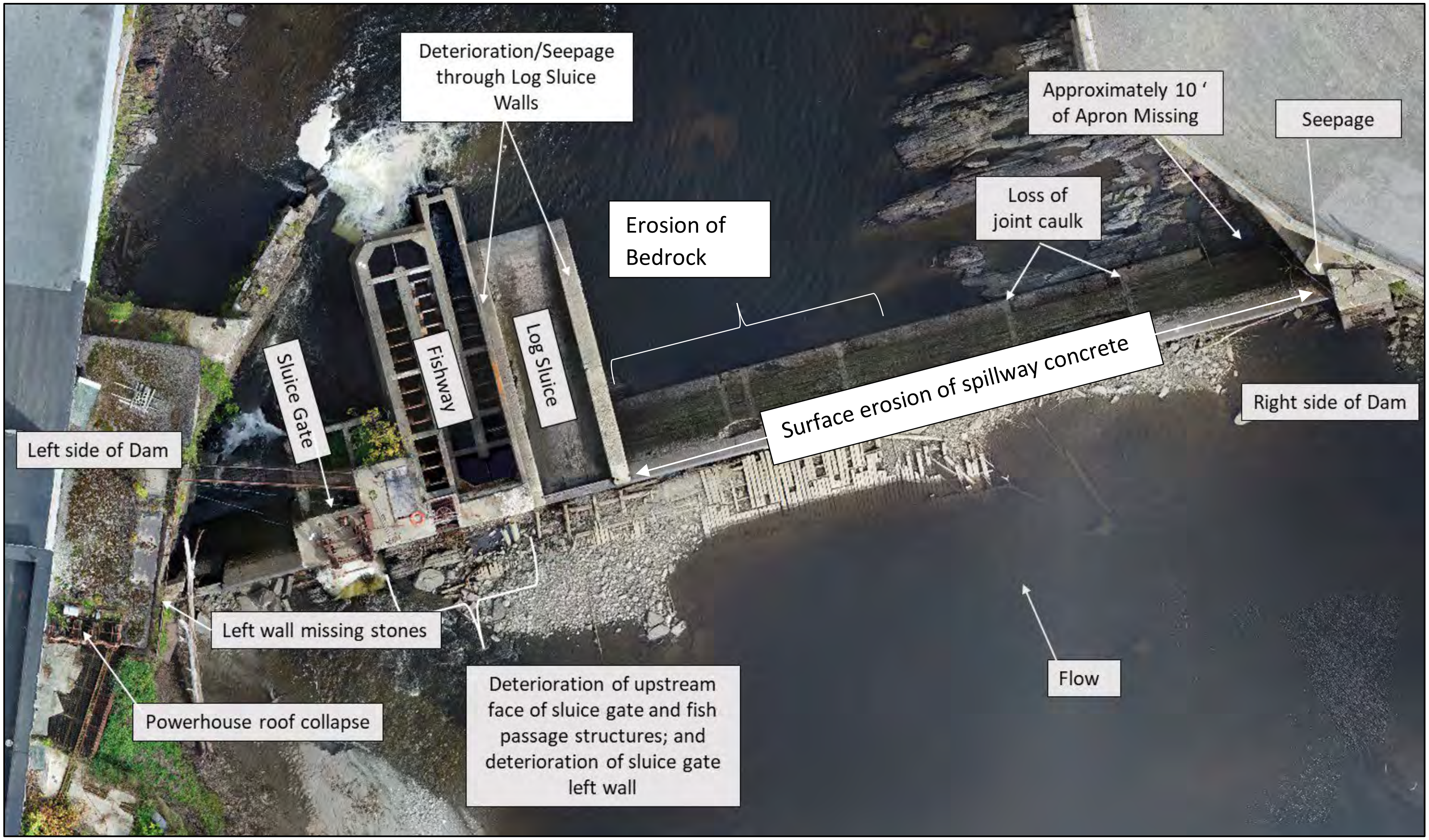

Figure 2.1-1. Aerial Image of Dam with Structural Deficiencies Labeled

3.0 Dam Stability Analysis

A dam stability analysis evaluates the forces on the dam under different loading cases (normal water level, winter water level with ice, design flood where water is flowing over the dam, and earthquakes) to determine the potential for the dam to slide or overturn under various loading conditions. **Figure 3.0-1** is a schematic showing the typical forces on a gravity dam, similar to the Project dam. Based on a review of the FERC record, it appeared a stability analysis had been conducted in the 1980's and the Town requested FERC to provide these records. While FERC provided the data, it yielded very limited information and no stability analysis information. Given this, as requested by Inter-Fluve, GSE conducted a dam stability analysis.

Information on the dam to conduct the stability analysis was obtained from the U.S. Army Corps of Engineer's National Inventory of Dams (NID). Per the NID, the dam (National I.D. ME00157) was initially completed in 1908, but was reportedly replaced in the 1980's. Pertinent engineering data presented in the NID includes:

Primary Dam Type:	Concrete Gravity
Dam Height:	12 Feet
Dam Length:	200 Feet
Spillway:	122 foot-long, Main Spillway and West, Uncontrolled Spillway
Hazard Classification:	Low
Normal Storage:	200 Acre-Ft
Surface Area:	30 Acres
Drainage Area:	345.2 Square Miles
Max Discharge:	22,000 cubic feet per second (cfs)

The dam stability evaluation was performed using the spillway cross-section obtained during GSE's visual inspection of the dam as shown in **Figure 3.0-2.** Detailed discussions about the analysis are included in the following sections. GSE did not perform test borings or laboratory testing.

3.1 FERC Criteria and Factors of Safety

Because the dam is under FERC's jurisdiction, FERC's dam stability criteria was applied in which four loading conditions were evaluated as follows:

- Case 1: Normal Pool, water level is at the spillway crest;
- Case 2: Normal Pool plus an ice load of 5,000 pounds per linear foot; ice level at spillway crest;
- Case 3: Spillway Design Flood, water level is above the spillway crest; and
- Case 4: Seismic or Earthquake conditions.

The calculations analyzed the structure for overturning, sliding, concrete stresses, and base pressures for the four loading conditions. The FERC stability criteria are shown in Table 3.1-1.

Table 3.1-1. FERC Dam Stability Criteria

Load Condition	Resultant Location from Overturning Analysis	Minimum Required Sliding Factor of Safety
Case 1: Normal Pool	Middle ⅓	2.0
Case 2: Normal Pool with Ice	Middle ½	1.25
Case 3: Spillway Design Flood	Middle ½	1.25
Case 4: Seismic	Within Base	1.25

Uplift pressures (forces from beneath the dam) were assumed to vary from full headwater pressure at the upstream side of the structure to full tailwater pressure at the toe. Values used for the friction angle between the spillway and its foundation were based on results of the site inspection and empirical laboratory studies by the U.S. Army Corps of Engineers included in EM 1100-1-1906 and ETL 1110-2-184. . Upstream sediment loading was not included in the analysis. No means of mechanical tie-down was included in the analysis. Overturning and resisting moments were calculated based on the magnitude of the forces acting on the spillway under the various loading conditions and the location of where the forces acted. The difference between the sum of the resisting moments and sum of the overturning moments is compared to the sum of vertical forces acting on the spillway to evaluate the location of the resultant along the base.

Sliding stability was evaluated by comparing the available sliding resistance with the driving force to be applied to the section. The factor of Safety against sliding failure is a function of the angle of internal friction.

$$FSs = \frac{F_V \tan\phi}{F_H}$$

Where:

F_V = Sum of vertical forces

tan ϕ = friction factor for concrete on base material

c = cohesion factor for concrete on base material

A = Area of the base

F_H = Sum of horizontal forces

Overturning stability of the spillway was evaluated comparing the available overturning resistance to the driving forces acting on the spillway. The factor of safety against overturning is defined as the ratio of the resisting moment to the overturning moments about the toe.

$$FSo = \frac{\Sigma M_R}{\Sigma M_O}$$

The location of the resultant of the forces acting on the spillway is defined as the summation of moments divided by the summation of the vertical forces acting on the spillway.

$$x = \frac{\Sigma M_R - \Sigma M_O}{F_V}$$

Design parameters used in the analyses are as follows:

- Unit weight of concrete = 150 pcf
- Unit weight of water = 62.4 pcf
- Angle of internal friction $\phi = 62°$
- Presumptive rock bearing capacity = 4,100 psi
- Spillway Crest (normal Pool) Elevation = 339.73’
- Normal Pool Tailwater Elevation = 328.31’
- Spillway Design Flood[1] (SDF) Headwater Elevation = 356.22’
- Spillway Design Flood Tailwater Elevation = 348.67’
- Seismic PGA = 0.19

The assumed angle of internal friction and presumptive bearing capacity used in the stability analysis were based on observations during the visual inspection of bedrock in the vicinity of the dam, the publication Reconnaissance Bedrock Geology of the Dover-Foxcroft Quadrangle, Maine[2], and the U.S Army Corps of Engineers ETL 1110-2-184, 25 Feb 74, Table III.

Bedrock at the dam site is judged to be of the Sangerville Formation. The Sangerville Formation underlies large parts of the Skowhegan, Kingsbury, Guilford, and Dover-Foxcroft quadrangles and is named from exposures on Route 23 between North Dexter and Sangerville (Guilford Quadrangle; Stops 5, 6, 7). It is composed primarily of interbedded shales and coarser elastics (siltstone, sandstone) of graywacke composition, but limestone, granule conglomerate, and highly carbonaceous shale members have also been mapped. The Sangerville is highly heterogeneous; rapid lateral and vertical changes are common[3].

Overturning stability of the spillway was evaluated comparing the available overturning resistance to the driving forces acting on the spillway. Resisting forces considered included:

- Dead load of the spillway
- Hydrostatic pressure of tailwater (at 60% of expected height)

3.2 Case 1: Normal Pool Results

The stability analysis was performed on the spillway cross-section assuming the reservoir level was at El. 339.73’. In all cases (Cases 1-4), silt loading was not considered in the analysis. The resultant of all forces acting on the spillway was found to act at 7.1 feet from the toe of the section and within the middle third of the base of the spillway section, indicating the full width of the spillway section base is in compression. The calculated factor of safety against sliding for the loading condition was 4.72. Based on the location of

[1] The Project SDF is 32,700 cfs as determined by the Federal Emergency Management Agency for the 100-year event.
[2] Source: “Reconnaissance Bedrock Geology of the Dover-Foxcroft Quadrangle”, Maine by John R. Griffin, 1971, Maine Geological Survey, Department of Conservation, Augusta, ME 04333.
[3] Source: “Stratigraphy and Structure of Central Maine, Authors Allan Ludman, Smith College Northampton, MA, John R. Griffin. University of California, and Davis Maine Geological Survey, Augusta

the resulting force and the factor of safety, sliding is not a concern under this load condition. The calculated maximum bearing pressure of 877 psf was acceptable.

3.3 Case 2: Normal Pool with Ice Results

The stability analysis was performed on the spillway cross-section assuming the reservoir level was at El. 339.73'. Additionally, an ice load equal to 5,000 pounds per linear foot was considered, acting at one foot below the spillway crest. The resultant of all forces acting on the spillway was found to act at 1.4 feet from the toe of the section, which is outside the middle half of the base of the spillway section, indicating the heel of the spillway section base is in tension. The calculated factor of safety against sliding for the loading condition was 2.28. The calculated maximum bearing pressure of 2,840 psf was acceptable.

3.4 Case 3: Spillway Design Flood Results

The stability analysis was performed on the spillway cross-section assuming the reservoir level was at El. 356.22'and the tailwater was at El. 348.67' based on the design flood of 32,700, cfs (100-year event). The reservoir level and tailwater level were provided by Interfluve based on its hydraulic model of the Project area. These values are also generally consistent with FEMA's earlier modeling of the base flood (100-year event) at the dam. The resultant of all forces acting on the spillway was found to act outside the base of the spillway, indicating the heel of the spillway section base is in tension. The calculated factor of safety against sliding for the loading condition was 0.33. The calculated maximum bearing pressure of 1,355 psf was acceptable.

Because the dam experienced a more significant flood event in 1987 (peak flow of 37,300 cfs) without sliding or overturning failure, GSE performed a sensitivity analysis to identify properties required for the structure's stability. The analysis focused on uplift pressures exerted on the base of the spillway and bond strength at the concrete/rock interface. The analysis found that for the structure to be stable against sliding failure, assumed uplift pressures had to be reduced (from 100 percent) to 75 percent of full headwater and 75 percent full tailwater. In addition, an allowable bond strength of 6 psi[4] was assumed at the structure's concrete/rock interface to achieve stability against overturning. The resultant of all forces acting on the spillway was found to act at 1.0 feet from the toe of the section, outside the middle half of the base. The calculated factor of safety against sliding for the loading condition was 1.17. The calculated maximum bearing pressure of 1,819 psf was acceptable.

3.4 Case 4: Seismic Results

The stability analysis was performed on the spillway cross-section assuming the reservoir level was at El. 339.73' and the upstream water loading acted over the full height of the spillway. Additionally, a seismic load was considered for this analysis using a seismic site coefficient equal to 0.19g. Silt loading and tailwater loading were not considered for this analysis case. The resultant of all forces acting on the spillway was found to act at 5.3 feet from the toe of the section and within the limits of the base of the spillway section, indicating the full width of the spillway section base is in compression. The calculated

[4] Reference: Journal of Rock Mechanics and Geotechnical Engineering Article "Tensile Strength and Failure Behavior of Rock-Mortar Interfaces: Direct and Indirect Measurements" published April 11, 2023, Authors: Ghasem Shams, Patrice Rivard, Omid Moradian.

factor of safety against sliding for the loading condition was 2.46. The calculated maximum bearing pressure of 1,451 psf was acceptable.

3.5. Summary of Results

The results of the analysis of the concrete gravity spillway are summarized in Table 3.5-1. Calculations shown in green shading mean the condition meets FERC dam safety criteria and those in red mean it is not met. Also presented in the table are results of the SDF analysis with reduced uplift pressure and assumed tensile bond between concrete and bedrock. The concrete spillway stability calculations are included in **Appendix B**.

Table 3.5-1. Summary of Stability Analysis

Load Case	Sliding Safety Factor (SSF)		Location of Resultant Force in Base (ft)		Maximum Bearing Stress (psf)
	Calculated	Required	Calculated	Required	
Normal Pool	4.72	2.0	7.1	Middle half (3.5' - 10.4')	878
Winter Pool plus Ice	2.28	1.25	1.4		2,840
SDF Pool	0.33	1.25	-14.7		1,355
Modified SDF Analysis	1.17	1.25	1.0		1,819
Seismic	2.46	1.25	5.3	Within Base	1,451

The existing spillway meets sliding and overturning stability criteria for the Normal Pool and Seismic Loading and sliding criteria for Ice Loading. For the SDF Loading Case, the structure can be shown to be stable by assuming reduced uplift and a tensile bond between the concrete and underlying rock of 6 psi. Even with these assumptions, the spillway section does not meet minimum FERC safety factors. Remedial measures are required to bring the structure into compliance with FERC stability criteria.

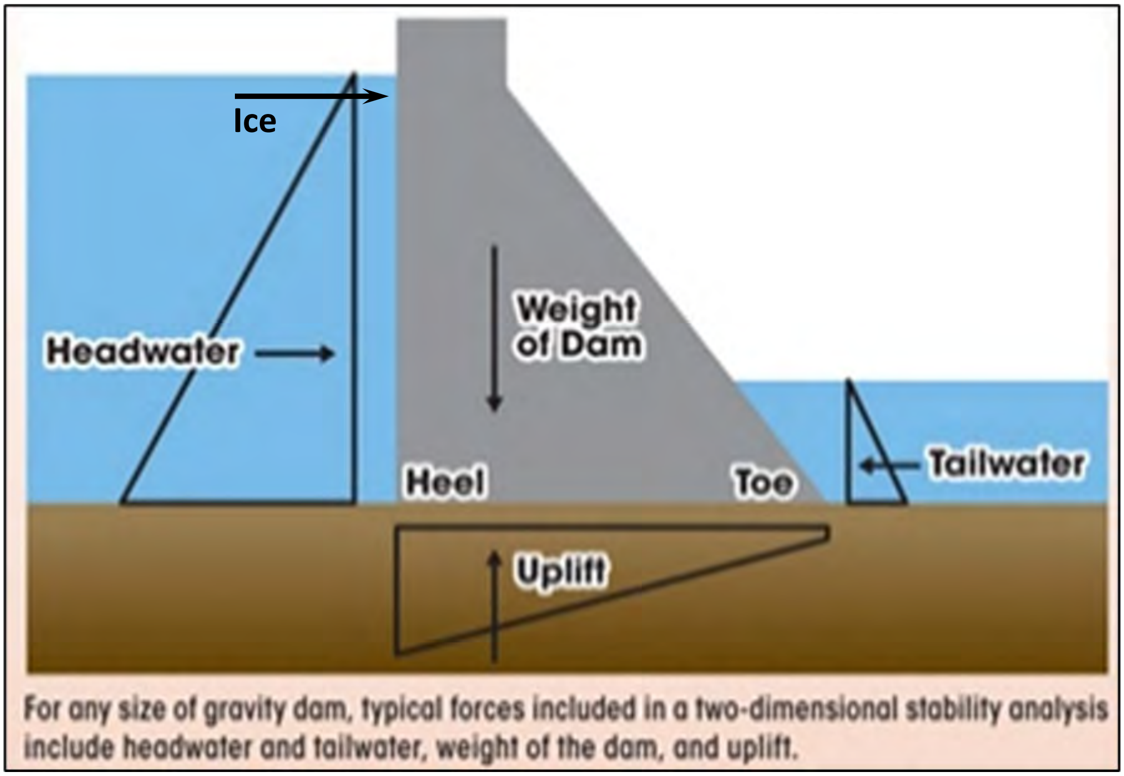

Figure 3.0-1. Typical Forces on a Gravity Dam

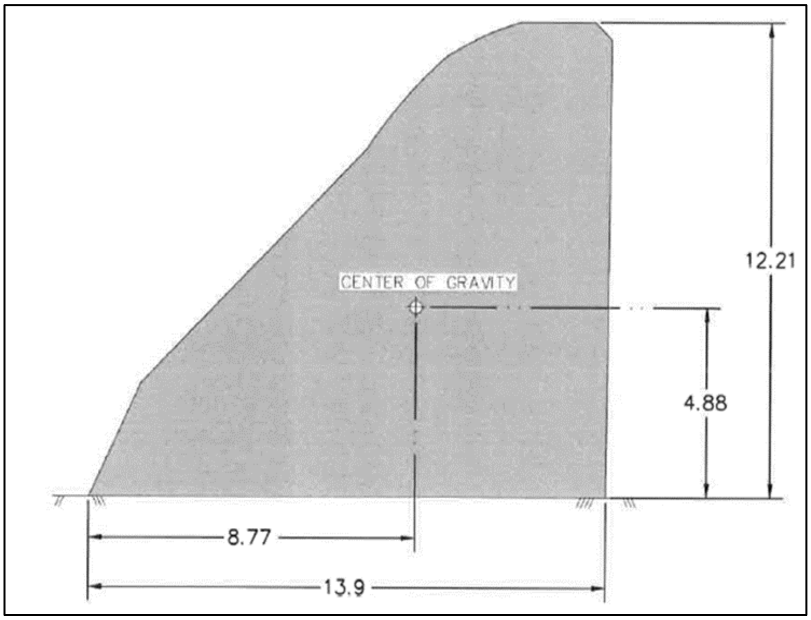

Figure 3.0-2. Dam Cross Section

4.0 Economics

As described above, the dam and the powerhouse building have several deficiencies that need to be addressed. GSE developed a conceptual level Opinion of Probable Construction Costs (OPCC) to address the dam deficiencies and the powerhouse building. Note that no detailed estimates were developed and the OPCC is based on professional judgement. The conceptual OPCC range to address the dam deficiencies is approximately $977,000 to $1,193,000 and to address the powerhouse deficiencies $99,000 to $118,000. Prior to initiating repairs to the powerhouse, approval by the SHPO will be required.

In addition to the above deficiencies, based on the above assessment, the dam has stability issues under certain loading conditions. The most common methods for rehabilitation of gravity dams that do not meet stability criteria include buttressing or anchoring. Buttressing consists of adding concrete to the downstream portion of the structure to resist sliding. Alternatively, high-capacity post-tensioned rock anchors have been used to stabilize gravity dams since the 1960s. Vertically installed post-tensioned anchors add normal force, increasing the sliding frictional resistance and preventing the development of tension at the heel of the dam. Anchors installed at an angle will provide additional sliding resistance by directly offsetting applied horizontal forces, but installation can be more costly than vertical anchors.

Based on conceptual design calculations, GSE recommends installation of approximately 17 post-tensioned anchors, installed on the downstream face of the spillway at an approximate angle of 45 degrees from horizontal. The depth of embedment into the underlying competent rock is approximately 15 feet. The conceptual OPCC range to install post-tensioned rock anchors is approximately $950,000 to $1,155,000.

Thus, collectively the OPCC range to address the dam and powerhouse building deficiencies and the rock anchors is approximately $2,030,000 to $2,465,000. A breakdown of the OPCC can be found in **Appendix C.**

Appendix A- FERC Dam Inspection Letter

FEDERAL ENERGY REGULATORY COMMISSION
OFFICE OF ENERGY PROJECTS
Division of Dam Safety and Inspections – New York Regional Office
19 West 34th Street – Suite 400
New York, New York 10001

Office No. (212) 273-5900 **FAX No. (212) 631-8124**

August 30, 2023

Via Electronic Mail
Mr. Jack Clukey
Town of Dover-Foxcroft
jclukey@dover-foxcroft.org

RE: P-5912-ME, Upper Dam (Moosehead Project)
2023 Dam Safety Inspection

Dear Mr. Clukey:

Thank you for the assistance that was provided to Mr. Noel Aglubat of this office during the dam safety inspection of the Moosehead Project that was conducted on August 3, 2023. Based upon our inspection findings, there were no dam safety deficiencies that required immediate remedial action.

By letter dated February 7, 2023, the Commission's Division of Hydropower Administration and Compliance gave you until December 31, 2023, to file an application to either amend or surrender your exemption. Should you decide to amend your exemption, and continue operating the project, you must include in your amendment application a plan and schedule for completing the following work:

1. According to our records, the project has not generated for over 10 years. Include a plan and schedule for making all repairs and/or modifications needed to return the project to operation.

2. Excessive brush and vegetation were noted at the left masonry wall, forebay and intake, and adjacent to the fish ladder. Include a plan and schedule for clearing this vegetation. Tree and brush removal should extend up to 15 feet from all water retaining structures.

3. Water was flowing over the spillway crest at the time of the inspection thus preventing a full visual inspection of the spillway. Include a plan and schedule for providing a full visual inspection of the spillway when flows permit. In addition, we recommend you examine the dam's foundation contact to check for scour.

4. A section of the powerhouse roof has collapsed. Include a plan and schedule to replace the roof.

The following work cannot be deferred until any Commission decision on your amendment or surrender application. Within 30 days from the date of this letter, file a plan and schedule for completing this work:

5. Significant concrete deterioration was noted at the upstream face and left wall of the sluicegate structure and the upstream face of the fish passage structure. Additionally, concrete deterioration has progressed at the left and right log sluice walls, and seepage through the walls is evident. You must repair these structures.

6. Repair of the masonry at the substructure of the powerhouse was previously requested by our October 12, 2018 letter. This area must still be repaired.

7. The project's Public Safety Plan (PSP) dated May 20, 1993, is over 30 years old. You must re-evaluate the project's public safety features and submit an updated PSP.

8. A Dam Safety Surveillance Monitoring Plan (DSSMP) and a Dam Safety Surveillance Monitoring Report (DSSMR) have not yet been submitted for the project. In accordance with Chapter 14 of the FERC Engineering Guidelines, you must submit a DSSMP and a DSSMR. Both documents must follow the outline/format contained in Chapter 14 Appendix J & K of the FERC Engineering Guidelines. For your reference, a link to this report requirement is provided below.

https://www.ferc.gov/sites/default/files/2020-04/chap14.pdf

File your submittal using the Commission's eFiling system at https://www.ferc.gov/ferc-online/overview. When eFiling, select Hydro: Dam Safety and New York Regional Office from the eFiling menu. The cover page of the filing must indicate that the material was eFiled. For assistance with eFiling, contact FERC Online Support at FERCOnlineSupport@ferc.gov, (866) 208-3676 (toll free), or (202) 502-8659 (TTY). If you have any questions regarding this letter, feel free to contact Mr. Noel Aglubat at (212) 273-5907 or by email at noel.aglubat@ferc.gov.

Sincerely,

JOHN SPAIN Digitally signed by JOHN SPAIN Date: 2023.08.30 10:38:03 -04'00'

John Spain, P.E.
Regional Engineer

Appendix B- Concrete Spillway Stability Calculations

Sliding/Overturning Stability Analysis: Normal Pool					
Normal Pool Condition: ,					
HW EL.	339.73				
TW EL.	328.31				
Base EL.	327.48				
Base Width	13.92	ft.			
Friction Angle (φ)	62	degrees			

Element	**Forces (pounds, lb)**		**Moment Arm (ft.)**	**Overturning Moment (lb-ft.)**	**Resisting Moment (lb-ft.)**
	Horizontal	**Vertical**			
Structure Weight		17434	8.77		152977
Hydrostatic Headwater	4682		4.08	19116	
Headwater Weight		0			0
Hydrostatic Tailwater	-31		0.33		10
Tailwater Weight		0			0
Uplift (Rectangle)		-869	6.96	6046	
Uplift (Triangle)		-4886	9.28	45327	
Summary	4651	11679		**70489**	**152987**

Resultant Location From Toe	7.1	ft.		Middle half, OK	
Location Along Base Width (b)	0.51				
Eccentricity	-0.1	ft.			
Stress at Toe	801.0	psf, or	5.6	psi	
Stress at Heel	877.5	psf, or	6.1	psi	
Sum of Moments	82499	lb-ft.		≥0, OK	
Sliding Factor of Safety	4.72			≥1.5, OK	

Sliding/Overturning Stability Analysis: Ice Loading

Ice Loading Condition: ,					
HW EL.	346.73				
TW EL.	335.73				
Base EL.	327.48				
Base Width	13.92	ft.			
Friction Angle (φ)	62	degrees			

Element	Forces (pounds, lb)		Moment Arm (ft.)	Overturning Moment (lb-ft.)	Resisting Moment (lb-ft.)
	Horizontal	Vertical			
Structure Weight		17434	8.77		152977
Hydrostatic Headwater	4682		6.13	28677	
Ice	5000		11.25	56250	
Headwater Weight		0			0
Hydrostatic Tailwater	-31		0.33		10
Tailwater Weight		0	2.17		0
Uplift (Rectangle)		-869	6.96	6046	
Uplift (Triangle)		-4886	9.28	45327	
Summary	9651	11679		**136299**	**152987**

Resultant Location From Toe	1.4	ft.		No good	
Location Along Base Width (b)	0.10				
Eccentricity	5.5	ft.			
Stress at Toe	2840.0	psf, or	19.7	psi	
Stress at Heel	-1161.5	psf, or	-8.1	psi	
Sum of Moments	16688	lb-ft.		≥0, OK	
Sliding Factor of Safety	2.28			≥1.5, OK	

Sliding/Overturning Stability Analysis: Spillway Design Flood

Design Flood Condition: ,					
Spillway Crest	339.73				
HW EL.	356.22				
TW EL.	348.67				
Base EL.	327.48				
Base Width	13.92	ft.			
Friction Angle (φ)	62	degrees			

Element	Forces (pounds, lb)		Moment Arm (ft.)	Overturning Moment (lb-ft.)	Resisting Moment (lb-ft.)
	Horizontal	Vertical			
Structure Weight		17434	8.77		152977
Hydrostatic Headwater (Rectangle)	12605		6.13	77205	
Hydrostatic Headwater (Triangle)	4667		4.08	19054	
Headwater Weight		0			0
Hydrostatic Tailwater (Rectangle)	-4100		6.11		25032
Hydrostatic Tailwater (Triangle)	-2800		7.06		19758
Tailwater Weight		6071	4.97		30175
Uplift (Rectangle)		-18406	6.96	128104	
Uplift (Triangle)		-3279	9.28	30419	
Summary	10371	1820		**254783**	**227941**

Resultant Location From Toe	-14.7	ft.		No good	
Location Along Base Width (b)	-1.06				
Eccentricity	21.7	ft.			
Stress at Toe	1354.9	psf, or	9.4	psi	
Stress at Heel	-1093.3	psf, or	-7.6	psi	
Sum of Moments	-26842	lb-ft.		No Good	
Sliding Factor of Safety	0.33			No Good	

Sliding/Overturning Stability Analysis: Spillway Design Flood

25 percent reduction in uplift and increase angle of internal friction from 55 to 62 degrees

Design Flood Condition: ,

Spillway Crest	339.73				
HW EL.	359				
TW EL.	351			356.22	
Base EL.	327.48			348.67	
Base Width	13.92	ft.			
Friction Angle (φ)	62	degrees			

Element	Forces (pounds, lb)		Moment Arm (ft.)	Overturning Moment (lb-ft.)	Resisting Moment (lb-ft.)
	Horizontal	Vertical			
Structure Weight		17434	8.77		152977
Hydrostatic Headwater (Rectangle)	14730		6.13	90221	
Hydrostatic Headwater (Triangle)	4667		4.08	19054	
Headwater Weight		0			0
Hydrostatic Tailwater (Rectangle)	-5169		6.11		31556
Hydrostatic Tailwater (Triangle)	-2800		7.83		21930
Tailwater Weight		6071	4.97		30175
Uplift (Rectangle)		-13805	6.96	96081	
Uplift (Triangle)		-2606	9.28	24174	
Summary	11428	7095		**229531**	**236638**

Resultant Location From Toe	1.0	ft.		No good	
Location Along Base Width (b)	0.07				
Eccentricity	6.0	ft.			
Stress at Toe	1819.1	psf, or	12.6	psi	
Stress at Heel	-799.4	psf, or	-5.6	psi	
Sum of Moments	7107	lb-ft.		≥0, OK	
Sliding Factor of Safety	1.17			No Good	

Sliding/Overturning Stability Analysis: Seismic Loading

Normal Pool Condition: ,		
HW EL.	339.73	
TW EL.	328.31	
Base EL.	327.48	
Base Width	13.92	ft.
Friction Angle (ϕ)	62	degrees

Element	Forces (pounds, lb)		Moment Arm	Overturning	Resisting
	Horizontal	Vertical	(ft.)	Moment (lb-	Moment (lb-
Structure Weight		17434	8.77		152977
Hydrostatic Headwater	4682		4.08	19116	
Headwater Weight		0			0
Hydrostatic Tailwater	-31		0.33		10
Tailwater Weight		0			0
Uplift (Rectangle)		-869	6.96	6046	
Uplift (Triangle)		-4886	9.28	45327	
Seismic Water	969		4.90	4750	
Seismic Structure	3312		4.90	16231	
Summary	8933	11679		**91470**	**152987**

Resultant Location From Toe	5.3	ft.		Middle half, OK
Location Along Base Width (b)	0.38			
Eccentricity	1.7	ft.		
Stress at Toe	1451.1	psf, or	10.1	psi
Stress at Heel	227.4	psf, or	1.6	psi
Sum of Moments	61517	lb-ft.		≥0, OK
Sliding Factor of Safety	2.46			≥1.5, OK

Seismic Loading		Few = 2/3*Ce*a*y(h*y)1/2		Mew = 4/15*Ce*a*y2 *(h*y)1/2		
		Where				
		Ce =	51/ {1-0.72 [h/1000te]2}0.5 =		51	
		te =	period of vibration (1 second)			
		a =	seismic coefficient (PGA) =		0.19	
		h =	Height of reservoir		12.25	feet
		y =	Height of dam		12.25	feet
	Water	Few	969.5	# at 0.4*(12.25) = 4.9" above dam base		
		Moew	4750.3	ft-#		
	Structure	Fes	3312.4	k acting at	4.9	feet
		Moes	16230.9	k-ft		

Appendix C- Opinion of Probable Construction Costs

	Description	OPCC Range [1][2][3][4][5] Low		OPCC Range High	
Dam Remediatipon	Resurface Downstream Face and Crest	$	339,000	$	415,000
	Replace 10 Feet of Apron	$	12,000	$	15,000
	Mitigate Seepage @ Right Abutment	$	21,000	$	25,000
	Fill Void(s) in Bedrock Downstream of Spillway	$	333,000	$	406,000
	Repair Log Sluice	$	54,000	$	66,000
	Repair Upstream Face of Spillway and Intake Gate	$	111,000	$	136,000
	Repair Left Abutment	$	107,000	$	130,000
	Subtotal	$	977,000	$	1,193,000
Powerhouse Remediation	Replace Turbine Floor	$	19,000	$	23,000
	Temporary Showing of Powerhouse Wall	$	4,000	$	5,000
	Timber & Steel Structure Remediation	$	35,000	$	42,000
	Roof Structural Repair and New Roof	$	24,000	$	28,000
	Stone Masonry Wall Seepage Repair	$	17,000	$	20,000
	Subtotal	$	99,000	$	118,000
Deficiency Repairs, Total Cost		**$**	**1,076,000**	**$**	**1,311,000**
Round		$	1,080,000	$	1,310,000
Post -Tensioned Rock Anchors[6]			**$950,000**		**$1,155,000**
Total			**$2,030,000**		**$2,465,000**

(1) Estimates are based on 2023 Construction Costs

(2) Includes Contractor General Requirements (e.g., mobilization/demobilizations) taken as 10% of total itemi

(3) Contingencey allowance taken as 40%

(4) Engineers OPCC is based on generally available databases (e.g. Means(and in-house pricing information

(5) Estimate does not include, control of water and erosion/sediment and pollution control

(6) Post-Tensioned Rock Anchors to stabilize structure to meet FERC stability requirements