TECHNICAL MEMORANDUM

To:	Casey Clark[1], John Burrows[2]
From:	Marcel Young-Scaggs PE; Cameron Twombly, EIT
Date:	February 26, 2024
Project:	Sabattus River Fish Passage
Re:	Base Flood Profile Impact Evaluation

Introduction

The Sabattus River Fish Passage Project (Project) will restore habitat connectivity in the Sabattus River Watershed, located in Androscoggin County, ME. The Project includes a number of habitat connectivity efforts, at different stages of completion, to restore passable conditions for native sea-run fish along the Sabattus River. These efforts include restoring fish passage at the three sites in the town of Lisbon: Upper Town Dam, Farwell Dam, and the former Farnsworth Dam Site (Mill Street Dam). The Project includes the removal of Upper Town Dam, removal of Mill Street Dam with supplemental fish passage improvements, and the partial removal of Farwell Dam in conjunction with the proposed installation of nature-like fish passage improvements. In addition, during the period evaluated, the Mill Street bridge was also replaced (Figure 1).

A Flood Insurance Study (FIS) for Androscoggin County was completed by the Federal Emergency Management Agency (FEMA), effective July 8, 2013 (FEMA 2013). This 2013 FIS study supersedes a previous study completed for the Town of Lisbon by FEMA in 1984. The Project area is located within a designated FEMA floodway (FIRM Numbers 23001C0364E, 23001C0363E, and 23001C0361E).

The analysis results described herein estimate that the Project actions and other changes cause a rise in base flood elevations in a short reach (~300 feet) just downstream of Farwell Dam ranging from 0 to 3.11 feet, when comparing the modeled pre-Project conditions and post-Project conditions. The results estimate that elsewhere in the study area the Project actions and other changes cause a reduction in base flood elevations ranging from 0 to 6.63 feet.

It should be noted that this base flood profile impact evaluation is not a determination of real base flood elevations, but an analysis to characterize changes to the base flood elevations as a result of past and future changes along the Sabattus River.

[1] Maine Department of Marine Resources
[2] Atlantic Salmon Federation

Figure 1. Sabattus River Project locator map

Hydraulic Analysis

A one-dimensional (1D) hydraulic model of the Sabattus River was developed using the U.S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System (HEC-RAS) software version 6.3.1 (USACE 2023). The model domain represents approximately 31,500 linear feet of the Sabattus River, occupying a geography that begins downstream of the former location of the Mill Street Dam and continues upstream through the Upper Town Dam impoundment, to the upstream extent of the influence of the dam on base flood water surface profiles. The model extends from FEMA Section E (HEC-RAS River Station 4125) located approximately 575 feet downstream of the Mill Street Fish Passage project area, to FEMA Section AE (HEC-RAS River Station 35,623) approximately 24,750 feet upstream of the Upper Town Dam project area, ending outside of the influence of the former Upper Town Dam and its impoundment. The Mill Street Fish Passage project area falls between cross sections at river stations 4543 and 4884. The Farwell Mill Dam project area falls between cross sections at river stations 9581 and 10166. The Upper Town Dam project area falls between cross sections at river stations 10859 and 12086.

The existing conditions model represents a pre-Project scenario with Upper Town Dam, Farwell Dam, Mill Street Dam, and the former Mill Street Bridge, all in place or prior to bridge replacement. The pre-Project scenario also represents the King Road Bridge geometry prior to its replacement in 2009. The proposed conditions model represents a designed post-Project scenario with Upper Town Dam removed (breached in 2012, removal completed in 2022), Mill Street Dam removed (completed in 2019), Mill Street Bridge replaced (completed in 2018), and King Road Bridge replaced (completed in 2009). The post-Project model also incorporates planned supplemental fish passage improvements at the Mill Street dam site (to be completed in 2024), along with breaching and nature-like fish passage enhancements proposed at Farwell Dam (to be completed 2024-25). The hydraulic model was used to evaluate the cumulative impact of completed and proposed changes on base flood water surface elevations for the Sabattus River.

The following sections describe the model setup in more detail and additional assumptions used for each of the separate models in the hydraulic analysis.

Pre-Project Conditions

The effective hydraulic model, which supported floodplain mapping in the prior effective FIS for the Town of Lisbon Maine (FEMA, 1984), was developed using the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) WSP-2 computer program. The more recently published FEMA FIS for Androscoggin County, ME (FEMA, 2013), which aggregated previously separate community studies into one FIS, did not include an updated detailed study of the Sabattus River. FEMA provided the effective model inputs and outputs in the form of a scanned printout for the WSP-2 model (Correspondence with FEMA on November 15, 2023), which were reviewed in detail. The vertical datum used for the elevations presented in the effective WSP-2 model could not be identified. Additionally, the section locations used in the effective model are not sufficient for adequate representation of the system. Therefore, a new pre-Project model was deemed necessary.

The existing conditions (pre-Project) model (Figure 2) was based off a composite digital terrain model (DTM) surface that was developed by combining 2020 USGS LiDAR data, and topographic and

bathymetric survey data collected by Inter-Fluve, Stantec, Sevee and Maher, and Titcomb and Associates between 2012 and 2023. In areas where no bathymetric survey data was available, simple river channel cross-section geometries were estimated using channel elevations reported in the FEMA FIS (2013), LiDAR, and the geometry of adjacent cross-sections where bathymetric data exists. All elevations reference the North America Vertical Datum of 1988 (NAVD88). A comprehensive list of the data sources used to develop the terrain models for pre-Project and post-Project conditions are presented in Table 1. Best engineering judgement was used to identify which data was prioritized in informing the development of the separate terrain models, resulting in the most accurate representation of pre-Project and post-Project conditions.

Table 1. Data sources used to construct the digital terrain model for hydraulic modeling purposes.

Topographic/Bathymetric Terrain Model Data Sources			
Data	**Location (River Stations)**	**Collected by / Source**	**Collection Date**
Bathymetric/Topographic Survey	Mill Street Dam Area (4543 - 4943)	Inter-Fluve	2022
Bathymetric/Topographic Survey	Mill Street Dam Area (4543 – 4943)	USFWS	2022
Bathymetric Survey	Mill Street Dam and Upstream Impoundment (4543- 7980)	Stantec	2012
Bathymetric/Topographic Survey	Downstream of Farwell Dam (9581 - 10008)	Sevee and Maher	2020
Bathymetric/Topographic Survey	Farwell Dam Area (9581 - 10517)	Inter-Fluve	2020 - 2023
Bathymetric/Topographic Survey	Upper Town Dam Area (10591 - 10859)	Titcomb and Associates	2014
Bathymetric/Topographic Survey	Upper Town Dam Area (10517 - 10859)	Inter-Fluve	2020
Bathymetric Survey	Upper Town Dam Impoundment (10591 – 14153)	Stantec	2014
River Channel Cross Section Elevation	Locations where bathymetric data is unavailable	FEMA FIS, 2013	2013
Light Detection and Ranging (LiDAR)	Entire Project Area	USGS	2020

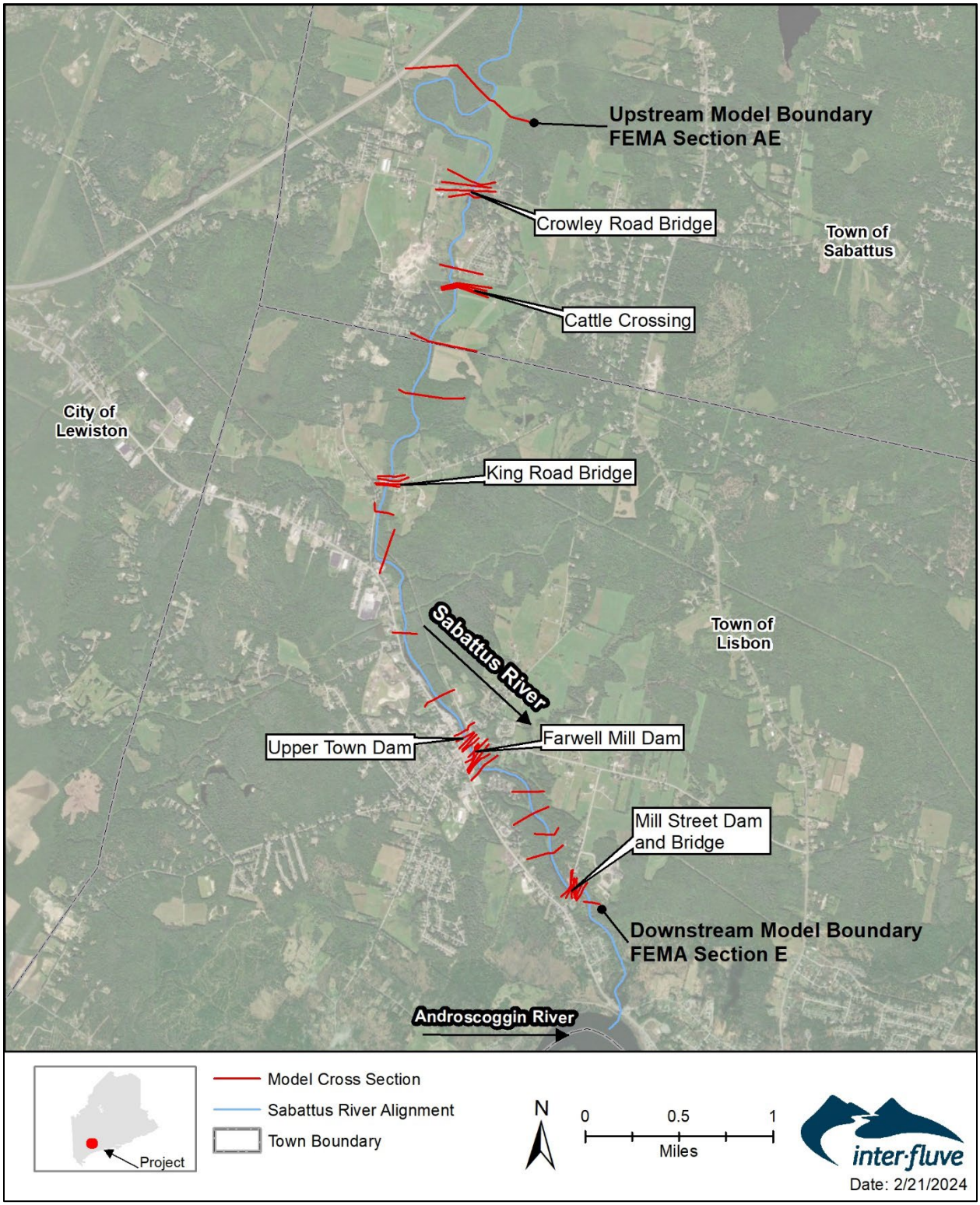

Figure 2. Model domain overview and cross section locations.

The model consists of a total of 53 cross-sections at locations that are representative of channel grade, changes in roughness or valley width, and existing infrastructure. Cross-sections were included in the Project work areas to assess the impact of the proposed Project elements in greater detail.

Roughness coefficients (Manning's n) for the cross sections were based on a combination of published guidance (Arcement & Schneider, 1989) and field observations of the conditions at the Project site. Hydraulic roughness coefficients for existing conditions were 0.04 to 0.07 for the mainstem channel depending on reach characteristics and 0.08 for overbank areas.

The downstream boundary condition for the 100-year flow event was set to the known water surface elevation (WSE) presented in the effective model at FEMA Section E, which is 140.7 ft (FEMA, 2013). The upstream boundary condition was defined as a flow input of 3,920 cubic feet per second (cfs), which is the regulatory base flood at Crowley Road as specified in the FEMA FIS for Androscoggin County (FEMA, 2013). Flow change locations included in the FEMA FIS were incorporated between the upstream and downstream boundaries of the models (see below). Steady flow computation methodology was used and a subcritical flow regime was assumed. The model results were reviewed for general concurrence with observed hydraulic patterns, but was not calibrated due to the lack of observed high water empirical data (peak discharges and associated water surface elevations).

Post-Project Conditions Model

The proposed conditions (post-Project) model was developed by adjusting the detailed pre-Project conditions model geometry to reflect the Project actions both completed to date, and proposed to be completed. The proposed channel geometry was updated to represent the Project actions, and other changes relative to the pre-Project model, by modifying cross section geometry directly within the Geometric Data Editor in HEC-RAS in selected locations and by modifying the DTM surface using AutoCAD Civil3D software in other locations. Roughness values were updated to represent post-Project conditions. Roughness was changed to 0.07 in the areas of the proposed nature-like fishways to represent the step-pool bed morphology. Additionally, roughness was changed to 0.06 at the location of Upper Town Dam to represent the bedrock channel at that location.

Project Hydrology

The impacts of the Project actions and other changes on the water surface elevations associated with the FEMA base flood (one percent annual exceedance probability flood event, also referred to as the 100-year flood event) were evaluated in this study. The 100-year flood event discharge magnitudes reported in the effective FEMA FIS (FEMA, 2013) for the Sabattus River were used in the evaluation (Table 2). The model flow file includes flow changes at each of the five locations presented in Table 2. While these flow change locations are repeated from the FIS, it should be noted that the increase in flow indicated at Webster Road may be attributed to No Name Brook which enters the river at Littlefield Road, approximately 6,000 feet upstream. This reach of river includes a substantial portion of the former Upper Town Dam impoundment. Future detailed analysis that may include map revision should evaluate the base flood flow change pattern in this area in more detail.

Table 2. Base flood (100-year event) flow values and flow change locations from the effective FEMA FIS (FEMA, 2013) used in the hydraulic model.

Location of Flow Change Along the Sabattus River	Flow Change River Station[1] (ft)	Discharge[2] (cfs)
Crowley Road	28340	3,920
0.84 Miles upstream of King Road	23448	4,660
King Road	18940	4,880
Webster Road (Memorial Bridge)	10550	7,430
Mill Street	4850	7,950

[1] *Station along Sabattus River alignment simulated in the Project hydraulic model.*

[2] *As reported in the effective Flood Insurance Study (FIS) for Androscoggin County (FEMA, 2013).*

Model Results

Modeled water surface elevation changes between the pre-Project and post-Project conditions are presented in Table 3. FEMA base flood elevations (FEMA, 2013) are also reported for comparison. All modeled cross sections are shown, including those representing bridge and dam infrastructure. The hydraulic model results estimate that the Project actions would result in a rise in the base flood water surface elevations between river stations 9819 and 10008 ranging from 1.38 to 3.11 feet. The area of rise diminishes to zero between station 9819 and Station 9669. This short reach of river is near the location of the effective model Section K, just downstream of Farwell Dam. In all other locations, model results estimate reduction in the base flood water surface elevation ranging from 0.0 to 6.63 feet. Maps depicting the base flood inundation boundaries for pre-project and post-project conditions are provided in Attachment A.

Table 3. Hydraulic model results for the FEMA 100-year event for pre-Project and post-Project conditions.

Station (ft)	Effective FEMA Section	FEMA Base Flood Elevation[1] (ft)	Infrastructure	Modeled Water Surface Elevations (ft, NAVD88)		Difference[2] (ft)
				Pre-Project Conditions	Post-Project Conditions	
35623	AE	200.2		198.40	198.40	0.00
28525	AD	200.2		197.29	197.29	0.00
28429				197.33	197.33	0.00
28340			Crowley Road Bridge	--	--	--
28253	AC	195.3		187.98	187.98	0.00
28138	AB	187.6		187.35	186.43	-0.92
25851	AA	187.4		187.01	185.94	-1.07
25335				187.00	185.92	-1.08
25306				186.96	185.86	-1.10
25290			Cattle Crossing	0.00	0.00	0.00
25263	Z	187.3		186.89	185.78	-1.11
25213				186.90	185.78	-1.12
23448	Y	186.9		186.47	185.07	-1.40
21861	X	186.6		186.23	184.64	-1.59
19116				185.71	183.67	-2.04
18979	W	186.2		185.73	183.69	-2.04
18940			King Road Bridge	--	--	--
18868				185.11	183.49	-1.62
18814	V	185.7		185.12	183.51	-1.61
18040	U	185.6		184.96	183.22	-1.74
16505	T	185.5		184.74	182.77	-1.97
14153	S	185.0		184.31	181.87	-2.44
12086	R	184.4		183.92	180.52	-3.40
10859	Q	183.6		183.27	177.49	-5.78
10811			Upper Town Dam	--	176.89	--
10702				177.13	177.10	-0.03
10591				176.67	176.63	-0.04
10550			Memorial Bridge	--	--	--

10517				176.48	176.44	-0.04
10411				175.64	175.59	-0.05
10166	M	172.0		173.55	172.09	-1.46
10045				174.41	172.99	-1.42
10030			Farwell Dam	--	--	--
10008	L	164.6		160.80	162.79	1.99
9901				158.44	161.55	3.11
9819	K	158.6		158.38	159.76	1.38
9669				158.11	157.44	-0.67
9581				157.95	156.05	-1.90
7980	J	158.6		157.61	154.59	-3.02
7356				157.51	154.36	-3.15
6584	I	158.3		157.40	154.07	-3.33
6067				157.28	153.80	-3.48
4943				156.82	152.56	-4.26
4918				156.77	152.49	-4.28
4884	H	157.7		156.49	151.43	-5.06
4850			Mill Street Bridge	--	--	--
4823				154.14	149.82	-4.32
4799	G	155.3		154.22	149.84	-4.38
4769				154.28	147.65	-6.63
4761			Mill Street Dam	--	--	--
4730				144.53	144.53	0.00
4635	F	148.7		144.24	144.24	0.00
4543				143.54	143.54	0.00
4125	E	140.7		140.70	140.70	0.00

[1]*Regulatory 1 percent annual chance flood water surface elevation (feet NAVD88) from FIS (FEMA, 2013).*
[2]*Negative values indicate a decrease from existing conditions.*

Conclusion

This memo summarizes the hydraulic analysis of the impact of the Project actions and other selected changes on FEMA base flood elevations along the Sabattus River. The results estimate that the Project actions and other changes cause a rise in base flood elevations in a short reach (~300 feet) just downstream of Farwell Dam (between river station 9669 and 9819 to station 10008) ranging from 0 to 3.11 feet, when comparing the modeled pre-Project conditions and post-Project conditions. The results estimate that elsewhere in the study area the Project actions and other changes cause a reduction in base flood elevations ranging from 0 to 6.63 feet.

References

Arcement G and Schneider V. 1989. Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains. US Geological Survey Water-Supply Paper 2339.

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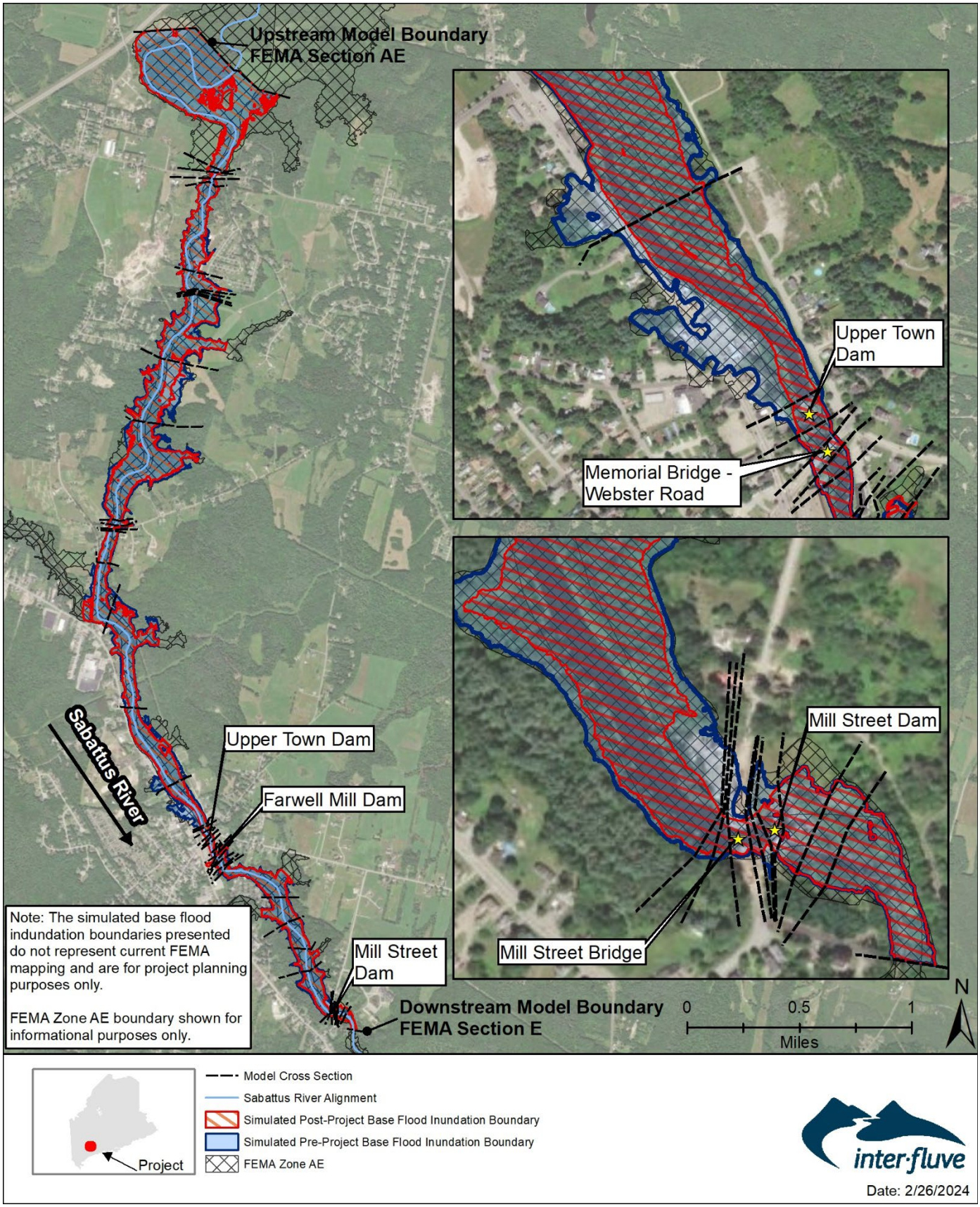
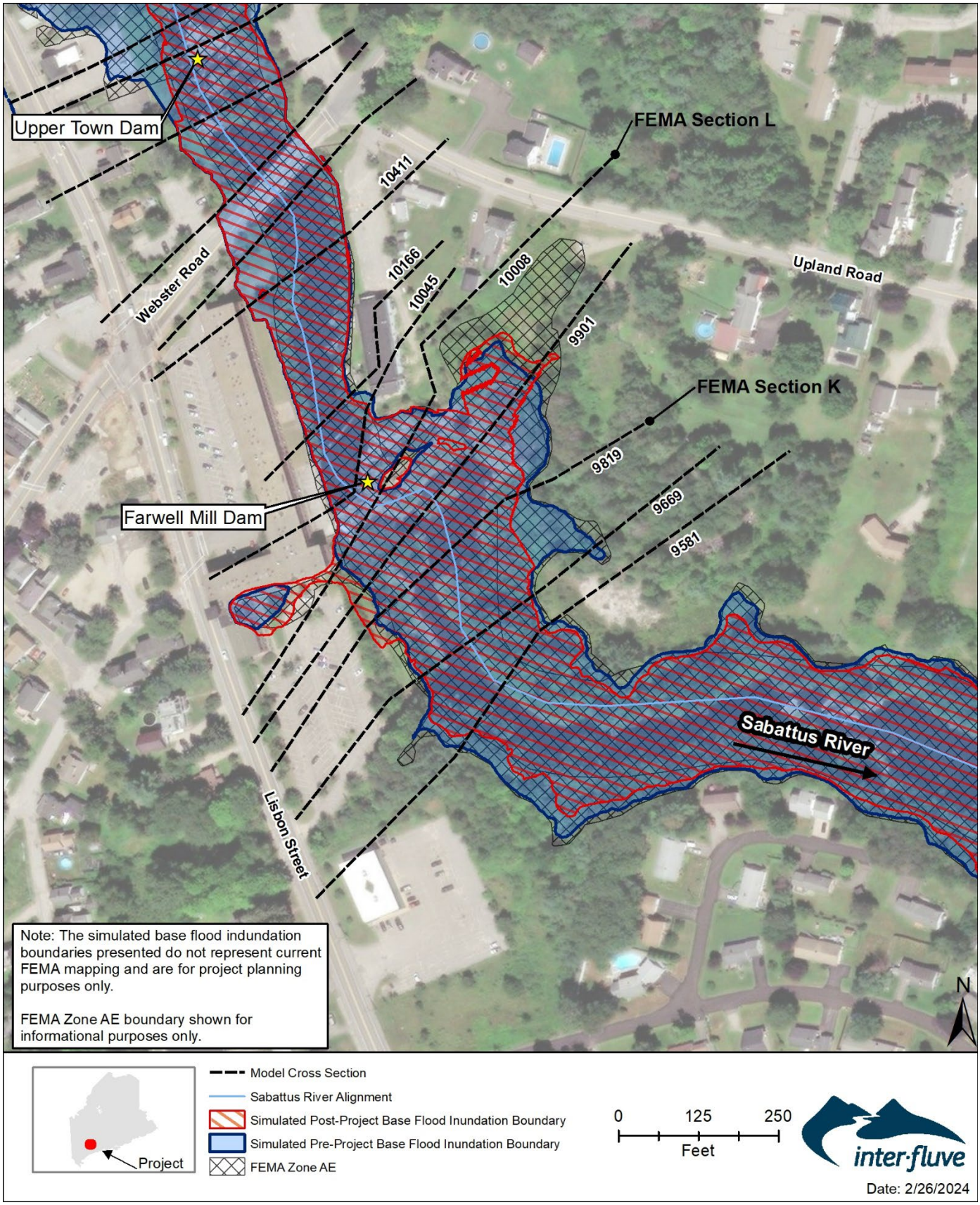
Federal Emergency Management Agency (FEMA) National Flood Hazard Layer (NFHL) Online Database and Viewer. Accessed 2023.

U.S. Army Corps of Engineers, (USACE). 2023. Hydrologic Engineering Center River Analysis System (HEC-RAS), HEC-RAS version 6.3.1.

Attachment A — Base Flood Inundation Maps



Map 1. Base flood inundation map of the Sabattus River study reach.



Map 2. Base flood inundation map of the Farwell Mill Dam project area.