HYDRAULIC ANALYSIS NARRATIVE

TO: MVP Action Grant Steering Committee, Haverhill, MA

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RE: **Little River Dam Removal Feasibility Study**
Hydrologic and Hydraulic Modeling Analysis Summary
MVP Action Grant – City of Haverhill

This narrative and attachments are provided to summarize Fuss & O'Neill's progress in generating pre- and post-conditions hydraulic models of the Little River (River) in assessing the impacts that dam removal will have on upstream ecological wetland communities, fish passage suitability, flooding, and sediment transport. Since the section of the Little River downstream of the dam is impacted by backflow from the Merrimack River during larger flood events as well as daily tidal fluctuations, these impacts were not only assessed under present-day hydrologic conditions, but also under future hydrologic conditions with consideration given to climate change as it relates to sea level rise and increased rainfall. A 50-year projection (to year 2070) was considered as it is generally recommended that projects be assessed considering climate change impacts (e.g. sea level rise, precipitation increases, etc.) anywhere from 30 to 50 years (at minimum) from present day depending on locality and reviewing agency.

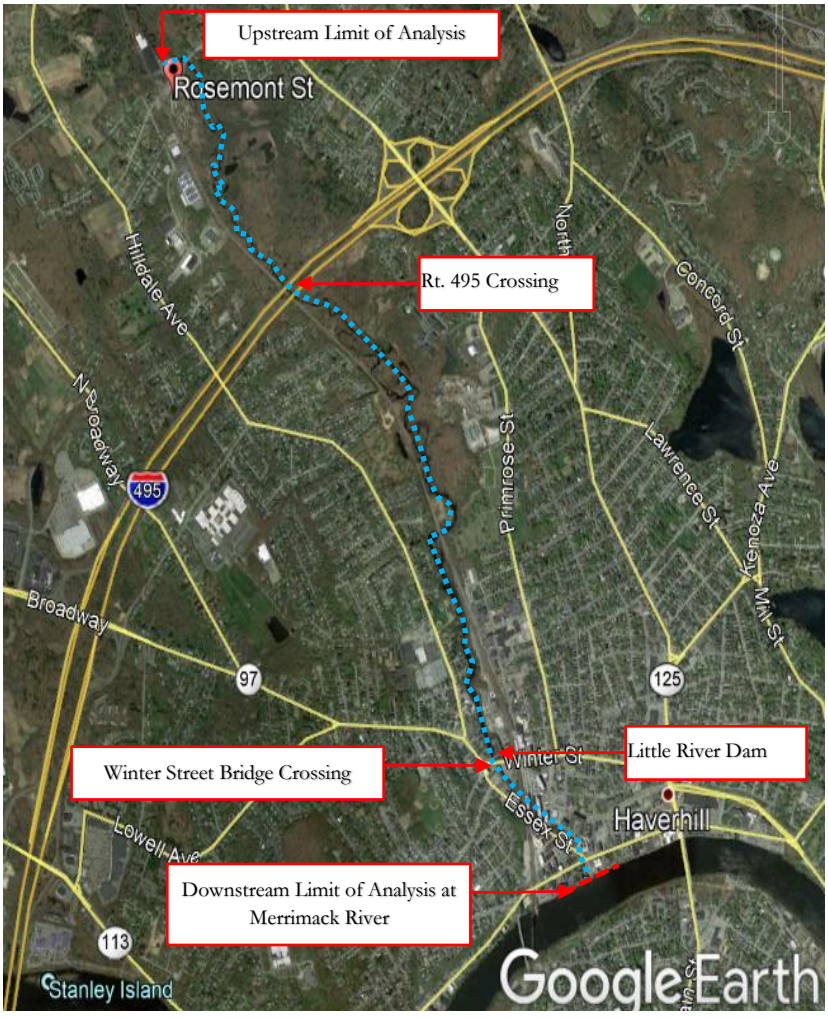


Figure 1: Project Limits of Hydraulic Analysis

For purposes of this analysis, the hydraulic model extends from a

point approximately 120 feet upstream of the Rosemont Avenue bridge crossing (referred to as the Project's upstream limit of analysis) to the Little River's confluence/discharge to the Merrimack River as shown in Figure 1 (referred to as the Project's downstream limit of analysis).

Hydrologic Evaluation

In order to assess fish passage suitability, ecological alterations, sediment mobility concerns, structural impacts, and flood protection benefits associated with removing the dam, pre- and post-conditions hydraulic models were developed using HEC-RAS. The anticipated impacts associated with the removal of the Dam have been assessed at three primary hydrologic levels; (1) selected flood flow intervals including the 10-, 50-, 100-, and 500-year recurrence interval flood events; (2) the existing August/September water level which represents base flow conditions; and (3) upstream fish migration flow conditions for target species (i.e. during minimum, normal, and maximum operating conditions).

Flood Flow Approximation

Flood flows for this analysis were obtained from FEMA's Flood Insurance Study (FIS) for Essex County, Massachusetts dated July 19, 2018. Table 1 summarizes peak discharges that were utilized for the 10-, 2-, 1-, and 0.2-percent annual chance floods (commonly referred to as the 10-, 50-, 100-, and 500-year recurrence interval flood events):

Table 1: Summary of Discharges for Little River within Limit of Study

Flooding Source and Location	Drainage Area (Square Miles)	10-Percent Discharge (cfs)	2-Percent Discharge (cfs)	1-Percent Discharge (cfs)	0.2-Percent Discharge (cfs)
At Corporate Upstream Limits	20.8	660	1,065	1,275	1,865
Upstream of I-495 (RS15341)	27.0	980	1,640	1,990	3,030
At Winter Street (RS11387)	37.0	1,160	1,920	2,330	3,520

According to the FIS, peak flows for the Little River were prepared by Cullinan Engineering Co., Inc., for FEMA under Contract No. H-4797 in January 1981. These flows were derived from peak-discharge frequency relationships using procedures described in USGS's *Estimating the Magnitude and Frequency of Floods for Natural-Flow Streams (1977)*. This methodology was developed using multiple regression analyses to estimate flood peaks on ungaged, natural-flow streams in Massachusetts by relating peak discharges to basin and climatic parameters. These resulting peak discharges were then verified using statistically analyzed data from nearby stream gages with similar watershed characteristics using a multiplication factor equal to the ratio for the drainage areas. Refer to **Attachment 1** for a copy of pertinent information for the Little River obtained from the FIS.

Base Flow Approximation

Removal of the dam will alter water surface elevations upstream of the dam. The ecology of wetland systems upstream of the dam may be governed by water surface elevations during the seasonal low-flow period (referred to herein as the base flow) that occurs during the months of August and September. To quantify

the anticipated reduction in upstream water levels during base flow conditions, the mean daily August-September flow was approximated and used to analyze the impact of dam removal on upstream water levels and wetlands.

Since the Little River is an ungauged river, Fuss & O'Neill used recorded USGS flow data from similar river basins to approximate the mean daily August-September flow. Three USGS gauge stations were chosen to make this approximation: East Branch Neponset River at Canton, MA (USGS 01105500), Indian Head River at Hanover, MA (USGS 01105730), and Wading River near Norton, MA (USGS 01109000). These three stations were chosen based on a combination of proximity, size, and other basin characteristics such as impervious cover, development, and slope. USGS StreamStats reports containing the contributing drainage area and relative statistics for each of these stations, as well as one for the current Little River Project Site, are provided as **Attachment 2**.

Daily flow data from 1990 to 2020 was retrieved from USGS, and the mean flow rates for each of the three stations during the months of August and September over this period were calculated. This base flow for the Little River site was calculated using the following formula:

$$Q_u = Q_g(A_u / A_g)$$

where Q_u is the flow rate at the ungauged site (South River), Q_g is the flow rate at the comparison station, A_u is the drainage area of the ungauged site, and A_g is the drainage area of the comparison station. The average of the three resulting values for Q_u was used as the base flow rate for this analysis. Table 2 below lists the resulting flow rates calculated using the above method.

Table 2: Calculation of Base Flow for Little River at Little River Dam (flow rates in cfs)

Station Name	Drainage Area (mi²)	Mean Flow, August-September	Qu Adjusted to Project Site
East Branch Neponset River	27.2	11.9	12.2
Indian Head River	30.5	12.4	11.3
Wading River	43.1	9.0	5.8
Little River (ungauged)	27.9		**9.8**

As shown, a base flow rate of 9.8 cfs was used to assess potential ecological effects upstream of the dam.

Fish Passage Flow Approximation

The removal of the Little River Dam will also result in a section of the river channel with an increased slope and reduced flow depths. In order to quantify flow velocities and depths to ensure that flow velocities and depths will be conducive for passage of targeted aquatic species, flows during the upstream fish passage/migration season were approximated using methods similar to those described within the base flow approximation section by analyzing flow data from similar river basins: East Branch Neponset River, Indian Head River, and Wading River.

Evaluation of fish passage flows must consider typical minimum, normal, and maximum flows, corresponding to the 95% exceedance, 50% exceedance, and 5% exceedance flows, respectively, during the

upstream migration/passage season. The upstream migration/passage season is dependent on the project's target species. The Little River is a tributary to the Merrimack River in the Gulf of Maine watershed. The Merrimack River is a valuable resource for diadromous fish including river herring (Alewife and Blueback herring), as well as of American shad, gizzard shad, striped bass, rainbow smelt, Atlantic salmon, and sea lamprey; it is also a valuable resource for catadromous species such as American eel. Per guidance from the Massachusetts Division of Marine Fisheries (DMF), the upstream migration/passage season is considered to last from March 1st to June 30th. Therefore, daily flow rates for this three-month period averaged over the past 30 years (same period used to calculate base flows) were used to approximate fish passage flows. The results of this analysis for the 5%, 50%, and 95% exceedance flows) obtained from USGS for the fish passage season are provided in **Attachment 3**. A summary of flow approximation results using the three noted USGS stations is provided below in Table 3.

Table 3: Calculation of Fish Passage Flows for Little River at Little River Dam (all flow rates in cfs)

Station Name	Drainage Area (mi2)	Mean Q95%. Flow, Mar. 1 - June 30	$Q95\%_{,min}$ Adjusted to Project Site	Mean 50%, Mar. 1- June 30	$Q50\%_{,normal}$ Adjusted to Project Site	Mean Q5%, Mar. 1- June 30	$Q5\%_{,max}$ Adjusted to Project Site
East Branch Neponset River	27.2	15.0	15.0	56.0	57.0	199.0	204.0
Indian Head River	30.5	16.0	15.0	61.0	56.0	238.0	218.0
Wading River	43.1	16.0	10.0	86.0	56.0	283.0	183.0
Little River (ungauged)	27.9		**13.3**		**56.3**		**201.7**

Current and Projected Tidal Conditions at Project Site

The section of the Little River that is downstream of the Little River Dam, especially within the Little River Conduit, is tidally impacted. The Little River empties into the Merrimack River through this conduit. While there is not a NOAA tidal station located immediately at the confluence of the Little River and the Merrimack River, there is a NOAA tidal station located along the Merrimack River (at the Bates Bridge) approximately 3.1 miles downstream of the Little River confluence. Table 4 represents approximate tidal conditions based on a review of tidal information recorded at this station. Tidal elevations are referenced to NAVD88 and were obtained using NOAA's Online Tides & Currents website (Datums - NOAA Tides & Currents) as included in **Attachment 4**.

Table 4: Approximate Present-Day Tide Elevations at the Mouth of the Merrimack River

Station Name	MLLW (feet)	MLW (feet)	MTL (feet)	MHW (feet)	MHHW (feet)
Merrimack River at Riverside Park (Bates Bridge)	**-1.38**	-1.26	1.60	4.46	4.92

Note: Based on a review of NOAA's Tide Predictions at this station for 2021, it appears that high tide elevations are expected to exceed El. 4.92 feet (NAVD88) anywhere between one to ten days per month with tides reaching as high as El. 5.8 feet (NAVD88).

Based on a review of the City of Haverhill's *Flood Protection System Improvement Plans*[1], the Little River Conduit is approximately 0.38 miles in length and extends from its outlet at the Merrimack River to its inlet that is located approximately 630 feet downstream of the Little River Dam. The invert elevations of the Little River Conduit (Conduit) range between El. -3.3 feet (NAVD88) to El. 5.2 feet (NAVD88). As a result, the

[1] City of Haverhill, Massachusetts, Flood Protection System Improvements (CWSRF-3662 / IFB020-13), AECOM USA, Inc. (February 14, 2013).

majority of the section of the Little River within this Conduit are impacted by tides on a daily basis. However, it does not appear that there is a significant tidal impact within the River upstream of the Conduit given approximate river channel bottom elevations between the Little River dam and the inlet of the Conduit that exceed El. 5.8 feet (NAVD88) with exception to periods of extreme high tides and/or coastal storm surge events. In such cases, the Dam restricts extreme high tide levels from extending any further upstream.

Although tidal effects within the River between the Dam and the Little River Conduit are relatively minor under present-day conditions, it should be noted that the sea level around Boston has risen by 8 inches since 1950 and is expected to continue rising. As documented within the *Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP)*, sea levels surrounding Boston are expected to rise by approximately 1.7 feet by 2040, 2.4 feet by 2050, 4.2 feet by 2070, and 7.6 feet by 2100 assuming a 'high' scenario. The following table (Table 5) summarizes projected mean lower low water (MLLW), mean low water (MLW), mean high water (MHW), and mean higher high water (MHHW) levels within the Little River in the vicinity of the Dam due to sea level rise (SLR).

Table 5: Estimated Present-Day versus Projected Tidal Elevations at Little River Dam

Time	SLR Increase	MLLW (feet)	MLW (feet)	MTL (feet)	MHW (feet)	MHHW (feet)
Present Day	----	-1.38	-1.26	1.60	4.46	4.92
2040	+1.7 feet	0.32	0.44	3.30	6.16	6.62
2050	+2.4 feet	1.02	1.14	4.00	6.86	7.32
2070	+4.2 feet	2.82	2.94	5.80	8.66	9.12
2100	+7.6 feet	6.22	6.34	9.20	12.06	12.52

As shown in the table above and in Figure 2 below, current sea level rise projections indicate that mean high water levels are expected to regularly (daily) extend as far upstream as the Dam sometime between 2050 and 2070.

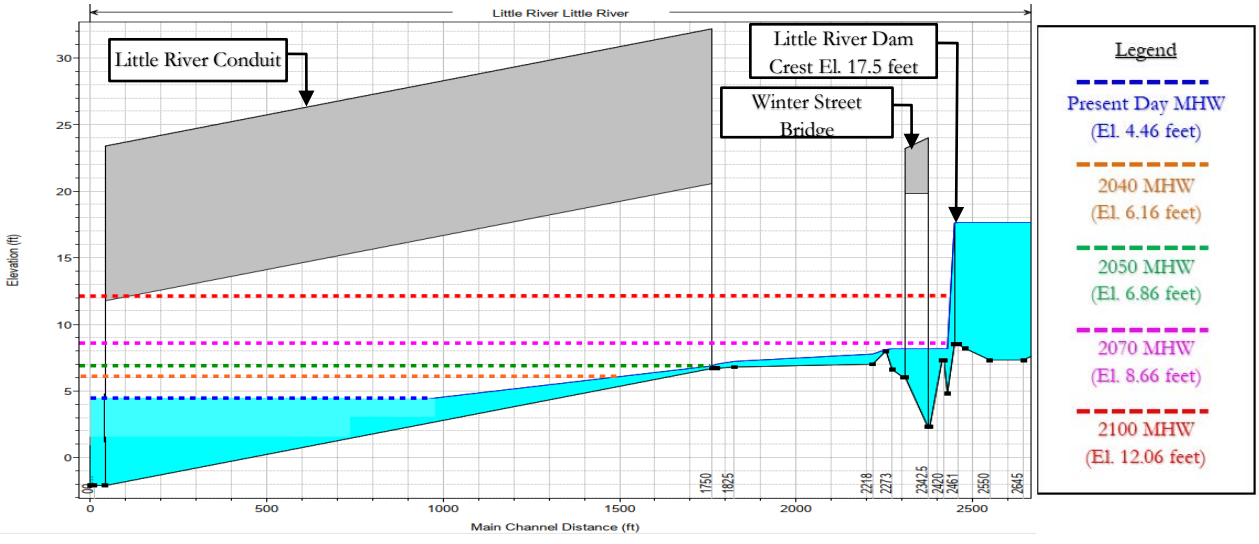


Figure 2: Present-Day and Projected Mean High Water Levels at Little River

Hydraulic Evaluation

To develop a pre-conditions hydraulic model of the River within the Project's limit of analysis prior to dam removal, Fuss & O'Neill first developed a HEC-RAS model of the River from hydraulic back-up data that was provided by FEMA. For purposes of this memorandum, this initial hydraulic model created by Fuss & O'Neill will be referred as FEMA's Duplicate Effective Model. Creating this model was Fuss & O'Neill's initial step in generating a hydrologic and hydraulic model that more accurately represents pre-dam removal hydraulic conditions experienced along Little River within the Project's limit of analysis.

This improved, Pre-Dam Removal model was then used as a basis for comparison to assess hydraulics through the River following the removal of Little River Dam. This hydraulic assessment was critical to:

- understanding the potential effects that the lowering of the river's profile would have on adjacent structures to remain (particularly the building upstream of the dam on river left and upstream bridge structures) and in designing measures/improvements to mitigate adverse impacts and protect such structures;
- performing a sediment mobility assessment;
- understanding the erosion potential of banks, and
- designing river restoration practices to maximize safe and effective fish passage.

Duplicate Effective Hydraulic Model

The current flood zone mapping for the Little River is based upon a detailed flood study which is documented in FEMA's Flood Insurance Study (FIS) for Essex County, Massachusetts (All Jurisdictions) dated July 19, 2018. The flood zone boundaries, which include Zone AE and Zone X in addition to the River's floodway, are depicted on the following Flood Insurance Rate Maps (FIRMs):

- FIRM No. 25009C0078F (dated July 3, 2012);
- FIRM No. 25009C0086F (dated July 3, 2012);
- FIRM No. 25009C0087F (dated July 3, 2012); and
- FIRM No. 25009C0088F (dated July 3, 2012).

For the Little River, the 1-percent annual chance flood elevations depicted within the FIS are based on flood elevations computed from a HEC-2 hydraulic model developed by USACE in 1976 and updated in 1979 ("1979 HEC-2 Model"). The 1-percent annual change flood elevations are based on flood elevations determined at each cross section.

Hydraulic Back-up Data (Obtained from FEMA)

In order to create the Duplicate Effective Model for Little River from a point approximately 120 feet upstream of the Rosemont Avenue bridge crossing (referred to as the Project's upstream limit of analysis) to the Little River's confluence/discharge to the Merrimack River (referred to as the Project's downstream limit of analysis), Fuss & O'Neill obtained hydraulic back-up data (from FEMA) used to create the hydraulic model that is currently reflected within the Flood Insurance Study (FIS) and Flood Insurance Rate Maps

(FIRMs) for Essex County, Massachusetts (All Jurisdictions). A copy of pertinent sections of that information that was provided to Fuss & O'Neill is included within **Attachment 5.**

This information includes river channel geometry, Manning's coefficients used in the river channel and its overbank areas, bridge/culvert geometry, peak flows utilized throughout the stretch of the flooding sources being analyzed, and floodway limits and pertinent input data. The input data was received in HEC-2 format.

Vertical Datum Conversion

Contour and water surface information included within the hydraulic back-up data provided by FEMA utilize elevations relative to the National Geodetic Vertical Datum of 1929 (NGVD29). However, contour and water surface information reflected within the current FIS and FIRMs utilize elevations relative to the North American Datum of 1988 (NAVD88). For comparison purposes, water surface elevations generated within the Duplicate Effective Model can be converted to NAVD by subtracting 0.80 feet from the NGVD values as recommended by the current county-wide FIS (with an effective date of July 19, 2018).

Hydraulic Methodology

In order to create the Duplicate Effective Model of the Little River within the Project's limit of analysis, the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) software, Version 5.0.7, was utilized.

Since water surface elevations included within the flood profiles of the Little River were generated from a HEC-2 hydraulic model, the steady flow option that allows conveyance calculations to be performed between every coordinate point in the cross section overbanks was selected since this is similar to the approach used in HEC-2.

Model Results and Comparison

Based on information provided within the hydraulic back-up (input) data received from FEMA, the Duplicate Effective Model within our limit of study includes:

- 44 cross sections; and
- 5 bridges.

Table 6 provides a comparison between 1-percent annual chance base flood water surface elevations (WSEs) computed by HEC-RAS for the Little River with those water surface elevations currently listed in the FIS for the county of Essex, Massachusetts (July 19, 2018).

Table 6: Duplicate Effective Model vs. Flood Insurance Study -1-Percent Annual Chance Base Flood WSE Comparison

Cross Section	River Station[1]	Duplicate Effective Base Flood WSE (ft.) NGVD29	Duplicate Effective Base Flood WSE (ft.) NAVD88	FIS Base Flood WSE (ft.) NAVD88	WSE Difference (ft.)
A	1775	17.53	16.7	22.4	-5.7[2]
B	1825	17.76	17.0	22.4	-5.4[2]
C	2305	17.91	17.1	22.4	-5.3[2]

Cross Section	River Station[1]	Duplicate Effective Base Flood WSE (ft.) NGVD29	Duplicate Effective Base Flood WSE (ft.) NAVD88	FIS Base Flood WSE (ft.) NAVD88	WSE Difference (ft.)
D	2380	23.22	22.4	22.4	0.0
E	4030	24.96	24.2	24.2	0.0
F	6115	26.75	26.0	26.3	-0.3
G	6195	27.44	26.6	26.6	0.0
H	7472	27.77	27.0	26.9	+0.1
I	8185	27.97	27.2	27.1	+0.1
J	10915	28.59	27.8	27.6	+0.2
K	11325	29.14	28.3	28.2	+0.1
L	11381	29.15	28.3	28.2	+0.1
M	12987	31.09	30.3	30.2	+0.1
N	15341	35.75	35.0	34.8	+0.2

Notes:

[1] River station represents the river section reference number provided within the FEMA flood profile provided in the 2018 Flood Insurance Study.

[2] The reason for discrepancy in excess of 6 inches is due to the subsequent application of 1% backwater impact from the Merrimack River. The HEC-2 analysis did not account for backwater impacts from the Merrimack River in its hydraulic analysis, whereas the profile included in the FIS was adjusted by extending a straight hydraulic line at El. 22.4 feet (NAVD88) up the Little River until it met the hydraulic grade line from the analysis upstream of the Little River Dam.

For this analysis, it was determined that a 0.5-foot WSE differential between results obtained from the Duplicate Effective Model and base flood WSEs provided within the FIS was within acceptable limits considering that the existing model was generated using HEC-2. As illustrated in Table 6, the 100-year water surface elevations approximate those listed within the FIS to within 0.3 feet or less with exception to Sections A through C. As a result, it was concluded that the results of the duplicate effective model accurately reflected the results included within FEMA's FIS. The reason for discrepancies in excess of 6 inches between Sections A through C did not have to do with modeling errors, but rather FEMA's subsequent application of 1% backwater impact from the Merrimack River. FEMA's original HEC-2 analysis did not account for backwater impacts from the Merrimack River, whereas the current profile of the River included in the FIS was adjusted by FEMA by extending a straight hydraulic line at El. 22.4 feet (NAVD88) up the Little River until it met the hydraulic grade line from the analysis upstream of the Little River Dam. This was done by FEMA to represent the worst case condition of a 1% annual chance flood peak on the Merrimack River coinciding perfectly in time with a 1% annual chance flood peak on the Little River.

Duplicate Effective Model water surface profiles for the 10-, 50-, 100-, and 500-year floods are included in **Attachment 6** along with a summary of results from the HEC-RAS analysis.

Improved (Pre-Dam Removal) Hydraulic Model

To further improve the accuracy of the initial hydraulic model in order to better assess hydraulic impacts to the river as a result of dam removal, field survey of the Little River Dam and adjacent areas (Project Site) was

performed and bathymetric data was collected in select locations in the River to a point approximately 3,625 feet upstream of the Dam. As a result, Fuss & O'Neill made the following modifications to the duplicate effective hydraulic model of the River within the Project's limit of analysis:

- Added 22 river cross-sections from a point 125 feet downstream of the Winter Street Bridge up to the MBTA Railroad Bridge, allowing development of a more accurate hydraulic model of this section of the River within the Project Site. Refer to Figure 3 for a depiction of river cross section locations where channel bathymetry was obtained. Channel sections shown in red represent FEMA river sections; channel sections shown in orange represent F&O added river cross sections.

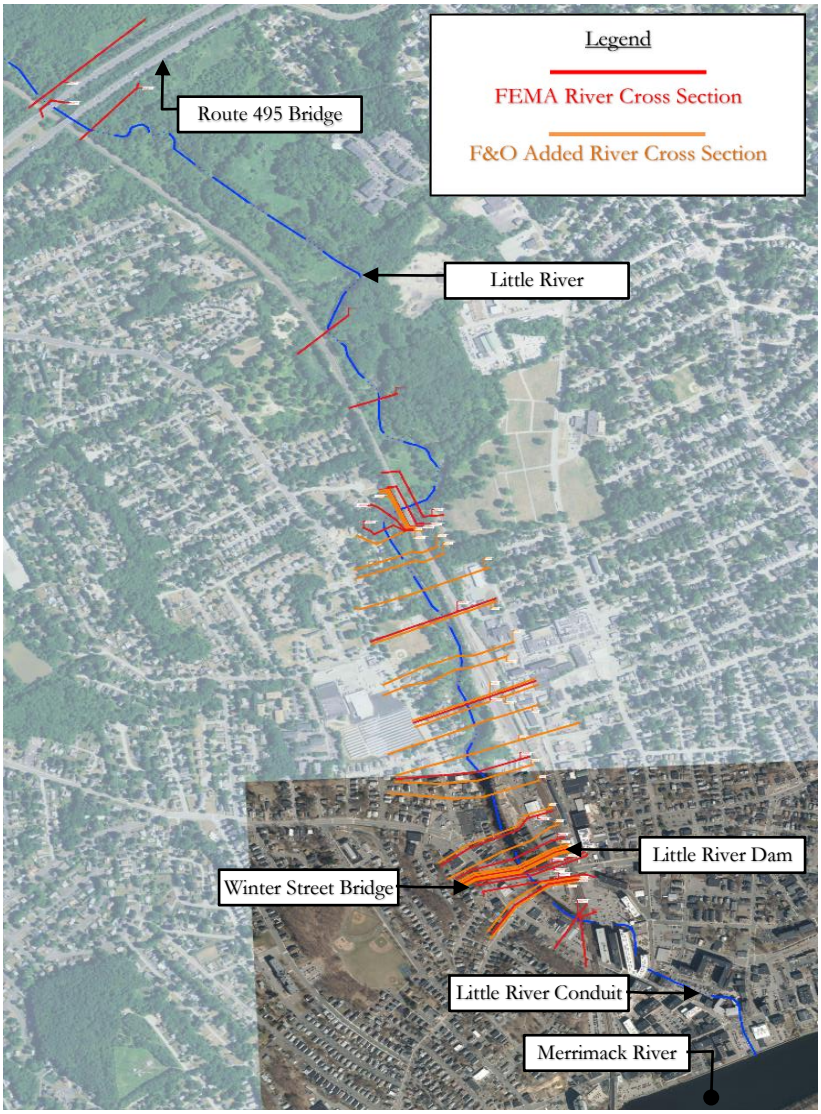


Figure 3: Little River Hydraulic Model Cross Section Locations

- Revised/modified channel geometry for FEMA cross sections from a point 125 feet downstream of the Winter Street Bridge up to the MBTA Railroad Bridge to reflect current conditions. These in-river channel geometry revisions were based on the following field survey work:
    - Approximate channel bathymetry obtained at selected transect locations upstream of the dam on November 17, 2020 by Fuss & O'Neill, Inc. (F&O).
    - Approximate channel bathymetry obtained at selected transect locations on December 15, 2020 by (F&O or Others).

  Refer to **Attachment 7** for a full-size depiction of all river cross-sections used in the hydraulic analysis that were added or revised by F&O in developing the updated hydraulic model. Channel bathymetry/spot elevations obtained during F&O's field surveys are also shown.

- Revised geometry of the Little River Conduit inlets and outlets to match record drawing information included within the City's "Flood Protection System Improvements" dated February 14, 2013.
- Changed the dam to an in-line structure. In FEMA's model, the dam was modeled as a raised channel bed. As a result, F&O changed the dam to an actual structure. The crest elevation of the dam (El. 17.5 feet-NAVD88) was maintained at the same elevation as the raised channel bed bottom in FEMA's hydraulic model, which correctly reflects the elevation of the dam's spillway crest.
    - In order to maintain similar flood elevations upstream of the dam as documented within FEMA's FIS, the steady flow expansion and contraction coefficients at sections immediately upstream and downstream of the dam was increased to 0.6 and 0.8, respectively. This is typical for sections having abrupt hydraulic transitions.
- Changed high flow bridge modeling approach to consistently utilize the Bridge Pressure Flow Computation method.
    - The submerged inlet discharge coefficient Cd varies depending upon the depth of water upstream with values for Cd ranging from 0.27 to 0.5, with a typical value of 0.5 commonly used in practice. As a result, this typical value of 0.5 was used at all bridges within the project modeling limits.
    - The combined submerged inlet and outlet discharge coefficient typically ranges from 0.7 to 0.9, with a value of 0.8 commonly used for most bridges. As a result, this value of 0.8 was used at all bridges within project modeling limits.
- Channel and overbank roughness factors largely remained unchanged from the 1979 HEC-2 Model. The only changes included the change to a few sections just upstream of the dam that had main channel roughness coefficients of 0.029.
- Since the majority of sections upstream of the dam (between the dam and upstream MBTA railroad) were modeled by FEMA as having a 0.065 main channel roughness coefficient, which is typical for main channels with sluggish reaches and deep pools/weeds, the main channel roughness coefficients for the few sections immediately upstream of the dam were changed since the sections immediately upstream of the dam would represent a sluggish reach.
- Fuss & O'Neill used flood flows reported in the 1979 HEC-2 Model for the 10-, 50-, 100-, and 500-year flood events. However, to better reflect actual hydraulic conditions this analysis was run as a mixed-flow regime hydraulic analysis. When mixed-flow regime is used, HEC-RAS allows for subcritical flow, supercritical flow, hydraulic jumps, and drawdowns (as applicable). Because starting boundary condition water surface elevations are necessary at the upstream and downstream limits of this type of hydraulic analysis, reported water surface elevations obtained from the 1979 HEC-2 Model were utilized.

Water surface elevations and flow velocities computed from this improved Pre-Dam Removal Hydraulic Model during base conditions, the upstream fish migration period, and selected flood flow events (i.e. 10-, 50-, 100-, and 500-year floods) will be used as a basis for comparison for post-dam removal water surface elevations and flow velocities. Water surface profiles and modeling results for the improved Pre-Dam Removal Hydraulic Model are included in **Attachment 8**.

Post-Dam Removal Hydraulic Model

Hydraulic conditions following dam removal were first modeled by simply removing the inline structure (representing the Dam) from the model geometry and performing the hydraulic analysis using HEC-RAS. This initial analysis assumed that the channel bottom upstream of the Dam would remain unchanged (i.e. that channel bottom sediment would remain in-place). After reviewing the preliminary hydraulic results from this analysis (i.e. the anticipated flow velocities and shallow flow depths) and the composition and gradation of the existing sediment that is located throughout the river channel upstream of the dam, it was concluded that channel bottom high points (which could represent areas of sediment build-up) are likely to erode during both low flow and flood event conditions. As a result, cross section geometry between the Winter Street Bridge and the MBTA Railroad Bridge was altered to reflect the following additional changes made to the post-dam removal hydraulic model:

- The removal of sediment build-up and other localized channel bottom high points immediately downstream of the Winter Street Bridge and between the Dam and the MBTA Railroad Bridge due to the high mobility potential of the fine sediment that exists throughout the channel bottom upstream of the Dam. This involved reducing the elevation of the channel bottom to reflect the creation of a thalweg (the deepest point within the channel) at the majority of the cross sections throughout the reach upstream of the Dam between the Dam and the MBTA Railroad Bridge. This also involved actively removing sediment accumulated behind the dam. As shown in Figure 4, this resulted in the creation of a more uniform channel bed slope. Removing the majority of sediment from localized high points and areas of increased flow velocities and stabilizing the channel bed within the river's thalweg immediately following dam removal reduces the risk of an uncontrolled headcut progressing upstream through the sediment and an uncontrolled release of sediment into the Little River Flood Conduit and Merrimack River. The changes made to the channel bottom do not reflect the complete removal of sediment (outside of the thalweg) as it would be assumed that mobile sediments would remain in the channel bed or newly formed bank areas following proposed

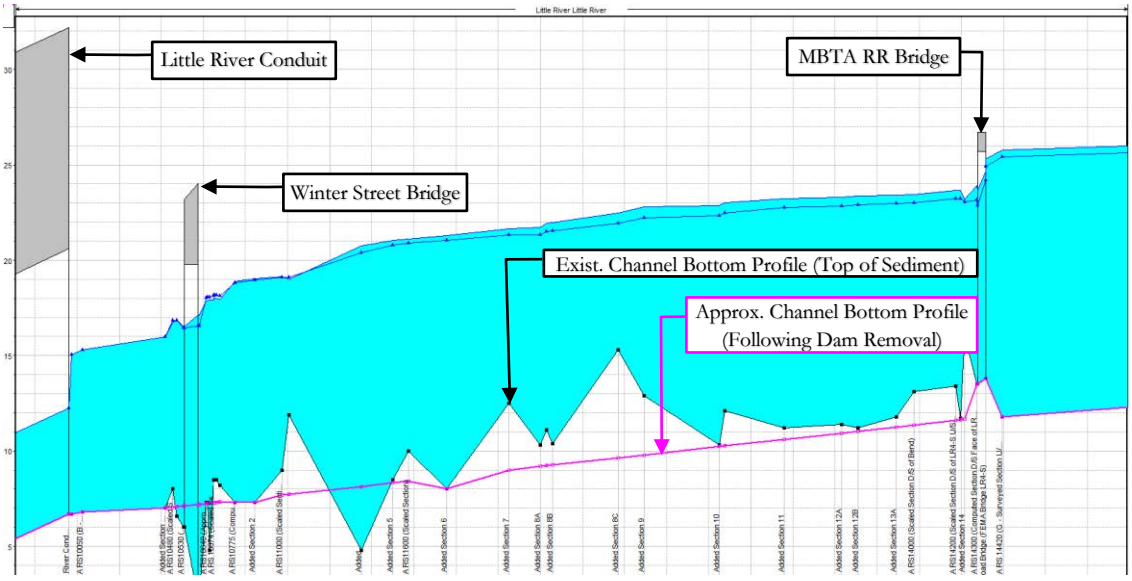


Figure 4: Approximate Channel Bottom Profile Following Dam Removal

dam removal and channel grading and would also settle out in existing scour hole areas or eroded sections within the channel bottom. Stabilizing the channel bottom within the thalweg will also assist in providing assurance that minimum flow depths will be maintained for aquatic and recreational passage during lower flow conditions.

- The filling of the large scour hole currently present under the Winter Street Bridge, to reduce the risk of further scour following dam removal. A portion of sediment that is removed from the build-up area upstream of the dam could be used to fill this area in conjunction with more stable and scour resistant materials.
- The elimination of a high point immediately downstream of the MBTA Railroad Bridge that has formed due to displacement of large stone material at the bridge. Further analysis revealed that this high point would form a fish passage barrier in terms of restricted flow depths. It was, therefore, assumed that removal of the high point would be necessary to achieve project goals.

Post-Dam Removal water surface profiles and modeling results are included in **Attachment 9**.

Sediment Mobility and Scour Assessment Summary

Sediment mobility and scour potential are key aspects of dam removal projects and can significantly impact implementation costs. If sediment exists within the headpond, this sediment can become mobile once the dam is removed resulting in the transfer of sediment to downstream locations including the Little River Conduit. Furthermore, there can also be adverse environmental and water quality impacts to downstream areas if this sediment is substantially impacted by contaminants trapped by the dam. The removal of dams can also have potential impacts at upstream bridge locations requiring the need for bridge foundation replacement, protection, or other in-river improvements to reduce or eliminate scour potential.

In support of this feasibility investigation for the removal of the Little River Dam, an Environmental Site Assessment (ESA) was performed to evaluate the size, composition, and quality of the impounded sediments that could potentially be mobilized as a result of dam removal. Refer to Fuss & O'Neill's *Little River Dam Removal Sediment Quality and Depth Assessment Memorandum (dated December 30, 2020)* for more detail. In summary, the general subsurface conditions of the river channel upstream of the dam was determined to include a layer of organic silt (occasionally overlain by fine gravel) which was underlain by a native channel bottom horizon consisting of sandy silt. Upstream organic silt/sediment depths ranged between 1.0 to 2.5 feet at the specific transect locations where sediment was analyzed. The river channel bottom downstream of the dam, however, was found to primarily be comprised of only cobbles with little to no sediment. The sediment samples collected at the three locations/transects within the headpond (referred to herein as Transects 1, 2, and 3) yielded D_{50} particle sizes of 0.2647 millimeters (or 0.010 inches), 1.2535 millimeters (or 0.049 inches), and 0.0901 millimeters (or 0.004 inches). Refer to **Attachment 10** for the results of the sieve analyses performed for each sample obtained.

To determine if river flow following removal of the dam would be capable of transporting this channel bed sediment, the velocity required to initiate motion (V_c) of the D_{50} size of channel bed sediment (as obtained through laboratory sieve analyses) was compared to the calculated mean velocity (V) of the flow in the main channel and/or overbank areas subsequent to dam removal (as obtained from HEC-RAS post-removal analysis results) at the three locations/transects where the sediment was collected and sampled. If the critical velocity of the bed material was larger than the mean velocity in the channel ($Vc > V$) at each location/

transect, it was assumed that sediment in that location would not become mobile as a result of dam removal. If the critical velocity was less than the mean velocity (Vc < V), it was then assumed that sediment would become mobile as a result of dam removal at that location/transect. The following equation (Equation 6.1, HEC-18) for critical velocity was used to determine if river flow following removal of the dam would potentially be capable of transporting bed material to downstream areas including the Little River Conduit. To determine if river flow following removal of the dam would be capable of transporting channel bed sediment, the velocity required to initiate motion (Vc) of the D_{50} size of channel bed sediment was compared to the calculated velocity (V) of the flow in the main river channel during each flow/flood event. Table 7 lists the anticipated post-dam removal flood event channel depths and flow velocities at each upstream transect location during low-tide conditions (i.e. assuming no backwater impacts from the Merrimack River); Table 8 provides a summary of computed flow velocities at each location during the analyzed flow/flood events and identifies locations where the potential for sediment mobility exists.

$$V_c = K_u * y^{1/6} * D^{1/3} \quad \textbf{(Equation 6.1)}$$

where:

- V_c = Critical velocity above which bed material of size D and smaller will be transported, ft/s
- y = Average depth of flow, ft.
- D = Particle size for V_c, ft.
- D_{50} = Particle size in a mixture of which 50 percent are smaller, ft.
- K_u = 11.17

Table 7: Post Dam-Removal Flow Depths and Critical Flow Velocities

Transect Location	Corresponding River Section(s)	Post Dam Removal Average Channel Depths (feet)[1]				Post Dam Removal Critical Flow Velocities for D_{50} Particles (fps)			
		Base Flow Condition	10-Year Flood	50-Year Flood	100-Year Flood	Base Flow Condition	10-Year Flood	50-Year Flood	100-Year Flood
1	1E (RS2450-RS2480)	0.56	7.10	10.19	12.06	0.10	0.15	0.16	0.16
2	8A (RS3850-RS4000)	0.67	5.75	8.23	10.30	0.17	0.24	0.25	0.26
3	12A (RS5510)	0.72	5.45	7.68	9.33	0.07	0.10	0.10	0.11

Table 8: Post Dam Removal Computed Flow Velocities and Sediment Mobility Potential

Transect Location	Corresponding River Section(s)	Post Dam Removal Computed Average Flow Velocities (fps)[1,2]				Potential for Sediment Mobility			
		Base Flow Condition	10-Year Flood	50-Year Flood	100-Year Flood	Base Flow Condition	10-Year Flood	50-Year Flood	100-Year Flood
1	1E (RS2450-RS2480)	0.57	3.21	3.1	2.88	High	High	High	High
2	8A (RS3850-RS4000)	0.59	2.25	2.39	2.25	High	High	High	High
3	12A (RS5510)	0.53	1.16	1.36	1.35	High	High	High	High

Notes:

[1] Where transects are located between one or more river sections, the average channel velocity or depth was used.

[2] Flow velocities are associated with model geometry that reflects the removal of some sediment from the headpond to create a more uniform channel bed slope between the site of the existing Dam and the MBTA railroad bridge.

In summary, it appears that there is a high potential that sediment within the headpond between the Dam and the MBTA railroad will become mobile during all analyzed flood events following dam removal. Since the results of our ESA revealed that the total concentrations of PCBs and VOCs for the samples collected at one of the transect locations (Transect #2) exceeded the MassDEP Maximum Allowable Contaminant Level (MACL) for reuse at a lined landfill and that levels of certain contaminants found in Transect #1 and Transect #2 exceeded their applicable Probability Effect Concentrations (PECs), it is recommended that sediment in this location be further assessed/delineated in order to determine the actual extent of impacted

sediment. Once the actual extent of impacted sediment is defined, the impacted sediment should be completely removed if full dam removal is proposed. Based on the average depth of sediment that was approximated from sediment depths obtained by F&O and TG&B Marine Services at 19 river section locations (as shown in Table 9) during its November 6 and November 17, 2020 field investigations, it is approximated that 16,000 cubic yards of sediment exists within the section of the River between the Dam and the MBTA Railroad could become mobile following dam removal.

Table 9: Headpond Sediment Depth Summary Table

Cross Section	A (12' off Left River Edge)	B (Center of River)	C (12' off Right River Edge)
1E (Transect 1)	1.2	2.2	1.4
1F	0.0	0.0	1.4
2	1.2	0.3	0.0
3	0.7	1.2	1.1
4	0.5	0.8	2.0
5	2.6	0.4	1.8
6	0.5	0.5	2.6
7	1.8	0.3	2.9
8A (Transect 2)	2.5	2.5	2.5
8B	2.0	0.8	0.2
8C	0.0	0.0	0.1
9	0.0	1.1	1.5
10	2.3	1.5	0.0
11	1.5	0.4	2.5
12A (Transect 3)	1.8	1.5	2.5
12B	0.6	0.3	0.8
13A	2.4	0.2	0.6
13B	0.0	0.0	1.2
14	0.0	0.0	0.0
Average Depth		1.05 feet	
Approximate Headpond Area		411,460 square feet	
Approx. Sediment Volume Within Headpond		432,000 cubic feet (or 16,000 cubic yards)	

Note:
Sediment depths represent the depth of the loose organic layer of sediment/silt within the bottom of the river channel and not the native silty/sandy layer beneath.

Since a portion of this sediment is impacted/contaminated requiring removal and disposal at a licensed facility prior to dam removal, only a portion of this total quantity of sediment would be allowed to mobilize naturally downstream in a controlled manner. Based on the results of our hydraulic analysis, flow velocities within the downstream river channel and Little River conduit (during dry- and wet-weather flow conditions) will ultimately flush this remaining sediment out to the Merrimack River with minimal impacts to hydraulics through the river channel or conduit.

Increased flow velocities are also predicted to occur at bridges within the Project Site due to dam removal during both base flow and flood conditions. Maximum flow velocities associated with the 2% or 1% annual chance floods (whichever velocity is greater) are listed in Table 10 along with the actual increase in velocity as compared to pre-dam removal (existing) conditions. Although flow velocities increase at all bridges included within the hydraulic analysis, the most significant increases occur at the Winter Street and MBTA railroad bridges. It is at these two bridge locations where the need for scour countermeasures is likely and should be further analyzed in order to design measures that reduce adverse impacts to the stability of the structures.

Table 10: Channel Flow Velocities at Little River Bridges During the 2% or 1% Annual Chance Flood Event

Structure	Highest Velocity in Vicinity of Bridge (ft/sec)	Velocity Change at this Location Due to Dam Removal (ft/s)
Winter Street Bridge	5.9	+0.7
MBTA Railroad Bridge	5.8	+1.0
Valley Pipe Support Structure	2.4	+0.2
I-495 Bridges	9.4	+0.4
Rosemont Avenue Bridge	15.2	+0.0

In addition to the potential for scour due to high velocity at the Winter Street and MBTA Railroad Bridges, there is a risk of erosion/scour along the banks of the River between the Dam and the MBTA Railroad Bridge if the dam is removed. Base condition elevations are expected to drop between 4.6 feet and 9.7 feet between the Dam and MBTA Railroad Bridge, between 2.7 feet and 2.8 feet between the MBTA Railroad Bridge and the Valley Pipe Support Structure, and between 0.0 feet and 2.7 feet between the Valley Pipe Support Structure and the I-495 Bridges. Flood elevations associated with the 10-, 50-, and 100-year floods are also expected to drop by up to 5.5 feet upstream of the Dam site following dam removal. As the banks are formed of fine-grained (and therefore highly mobile) material, in locations where base condition and/or flood elevations have dropped more than 2 feet to 3 feet (i.e. between River Sections 2449-5160, or from the Dam upstream to Cashman Park) and the banks are not retained by existing concrete walls, bank stabilization measures may be required to prevent the collapse of the banks. These measures could consist of the installation of natural erosion control blanketing



Figure 5: Potential Sediment Removal, Scour Countermeasure, and Bank Stability Concern Locations

planted with fast-growing native live stakes and possibly seeded with a native plant seed mix. In areas near critical infrastructure, revetments formed of natural materials (e.g. wood and brush) and/or vegetated soil lifts may be required to further reduce risk.

Upstream Base Condition Water Level Changes and Changes to Upstream Wetland Communities

Removal of the dam has the potential to alter and/or shift upstream wetland communities. The extents of potential alterations to these adjacent wetlands are generally a function of the wetland's depth to groundwater (which can be governed by impounded base condition water surface elevations), underlying soil characteristics, and amount of surface runoff discharged from contributing subwatersheds. For preliminary analysis purposes, a drop of more than six inches in upstream base condition water-surface elevations was conservatively assumed to potentially result in an ecological change to adjoining upstream wetland communities. Based on the results of our analysis, the section of River between the Little River Dam and its crossing beneath the Interstate 495 (I-495) bridges will experience base condition water surface elevation drops of six inches or more. As shown in Figure 6, these drops will range between 9.8 feet and 4.6 feet between the Dam and the upstream MBTA Railroad bridge; between 2.8 feet and 2.7 feet between the MBTA Railroad bridge and the Utility Conduit Crossing; and between 2.7 feet and 0.0 feet between the Utility Conduit Crossing and the I-495 bridges.

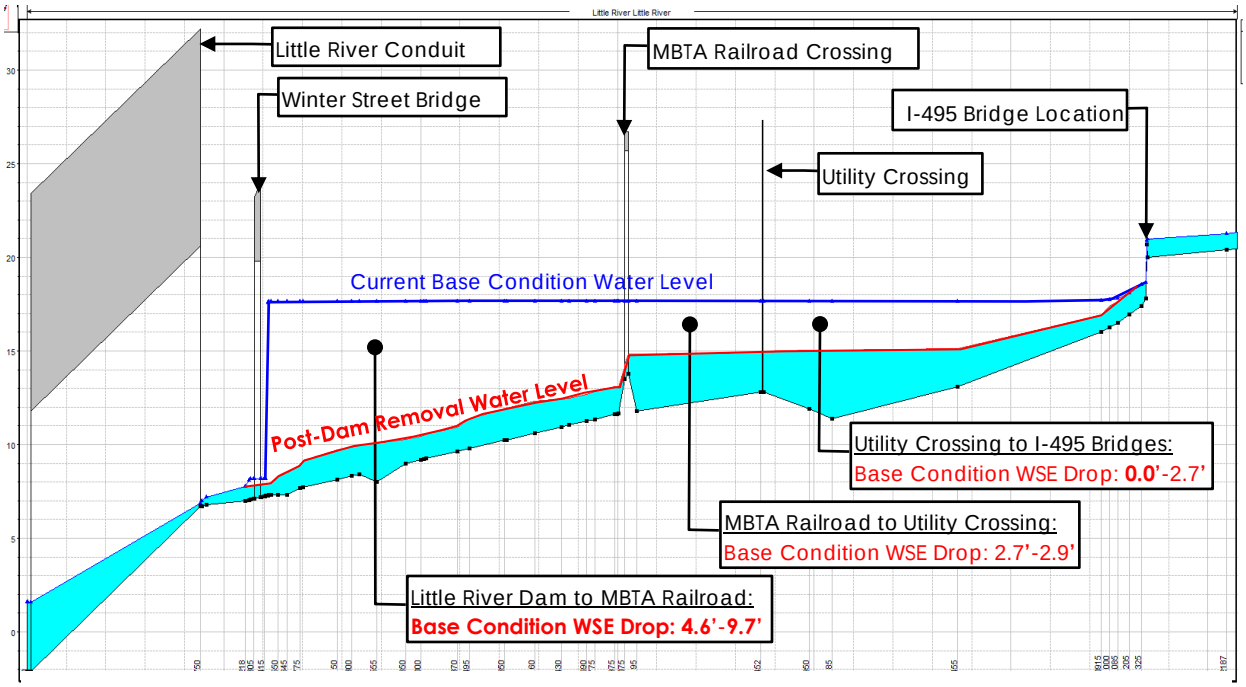


Figure 6: Pre- Versus Post-Dam Removal Base Condition Water Surface Profiles

According to MassDEP Wetland (2005) data, and as reflected in Figure 7, there are several wetland communities that border the River between the River's crossings with the MBTA bridge and Interstate 495 (I-495) Bridge. Based on MassGIS data, within that stretch of the River, there are approximately:

- 11.5 acres of deciduous wooded swamp;

- 13.4 acres of shrub swamp;
- 20.2 acres of shallow marsh meadow or fen;
- 2.8 acres of deep marsh; and
- 20.3 acres of open water/riverine habitat.

There are, however, no mapped natural heritage estimated habitats of rare wildlife, natural communities, certified vernal pools, priority habitats of rare wildlife, or priority habitats of rare species.

At this initial stage of dam removal feasibility analysis, it is conservative to assume that a significant portion of the wetlands listed above may potentially be altered. It is possible that some existing areas of wetlands may convert to upland. Simultaneoulsly, it is likely that existing area currently inundated by the Little River Dam impoundment may develop into various wetland types once that land is exposed. As noted above, the specific changes will be dictated by additional factors such as underlyling soils and geology and site-specific patterns of surface and ground water circulation.

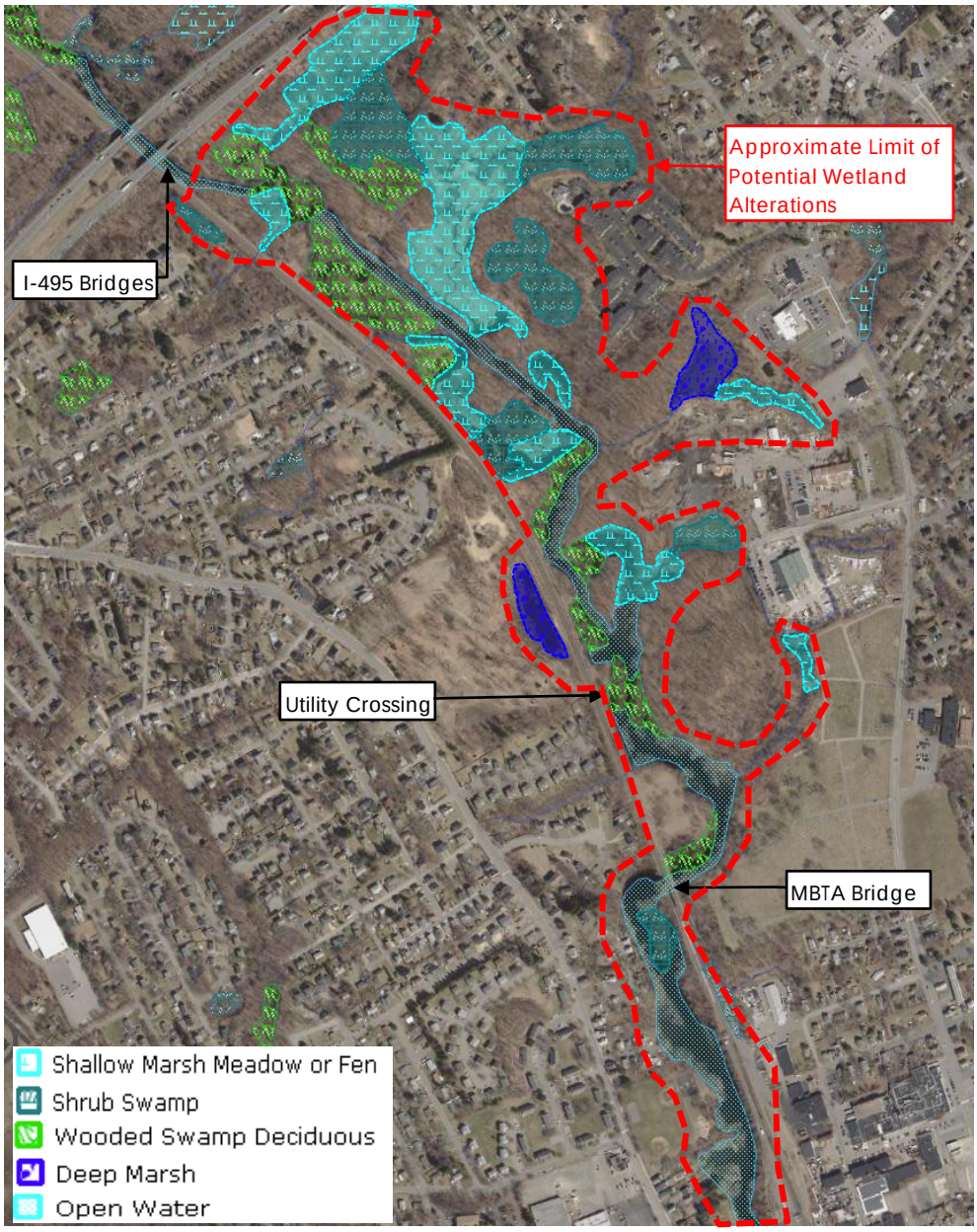


Figure 7: Wetland Communities Upstream of the Little River Dam

The removal of the dam is also expected to result in base condition average river width reductions. As shown in Figure 8, it is anticipated the river

will revert back to its natural river width of approximately 25 to 35 feet (between the Dam and MBTA Railroad) under base flow conditions following full dam removal. This represents width reductions of approximately: 60 feet between the Dam and the upstream MBTA Railroad bridge; 25 feet between the MBTA Railroad bridge and the Utility Conduit Crossing; and 15 feet between the Utility Conduit Crossing and the I-495 bridges. It is likely that this area between the new river width and the former river width will revert to riparian habitat; and that riverine and wetland vegetation will gradually replace reservoir taxa (Stanley and Doyle 2003) within these newly exposed riverbank areas.



Figure 8: Low Flow River Width Reductions

Refer to **Attachment 11** for base condition flow pre- versus post- hydraulic analysis results. The average depth of the river channel between a point approximately 325 feet upstream of the former Dam and the MBTA railroad is also expected to range between 15 to 18 inches under base flow (or low flow) conditions.

These conditions are expected to still allow for canoeing and kayaking, though conditions may not be optimal during the peak of summer.

Flood Reduction Benefits

Fully removing the Dam will result in a notable reduction in upstream water levels during flood events up to Rosemont Avenue. The following table provides a summary of the range of upstream flood level reductions during the 10%, 2%, 1%, and 0.2% Annual Chance Flood Events commonly referred to as the 10-, 50-, 100-, and 500-year flood events. It is assumed that these are inland flood events with no coastal storm surge. This assumption was made to conservatively approximate changes in flood velocities since assuming storm surge elevations will result in more backflow impacts and lower flow velocities which would result in an underestimation of peak flow velocities that would result during inland flood events.

Table 11: Flood Level Reductions During the 10%, 2%, 1%, and 0.2% Annual Chance Flood Events

Section of River	10-Year Flood Level Reduction Range (Minimum to Maximum, feet)	50-Year Flood Level Reduction Range (Minimum to Maximum, feet)	100-Year Flood Level Reduction Range (Minimum to Maximum, feet)	500-Year Flood Level Reduction Range (Minimum to Maximum, feet)
Dam to MBTA Railroad Bridge	5.5-1.4 feet[1]	2.7-1.3 feet[1]	0.8-0.7 feet[1]	Less than 0.2 feet[1]
MBTA Railroad Bridge to Utility Crossing	1.3-0.9 feet	0.9-0.7 feet	0.1 feet	0.1 feet
Valley Pipe Crossing to I-495 Bridges	0.9-0.2 feet	0.7-0.2 feet	0.1 feet	0.0- 0.1 feet
I-495 Bridges to Rosemont Avenue	Less than 0.2 feet	Less than 0.2 feet	Less than 0.1 feet	Less than 0.1 feet

1 Reductions will be less during coastal storm events. As reflected in the FIS, storm surge elevations in the Merrimack River were approximated to be El. 15.3 feet, El. 19.5 feet, El. 22.4 feet, and El. 28.7 feet during the 10-Year, 50-Year, 100-Year, and 500-Year flood events, respectively.

Figure 9 illustrates the reduction in flood levels during the 100-year flood event during an inland flood event.

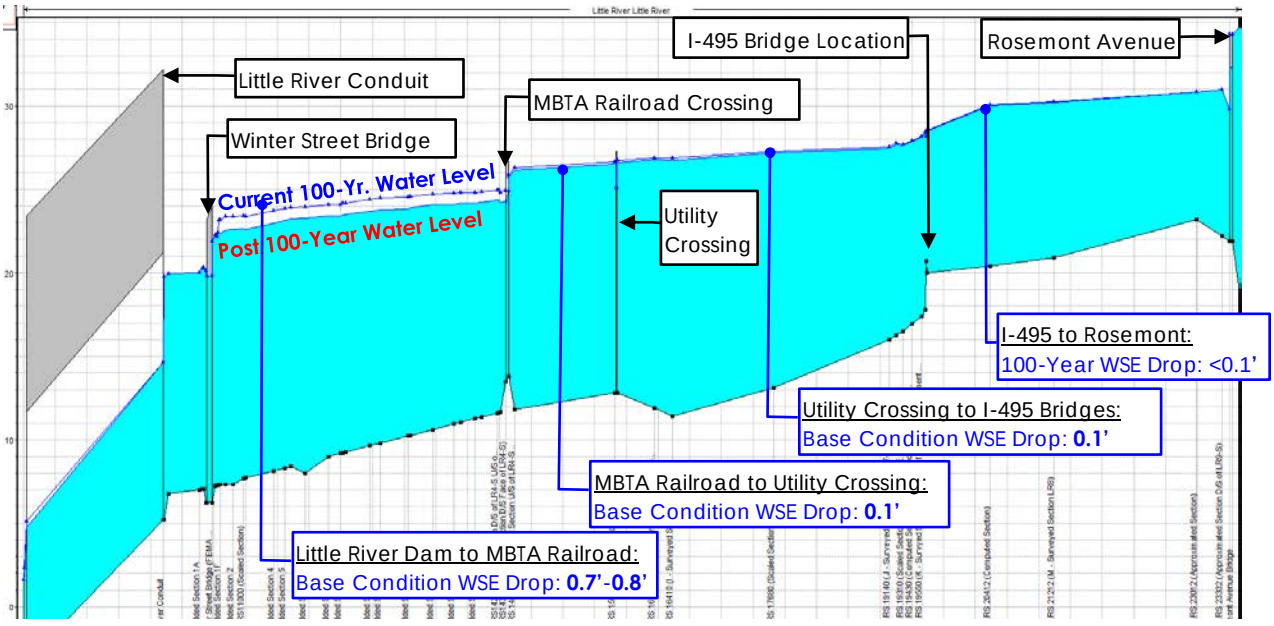


Figure 9: 100-Year Water Surface Elevation Reductions During Inland Flood Event

While these flood benefits will be realized during inland flood events, it is not anticipated that dam removal will have a significant impact on flood insurance rates for properties currently located within the floodplain. This is because the flood insurance rates are conservatively based on a 100-year flood event coupled with a storm surge scenario as reflected in the current FIS for Essex County. When applying backwater impacts from the Merrimack River during a coastal flood, 100-year flood reductions between the Dam and the MBTA Railroad will only range between 0.1 feet and 0.2 feet as shown in Figure 10.

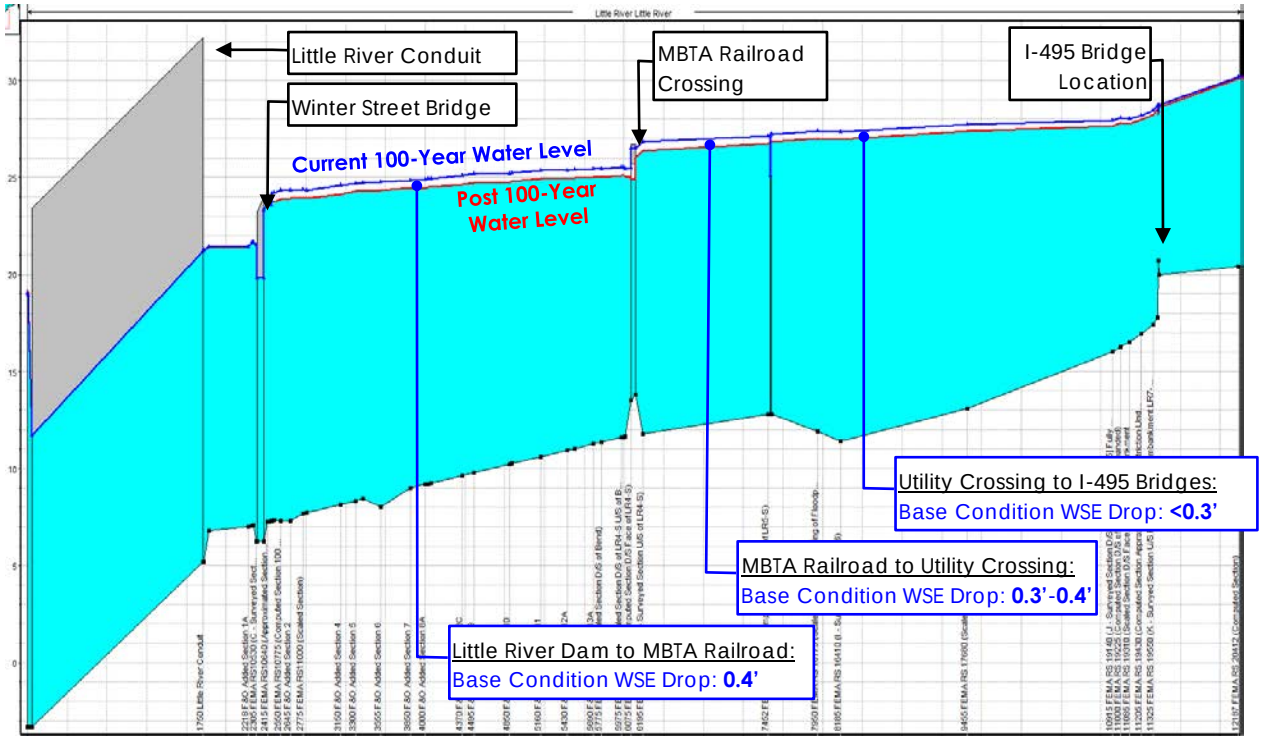


Figure 10: 100-Year Water Surface Elevation Reductions During Coastal Flood Event

It is important to note that with these notable reductions in flood elevations during inland storm events, there will be increases in flow velocities throughout the River between the Dam and the Rosemont Avenue Bridge. Such increases will be greatest just upstream of the Dam (e.g. the maximum increase in velocity is 3.4 ft/s approximately 30 feet upstream of the current location of the dam during the 10-year flood) and immediately downstream of the MBTA Railroad and I-495 Bridges. These increases in velocities at these specific locations may increase the potential for scour during flood events and require the installation of scour countermeasures (as previously mentioned in this memorandum).

Reductions in flood elevations during inland storm events may also leave banks vulnerable to undercutting and collapse in some locations upstream of the Dam. Based on the results of the pre- versus post-dam removal results for the 10-year, 50-year, 100-year, and 500-year inland storm events, it appears that reductions in flood elevations (coupled with increased flow velocities) will primarily occur between the Dam and the MBTA Bridge. As a result, there is the potential that bank stabilization will be required along both sides of the River within this stretch of the River. Once it is determined through further discussion with the Massachusetts Division of Marine Fisheries and the City regarding the target species minimum flow depth

requirements and maximum flow velocities that will be deemed acceptable for this River/project, the type of nature-like fishway and/or river channel improvements that are currently being considered (as described in following sections) can be incorporated into the design and the post-project hydraulic model will be refined. This will allow us to more accurately define the limits of required bank stabilization measures and the type of stabilization measure that is most suitable. As previously mentioned, these measures could consist of a combination of natural erosion control blanketing, fast-growing native live stakes, and native wetland/conservation seed mix; revetments formed of natural materials (e.g. wood and brush); and/or vegetated soil lifts.

Fish Passage Assessment

The removal of the Little River Dam will result in a section of the river channel with reduced flow depths and increased flow velocities during all flow conditions including the upstream migration period of the target fish species. The following sections summarize the biological characteristics of the target species including the minimum flow depths and maximum flow velocities necessary to assess safe and effective fish passage.

Fish Passage Design Criteria Used in Evaluation of Dam Removal

In evaluating the minimum flow depth that would be required to effectively pass fish during the upstream and downstream fish passage migration seasons, the following guidance from USFWS's *Fish Passage Engineering Design Criteria (June 2019)* was considered:

> *Providing sufficient depth allows fish to swim normally (i.e., fully submerged, including dorsal fin) and may alleviate any adverse behavioral reaction to shallow water. In general, engineering recommends that the depth of flow be greater than or equal to two times the largest fish's body depth. Greater depth criteria may apply to various fishway components to meet the needs of certain species or to address site-specific concerns.*

Maximum body lengths, depths, and swim speeds of target migratory fish within the project area are shown in Table 12 below. From this table it is noted that the maximum body depth of striped Bass, the largest fish of the project's target species, is approximately 12.4 inches. This translates to a minimum 2.1-foot flow depth required for the effective passage of striped bass. Table 12 also lists other design parameters (e.g. minimum weir opening width, minimum weir opening depth, and minimum channel/pool depths) to be used in the design of nature-like fishways. All of the parameters provided in Table 12 were obtained from *Appendix C* of USFWS's *Fish Passage Engineering Design Criteria (June 2019*) document.

In addition to flow depths, flow velocities are also a major consideration for the design of channel modifications to improve fish passage. As shown above, different species of fish have differing burst and cruising speeds, reflective of their respective endurance characteristics. Burst speeds are generally accepted as the speed a fish can swim between 2 and 10 seconds, prolonged speeds are generally accepted as the speed a fish can maintain for five to eight minutes before tiring (Bell (1991) and Bain (1999)), and cruising/sustained speeds are considered the speed that a fish can maintain for hours. In collectively reviewing the cruising and burst speeds of the target species, the following design criteria have been determined:

Table 12: Summary of Biological Characteristics and Fishway Design Criteria for Target Species

Target Species	Maximum Body Depth (in)	Burst Speed (ft/sec)	Cruising Speed (ft/sec)	Min. Flow Depth Required (ft)	USFWS Recommended Fishway Min. Weir Opening Width (ft)	USFWS Recommended Fishway Min. Weir Opening Depth (ft)	USFWS Recommended Fishway Min. Pool Depth (ft)
Alewife	3.5	6.0	1.0	0.6	2.50	0.75	2.00
Blueback herring	3.1	6.0	1.0	0.5	2.25	1.00	2.00
American eel (adult)	3.1	1.0	0.2	0.5	0.75	1.00	2.00
American shad	8.7	8.25	1.4	1.5	5.00	2.25	4.00
Rainbow Smelt	1.4	**3.25**	**0.5**	0.25	1.00	0.50	1.50
Striped Bass	**12.4**	5.25	0.9	**2.0**	**9.25**	**3.25**	**5.25**
Sea Lamprey	2.4	6.00	1.0	0.4	0.75	0.75	2.00
Gizzard Shad	6.4	4.00	0.7	1.1	3.50	1.75	3.25

In addition to flow depths, flow velocities are also a major consideration for the design of channel modifications to improve fish passage. As shown above, different species of fish have differing burst and cruising speeds, reflective of their respective endurance characteristics. Burst speeds are generally accepted as the speed a fish can swim between 2 and 10 seconds, prolonged speeds are generally accepted as the speed a fish can maintain for five to eight minutes before tiring (Bell (1991) and Bain (1999)), and cruising/sustained speeds are considered the speed that a fish can maintain for hours. In collectively reviewing the cruising and burst speeds of the target species, the following design criteria have been determined:

- A flow velocity of 0.5 feet per second or less was selected as the target (goal) cruising speed for assessing effective passage for long distances upstream, which would effectively allow passage of Alewife, Blueback herring, American shad, and rainbow smelt. This was based on the cruising speed for smelt being the limiting (most conservative) species. It is recognized that juvenile American eel would find avenues for passage at minor eddies and/or during flow conditions where velocities are suitable. An average channel flow velocity of 0.5 feet per second may not be achievable at all locations in the project area, but flow velocities are typically slower than the average channel velocity along the edges and bottom of the channel.
- A flow velocity of approximately 3.25 feet per second or less was selected as the target (goal) burst speed for assessing effective passage for migrating upstream for short distances (i.e. through weir openings and/or riffles). This was based on the burst speed for smelt being the limiting (most conservative) species. It is noted in *Appendix C* of *USFWS's Fish Passage Engineering Design Criteria* document that this value could be as high as 3.9 feet per second but was conservatively rounded down. It is recognized that juvenile American eel would find avenues for passage at minor eddies and/or during flow conditions where velocities are suitable.

Need for Fish Passage Improvements

Based on a review of post-dam removal channel depths and average channel flow velocities obtained through analysis, the following potential passage concerns were noted during the upstream migration period. Only the section of the Little River between the I-495 Bridges and the River's confluence with the

Merrimack River were assessed for passage since minimal changes in hydraulics are expected upstream of the I-495 Bridges during the upstream migration period.

- The first barrier to upstream passage will occur at the upstream end (entrance) of the Little River Conduit and the section of the river channel approximately 50 feet upstream. Flow depths at the entrance will be approximately 10 inches during minimum (95% exceedance) flow conditions anticipated during the upstream passage season. This could present passage issues for American shad and striped bass. However, depths at this location during normal (50% exceedance) and maximum (5% exceedance) flow conditions should be adequate for passage. It should also be noted that the Little River Conduit is approximately 2,000 feet in length. This could also impact passage effectiveness given the unnatural culvert bottom and lack of natural light within. American shad would be the species most sensitive to a lack of light within the conduit and the various cross section geometry changes and bends within the conduit. Rainbow smelt also prefer clean, unsilted, and non-urban waters which may result in a non-ideal habitat for this particular species.
- The second barrier to upstream passage may occur within the section of the river channel between the Little River Conduit and the Winter Street Bridge. In general, flow depths during minimum (or 95% exceedance) flow conditions during the upstream migration will vary between approximately 5 inches and 10 inches; and approximately 18 inches and 22 inches during normal flow conditions. This will likely make passage difficult for American shad, gizzard shad, and striped bass; and could prove to be challenging for some larger river herring. Flow depths during normal (50% exceedance) flow conditions during the upstream migration will vary between approximately 18 inches and 22 inches which could impact passage for striped bass. In order to increase the effectiveness of fish passage through this stretch of the River, a low flow channel could be constructed that would increase depths to approximately 24 inches during low and normal flow conditions. Prior to constructing this channel, an actual survey of this stretch of the River should be performed to confirm that a low-flow channel is required. The incorporation of a pool (or excavated area approximately 24-inches in depth) is recommended approximately 50 feet upstream of the entrance of the Little River Conduit to address a localized area of increased flow velocities which could prove problematic for rainbow smelt and gizzard shad. It is likely that the existing scour hole approximately 60 feet downstream of the Winter Street Bridge on river right can also serve as a second resting pool during the upstream migration period within this stretch of the River.
- Removal of the dam without specific improvements to encourage fish passage will also result in relatively shallow depths (of approximately 8 to 16 inches) in the section of the river between the Winter Street Bridge and approximately 325 feet upstream of the former dam location during minimum (95% exceedance) flow conditions. It is in this location where the addition of a roughened low flow channel or the construction of a nature-like fishway would significantly minimize effective passage concerns for the larger sized fish within the target species such as American shad, gizzard shad, and striped bass. Potential nature-like fishway alternatives at this location are discussed in subsequent sections within this memorandum.
- The last barrier to passage may likely occur as flow passes beneath the MBTA Railroad Bridge. During minimum (95% exceedance) and normal (50% exceedance) flow conditions, model results indicate that there will be flow depths through the bridge of between 8 inches and 14 inches, respectively, and flow velocities of between 3.4 feet per second and 4.5 feet per second just downstream of the bridge. It is recommended that a low flow channel be created in this location to increase depth and reduce flow

velocities that could otherwise reduce fish passage effectiveness.

A summary of hydraulic modeling results for post-dam removal flow velocities and depths upstream of the Little River Conduit and downstream of the I-495 Bridges during the upstream migration season is provided below in Table 13. Values in red indicate values that exceed the burst speed or fall below minimum required flow depth of the most conservative fish within the target species. Note that this model accounts for dam removal, but does not yet account for any modifications designed to improve fish passage conditions.

Table 13: Hydraulic Summary Results for Dam Removal Alternative

Upstream Migration Flow Condition	Flow Velocities (ft/sec)	Average Flow Velocity (ft/sec)	Flow Depths (feet)	Average Flow Depth (feet)
Stretch of River between Little River Conduit and Winter Street				
Minimum Design Flow (Q95%)	0.34 – 2.57	1.22	0.42 – 1.66	0.95
Normal Design Flow (Q50%)	0.79 – 3.94	1.86	0.73 – 2.37	1.61
Maximum Design Flow (Q5%)	1.63 – 4.13	2.70	1.85 – 3.48	2.78
Stretch of River between Winter Street and MBTA Railroad				
Minimum Design Flow (Q95%)	0.25 - 3.37	0.86	0.67 – 2.26	1.40
Normal Design Flow (Q50%)	0.46 – 3.47	1.25	1.23 – 3.49	2.44
Maximum Design Flow (Q5%)	0.73 – 3.92	1.78	2.58 – 5.25	4.06
Stretch of River between MBTA Railroad and I-495 Bridges				
Minimum Design Flow (Q95%)	0.24 – 1.86	0.88	0.99 – 3.82	2.01
Normal Design Flow (Q50%)	0.56 – 2.26	1.29	1.94 – 5.11	3.10
Maximum Design Flow (Q5%)	1.03 – 3.06	1.85	3.37 – 7.12	4.82

A full summary of fish passage flow depths and velocities at all river sections within the Project Site following removal of the dam is provided in **Attachment 12**. Water surface profiles during base flow and

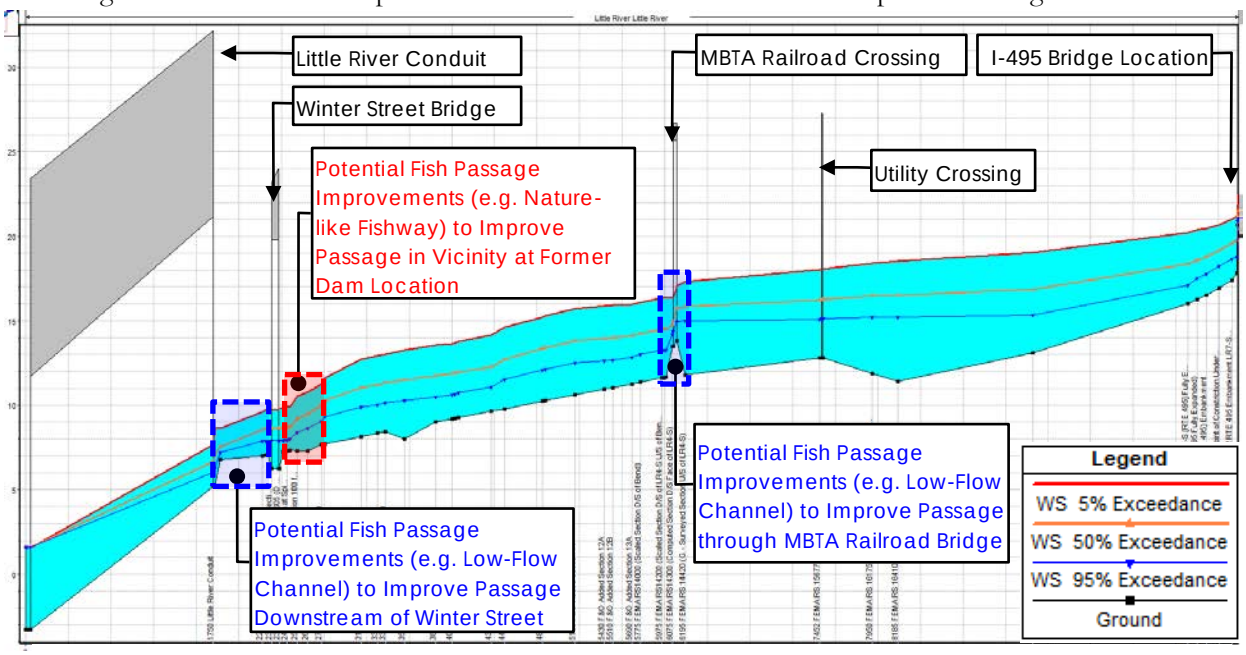


Figure 11: Post-Dam Removal Fish Passage Season Water Surface Profiles

upstream fish passage migration season flow conditions following dam removal are depicted in Figure 11, respectively.

It should be noted that the fish passage flows were modeled under mean tide level conditions to assess average post-construction conditions for fish passage without impacts from fluctuating tidal conditions. Flow conditions were also analyzed under mean low and high tide conditions through the Little River Conduit. There were minimal changes experienced in flow depths and velocities at the upstream entrance of the Little River Flood Conduit because the elevation of the upstream end of the Little River Flood Conduit (El. 5.20 feet) is greater than the elevation of mean high water (El. 4.46 feet). However, an analysis of hydraulics through the conduit revealed that there are potential fish passage flow velocity and depth barriers within the upstream end of the conduit under varying flow conditions. During minimum (95% exceedance flow conditions), a flow depth of 0.8 feet is expected which could be a barrier to shad and striped bass. During maximum (5% exceedance) flow conditions, a flow velocity of 7.4 feet per second exceeds the burst speed for all fish within the target species with the exception of American shad. Flow velocities through the conduit may also be problematic for rainbow smelt during all but lower flow conditions anticipated during the upstream migration period. As a result, the Little River Conduit may be the first true barrier to effective passage for several fish included within the target species when lower and higher flows are conveyed by the River during the upstream migration period. As a result, it is recommended that the City or the Massachusetts Department of Marine Fisheries (DMF) observe fish species that are present at the base of the existing dam during the upstream migration period (March 1st to June 30th). This will assist in confirming which species are expected to migrate upstream following dam removal and the actual depth that fish passage and/or river channel improvements should be assessed and designed for. If possible, DMF could do pit tagging or radio telemetry at the entrance and exit of the Little River Conduit to get a better understanding of how much of a barrier the Little River Conduit is to fish passage. If it is determined that fish are passing through the Conduit under current conditions, there may be opportunities to improve passage by increasing the amount of daylight that is allowed to enter the culvert through openings like manholes (i.e. ones that let light in) and/or the addition of natural substrates/smaller baffles that help reduce velocities and create added depth in certain locations within the conduit while avoiding impacts to flood flows.

Fish Passage Alternatives to Be Considered

In order to provide adequate flow depths and suitable flow velocities for the target species during the range of flows that are anticipated during the upstream fish migration season, it appears that the following fish passage improvements may be required.

- A low-flow channel upstream of the Little River conduit between its upstream end (entrance) and the Winter Street Bridge can help to overcome reduced flow depths during minimum (or 95% exceedance) flow conditions and normal (or 50% exceedance) flow conditions which will otherwise likely make passage difficult for American shad, gizzard shad, and striped bass, and could prove to be challenging for some larger river herring. A low-flow channel could be constructed as required to increase depths to approximately 24 inches (ideally) or 18 inches (minimum) during low and normal flow conditions. A resting pool (or excavated area approximately 24-inches in depth) would also be recommended approximately 50 feet upstream of the entrance of the Little River Conduit to address

a localized area of increased flow velocities which could prove problematic for rainbow smelt and gizzard shad.

- A low-flow channel at the MBTA Railroad Bridge. During minimum (95% exceedance) and normal (50% exceedance) flow conditions, there will be reduced flow depths through the bridge in addition to increased flow velocities just downstream of the bridge. To address this, it is recommended that a low flow channel be created in this location to increase depth to 24-inches and potentially reduce flow velocities.
- A thalweg/low-flow channel throughout the reach upstream of the Dam (between the Dam and the MBTA Railroad Bridge). This would result in the creation of a more uniform and stable channel bed slope. The bottom of the thalweg would be reinforced with cobbles and native gravel material and would provide a means of adequate depths (approximately 18 to 24 inches) for aquatic/fish passage during minimum and lower flow conditions experienced during the upstream migration period. Stabilizing the channel bottom within the thalweg will also assist in maintaining minimum flow depths for recreational passage during minimum and lower flow conditions.
- A nature-like fishway between the Winter Street Bridge and a point approximately 200 feet upstream of the former dam location. Removal of the dam will also result in relatively shallow depths (of 12 inches or less) throughout an approximate 225-foot section of the river between the Winter Street Bridge and a point approximately 200 feet upstream of the former dam location during minimum (95% exceedance) flow conditions. This will generally limit effective passage of American shad and striped bass throughout this stretch of the River. Two potential nature-like fishway alternatives are discussed in subsequent sections and include: (1) a roughened channel/riffle fishway and (2) a riffle-pool fishway.

Roughened/Riffle Nature-Like Fishway Alternative

The first alternative consists of the installation of a roughened channel/riffle. As shown in Figure 12, roughened channels/riffles are characterized as being relatively shallow and having relatively rapid current velocities. Because riffles can have high turbulence, they are areas that provide a good deal of oxygen to the stream or river. However, analysis of this alternative will be required to determine if flow depths and velocities will meet respective criteria for effective passage of the target migratory species



Figure 12: Riffle Example (Billington Street Dam Removal, NOAA)

For this project, the roughened

channel/riffle could be designed as a compound channel with a low-flow channel (with a minimum width of approximately 5 feet) to allow for increased flow depths (of approximately 24 inches) during periods of lower flows experienced during the upstream migration period. A 5-foot width was selected as the low-flow channel's maximum width as it will likely be difficult to achieve 24-inches of flow depth during minimum flow conditions with a larger channel width. The upper stage of the roughened channel would then be designed to be approximately 20 feet in accordance with USFWS guidelines for striped bass, American shad, and gizzard shad to accommodate normal (50% exceedance) and maximum (5% exceedance) flows during the upstream migration period. During significant storm and flood events, flow will inundate and spread into the adjacent upper stage river channel areas/benches on both sides of the roughened channel. The substrate of the low-flow channel and upper banks of the roughened channel would consist of gravel, cobbles, and scattered boulders.

Riffle-Pool Nature-Like Fishway

Because roughened channels/ riffles can have high turbulence during periods of higher flows within the upstream migration season and may not achieve desired flow depths during minimum flow conditions, which can have adverse effects on the passage efficiency of American shad (Raabe at al., 2014) and striped bass, the addition of pools to the system can help to dissipate such energy/turbulence and create areas of greater depths and low velocities for resting (i.e. where average flow velocities exceed the cruising speeds of the majority of fish included within the target species). The addition of pools also creates areas of refuge from terrestrial predators. Rainbow smelt is a schooling species and often aggregates in large numbers while resting in pools.

Riffle-pool designs approximate pool-and-weir technical fishways in a more natural manner. Fish move through this type of fishway system by bursting over a boulder riffle or through an opening/gap within the riffle then momentarily resting in the upstream



Figure 13: Riffle-Pool Example (Filley Park and Lower Shannock Falls, F&O)

pool. Suitable fish passage conditions (e.g., flow velocity) can often be created in riffle pools with slopes of 3% or less. Boulder weirs/riffles used to separate pools are typically braced upon footer stones and sized to remain stable under flood flow conditions. Photographs of an example riffle-pool system are provided in Figure 13.

Given this River's relatively low flow during minimum flow conditions of approximately 13 cubic feet per second (cfs), a riffle-pool system may provide better passage for the target species during minimum (95% exceedance) flow conditions than a roughened channel. The upstream-most riffle could also be designed to create added depth for a short distance upstream.

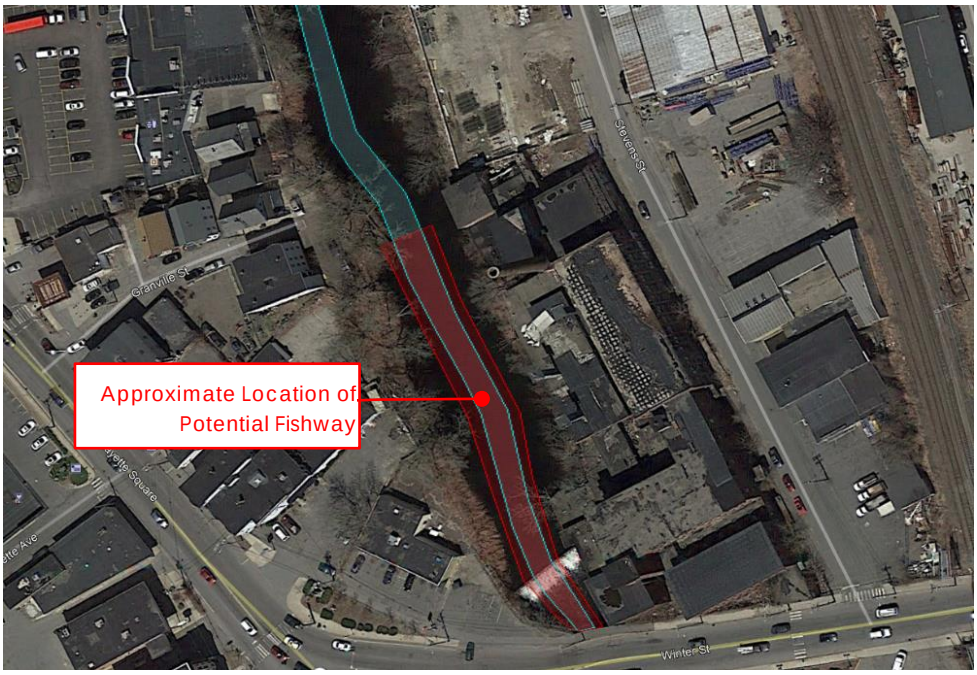


Figure 14: Approximate Location of Nature-like Fishway Just Upstream of Former Dam Location

Other River Restoration Measures

While the potential installation of a nature-like fishway will improve habitat and provide better flow depths for aquatic/fish passage in the immediate vicinity of the former dam location, added river restoration techniques/ measures such as natural boulder vanes (with notches for fish and canoe/kayak passage) strategically installed upstream of the fishway between Benjamin Street, Cashmans Park, and the MBTA Railroad could be used to create added depth



Figure 15: Example of Boulder Vane
(USDA NRCS Georgia Fish and Wildlife Habitat Improvement Practices)

during lower flows to better facilitate aquatic/fish and recreational passage. These vanes will also protect streambanks by redirecting the river's thalweg away from the streambank and toward the center of the channel and enhance in-stream habitat by creating scour pools and providing oxygen. Providing a cross vane approximately 200 feet downstream of the MBTA railroad bridge at the river's sharp bend location could also help reduce flow velocities and increase flow depths through the MBTA bridge which could potentially eliminate the need for a low-flow channel or other scour countermeasure improvements at that location.

Climate Change Applicability

Should climate change predictions documented within the *SHMCAP* become realized, it is anticipated that annual precipitation will increase up to 16% (or 7.3 inches), days with rainfall accumulation of greater than one inch will increase by 57% (or 4 days), the number of consecutive dry days will increase by 18 percent, and summer precipitation will decrease. It is also anticipated that there will be an increase in the intensity and frequency of larger storm events and a rise in sea levels.

Due to the removal of the dam, the limits of tidal inundation (during high tide conditions) will continuously extend further upstream than currently exists. Mean high water is anticipated to potentially rise to El. 8.7 feet (NAVD88) by the year 2070 based on the "high" scenario for Boston as documented within the SHMCAP. This 'high' scenario is recommended since sea-level rise is projected to be greater than the global average along the New England coast. In terms of in-river impacts, with the dam removed, high tide will extend approximately 1,400 feet upstream of the dam's current location in 2070 (up to Apple Street). If a nature-like fishway is installed in the vicinity of the dam, the fishway would likely be inundated during mean high water conditions during 2070, but would continue to operate as designed under mean tide and mean low water conditions. As high tide levels continue to rise, more and more of the River will begin to experience inundation. This, however, would not adversely impact passage.

According to *USGS Scientific Investigations Report 2012-5109*[2], average flood magnification factors of 1.06, 1.13, and 1.21 were computed from local stream gauge data for 10-, 20-, and 30-year projections, respectively, out from 2010. The magnification factor is computed as a function of the slope of the regression and the time period as follows:

$M = e^{\beta \times \Delta t}$ where

M	is the flood modification factor, that is, the change in flood magnitude over a specified time;
β	is the slope of the lognormal regression of annual peak flow and time; and
Δt	is the projected time period.

Using this equation, we estimate that the magnification factor could range between 1.21 and 1.48 for 2070. Table 14 reflects the impact to flood flows conveyed by the Little River at the project site as projected for

[2] USGS, Magnitude of Flood Flows for Selected Annual Exceedance Probabilities in Rhode Island Through 2010, Scientific Investigations Report 2012-5109.

2070, using a flood flow magnification factor of 1.48. In addition, for the climate change analysis a high tide water surface elevation of 8.7 feet (equivalent to the 2070 projected high tide) was assumed for the downstream boundary condition.

Table 14: Peak Flood Event Inflow Rates Projected for 2070

Location	Present-Day 10-Year Flood (cfs)	Projected 10-Year Flood (cfs)	Present-Day 50-Year Flood (cfs)	Projected 50-Year Flood (cfs)	Present-Day 100-Year Flood (cfs)	Projected 100-Year Flood (cfs)
RS 15341 - Upstream Limit of Model	980	1,450	1,640	2427	1,990	2,945
RS 11387 – Upstream of I-495 and Riprap Obstruction	1,160	1,717	1,920	2,842	2,330	3,448

In general, climate change will lead to increased flow velocities during flood flows, which will increase scour potential throughout the project area. Flood elevations will also typically increase whether or not the Dam is removed. However, under a climate change scenario the removal of the Dam will reduce flood risks to upstream structures during analyzed flood events between Winter Street and the I-495 bridges. Flood reductions are most significant immediately upstream of the dam and during the smaller, more frequent flood events such as the 10-year flood event. Flood reductions are less significant during the larger, more infrequent flood events such as the 50- and 100-year flood events.

Table 15: Peak Flood Elevation Comparison Between Present-Day and Projected Flood Conditions

Location	Present 10-Year WSE (feet) With Dam	Projected 10-Year WSE (feet) With Dam	Projected 10-Year WSE (feet) Without Dam	Present 50-Year WSE (feet) With Dam	Projected 50-Year WSE (feet) With Dam	Projected 50-Year WSE (feet) Without Dam	Present 100-Year WSE (feet) With Dam	Projected 100-Year WSE (feet) With Dam	Projected 100-Year WSE (feet) Without Dam
RS 2645 – Just Upstream of Little River Dam	21.14	22.22	18.99	22.57	25.89	25.42	23.39	27.24	27.06
RS 4060 – In Vicinity of Little River Road	21.63	22.89	20.66	23.31	26.44	25.99	24.19	27.78	27.59
RS 6195 – Upstream of MBTA Railroad	23.18	24.78	23.81	25.29	28.01	27.80	26.28	28.87	28.77
RS-7488 – Upstream of Valley Pipe Support Structure	23.57	25.19	24.41	25.72	28.40	28.22	26.74	29.27	29.19
RS 12187 – Upstream of I-495 Bridges	27.08	28.60	28.51	29.10	31.31	31.26	30.07	32.42	32.39

Refer to **Attachment 13** for base condition flow present-day versus projected flood analysis results. Fish passage flows were also projected for 2070 using the same methods as that used for flood flows. Table 16 reflects the impact to fish passage flows conveyed by the Little River at the project site as projected for 2070, using a flood flow magnification factor of 1.48. In addition, for the climate change analysis a high tide water surface elevation of 8.7 feet (equivalent to the 2070 projected high tide) was assumed for the downstream boundary condition.

Table 16: Peak Fish Passage Inflow Rates Projected for 2070

Location	Present-Day 5% Exceedance Flow (cfs)	Projected 5% Exceedance Flow (cfs)	Present-Day 50% Exceedance Flow (cfs)	Projected 50% Exceedance Flow (cfs)	Present-Day 95% Exceedance Flow (cfs)	Projected 95% Exceedance Flow (cfs)	Present-Day Base Flow (cfs)	Projected Base Flow (cfs)
R.S. 15341 - Upstream Limit of Model	201.7	298.5	56.3	83.3	13.3	19.7	18.0	14.5
R.S. 11387 – Upstream of I-495 and Riprap Obstruction	201.7	298.5	56.3	83.3	13.3	19.37	18.0	14.5

The hydraulic analysis for these conditions indicates that under dam removal conditions, climate change will result in an increase in water surface elevations and flow depths throughout the project area in addition to flow velocities during the upstream migration season. Such increases in velocity will be marginal and will have little impact on fish passage. For example, a velocity barrier will still exist at the MBTA Railroad Bridge under future climate change conditions across the full range of fish passage flows. The increase in passage depths, however, will improve passage depths by an average of 14 inches between the Little River Conduit and the Winter Street Bridge (during minimum flow conditions); by an average of 5 inches between the Winter Street Bridge and the MBTA Bridge (during minimum flow conditions); and by an average of 3 inches (during minimum flow conditions) between the MBTA Bridge and the I-495 Bridges. Although projected climate change conditions will reduce, but not eliminate flow depth barriers for most target species, flow depth fish passage barriers will still occur in multiple locations for striped bass. As a result, a nature-like fishway would still be beneficial in providing effective passage for this fish under projected climate change conditions. Climate change could also result in passage barriers to resident species during the summer months since climate change is expected to result in increased periods of drought. During these periods, base flows may decrease to levels where flow depths are inadequate for any upstream passage. The implementation of a riffle-pool fishway would continue to provide areas of habitat or refuge (in the pools) for resident species during these drier periods (i.e. periods of extremely low flow).

Since the nature-like fishway would be primarily designed to accommodate non-flood flows that are anticipated to occur throughout the upstream fish migration period, the impacts of flood flows will have little impact on the operation of the fishway. However, it is recommended that boulder/riffle weirs and channel substrates and side slopes be sized with a factor of safety of between 1.2 and 1.5 to account for these anticipated increases in flood flows. This will add resilience in terms of the stability of the fishway.

Recommendations for Further Design, Modeling Analyses, and Next Steps

The following next steps will be required for project development and implementation should the City wish to continue pursuing full dam removal.

1. Both nature-like fishway alternatives should be modeled under current and future climate change conditions to determine which alternative best meets project objectives. The fishway would be proposed just upstream of the dam (within the current headpond) in order to avoid increases to flood elevations just downstream of the Dam.
2. Low-flow channels at the MBTA Bridge and within the stretch of the River between the Little River Conduit and the Winter Street Bridge should also be modeled under current and future climate change conditions.
3. Added river restoration techniques/ measures such as natural boulder vanes (with notches for fish passage) should be modeled at strategic locations upstream of the fishway between Benjamin Street, Cashmans Park, and the MBTA Railroad to create added depth during lower flows to better facilitate aquatic/fish and recreational passage. This will include the installation of a cross vane approximately 200 feet downstream of the MBTA railroad bridge at the river's sharp bend to determine if it would eliminate the need for a low-flow channel or other scour countermeasure improvements at the MBTA railroad.
4. It is recommended that the City or the Massachusetts Department of Marine Fisheries (DMF) observe fish species that are present at the base of the existing dam during the upstream migration period (March 1st to June 30th). This will assist in confirming which species are expected to migrate upstream following dam removal and the actual depth that fish passage and/or river channel improvements should be assessed and designed for.
5. Once the post-dam removal model (including river restoration improvements) has been refined based on a confirmed or more concise target species list, it should be provided to the USFWS Fish Passage Team for review and comment. It is anticipated that USFWS will provide review comments such that the design of the fishway and/or river improvements (including details and specifications) can be finalized.
6. Appropriate scour countermeasures and bank stabilization measures should be selected and designed for areas where erosion cannot be tolerated including the MBTA Railroad and Winter Street Bridges. Nature-based solutions should be utilized where appropriate.

Attachments

Attachment 1 – Pertinent Reference Information Obtained from FEMA Flood Insurance Study
Attachment 2 – StreamStats Hydrologic Characteristics for Nearby USGS Gauge Stations and USGS Recorded Flow Data for Base Condition Flow Determination
Attachment 3 – USFWS Fish Passage Flow Determination Spreadsheets
Attachment 4 – NOAA Tide Data for Merrimack River

Attachment 5 – FEMA Duplicate Effective Model Hydraulic Back-up Data
Attachment 6 – Duplicate Effective Model HEC-RAS Profile and Output Summary
Attachments 7 – Hydraulic Cross-Section Location Plans Including Bathymetric Topographic Information (Spot Elevations) Obtained from Field Investigations
Attachment 8 – Pre-Dam Removal Model HEC-RAS Profile and Output Summary (Flood Flows)
Attachment 9 – Post-Condition Model HEC-RAS Profile and Output Summary (Flood Flows)
Attachment 10 – Sediment Sieve and Mobility Analysis Results
Attachment 11 – Pre- Versus Post-Dam Removal HEC-RAS Summary Profile and Results (Base Flow)
Attachment 12 – Post-Dam Removal HEC-RAS Results for Fish Passage Assessment
Attachment 13 – Climate Change Pre-Versus Post-Dam Removal HEC-RAS Summary Profiles and Results

ATTACHMENT 1 - PERTINENT REFERENCE INFORMATION OBTAINED FROM FEMA FLOOD INSURANCE STUDY

FLOOD INSURANCE STUDY



ESSEX COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)
Volume 1 of 4



COMMUNITY NAME	COMMUNITY NUMBER
AMESBURY, CITY OF	250075
ANDOVER, TOWN OF	250076
BEVERLY, CITY OF	250077
BOXFORD, TOWN OF	250078
DANVERS, TOWN OF	250079
ESSEX. TOWN OF	250080
GEORGETOWN, TOWN OF	250081
GLOUCESTER, CITY OF	250082
GROVELAND, TOWN OF	250083
HAMILTON, TOWN OF	250084
HAVERHILL, CITY OF	250085
IPSWICH, TOWN OF	250086
LAWRENCE, CITY OF	250087
LYNN, CITY OF	250088
LYNNFILED, TOWN OF	250089
MANCHESTER BY THE SEA, TOWN OF	250090
MARBLEHEAD, TOWN OF	250091
MERRIMAC, TOWN OF	250092
METHUEN, CITY OF	250093
MIDDLETON, TOWN OF	250094
NAHANT, TOWN OF	250095
NEWBURY, TOWN OF	250096
NEWBURYPORT, CITY OF	250097
NORTH ANDOVER, TOWN OF	250098
PEABODY, CITY OF	250099
ROCKPORT, TOWN OF	250100
ROWLEY, TOWN OF	250101
SALEM, CITY OF	250102
SALISBURY, TOWN OF	250103
SAUGUS, TOWN OF	250104
SWAMPSCOTT, TOWN OF	250105
TOPSFIELD, TOWN OF	250106
WENHAM, TOWN OF	250107
WEST NEWBURY, TOWN OF	250108

REVISED
JULY 19, 2018

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
25009CV001C

Danvers, Town of	The hydrologic and hydraulic analyses for the January 1990 study were prepared by Anderson-Nichols and Company, Inc., for the Federal Insurance Administration (FIA), under Contract No. H-4524. This work, which was completed in November 1978, covered all significant flooding sources in the Town of Danvers (Reference 5).
Essex, Town of	The hydrologic and hydraulic analyses for the July 17, 1986 study were prepared by Stone & Webster Engineering Corporation for FEMA, under Contract No. H-4772. This work was completed in April 1984 (Reference 6).
Georgetown, Town of	The hydrologic and hydraulic analyses for the December 1979 study were performed by Sverdrup & Parcel and Associates, Inc., for the FIA under Contract No. H-4037. This work was completed in March 1978, and covered all significant flooding sources affecting the Town of Georgetown (Reference 7).
Gloucester, City of	The hydrologic and hydraulic analyses for the January 17, 1986 study were prepared by Stone & Webster Engineering Corporation for FEMA under Contract No. H-4772. This work was completed in September 1983 (Reference 8).
Groveland, Town of	The hydrologic and hydraulic analyses for the April 1980 study were performed by Sverdrup & Parcel and Associates, for the FIA under Contract No. H-4037. This work was completed in April 1978, and covered all significant flooding sources affecting the Town of Groveland (Reference 9).
Hamilton, Town of	The hydrologic and hydraulic analyses for the June 4, 1990 study were prepared by CDM for FEMA, under Contract No. EMW-86-R-2250. This work was completed in November 1987 (Reference 10).
Haverhill, City of	The hydrologic and hydraulic analyses for the August 16, 1982 study were prepared by Cullinan Engineering Co., Inc., for FEMA under Contract No. H-4797. The hydrologic and hydraulic analyses for a portion of the Merrimack River were performed by

TABLE 2 –FLOODING SOURCES STUDIED BY DETAILED METHODS-continued

Flooding Source Name	Description of Study Reaches
Howlett Brook & Pye Brook	In the Town of Topsfield, from its confluence with the Ipswich River to approximately 600 upstream from State Highway 97 (Haverhill Road)
Hussey Brook	In the Town of Andover, from its confluence with the Shawsheen River to approximately 3700 feet upstream from Beacon Street
Hussey Brook Tributary	In the Town of Andover, from its confluence with Hussey Brook to approximately 200 feet upstream from Beacon Street
Ipswich River	In the Town of Ipswich, from State Route 133 to the Essex County (Town of Lynnfield)/Middlesex County (Town of North Reading) County Limits
Jackman Brook	In the Town of Georgetown, from Parish Road to Jewett Street
Johnson Creek	In the Town of Groveland, from its confluence with the Merrimack River to Washington Street
Lake Attitash	On the City of Amesbury/Town of Merrimac Corporate Limits
Little River	In the City of Haverhill, from its confluence with the Merrimack River to approximately 5000 feet upstream from Rosemont Street
Massachusetts Bay	Along the eastern coastline of Essex County from its southern border to Cape Anne

been documented by gage records and high-water marks. Records at the Middleton gage on the Ipswich River give an indication of the magnitude of flood discharges in Danvers, located just downstream. The Middleton gage began operation in 1938. The flood of record occurred on January 26, 1979, and had a measured peak discharge of 835 cfs.

Georgetown has not experienced any severe storm damage in the past. Minor flooding has occurred throughout the town. Two of these areas are Baldpate Road, which floods due to runoff from Littles Hill, and Andover Street, North Street, and Bailey Lane at Parker River. Rock pond and Pentucket Pond have not had flood problems in the past.

Groveland has experienced extensive flooding in the past. The most notable storm was in 1936, a storm classified as being greater than a 1-percent-annual-chance storm. Major flooding inundated the banks of the Merrimack River. The hardest hit area was along Main Street, near Gardener Street. Bates Bridge over the Merrimack River was nearly overtopped. Also hit hard were areas along Johnson Creek from its confluence with Merrimack River to a point upstream of Main Street. Minor flooding is caused by blocked and inadequate culverts throughout the town.

History of flooding on the Merrimack River in Hamilton, Lawrence, and Merrimac contains information dating back to 1846. The most significant recorded floods were those occurring in March 1936 and September 1938. The 1936 flood was the result of a combination of heavy rains and excessive snowmelt. The 1938 flood was caused by torrential rains associated with a tropical storm passing over the Merrimack River basin at a time when the ground was saturated from an earlier storm. The USACE estimated that the 1936 flood has a recurrence interval in excess of 1-percent-annual-chance and the 1938 flood has a recurrence interval of approximately 2-percent-annual-chance. Flooding along the Little River is influenced by the rise in water-surface elevations from the Merrimack River, During severe flooding, the backwater from the Merrimack River extends up the Little River above the entrance to the arch culvert running under the city. During these periods of high backwater, pumps have been utilized to convey floodwaters from the Little River to the Merrimack River. The Massachusetts Geodetic Survey gathered Merrimack, Shawsheen and Spicket River high-water mark data in the City of Lawrence resulting from the 1936 flood (Reference 38).

Riverine flooding in Ipswich caused by inland precipitation runoff has led to little damage from the Ipswich and Miles Rivers due to limited construction in vulnerable areas. In March 1936 and March 1968, floods with recurrence intervals of approximately 50 years were recorded on the Ipswich River at the gage located at the Willowdale Dam. There is no gage on the Miles River, but it can be assumed that this river had floods of similar severity in 1936 and 1968. Neither flood had significant effects on developed land. Kimball Brook, another tributary of the Ipswich River, has flooded Peabody Street, Safford Street, and Cherry

area of 28 square miles and flood control storage of 46,000 acre-feet. The Edward MacDowell Dam, completed in 1950 at Peterborough, New Hampshire has a drainage area of 44 square miles and flood control storage of 12,800 acre-feet. The Franklin Falls Dam, completed in 1943 at Franklin, New Hampshire, has a drainage area of 1,000 square miles and flood control storage of 150,600 acre-feet. Hopkinton Lake Dam, completed in 1962 at Hopkinton, New Hampshire, has a drainage area of 382 square miles and a flood control storage of 70,100 acre-feet. Everett Lake Dam, completed in 1961 at Weare, New Hampshire, has a drainage area of 64 square miles and flood control storage of 85,500 acre-feet. Hopkinton Lake and Everett Lake Dam projects are considered to operate as a single unit since they are connected by a canal. By the operation of these five projects, peak flows at the Lowell gage would be reduced from 173,000 cfs to 112,000 cfs during a recurrence of the record 1936 flood. Tidal flood barriers have not been constructed and are not planned for this area; however, the USACE has constructed and maintains two jetties, 4,118 and 2,445 feet long respectively, at the confluence of the Merrimack River to maintain a good navigational opening and to reduce the erosion of Plum Island and Salisbury Beach.

In addition, several reservoirs exist in Haverhill that do not significantly contribute to flood control, including Crystal Lake Reservoir and Millvale Reservoir. Prior to the flood of September 1938, the Emergency Relief Administration completed construction of concrete floodwalls and a concrete pressure conduit along the north bank of the Merrimack River and the Little River in the vicinity of the center of the City of Haverhill. The concrete floodwalls are equipped with 2.5 foot concrete caps with a crest elevation of 25.7 feet. The Haverhill Flood Protection System includes a levee, the Little River Conduit, and a pump station. A re-alignment of the West Wing Wall area of the levee was performed in 2013-2014 during the construction of the Riverside Place Condominium Building. The accredited levee is shown on the effective FIRM as providing protection from the 1-percent-annual-chance flood.

The Essex Company Dam, also known as Great Stone Dam, is located on the Merrimack River in Lawrence (Reference 51), It was built to utilize the water power of Bodwells Falls. There are canals on both the north and south sides of the river, Under normal conditions, the canals would never be allowed to exceed an elevation of 41.77 feet due to control gates operated by the Essex Company. The dam does not provide flood protection other than to control water levels in the canals. The Malden Mills Dam is located at the outlet of Stevens Pond on the Spicket River. This dam provides flood control during periods of large flows in the Spicket River.

No tidal or riverine flood control structures have been built that would significantly affect flood conditions in Ipswich. The Willowdale dam is located approximately 4.6 miles upstream of State Route 133 on the Ipswich River. Also, there are several other small dams on the Ipswich and Miles Rivers within the town. These dams are used for water power, and none affect flood flows.

Flow frequencies for the Ipswich River in Ipswich were developed by the USGS from data at the gage located at the Willowdale Dam. These frequencies were based on a statistical analysis of the systematic discharge record of 46 years and a historic record of 92 years. The standard log-Pearson Type III method outlined by Water Resources Council Bulletin No. 17 was followed in the analysis (Reference 58). Once the 10-, 2-, l-, and 0.2-percent-annual-chance discharges were obtained at the gage, the flows downstream of the gage were adjusted by using a formula that relates the flows between two basins as a function of the drainage areas (Reference 70). Since the Miles River in Ipswich is ungaged, the l0-, 2-, l-, and 0.2-percent-annaul-chance discharges were computed based on the Massachusetts flood magnitude and frequency formulas developed by the USGS (Reference 55). The study contractor performed a separate evaluation of these formulas and found them to be applicable to the Ipswich region. The USGS formulas predict discharges based on the parameters of watershed drainage area and main channel slope.

Peak discharge-frequency relationships for the Little River and Riverside Airport Brook were derived using procedures described by the USGS in Estimating the Magnitude and Frequency of Floods for Natural-Flow Streams (Reference 55). The technique was developed using multiple regression analyses to estimate flood peaks on ungaged, natural-flow streams in Massachusetts by relating peak discharges to basin and climatic parameters. The resulting peak discharges were verified using statistically analyzed data from nearby stream gages with similar watershed characteristics using a multiplication factor equal to the ratio of the drainage areas to the 0.75 exponential power. They were found to be in general agreement. The derivation of peak discharge-frequency relationships for Creek Brook and Millvale Reservoir Brook used the previously referenced USGS method in conjunction with a numerical integration reservoir routing of triangular inflow hydrographs (References 71 and 72). The routing process was incorporated to take into account the effects of storage in Crystal Lake and Millvale Reservoir upstream of Creek Brook and Millvale Reservoir Brook, respectively.

For the Spicket River, flows of selected recurrence intervals were developed utilizing a drainage area-peak discharge relationship in conjunction with corresponding peak discharges from the pre-countywide FIS for the Town of Methuen (Reference 73). The discharges were further refined by applying an adjustment for impervious land area in consideration of extensive urbanization over the lower reaches of the stream (Reference 74).

The Saugus River watershed is a complex hydrologic system. It contains three major storage areas: Lake Quannapowitt, a large swampy area in Reading; the swamp by the Wakefield Industrial Park; and two major tributary streams (the Reading Drainage Canal and Beaverdam Brook).

TABLE 6 – SUMMARY OF DISCHARGES-continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQUARE MILES)	PEAK DISCHARGES (CUBIC FEET PER SECOND) 10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
Corporate Limits (Parish Road)					
Jackman Street	0.66	12	19	22	34
Approximately 1,200 feet upstream of Jackman Street	0.45	8	13	15	24
Jewett Street	0.24	4	7	8	13
JOHNSON CREEK					
Approximately 430 feet downstream of Haverhill/Groveland Corporate Limits	6.00	511	731	877	1,623
At Main Street	4.30	225	350	410	720
At Gravel Road Over Dam	3.00	200	320	385	650
At Center Street	2.90	190	308	362	603
Approximately 620 feet upstream of Center Street	2.20	164	270	315	525
At Salem Street	2.10	148	233	270	442
At Uptrack Road	1.70	110	170	200	310
At Washington Street	1.50	98	145	164	252
LITTLE RIVER					
At Winter Street	37.00	1,160	1,920	2,330	3,520
Upstream of I-95	27.70	980	1,640	1,990	3,030
Downstream of Haverhill/ Plaistow corporate limits	20.80	660	1,065	1,275	1,865
MERRIMACK RIVER					
At Salisbury/Amesbury /Newburyport	5010.00	61,000	92,000	115,000	172,100

In those areas where the analysis indicated super critical flow conditions, critical depth was assumed for the flood elevations because of the inherent instability of supercritical flow.

Water-surface elevations of floods of the selected recurrence intervals for the communities in Essex County were computed using the USACE HEC-2 step-backwater computer program (Reference 79). Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals.

The Powwow River starting water-surface elevation for the 10-percent-annual-chance flood elevation was taken from the annual tidal stage-elevation; the 2-percent-annual-chance was taken from the 5-year tidal stage-elevation; the 1-percent-annual-chance flood elevation was taken from the 10- tidal stage-elevation; and the 0.2-percent-annual-chance flood elevation was taken from the 25-year tidal stage elevation (Reference 59). For the pre-countywide revised portion of the Powwow River, the starting water-surface elevation for the 1-percent-annual-chance flood was taken from the FIS for the Town of South Hampton, New Hampshire (Reference 60).

Starting water-surface elevations for Unnamed Tributary to Fish Brook was determined using the discharge characteristics of the dam downstream of Lockwood Lane.

Starting water-surface elevations for Ipswich River, Bartlett Brook, Boston Brook, Emerson Brook, Howlett Brook, Pye Brook, Mile Brook, Branch of Ipswich, Bennett's Pond Brook, Cleveland Brook, School Brook, Shute Brook, Fish Brook, Parker River, North Beverly Drainage Ditch, Miles River, Tributary A to the Ipswich River, Fiske Brook, and Fish Brook were computed using the slope/area method.

Starting water-surface elevations for the Ipswich River in Ipswich and for Parker River in Newbury were determined using critical depth.

Starting water-surface elevations for the Little River, Creek Brook, Millvale Reservoir Brook, Shawsheen River, Spicket River, Cochichewick Brook, Bare Meadow Brook, and Riverside Airport Brook were determined to be the normal water-surface elevation of the Merrimack River at their respective confluences.

Starting water-surface elevations for Fish Brook were based on a stage discharge rating curve developed at the dam located at its mouth. Starting water-surface elevations on Hussey Brook were found to be coincident with developed flood profiles on the Shawsheen River. Starting water-surface elevations for Hussey Brook Tributary were found to be coincident with developed flood profiles on Hussey Brook.

Starting water-surface elevations for Chubbs Brook, Mill River, Saugus River, and Centerville Creek were based on the average spring high tide level.

TABLE 7 – MANNING'S "n" VALUES-continued

Flooding Source	Channel "n"	Overbanks
Ipswich River (Middleton)	0.03-0.045	0.033-0.15
Ipswich River (Topsfield)	0.010-0.060	0.11
Ipswich River (Wenham)	0.010-0.060	0.11
Little River	0.029-0.065	0.030-0.125
Merrimack River (Andover)	0.035-0.020	0.065-0.075
Merrimack River (Haverhill)	0.025-0.035	0.065
Merrimack River (Lawrence)	0.028	0.07
Merrimack River (Merrimac)	0.030-0.040	0.060-0.100
Merrimack River (Methuen)	0.023	0.08
Merrimack River (Newburyport)	0.04	0.075
Merrimack River (North Andover)	0.022-0.032	0.060-0.080
Merrimack Tributary to Neal Pond	0.030-0.040	0.060-0.100
Mile Brook (Topsfield)	0.010-0.100	0.050-0.100
Miles River (Ipswich)	0.020-0.050	0.035-0.100
Miles River (Wenham)	0.020-0.050	0.020-0.070
Mill River (Gloucester)	0.013-0.040	0.1
Mill River (Newbury)	0.015-0.050	0.015-0.050
Mill River (Rowley)	0.015-0.060	0.015-0.090
Millvale Reservoir Brook	0.035-0.042	0.112-0.125
Mosquito Brook	0.020-0.070	0.020-0.070
North River (Peabody)	0.023-0.045	0.030-0.15
Parker River	0.020-0.040	0.1
Peat Meadow Brook	0.025-0.050	0.090-0.100
Porter River (Danvers)	0.020-0.040	0.035-0.090
Powwow River	0.035	0.06
Proctor Brook (Peabody)	0.023-0.045	0.030-0.15
Pye Brook (Topsfield)	0.010-0.100	0.050-0.100
Riverside Airport Brook	0.035-0.040	0.100-0.060
Saugus River	0.020-0.040	0.050-0.100
Saugus River (Lynnfield)	0.020-0.110	0.11
School Brook (Topsfield)	0.010-0.060	0.11
Shawsheen River	0.035-0.065	0.030-0.170
Shute River	0.012-0.050	0.035-0.100
Spicket River (Methuen)	0.035-0.050	0.060-0.080
Spicket River (Lawrence)	0.03	0.07

Figure 2, "Transect Schematic" represents s sample transect that illustrates the relationship between stillwater elevation, the wave crest elevation, the ground elevation profile and the location of the V/A zone boundary.

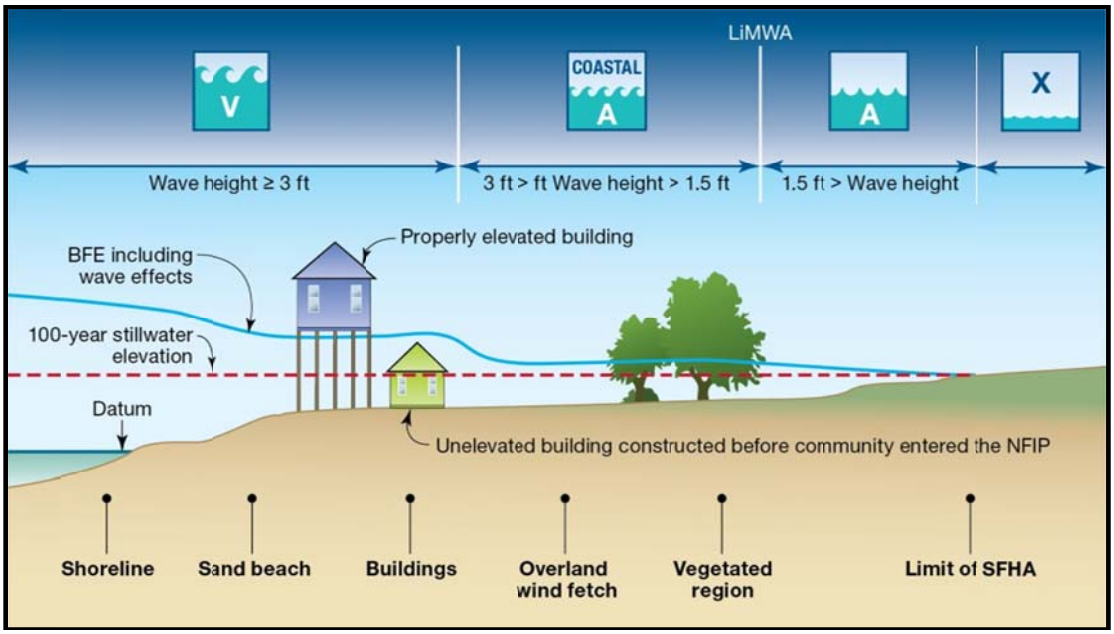


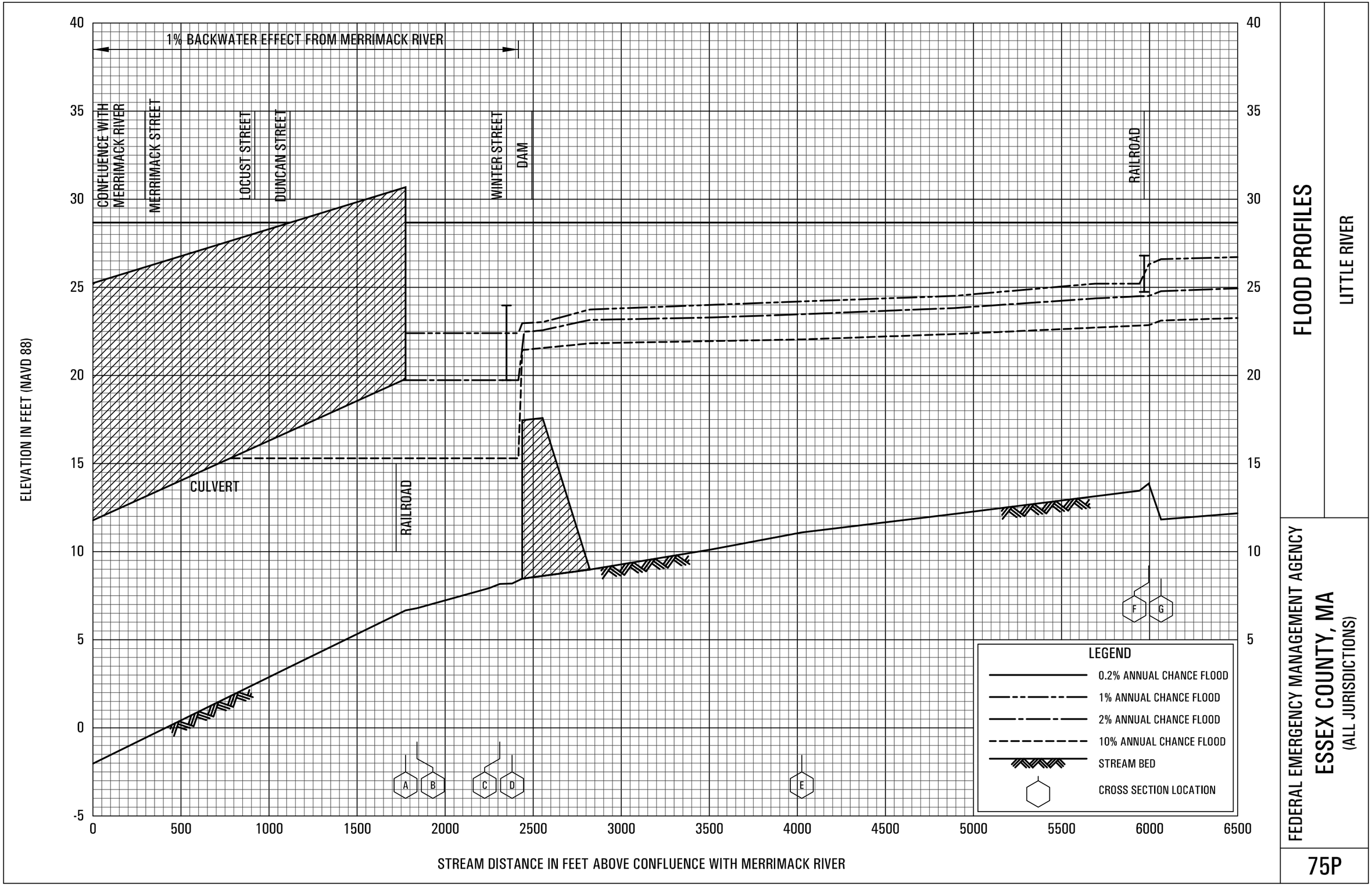
Figure 2. Transect Schematic

3.4 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD 29). With the completion of the North American Vertical Datum of 1988 (NAVD 88), many FIS reports and FIRMs are now prepared using NAVD 88 as the referenced vertical datum.

All flood elevations shown in this FIS report and on the FIRM are referenced to the NAVD 88. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. Ground, structure, and flood elevations may be compared and/or referenced to NGVD 29 by applying a standard conversion factor. **The conversion factor from NGVD 29 to NAVD 88 is -0.8, and from NAVD 88 to NGVD 29 is +0.8.**

For information regarding conversion between the NGVD 29 and NAVD 88, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:



FLOOD PROFILES

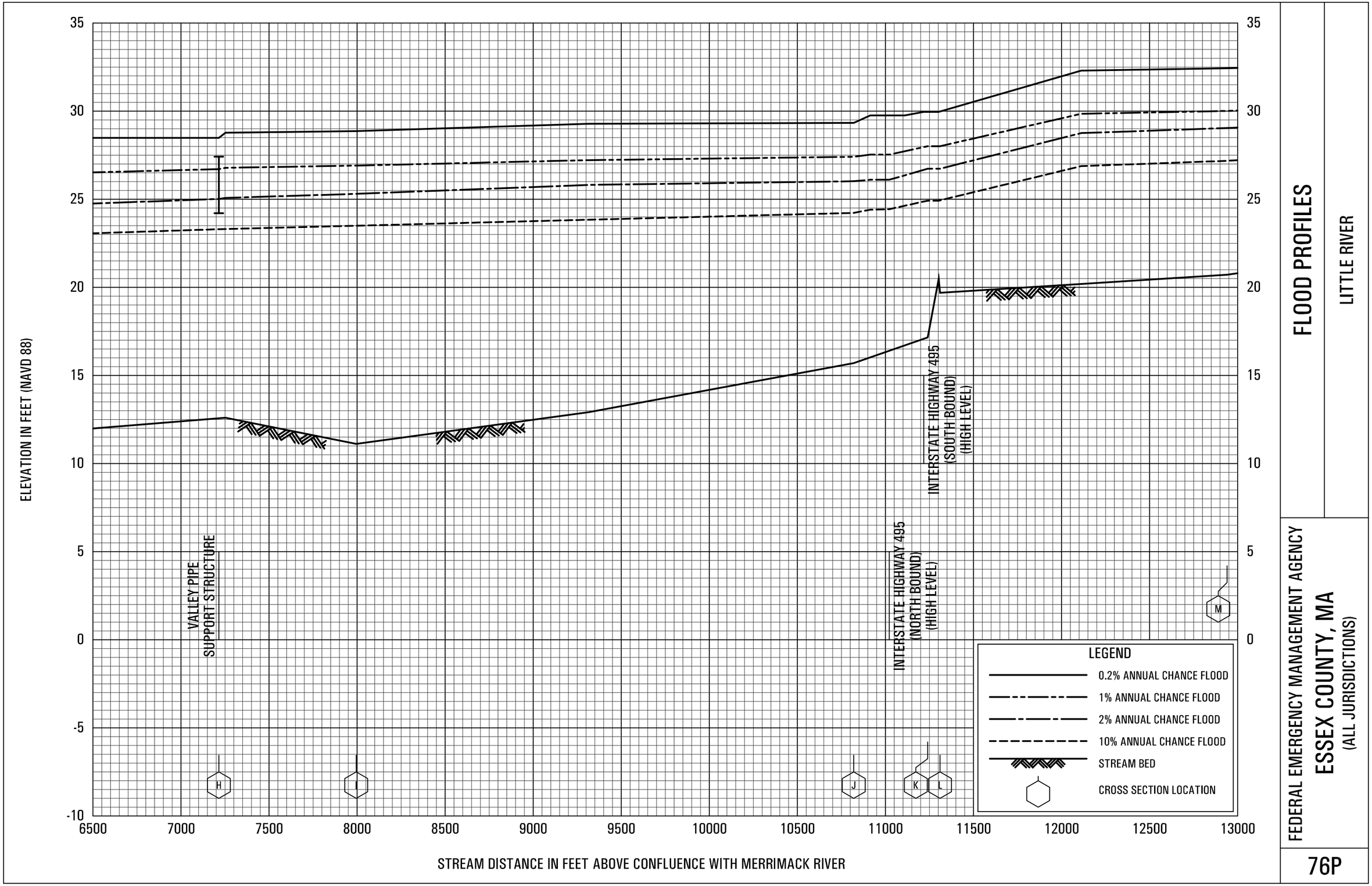
LITTLE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

ESSEX COUNTY, MA

(ALL JURISDICTIONS)

75P



FLOOD PROFILES

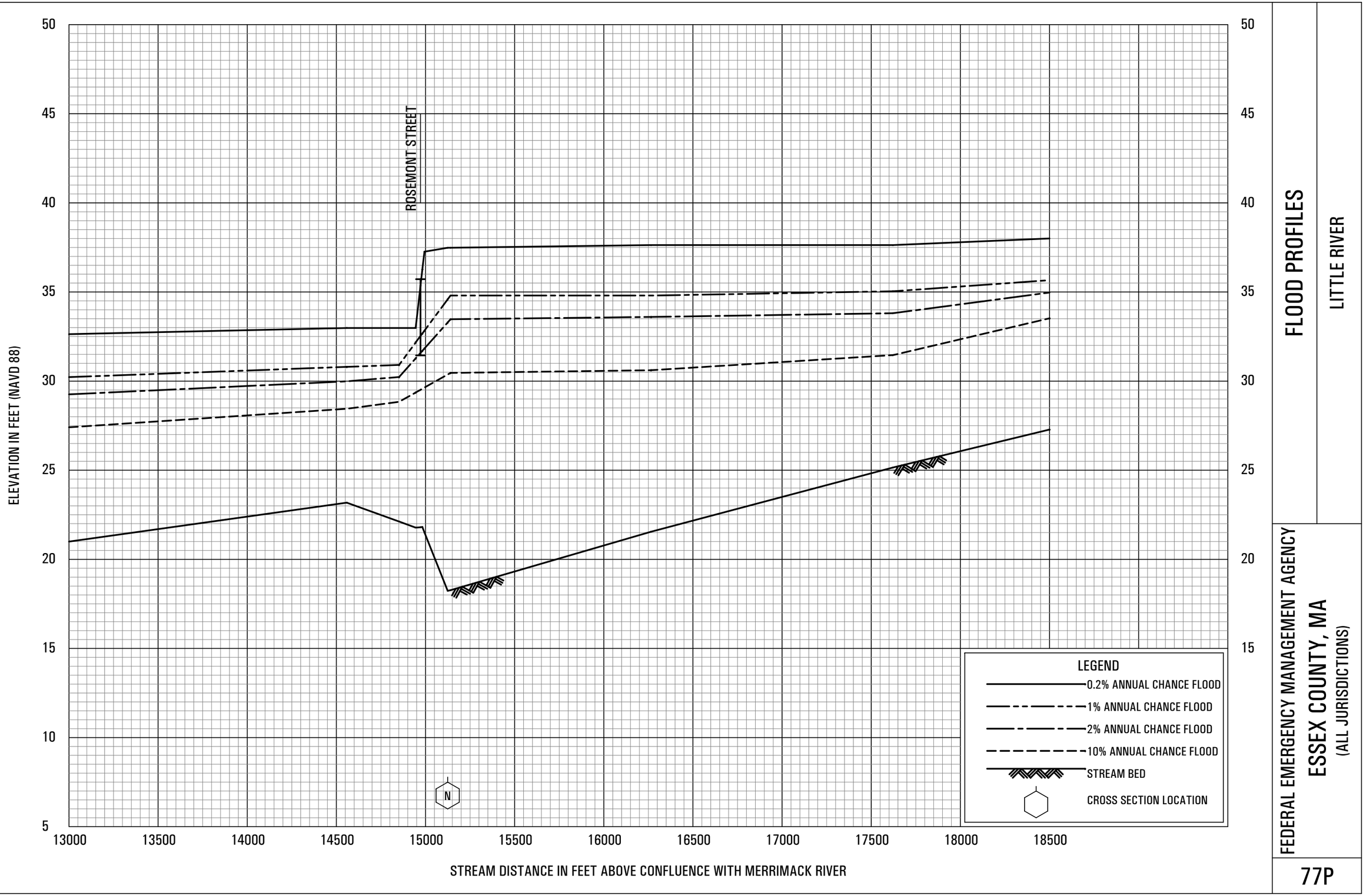
LITTLE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

ESSEX COUNTY, MA

(ALL JURISDICTIONS)

76P



FLOOD PROFILES

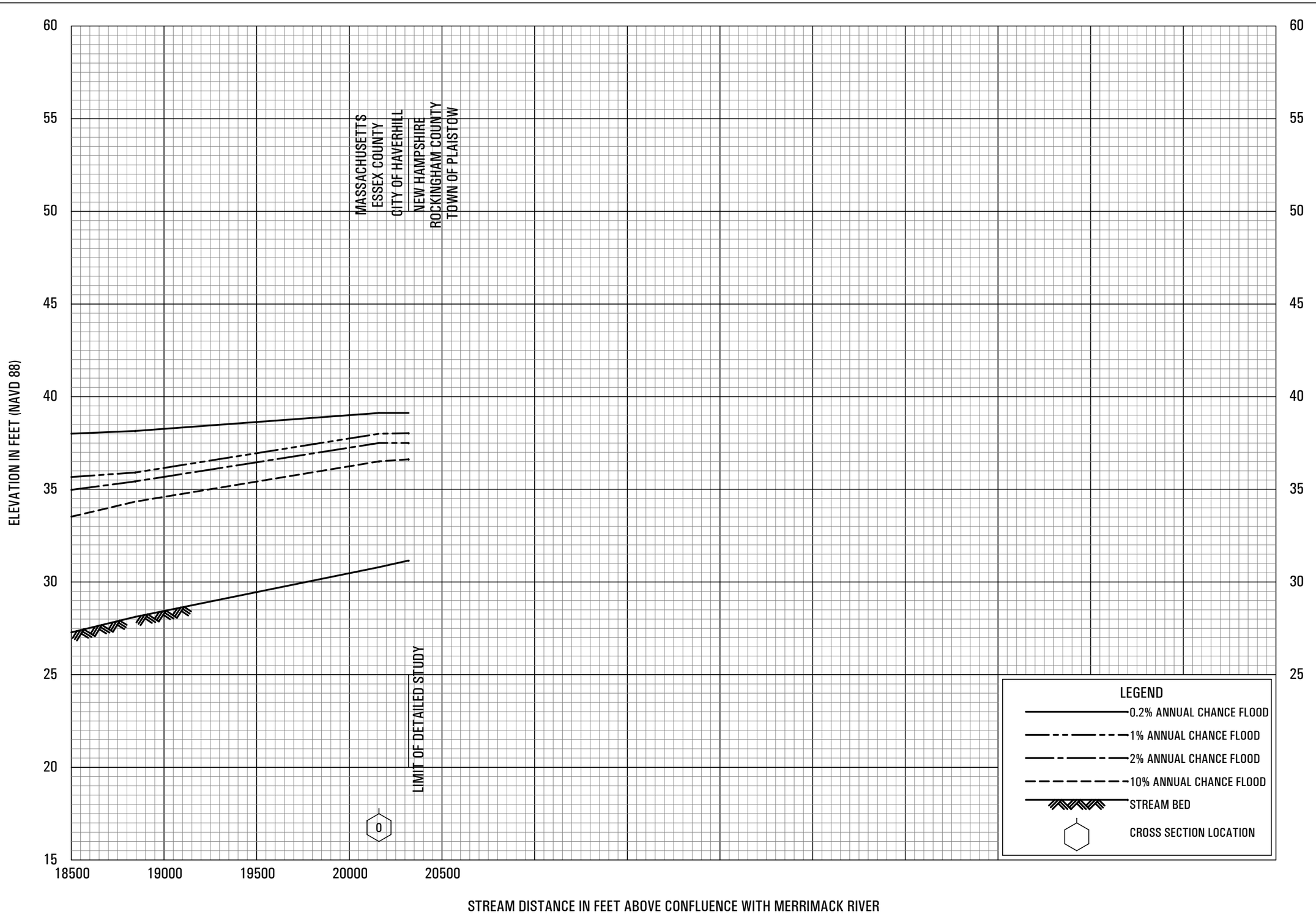
LITTLE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

ESSEX COUNTY, MA

(ALL JURISDICTIONS)

77P



FLOOD PROFILES

LITTLE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

ESSEX COUNTY, MA

(ALL JURISDICTIONS)

78P

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	1775	*	248	9.4	22.4	15.7 [2]	16.2 [2]	0.5
B	1840	51	407	5.7	22.4	16.9 [2]	17.4 [2]	0.5
C	2310	*	259	9.0	22.4	17.0 [2]	17.4 [2]	0.4
D	2,380	*	226	10.3	22.4	17.0 [2]	17.5 [2]	0.5
E	4,025	*	1,121	2.1	24.2	24.2	24.3	0.1
F	5,995	95	785	3.0	26.3	26.3	26.4	0.1
G	6,065	160	1,590	1.5	26.6	26.6	26.7	0.1
H	7,215	197	1,544	1.5	26.9	26.9	27.1	0.2
I	7,995	*	721	3.2	27.1	27.1	27.3	0.2
J	10,820	*	520	4.5	27.6	27.6	28.0	0.4
K	11,240	*	318	7.3	28.2	28.2	28.9	0.7
L	11,310	62	383	6.1	28.2	28.2	29.1	0.9
M	12,940	695	2,997	0.7	30.2	30.2	30.6	0.4
N	15,140	240	2,535	0.8	34.8	34.8	34.9	0.1
O	20,160	45	733	1.7	38.0	38.0	38.2	0.2

[1] FEET ABOVE CONFLUENCE WITH MERRIMACK RIVER

[2] ELEVATIONS COMPUTED WITHOUT CONSIDERING BACKWATER EFFECTS FROM MERRIMACK RIVER

* FLOODWAY COINCIDENT WITH CHANNEL BANKS

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

ESSEX COUNTY, MA

(ALL JURISDICTIONS)

FLOODWAY DATA

LITTLE RIVER

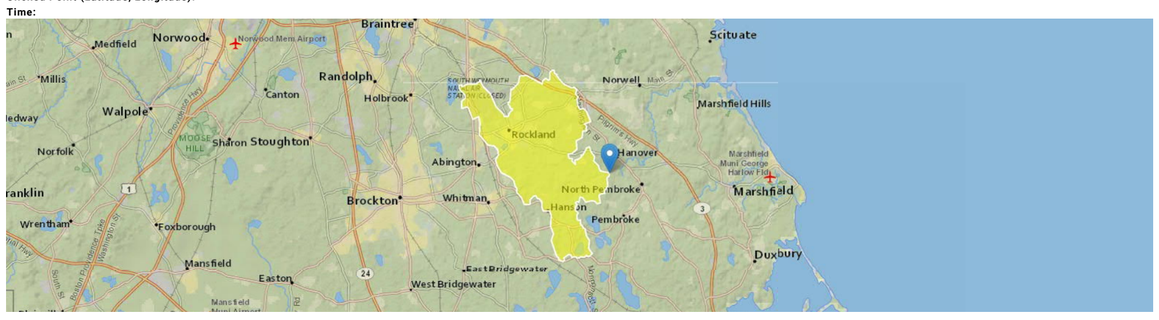
ATTACHMENT 2 - STREAMSTATS HYDROLOGIC CHARACTERISTICS FOR NEARBY USGS GAUGE STATIONS AND USGS RECORDED FLOW DATA FOR BASE CONDITION FLOW DETERMINATION

USGS 01105730 Indian Head River at Hanover, MA

00060, Discharge, cubic feet per second,													
Day of month	50th percentile (median) of daily mean values for each day for water year of record in, ft3/s (Calculation Period 1989-10-01 -> 2021-09-30) Period-of-record for statistical calculation restricted by user												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	71	61	68	88	68	38	19	10	10	15	36	54	
2	67	62	80	94	73	35	18	9.2	11	18	35	47	
3	66	58	84	117	75	36	17	8.2	12	17	33	46	
4	75	55	82	102	67	35	15	8.2	11	14	31	48	
5	78	61	74	118	67	36	14	8.6	12	14	33	52	
6	69	62	80	99	63	41	16	9.4	12	15	36	52	
7	65	64	87	94	62	34	18	9.2	11	15	39	61	
8	62	72	82	86	56	35	16	8.8	10	14	40	55	
9	57	70	91	93	55	29	14	8.4	9.8	14	39	51	
10	59	60	79	86	56	30	14	8.8	11	17	37	58	
11	60	64	87	86	48	30	16	10	13	17	39	60	
12	65	64	98	88	48	32	14	10	13	20	46	67	
13	69	68	98	90	47	38	12	12	11	19	48	59	
14	69	68	100	79	45	33	11	12	9.4	19	53	55	
15	62	76	114	76	47	29	11	17	11	19	43	64	
16	67	84	124	83	49	29	17	18	10	22	42	62	
17	59	78	125	84	61	27	15	14	11	26	47	62	
18	66	71	102	93	54	28	15	17	13	25	44	61	
19	69	72	107	81	52	25	14	17	12	23	43	64	
20	66	69	97	73	50	22	13	16	15	26	46	54	
21	61	78	97	81	46	22	11	15	13	27	51	48	
22	56	78	101	85	41	21	9.7	14	16	25	49	55	
23	60	73	90	87	42	25	12	14	19	25	47	68	
24	61	80	84	81	48	27	11	12	17	24	47	85	
25	62	80	83	84	49	25	11	13	14	23	48	72	
26	66	82	86	79	46	23	12	11	16	24	46	68	
27	65	84	88	72	44	21	14	11	16	29	56	70	
28	62	72	86	72	44	23	14	12	18	30	66	72	
29	58	81	92	76	41	21	14	11	16	44	66	64	
30	57		97	70	38	21	13	11	18	39	56	80	
31	59		93		36		11	10		36		75	
MEAN								11.8	13.0				

Indian River StreamStats Report

Region ID: MA
Workspace ID: MA20201222181310376000
Clicked Point (Latitude, Longitude): 42.10056, -70.82283
Time: 2020-12-22 13:13:30 -0500



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	30.5	square miles
ELEV	Mean Basin Elevation	101	feet
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	20.33	percent
BSLDEM250	Mean basin slope computed from 1:250K DEM	0.788	percent
DRFTPERSTR	Area of stratified drift per unit of stream length	0.31	square mile per mile
MAREGION	Region of Massachusetts 0 for Eastern 1 for Western	0	dimensionless
BSLDEM10M	Mean basin slope computed from 10 m DEM	2.803	percent
PCTSNDGRV	Percentage of land surface underlain by sand and gravel deposits	68.63	percent
FOREST	Percentage of area covered by forest	26.72	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	17.8	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	50.7	percent

Peak-Flow Statistics Parameters[Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	30.5	square miles	0.16	512
ELEV	Mean Basin Elevation	101	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	20.33	percent	0	32.3

Peak-Flow Statistics Flow Report[Peak Statewide 2016 5156]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
50_percent_AEP_flood	404	ft^3/s	207	787	42.3
20_percent_AEP_flood	648	ft^3/s	328	1280	43.4
10_percent_AEP_flood	835	ft^3/s	413	1690	44.7
4_percent_AEP_flood	1100	ft^3/s	527	2300	47.1
2_percent_AEP_flood	1320	ft^3/s	612	2850	49.4
1_percent_AEP_flood	1540	ft^3/s	693	3420	51.8
0_5_percent_AEP_flood	1780	ft^3/s	778	4070	54.1
0_2_percent_AEP_flood	2120	ft^3/s	885	5080	57.6

Peak-Flow Statistics Citations

Zarriello, P.J.,2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 99 p. (https://dx.doi.org/10.3133/sir20165156)

Low-Flow Statistics Parameters[Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	30.5	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	0.788	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.31	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

Low-Flow Statistics Flow Report[Statewide Low Flow WRIR00 4135]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SE	SEp
7 Day 2 Year Low Flow	3.59	ft^3/s	0.884	14	49.5	49.5
7 Day 10 Year Low Flow	1.35	ft^3/s	0.273	6.23	70.8	70.8

Low-Flow Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Flow-Duration Statistics Parameters[Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	30.5	square miles	1.61	149
DRFTPERSTR	Stratified Drift per Stream Length	0.31	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1
BSLDEM250	Mean Basin Slope from 250K DEM	0.788	percent	0.32	24.6

Flow-Duration Statistics Flow Report[Statewide Low Flow WRIR00 4135]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SE	SEp
50 Percent Duration	31.2	ft^3/s	18.6	52.2	17.6	17.6
60 Percent Duration	24.7	ft^3/s	9.79	61.9	19.8	19.8
70 Percent Duration	17.1	ft^3/s	6.96	41.6	23.5	23.5
75 Percent Duration	13.9	ft^3/s	5.77	33.1	25.8	25.8
80 Percent Duration	9.78	ft^3/s	3.09	30.5	28.4	28.4
85 Percent Duration	7.08	ft^3/s	2.25	21.9	31.9	31.9
90 Percent Duration	4.99	ft^3/s	1.53	16	36.6	36.6
95 Percent Duration	2.89	ft^3/s	0.759	10.6	45.6	45.6
98 Percent Duration	2	ft^3/s	0.466	8.13	60.3	60.3
99 Percent Duration	1.53	ft^3/s	0.324	6.8	65.1	65.1

Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

August Flow-Duration Statistics Parameters[Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	30.5	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	0.788	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.31	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

August Flow-Duration Statistics Flow Report[Statewide Low Flow WRIR00 4135]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SE	SEp
August 50 Percent Duration	8.27	ft^3/s	2.58	26	33.2	33.2

August Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Bankfull Statistics Parameters[Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	30.5	square miles	0.6	329
BSLDEM10M	Mean Basin Slope from 10m DEM	2.803	percent	2.2	23.9

Bankfull Statistics Flow Report[Bankfull Statewide SIR2013 5155]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
Bankfull Width	49	ft	21.3
Bankfull Depth	2.24	ft	19.8
Bankfull Area	109	ft^2	29
Bankfull Streamflow	239	ft^3/s	55

Bankfull Statistics Citations

Bent, G.C., and Waite, A.M.,2013, Equations for estimating bankfull channel geometry and discharge for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2013–5155, 62 p., (http://pubs.usgs.gov/sir/2013/5155/)

Probability Statistics Parameters[Perennial Flow Probability]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	30.5	square miles	0.01	1.99
PCTSNDGRV	Percent Underlain By Sand And Gravel	68.63	percent	0	100
FOREST	Percent Forest	26.72	percent	0	100
MAREGION	Massachusetts Region	0	dimensionless	0	1

Probability Statistics Disclaimers[Perennial Flow Probability]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Probability Statistics Flow Report[Perennial Flow Probability]

Statistic	Value	Unit
Probability Stream Flowing Perennially	0.998	dim

Probability Statistics Citations

Bent, G.C., and Steeves, P.A.,2006, A revised logistic regression equation and an automated procedure for mapping the probability of a stream flowing perennially in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2006–5031, 107 p. (http://pubs.usgs.gov/sir/2006/5031/pdfs/SIR_2006-5031rev.pdf)

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Application Version: 4.4.0

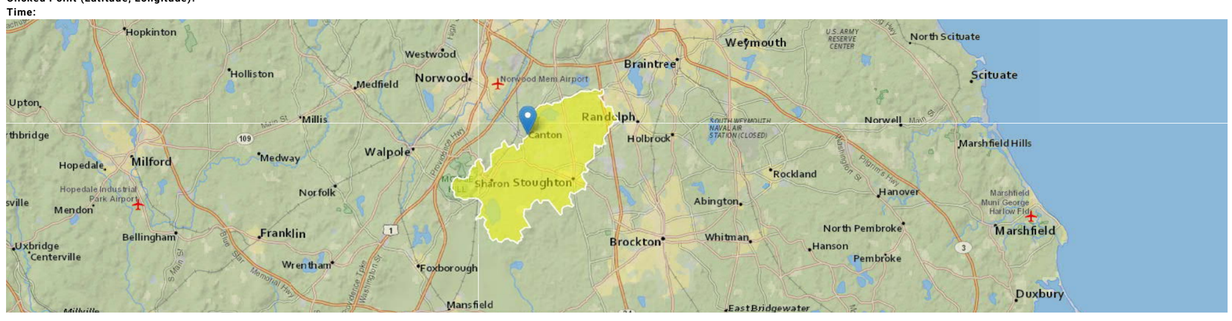
USGS 01105500 EAST BRANCH NEPONSET RIVER AT CANTON, MA

Day of month	50th percentile (median) of daily mean values for each day for water year of record in, ft3/s (Calculation Period 1989-10-01 -> 2021-09-30) Period-of-record for statistical calculation restricted by user											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	59	55	62	80	51	34	18	12	9.1	13	28	42
2	57	51	72	88	52	34	22	12	11	12	29	36
3	58	48	72	87	62	33	18	11	10	13	26	33
4	56	50	76	90	53	34	18	9.9	9.5	12	28	35
5	64	50	64	92	58	32	16	9.7	12	12	23	37
6	56	49	66	81	61	32	17	13	11	13	27	56
7	54	56	64	96	55	34	16	10	12	12	29	49
8	58	57	63	90	52	32	18	11	10	11	29	43
9	55	52	67	86	48	29	15	9.6	9.8	12	28	41
10	54	56	72	88	49	28	15	11	9.3	14	32	47
11	57	54	67	82	43	25	14	14	9.1	12	30	49
12	58	52	71	84	39	29	13	15	8.3	12	29	53
13	57	51	77	80	38	29	16	14	8.8	14	34	54
14	54	61	76	81	38	27	15	16	8.7	14	31	50
15	55	60	94	81	40	24	14	16	11	13	33	52
16	60	70	81	81	43	21	14	20	12	18	34	57
17	59	63	91	79	53	24	14	16	13	21	33	51
18	60	56	87	89	49	20	14	16	11	16	32	61
19	57	58	93	75	57	21	14	14	11	18	39	58
20	57	64	88	72	53	20	14	14	11	19	36	48
21	53	72	80	76	43	20	13	13	9.6	19	37	56
22	52	64	80	78	40	25	12	14	12	20	36	55
23	53	62	76	79	43	25	12	15	13	20	36	60
24	64	69	84	89	45	22	14	13	12	21	33	80
25	59	79	78	77	44	21	14	13	11	20	35	61
26	59	76	74	67	43	18	15	11	12	20	36	60
27	61	72	74	65	39	17	18	11	12	22	52	64
28	56	66	74	62	34	23	16	12	13	27	53	61
29	56	70	78	57	32	20	16	12	14	28	49	60
30	52		79	55	35	18	14	12	13	25	41	62
31	56		78		33		12	10		28		60
MEAN								12.9	11.0			

A study area is needed before viewing the report

East Branch Neponset StreamStats Report

Region ID: MA
Workspace ID: MA20201222184755443000
Clicked Point (Latitude, Longitude): 42.15454, -71.14574
Time: 2020-12-22 13:48:15 -0500



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	27	square miles
ELEV	Mean Basin Elevation	216	feet
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	15.45	percent
BSLDEM250	Mean basin slope computed from 1:250K DEM	1.461	percent
DRFTPERSTR	Area of stratified drift per unit of stream length	0.27	square mile per mile
MAREGION	Region of Massachusetts 0 for Eastern 1 for Western	0	dimensionless
BSLDEM10M	Mean basin slope computed from 10 m DEM	4.536	percent
PCTSNDGRV	Percentage of land surface underlain by sand and gravel deposits	60.24	percent
FOREST	Percentage of area covered by forest	35.45	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	20.1	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	51	percent
WETLAND	Percentage of Wetlands	12.68	percent

General Disclaimers

Parameter values have been edited, computed flows may not apply.

Upstream regulation was checked for this watershed.

This watershed is percent regulated, computed flows may not apply.

This watershed has been edited, computed flows may not apply.

The resulting delineations are derived from digital elevation data and storm drain vectors that have been processed to enforce drainage through storm drains.

Urban regression equations for peak flows were not developed using streamgages which incorporate storm drain delineations and therefore should be used with caution.

Peak-Flow Statistics Parameters[Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	27	square miles	0.16	512
ELEV	Mean Basin Elevation	216	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	15.45	percent	0	32.3

Peak-Flow Statistics Disclaimers[Peak Statewide 2016 5156]

Peak-Flow Statistics Flow Report[Peak Statewide 2016 5156]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
50_percent_AEP_flood	437	ft^3/s	225	851	42.3
20_percent_AEP_flood	704	ft^3/s	357	1390	43.4
10_percent_AEP_flood	910	ft^3/s	451	1840	44.7
4_percent_AEP_flood	1200	ft^3/s	575	2500	47.1
2_percent_AEP_flood	1450	ft^3/s	674	3120	49.4
1_percent_AEP_flood	1700	ft^3/s	766	3770	51.8
0_5_percent_AEP_flood	1970	ft^3/s	863	4500	54.1
0_2_percent_AEP_flood	2360	ft^3/s	987	5640	57.6

Peak-Flow Statistics Citations

Zarriello, P.J.,2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 99 p. (https://dx.doi.org/10.3133/sir20165156)

Low-Flow Statistics Parameters[Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	27	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	1.461	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.27	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

Low-Flow Statistics Disclaimers[Statewide Low Flow WRIR00 4135]

Low-Flow Statistics Flow Report[Statewide Low Flow WRIR00 4135]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SE	SEp
7 Day 2 Year Low Flow	3.39	ft^3/s	1.07	10.3	49.5	49.5
7 Day 10 Year Low Flow	1.42	ft^3/s	0.361	5.2	70.8	70.8

Low-Flow Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Flow-Duration Statistics Parameters[Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	27	square miles	1.61	149
DRFTPERSTR	Stratified Drift per Stream Length	0.27	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1
BSLDEM250	Mean Basin Slope from 250K DEM	1.461	percent	0.32	24.6

Flow-Duration Statistics Disclaimers[Statewide Low Flow WRIR00 4135]

Flow-Duration Statistics Flow Report[Statewide Low Flow WRIR00 4135]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SE	SEp
50 Percent Duration	27.5	ft^3/s	16.5	45.6	17.6	17.6
60 Percent Duration	21.5	ft^3/s	9.34	49.2	19.8	19.8
70 Percent Duration	14.5	ft^3/s	6.28	33.2	23.5	23.5
75 Percent Duration	11.6	ft^3/s	5.09	26.1	25.8	25.8
80 Percent Duration	9	ft^3/s	3.68	21.7	28.4	28.4
85 Percent Duration	6.73	ft^3/s	2.68	16.6	31.9	31.9
90 Percent Duration	5.05	ft^3/s	1.92	13	36.6	36.6
95 Percent Duration	3.02	ft^3/s	1	8.81	45.6	45.6
98 Percent Duration	2.02	ft^3/s	0.585	6.6	60.3	60.3
99 Percent Duration	1.55	ft^3/s	0.417	5.42	65.1	65.1

Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

August Flow-Duration Statistics Parameters[Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	27	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	1.461	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.27	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

August Flow-Duration Statistics Disclaimers[Statewide Low Flow WRIR00 4135]

August Flow-Duration Statistics Flow Report[Statewide Low Flow WRIR00 4135]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SE	SEp
August 50 Percent Duration	7.48	ft^3/s	2.95	18.6	33.2	33.2

August Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Bankfull Statistics Parameters[Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	27	square miles	0.6	329
BSLDEM10M	Mean Basin Slope from 10m DEM	4.536	percent	2.2	23.9

Bankfull Statistics Disclaimers[Bankfull Statewide SIR2013 5155]

Bankfull Statistics Flow Report[Bankfull Statewide SIR2013 5155]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
Bankfull Width	50.8	ft	21.3
Bankfull Depth	2.31	ft	19.8
Bankfull Area	117	ft^2	29
Bankfull Streamflow	316	ft^3/s	55

Bankfull Statistics Citations

Bent, G.C., and Waite, A.M.,2013, Equations for estimating bankfull channel geometry and discharge for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2013–5155, 62 p., (http://pubs.usgs.gov/sir/2013/5155/)

Probability Statistics Parameters[Perennial Flow Probability]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	27	square miles	0.01	1.99
PCTSNDGRV	Percent Underlain By Sand And Gravel	60.24	percent	0	100
FOREST	Percent Forest	35.45	percent	0	100
MAREGION	Massachusetts Region	0	dimensionless	0	1

Probability Statistics Disclaimers[Perennial Flow Probability]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

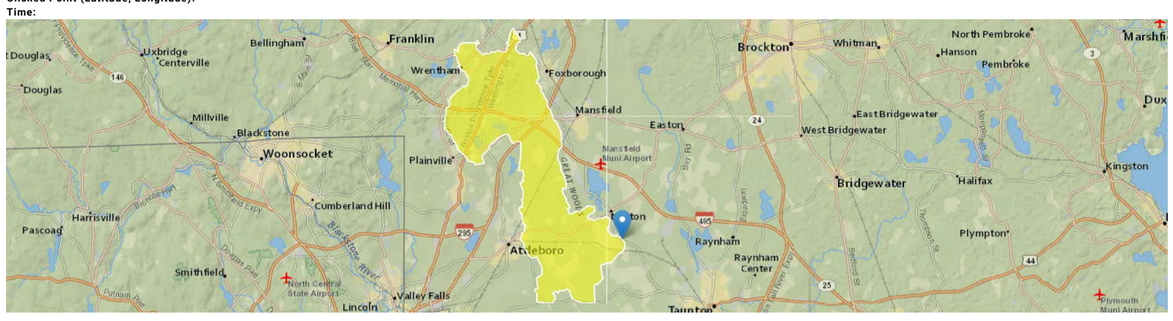
USGS 01109000 WADING RIVER NEAR NORTON, MA

Day of month	50th percentile (median) of daily mean values for each day for water year of record in, ft3/s (Calculation Period 1989-10-01 -> 2021-09-30) Period-of-record for statistical calculation restricted by user											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	91	87	92	133	95	45	18	6.4	8.4	11	30	63
2	87	83	97	139	105	54	16	6.1	7.6	11	29	57
3	87	79	105	133	94	52	15	6.1	7.2	11	34	61
4	92	80	112	151	96	46	16	7.4	7	9.9	31	57
5	98	78	102	148	91	48	16	7.3	7.4	11	31	63
6	94	77	98	139	92	50	18	7.7	6.8	12	39	66
7	97	83	96	143	94	48	19	7.3	6.5	12	40	64
8	90	84	101	143	81	47	20	7.5	6.4	11	35	75
9	82	82	104	131	81	39	18	6.5	6.5	13	32	66
10	75	77	102	129	78	39	15	7.5	6.5	14	31	73
11	80	77	112	132	72	37	13	7.1	6.4	12	36	79
12	86	77	117	128	69	36	13	8.2	8.1	12	40	83
13	100	82	118	127	73	42	14	7.6	8	12	44	86
14	94	91	126	143	66	43	12	8.2	8.2	12	45	77
15	93	104	135	126	62	42	13	8.7	8.3	17	44	76
16	91	104	132	127	64	38	14	8.6	8.8	20	42	81
17	93	103	136	124	70	34	12	12	9.4	23	43	85
18	94	101	150	122	72	30	11	9.9	10	26	45	85
19	95	105	148	122	75	30	12	12	9.8	26	46	85
20	94	104	151	112	71	25	12	10	9	26	41	79
21	88	108	139	117	67	23	12	12	8.7	24	45	78
22	85	103	126	136	61	21	10	12	9.8	24	46	76
23	81	101	136	132	57	21	8.7	12	12	26	50	80
24	89	110	131	133	57	20	10	11	12	23	48	101
25	85	113	131	129	59	24	10	11	12	21	51	100
26	83	107	126	126	55	23	9.3	9.8	10	22	55	94
27	86	104	125	117	55	21	10	8.6	11	22	61	87
28	86	98	129	109	50	19	9.4	10	11	24	69	91
29	83	122	120	107	47	21	8.4	9.9	13	22	67	86
30	79		124	101	53	17	11	11	12	27	64	97
31	89		115		45		8.9	10		29		90
MEAN								9.0	8.9			

A study area is needed before viewing the report

Wading River StreamStats Report

Region ID: MA
Workspace ID: MA20201222212446894000
Clicked Point (Latitude, Longitude): 41.94743, -71.17669
Time: 2020-12-22 16:25:07 -0500



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	43.1	square miles
ELEV	Mean Basin Elevation	181	feet
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	17.96	percent
BSLDEM250	Mean basin slope computed from 1:250K DEM	1.197	percent
DRFTPERSTR	Area of stratified drift per unit of stream length	0.28	square mile per mile
MAREGION	Region of Massachusetts 0 for Eastern 1 for Western	0	dimensionless
BSLDEM10M	Mean basin slope computed from 10 m DEM	3.844	percent
PCTSNDGRV	Percentage of land surface underlain by sand and gravel deposits	58.17	percent
FOREST	Percentage of area covered by forest	58.13	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	32.4	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	11.3	percent
WETLAND	Percentage of Wetlands	15.62	percent

General Disclaimers

Parameter values have been edited, computed flows may not apply.

Upstream regulation was checked for this watershed.

This watershed is percent regulated, computed flows may not apply.

This watershed has been edited, computed flows may not apply.

The resulting delineations are derived from digital elevation data and storm drain vectors that have been processed to enforce drainage through storm drains.

Urban regression equations for peak flows were not developed using streamgages which incorporate storm drain delineations and therefore should be used with caution.

Peak-Flow Statistics Parameters[Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	43.1	square miles	0.16	512
ELEV	Mean Basin Elevation	181	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	17.96	percent	0	32.3

Peak-Flow Statistics Disclaimers[Peak Statewide 2016 5156]

Peak-Flow Statistics Flow Report[Peak Statewide 2016 5156]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
50_percent_AEP_flood	587	ft^3/s	302	1140	42.3
20_percent_AEP_flood	939	ft^3/s	476	1850	43.4
10_percent_AEP_flood	1210	ft^3/s	600	2440	44.7
4_percent_AEP_flood	1590	ft^3/s	762	3320	47.1
2_percent_AEP_flood	1910	ft^3/s	887	4110	49.4
1_percent_AEP_flood	2230	ft^3/s	1010	4950	51.8
0_5_percent_AEP_flood	2590	ft^3/s	1130	5910	54.1
0_2_percent_AEP_flood	3080	ft^3/s	1290	7360	57.6

Peak-Flow Statistics Citations

Zarriello, P.J.,2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 99 p. (https://dx.doi.org/10.3133/sir20165156)

Low-Flow Statistics Parameters[Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	43.1	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	1.197	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.28	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

Low-Flow Statistics Disclaimers[Statewide Low Flow WRIR00 4135]

Low-Flow Statistics Flow Report[Statewide Low Flow WRIR00 4135]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SE	SEp
7 Day 2 Year Low Flow	5.57	ft^3/s	1.5	19.9	49.5	49.5
7 Day 10 Year Low Flow	2.29	ft^3/s	0.508	9.61	70.8	70.8

Low-Flow Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Flow-Duration Statistics Parameters[Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	43.1	square miles	1.61	149
DRFTPERSTR	Stratified Drift per Stream Length	0.28	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1
BSLDEM250	Mean Basin Slope from 250K DEM	1.197	percent	0.32	24.6

Flow-Duration Statistics Disclaimers[Statewide Low Flow WRIR00 4135]

Flow-Duration Statistics Flow Report[Statewide Low Flow WRIR00 4135]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SE	SEp
50 Percent Duration	44.4	ft^3/s	25.3	77.4	17.6	17.6
60 Percent Duration	35.2	ft^3/s	14.1	87.2	19.8	19.8
70 Percent Duration	24.1	ft^3/s	9.51	60.5	23.5	23.5
75 Percent Duration	19.5	ft^3/s	7.8	48.2	25.8	25.8
80 Percent Duration	14.5	ft^3/s	5.04	41.2	28.4	28.4
85 Percent Duration	10.8	ft^3/s	3.77	30.4	31.9	31.9
90 Percent Duration	7.93	ft^3/s	2.65	23.2	36.6	36.6
95 Percent Duration	4.78	ft^3/s	1.38	16	45.6	45.6
98 Percent Duration	3.24	ft^3/s	0.824	12.1	60.3	60.3
99 Percent Duration	2.52	ft^3/s	0.59	10.1	65.1	65.1

Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

August Flow-Duration Statistics Parameters[Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	43.1	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	1.197	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.28	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

August Flow-Duration Statistics Disclaimers[Statewide Low Flow WRIR00 4135]

August Flow-Duration Statistics Flow Report[Statewide Low Flow WRIR00 4135]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SE	SEp
August 50 Percent Duration	12.2	ft^3/s	4.22	34.7	33.2	33.2

August Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Bankfull Statistics Parameters[Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	43.1	square miles	0.6	329
BSLDEM10M	Mean Basin Slope from 10m DEM	3.844	percent	2.2	23.9

Bankfull Statistics Disclaimers[Bankfull Statewide SIR2013 5155]

Bankfull Statistics Flow Report[Bankfull Statewide SIR2013 5155]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
Bankfull Width	59.4	ft	21.3
Bankfull Depth	2.59	ft	19.8
Bankfull Area	153	ft^2	29
Bankfull Streamflow	396	ft^3/s	55

Bankfull Statistics Citations

Bent, G.C., and Waite, A.M.,2013, Equations for estimating bankfull channel geometry and discharge for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2013–5155, 62 p., (http://pubs.usgs.gov/sir/2013/5155/)

Probability Statistics Parameters[Perennial Flow Probability]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	43.1	square miles	0.01	1.99
PCTSNDGRV	Percent Underlain By Sand And Gravel	58.17	percent	0	100
FOREST	Percent Forest	58.13	percent	0	100
MAREGION	Massachusetts Region	0	dimensionless	0	1

Probability Statistics Disclaimers[Perennial Flow Probability]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

ATTACHMENT 3 - USFWS FISH PASSAGE FLOW DETERMINATION SPREADSHEETS

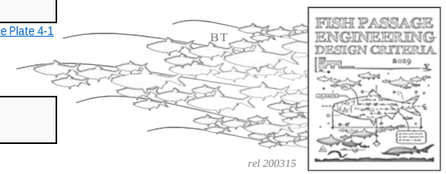
Fish Passage Design Flows

Name : sarruda

Date : 12/22/2020

The high & low design flows are used to establish the range of river flows over which a fishway should be functional (if not operational). For proposed facilities, this analysis identifies the flows corresponding to exceedance design criteria (typically, 5% and 95%). For existing facilities, this analysis can be used to verify conformity with design criteria*.

* see USFWS Fish Passage Engineering Design Criteria; Chapter 4 and Reference Plate 4-1



rel 200315

Site Information

Project Name : Little River Dam Removal

Gage Name : USGS 01105500 EAST BRANCH NEPONSET RIVER AT CANTON, MA [USGS Mapper]

Project Drain. Area (mi^2)** : 27.90

Gage Drain. Area (mi^2) **: 27.20

Empty flow cells in Gage Data were found and treated as zero cfs.

** if Project DA and Gage DA are equal, then the flows are not prorated and the Exceedance Tables (below) will match.

Summary

Available Gage Data	
Start	3/1/1990
End	6/30/2020
No. Days	11,079
No. Years	30.4

Annual Period Analyzed[1]	
Start	3/1/1990
End	6/30/2020
No. Days	11,079
% Gage Data	100.0%

Fish Passage Season[2]	
Start	Mar 1
End	Jun 30
Days/Yr	121
Weeks/Yr	17.3

Design Flows	
Hi. Exc.	5.0%
Low Exc.	95.0%
High Q (cfs)	204
Low Q (cfs)	15

Non-Pass Events	
1 D High	14
> 1 D High	43
1 D Low	6
> 1 D Low	26

Exceedance Table : Project Flows (cfs) prorated by ratio of Project DA to Gage DA. Year and months based on Annual Period Analyzed[1]; Season based on abbreviated Fish Passage Season[2].

	Year[1]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season[2]
FLOOD	0.001	516	371	372	996	450	380	652	276	170	371	712	292	462	759
	0.01	276	257	237	444	334	237	345	154	110	170	257	213	296	355
	0.05	166	155	151	244	226	131	152	78	59	76	131	144	186	204
	0.1	121	123	120	184	186	101	99	50	37	44	83	99	148	156
	0.2	84	95	95	134	150	77	57	30	26	25	49	75	107	109
	0.3	65	79	82	106	117	63	41	23	19	17	33	55	83	83
	0.4	50	68	71	88	98	53	33	18	16	14	24	42	68	69
	0.5	39	58	62	78	81	45	28	15	13	11	16	35	56	57
	0.6	30	51	53	69	69	41	23	12	10	9	13	28	42	47
	0.7	21	45	46	59	59	35	18	10	8	7	11	22	34	38
	0.8	14	39	39	50	47	29	16	8	6	6	9	15	27	29
	0.9	9	32	32	42	34	23	12	6	5	4	7	11	18	19
	0.95	6	28	29	34	26	19	10	5	4	3	6	9	14	15
	0.99	4	21	22	27	17	15	6	4	3	2	4	8	10	9
DROUGHT	0.999	2	13	18	24	15	12	4	3	3	2	3	7	8	5
	MIN	0	12	18	24	15	8	4	2	3	2	3	7	0	4
	MAX	1,003	517	448	1,003	487	384	908	377	178	372	791	307	485	1,003
	MEAN	56	71	72	102	100	57	48	25	19	22	37	49	71	77
	MEAN[95-05]	49	66	67	91	94	52	37	20	16	16	28	43	65	68

--> MEAN[95-05] is the trimmed mean that excludes the upper 5% and lower 5% of all data.

Exceedance Table : Gage Flows (cfs) as recorded by USGS. Year and months based on Annual Period Analyzed[1]; Season based on abbreviated Fish Passage Season[2].

	Year[1]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season[2]
FLOOD	0.001	503	362	362	971	439	370	636	270	166	362	694	285	451	740
	0.01	269	251	231	433	326	231	337	150	107	166	250	208	288	346
	0.05	162	152	147	238	220	128	149	76	58	74	128	140	182	199
	0.1	118	120	117	179	181	98	97	49	36	43	81	97	144	152
	0.2	82	93	93	130	146	75	55	29	25	24	48	73	104	106
	0.3	63	77	80	103	114	61	40	22	19	17	32	54	81	81
	0.4	49	66	69	86	96	52	32	18	16	13	23	41	66	67
	0.5	38	57	60	76	79	44	27	15	13	11	16	34	55	56
	0.6	29	50	52	67	67	40	22	12	10	9	13	27	41	46
	0.7	20	44	45	58	58	34	18	10	8	7	11	21	33	37
	0.8	14	38	38	49	46	28	16	8	6	6	9	15	26	28
	0.9	9	31	31	41	33	22	12	6	5	4	7	11	18	19
	0.95	6	27	28	33	25	19	10	5	4	3	6	9	14	15
DROUGHT	0.99	4	20	21	26	17	15	6	4	3	2	4	8	10	9
	0.999	2	13	18	23	15	12	4	3	3	2	3	7	7	5
	MIN	0	12	18	23	15	8	4	2	3	2	3	7	0	4
	MAX	978	504	437	978	475	374	885	368	174	363	771	299	473	978
	MEAN	55	69	70	99	98	56	46	24	19	21	36	48	70	75
	MEAN[95-05]	48	64	65	88	91	51	36	20	16	15	27	42	63	66

--> MEAN[95-05] is the trimmed mean that excludes the upper 5% and lower 5% of all data.

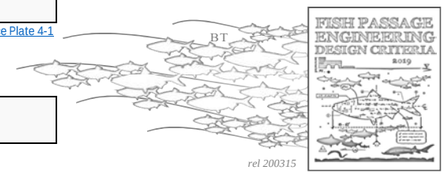
Fish Passage Design Flows

Name : sarruda

Date : 12/22/2020

The high & low design flows are used to establish the range of river flows over which a fishway should be functional (if not operational). For proposed facilities, this analysis identifies the flows corresponding to exceedance design criteria (typically, 5% and 95%). For existing facilities, this analysis can be used to verify conformity with design criteria*.

* see USFWS Fish Passage Engineering Design Criteria; Chapter 4 and Reference Plate 4-1



rel 200315

Site Information

Project Name : Little River Dam Removal

Gage Name : USGS 01105730 INDIAN HEAD RIVER AT HANOVER, MA [USGS Mapper]

Project Drain. Area (mi^2)** : 27.90

Gage Drain. Area (mi^2) **: 30.50

Empty flow cells in Gage Data were found and treated as zero cfs.

** if Project DA and Gage DA are equal, then the flows are not prorated and the Exceedance Tables (below) will match.

Summary

Available Gage Data	
Start	3/1/1990
End	6/30/2020
No. Days	11,079
No. Years	30.4

Annual Period Analyzed[1]	
Start	3/1/1990
End	6/30/2020
No. Days	11,079
% Gage Data	100.0%

Fish Passage Season[2]	
Start	Mar 1
End	Jun 30
Days/Yr	121
Weeks/Yr	17.3

Design Flows	
Hi. Exc.	5.0%
Low Exc.	95.0%
High Q (cfs)	218
Low Q (cfs)	15

Non-Pass Events	
1 D High	19
> 1 D High	47
1 D Low	7
> 1 D Low	22

Exceedance Table : Project Flows (cfs) prorated by ratio of Project DA to Gage DA. Year and months based on Annual Period Analyzed[1]; Season based on abbreviated Fish Passage Season[2].

	Year[1] →	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season[2]
FLOOD	0.001	741	534	585	1,153	572	662	620	403	461	396	1,054	427	722	846
	0.01	363	327	365	645	437	284	365	178	180	184	326	295	392	450
	0.05	183	187	190	273	252	141	146	73	69	67	149	160	206	218
	0.1	131	138	141	198	192	104	86	50	43	40	100	116	155	161
	0.2	88	102	105	150	138	77	49	28	27	26	49	81	114	113
	0.3	65	83	86	121	112	62	38	21	18	19	34	63	88	85
	0.4	51	68	72	102	92	54	31	16	14	16	25	50	70	69
	0.5	40	58	63	84	78	48	27	14	10	12	20	40	57	56
MEDIAN	0.6	31	50	55	71	67	42	23	11	8	9	15	33	47	47
	0.7	22	44	47	60	57	37	18	8	6	7	11	27	38	38
	0.8	14	38	39	51	47	31	15	6	5	5	8	22	28	29
	0.9	8	31	34	41	35	24	10	5	4	4	6	13	22	20
	0.95	5	27	31	36	28	21	7	4	3	3	5	10	19	15
	0.99	3	16	24	27	19	15	5	2	2	2	4	7	13	7
DROUGHT	0.999	1	12	21	23	15	13	5	2	1	1	4	5	9	5
	MIN	0	0	20	23	14	7	5	2	1	1	4	5	9	5
	MAX	1,153	600	742	1,153	600	722	818	587	503	580	1,079	455	867	1,153
	MEAN	61	77	81	114	101	61	46	23	22	21	43	58	80	81
	MEAN[95-05]	51	70	72	99	92	54	34	18	15	15	30	50	70	69

--> MEAN[95-05] is the trimmed mean that excludes the upper 5% and lower 5% of all data.

Exceedance Table : Gage Flows (cfs) as recorded by USGS. Year and months based on Annual Period Analyzed[1]; Season based on abbreviated Fish Passage Season[2].

	Year[1] →	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season[2]
FLOOD	0.001	810	584	639	1,260	625	724	678	440	504	433	1,152	467	789	925
	0.01	397	357	399	705	478	310	399	195	197	201	356	323	428	492
	0.05	200	204	208	298	275	154	160	80	76	73	163	175	225	238
	0.1	143	151	154	216	210	114	94	55	47	44	109	127	169	176
	0.2	96	111	115	164	151	84	54	31	29	28	54	88	125	123
	0.3	71	91	94	133	122	68	42	23	20	21	37	69	96	93
MEDIAN	0.4	56	74	79	112	101	59	34	18	15	17	27	54	77	75
	0.5	44	63	69	92	85	52	29	15	11	13	22	44	62	61
	0.6	34	55	60	78	73	46	25	12	9	10	17	36	51	51
	0.7	24	48	51	66	62	40	20	9	7	8	12	30	41	41
	0.8	15	42	43	56	51	34	16	7	6	6	9	24	31	32
	0.9	9	34	37	45	38	26	11	5	4	4	7	14	24	22
DROUGHT	0.95	6	30	34	39	31	23	8	4	3	3	6	11	20	16
	0.99	3	18	26	30	21	17	6	2	2	2	4	8	14	8
	0.999	1	13	23	25	16	15	5	2	1	1	4	6	10	5
	MIN	0	0	22	25	15	8	5	2	1	1	4	6	10	5
	MAX	1,260	656	811	1,260	656	789	894	642	550	634	1,180	497	948	1,260
	MEAN	66	85	89	125	111	67	50	26	24	23	46	63	87	88
	MEAN[95-05]	56	76	79	108	100	59	37	20	17	17	33	55	77	76

--> MEAN[95-05] is the trimmed mean that excludes the upper 5% and lower 5% of all data.

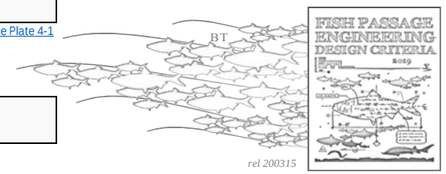
Fish Passage Design Flows

Name : sarruda

Date : 12/22/2020

The high & low design flows are used to establish the range of river flows over which a fishway should be functional (if not operational). For proposed facilities, this analysis identifies the flows corresponding to exceedance design criteria (typically, 5% and 95%). For existing facilities, this analysis can be used to verify conformity with design criteria*.

* see USFWS Fish Passage Engineering Design Criteria; Chapter 4 and Reference Plate 4-1



rel 200315

Site Information

Project Name : Little River Dam Removal

Gage Name : USGS 01109000 WADING RIVER NEAR NORTON, MA [USGS Mapper]

Project Drain. Area (mi^2)** : 27.90

Gage Drain. Area (mi^2) **: 43.10

enter notes

** if Project DA and Gage DA are equal, then the flows are not prorated and the Exceedance Tables (below) will match.

Summary

Available Gage Data	
Start	3/1/1990
End	6/30/2020
No. Days	11,079
No. Years	30.4

Annual Period Analyzed[1]	
Start	3/1/1990
End	6/30/2020
No. Days	11,079
% Gage Data	100.0%

Fish Passage Season[2]	
Start	Mar 1
End	Jun 30
Days/Yr	121
Weeks/Yr	17.3

Design Flows	
Hi. Exc.	5.0%
Low Exc.	95.0%
High Q (cfs)	183
Low Q (cfs)	10

Non-Pass Events	
1 D High	10
> 1 D High	39
1 D Low	3
> 1 D Low	19

Exceedance Table : Project Flows (cfs) prorated by ratio of Project DA to Gage DA. Year and months based on Annual Period Analyzed[1]; Season based on abbreviated Fish Passage Season[2].

	Year[1] →	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season[2]
FLOOD	0.001	468	373	305	724	457	259	694	382	174	161	425	272	412	682
	0.01	247	228	235	369	290	179	358	129	79	109	191	230	252	310
	0.05	150	155	148	207	204	112	134	61	44	47	107	128	163	183
	0.1	113	126	116	174	166	94	75	38	28	29	69	98	133	142
	0.2	80	95	95	134	131	74	47	23	17	15	34	66	102	102
	0.3	61	79	79	104	108	61	37	16	12	10	21	48	79	82
	0.4	47	67	69	88	94	53	28	12	8	8	15	37	65	67
	0.5	36	57	60	78	82	47	22	8	6	6	11	28	52	56
	0.6	24	49	52	67	70	40	17	6	5	5	8	22	43	45
	0.7	15	42	44	59	60	35	14	5	3	3	6	16	32	36
	0.8	8	36	38	50	48	28	10	3	2	3	4	10	21	27
	0.9	4	27	30	39	36	21	6	3	1	1	2	6	14	16
	0.95	3	22	25	33	28	16	5	2	1	1	1	5	10	10
	0.99	1	16	20	23	11	13	3	1	1	0	1	3	6	5
DROUGHT	0.999	0	7	17	18	8	9	1	1	1	0	1	3	4	2
	MIN	0	7	16	17	8	8	1	1	1	0	1	2	4	1
	MAX	880	388	343	880	590	285	719	500	195	180	619	293	469	880
	MEAN	50	69	70	96	94	54	41	17	12	12	26	43	66	71
	MEAN[95-05]	44	64	65	88	89	50	29	13	9	9	19	37	60	64

--> MEAN[95-05] is the trimmed mean that excludes the upper 5% and lower 5% of all data.

Exceedance Table : Gage Flows (cfs) as recorded by USGS. Year and months based on Annual Period Analyzed[1]; Season based on abbreviated Fish Passage Season[2].

	Year[1] →	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season[2]
FLOOD	0.001	724	577	471	1,118	707	401	1,073	590	268	248	657	421	636	1,054
	0.01	381	353	362	570	447	276	552	200	123	168	294	356	390	479
	0.05	232	240	229	320	316	173	207	95	68	73	165	198	252	283
	0.1	175	195	179	269	256	145	115	59	44	45	106	151	206	220
	0.2	124	147	146	206	202	114	73	36	26	23	52	102	157	157
	0.3	95	122	122	161	167	95	57	24	18	16	33	74	122	126
	0.4	73	103	107	136	145	82	43	18	13	12	23	57	100	104
	0.5	55	88	93	121	127	72	34	12	9	9	17	43	81	86
	0.6	37	76	80	104	108	62	27	9	7	7	12	34	66	70
	0.7	23	65	68	91	92	54	21	7	5	5	9	25	50	56
	0.8	12	55	58	77	74	44	16	5	3	4	6	15	33	41
	0.9	6	42	46	60	55	32	10	4	2	1	3	9	21	24
DROUGHT	0.95	4	34	39	51	43	25	7	3	1	1	2	7	16	16
	0.99	1	24	31	35	17	20	4	2	1	0	1	5	9	7
	0.999	0	11	27	28	13	14	2	1	1	0	1	4	7	3
	MIN	0	11	25	27	13	13	2	1	1	0	1	3	6	2
	MAX	1,360	599	530	1,360	911	440	1,110	772	301	278	957	452	724	1,360
	MEAN	77	107	108	149	145	83	63	27	18	19	41	66	102	110
	MEAN[95-05]	67	99	101	136	137	78	45	20	14	14	30	57	93	99

--> MEAN[95-05] is the trimmed mean that excludes the upper 5% and lower 5% of all data.

ATTACHMENT 4 - NOAA TIDE DATA FOR MERRIMACK RIVER

Datums for 8440889, RIVERSIDE, MERRIMACK RIVER MA

NOTICE: All data values are relative to the NAVD88.

Elevations on NAVD88

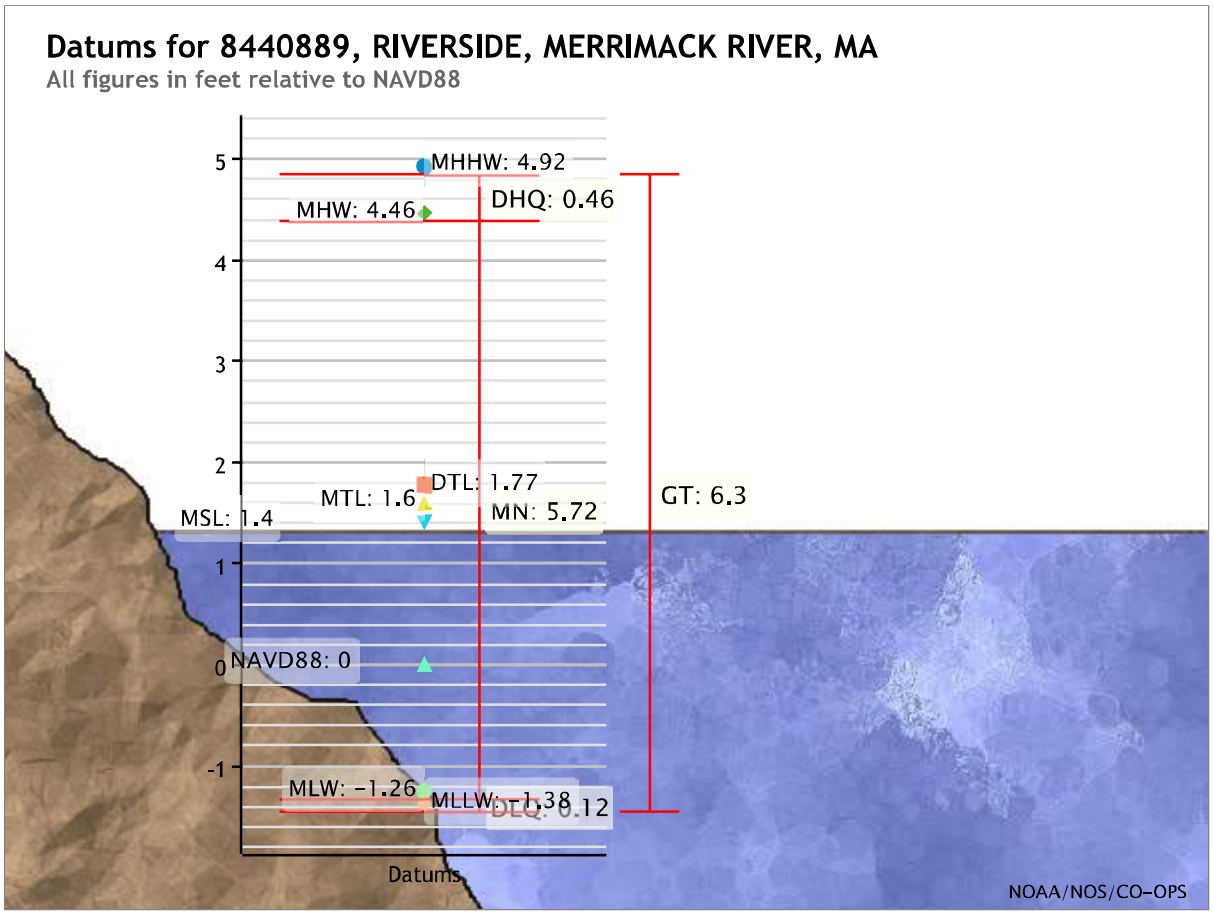
Station: 8440889, RIVERSIDE, MERRIMACK RIVER, MA
Status: Accepted (Sep 8 2003)
Units: Feet
Control Station: 8440466 NEWBURYPORT, MERRIMACK RIVER, MA
T.M.: 75
Epoch: (/datum_options.html#NTDE) 1983-2001
Datum: NAVD88

Datum	Value	Description
MHHW (/datum_options.html#MHHW)	4.92	Mean Higher-High Water
MHW (/datum_options.html#MHW)	4.46	Mean High Water
MTL (/datum_options.html#MTL)	1.60	Mean Tide Level
MSL (/datum_options.html#MSL)	1.40	Mean Sea Level
DTL (/datum_options.html#DTL)	1.77	Mean Diurnal Tide Level
MLW (/datum_options.html#MLW)	-1.26	Mean Low Water
MLLW (/datum_options.html#MLLW)	-1.38	Mean Lower-Low Water
NAVD88 (/datum_options.html)	0.00	North American Vertical Datum of 1988
STND (/datum_options.html#STND)	-4.88	Station Datum
GT (/datum_options.html#GT)	6.30	Great Diurnal Range
MN (/datum_options.html#MN)	5.72	Mean Range of Tide
DHQ (/datum_options.html#DHQ)	0.46	Mean Diurnal High Water Inequality
DLQ (/datum_options.html#DLQ)	0.12	Mean Diurnal Low Water Inequality

Datum	Value	Description
HWI (/datum_options.html#HWI)	5.52	Greenwich High Water Interval (in hours)
LWI (/datum_options.html#LWI)	0.84	Greenwich Low Water Interval (in hours)
Max Tide (/datum_options.html#MAXTIDE)		Highest Observed Tide
Max Tide Date & Time (/datum_options.html#MAXTIDEDT)		Highest Observed Tide Date & Time
Min Tide (/datum_options.html#MINTIDE)		Lowest Observed Tide
Min Tide Date & Time (/datum_options.html#MINTIDEDT)		Lowest Observed Tide Date & Time
HAT (/datum_options.html#HAT)		Highest Astronomical Tide
HAT Date & Time		HAT Date and Time
LAT (/datum_options.html#LAT)		Lowest Astronomical Tide
LAT Date & Time		LAT Date and Time

Tidal Datum Analysis Periods

07/01/1989 - 09/30/1989



Showing datums for

8440889 RIVERSIDE, MERR...

^

Datum

NAVD88

Data Units ◉ Feet
○ Meters

Epoch ◉ Present (1983-2001)
○ Superseded (1960-1978)

Submit

Show nearby stations

Products available at 8440889 RIVERSIDE, MERRIMACK RIVER, MA

TIDES/WATER LEVELS

Water Levels

NOAA Tide Predictions (/noaatidepredictions.html?id=8440889)

Harmonic Constituents (/harcon.html?id=8440889)

Sea Level Trends

Datums (/datums.html?id=8440889)

Bench Mark Sheets (/benchmarks.html?id=8440889)

Extreme Water Levels

Reports (/reports.html?id=8440889)

METEOROLOGICAL/OTHER

Meteorological Observations

Water Temp/Conductivity

PORTS®

This station is not a member of PORTS®

OPERATIONAL FORECAST SYSTEMS

This station is not a member of OFS

INFORMATION

Station Home Page (/stationhome.html?id=8440889)

Data Inventory (/inventory.html?id=8440889)

Measurement Specifications (/measure.html)

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ATTACHMENT 5 - FEMA DUPLICATE EFFECTIVE MODEL HYDRAULIC BACK-UP DATA

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**********                                                    THIS RUN EXECUTED 05/07/81  10.25.07
 HEC2 RELEASE DATED NOV 76 UPDATED JULY 1979
 ERROR CODE = 01,02,03
 MODIFICATION - 50,51,52,53, *, *, *, *,98
**********

C
T1     HAVERHILL
T2     LITTLE RIVER
T3     ENCROACHMENT  ANALYSIS

J1  ICHECK      INQ        NINV       IDIR       STRT       METRIC     HVINS      Q          WSEL       FQ
             0.         4.         0.         0.  0.0            C.0        0.0        0.     1.600      0.0
J2  NPROF       IPLOT      PRFVS      XSECV      XSECH      FN         ALLDC      IBW        CHNIM      ITRACE
            0.0        0.0       -1.000      0.0        0.0        0.0        0.0        0.0        0.0        0.0
J3  VARIABLE CODES FOR SUMMARY PRINTOUT
          110.000    200.000      0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0

NC          0.029      0.029      0.029      0.300      0.300      0.0        0.0        0.0        0.0        0.0
QT          9.000   1160.000   1920.000   2330.000   3520.000   2330.000   2330.000   2330.000   2330.000   2330.000

        APPROXIMATED SECTION AT CONFLUENCE WITH MERRIMACK RIVER

X1      8225.000      5.000   1984.000   2016.000      0.0        0.0        0.0        0.0        0.0        0.0
GR        10.000   1000.000     -1.000   1984.000   -1.000  2000.000     -1.000   2016.000   10.000  3000.000
NC         0.025      0.025      0.029      0.0        0.0        0.0        0.0        0.0        0.0        0.0
ET          0.0        0.0        0.0        0.0        0.0        0.0        8.110   1984.000   2016.000      0.0

        APPROXIMATED SECTION

X1      8235.000      5.000   1984.000   2016.000   10.000     10.000     10.000      0.0        0.0        0.0
GR        10.000      0.0        0.0        0.0        0.0        0.0        0.0     20.000     20.000      0.0
GR        10.000   1000.000     -1.000   1984.000   -1.000  2000.000     -1.000   2016.000   10.000  3000.000
SD         1.250      1.250      1.000      0.0       33.000     0.0      303.000      0.0        0.0        0.0
ET          0.0        0.0        0.0        0.0        0.0        0.0        8.110   1983.000   2017.000      0.0

        LETTERS IN PARENTHESIS DENOTE SURVEYED SECTIONS CORRESPONDING
        TO THE FREM.
        (A) SURVEYED SECTION AT FACE OF WALL AT CULVERT ENTRANCE     LR1-S

X1      16000.000     13.000   1983.400   2016.600   1765.000   1765.000   1765.000      0.0        0.3        0.0
XS          0.0        0.0        1.000     21.400     33.000     0.2        0.0        0.0        0.0        0.0
XT         10.000      0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
RT         13.000   1540.000     43.000     0.0        0.0        0.0        0.0       33.000     35.000     0.0
RT       1983.400      39.200     7.700   1988.400     0.0     1967.000     33.000     0.0     1569.000     39.600     0.0
RT         38.800     21.400   2005.500     38.600     31.000     39.100     15.000   1994.500     39.900     21.000  2000.000
RT          7.700   2027.400     38.500     0.0     2030.000   2011.100     38.500     15.000   2016.600     38.300     0.0
GR         42.000   1840.000     35.000   1967.000     36.600   1969.000     0.0     1540.000     50.000     0.0
GR       1983.400      0.0        0.0        0.0        0.0        0.0        7.700   1983.400     7.400   1388.900
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GR	38.000	2027.600	35.000	2030.000	[illegible]	2540.000	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1973.000	2024.890	0.0

(B) SURVEYED SECTION U/S OF LR1-S

X1	10050.000	15.000	1984.000	2014.000	35.000	60.000	50.000	0.0	0.0	0.0
GR	41.900	1880.000	35.600	1980.000	34.000	1930.000	24.800	1754.000	20.000	1970.000
GR	8.100	1984.000	7.000	2000.000	4.100	2015.000	15.000	2320.000	13.400	2130.000
GR	26.100	2034.000	28.400	2040.000	29.000	2050.000	30.000	2090.000	50.000	2101.000
NC	0.0	0.0	0.0	0.0	0.300	0.0	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1972.000	2020.500	0.0

SCALED SECTION D/S OF LR2-S

X1	10480.000	10.000	1972.000	2020.000	430.000	430.000	430.000	0.0	0.0	0.0
GR	56.000	1779.000	30.000	1780.000	25.000	1909.000	25.000	1972.000	8.500	1973.000
GR	8.500	2019.000	20.000	2020.000	25.000	2045.000	30.000	2125.000	50.000	2126.000
NC	0.0	0.0	0.0	0.0	0.300	0.0	0.0	0.0	0.0	0.0
NH	4.000	0.025	1973.100	0.029	2018.900	0.025	2019.000	0.040	2430.000	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1986.000	2014.000	0.0

(C) SURVEYED SECTION D/S FACE OF LR2-S

X1	10530.000	16.000	1986.000	2014.000	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	22.700	22.700	0.0
GR	30.000	1560.000	25.700	1666.000	25.100	1756.000	24.700	1806.000	24.500	1856.000
GR	24.300	1960.000	27.000	1956.000	24.800	1975.000	24.800	1973.100	27.800	1986.000
GR	9.000	2000.000	9.000	2014.000	9.000	2018.900	24.800	2019.000	27.800	2256.000
GR	30.000	2430.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GR	0.250	14.500	0.000	0.0	28.000	0.0	220.000	0.0	9.000	7.000
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1986.000	2014.000	0.0

(D) SURVEYED SECTION U/S FACE OF LR2-S

X1	10605.000	15.000	1986.000	2014.000	75.000	75.000	75.000	0.0	0.0	0.0
X2	0.0	0.0	1.000	20.600	24.800	0.0	0.0	0.0	24.800	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	24.800	24.800	0.0
BT	7.000	1973.000	24.800	24.800	1986.000	24.800	9.000	1993.000	24.800	18.000
BT	2000.000	24.800	26.500	2007.000	24.800	14.000	2019.000	24.800	9.000	2014.900
BT	24.800	24.800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GR	56.000	1906.000	54.000	1972.900	24.800	1973.000	9.000	1973.100	9.000	1986.000
GR	9.000	1993.000	9.000	2000.000	9.000	2007.000	9.000	2014.900	9.000	2014.900
GR	24.800	2019.000	26.500	2206.000	27.400	2235.000	27.800	2256.000	30.000	2430.000
NC	0.030	0.065	0.030	0.0	0.300	0.0	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1972.000	2039.000	0.0

APPROXIMATED SECTION U/S OF LR2-S

X1	10640.000	7.000	1972.900	2038.100	35.000	35.000	35.000	0.0	0.0	0.0
GR	54.000	1972.900	9.200	1973.000	9.200	2038.000	25.500	2038.100	28.000	2250.000
GR	30.000	2430.000	50.000	2450.000	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.0	0.0	0.0	0.0	0.0	0.0
NH	6.000	0.065	1680.000	0.025	1740.000	0.065	1790.000	0.025	1959.900	0.029
NH	2035.100	0.065	2229.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1959.000	2036.000	0.0

SCALED SECTION AT SPILLWAY D/S

X1	10674.000	18.000	1959.900	2035.100	34.000	34.000	34.000	0.0	0.0	0.0
GR	40.000	1570.000	35.000	1680.000	50.000	1680.100	50.000	1739.900	30.000	1740.000
GR	30.000	1790.000	54.000	1790.100	54.000	1959.900	54.000	1960.000	54.000	2035.000

GR	27.800	2229.000	30.000	2425.000	35.000	2560.000	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1959.000	2036.000	0.0

SCALED SECTION AT SPILLWAY ON

X1	10675.000	18.000	1959.900	2035.100	1.000	1.000	1.000	0.0	0.0	0.0
GR	40.000	1570.000	35.000	1680.000	50.000	1680.100	50.000	1739.900	30.000	1740.000
GR	30.000	1790.000	54.000	1790.100	54.000	1959.900	19.300	1960.000	19.300	2035.000
GR	26.200	2035.100	45.600	2037.000	25.300	2106.000	24.700	2113.000	27.600	2208.000
GR	27.800	2229.000	30.000	2425.000	35.000	2560.000	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1959.000	2036.000	0.0

SCALED SECTION AT SPILLWAY U/S

X1	10676.000	18.000	1959.900	2035.100	1.000	1.000	1.000	0.0	0.0	0.0
GR	40.000	1570.000	35.000	1680.000	50.000	1680.100	50.000	1739.900	30.000	1740.000
GR	30.000	1790.000	54.000	1790.100	54.000	1959.900	19.300	1960.000	19.300	2035.000
GR	26.200	2035.100	45.600	2037.000	25.300	2106.000	24.700	2113.000	27.600	2208.000
GR	27.800	2229.000	30.000	2425.000	35.000	2570.000	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	1.410	8.110	1959.000	2036.000	0.0

COMPUTED SECTION 100'U/S OF SPILLWAY

X1	10775.000	0.0	0.0	0.0	99.000	99.000	99.000	0.0	0.150	0.0
NM	4.000	0.112	1790.000	0.025	1960.000	0.065	2030.000	0.112	2580.000	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1960.000	2085.000	0.0

SCALED SECTION

X1	11000.000	10.000	1960.000	2030.000	225.000	225.000	225.000	0.0	0.0	0.0
GR	40.000	1570.000	35.000	1670.000	30.000	1790.000	54.000	1790.100	54.000	1959.900
GR	17.000	1960.000	9.800	2000.000	17.000	2030.000	30.000	2420.000	40.000	2580.000
NC	0.112	0.112	0.065	0.150	0.360	0.0	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1940.000	2085.000	0.0

SCALED SECTION

X1	11600.000	11.000	1940.000	2060.000	600.000	600.000	600.000	0.0	0.0	0.0
GR	40.000	1590.000	35.000	1670.000	35.000	1869.000	30.000	1920.300	25.000	1930.000
GR	18.000	1940.000	10.800	2000.000	18.000	2060.000	25.000	2080.300	30.000	2550.000
GR	40.000	2660.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1920.000	2045.000	0.0

(E) SURVEYED SECTION LR3

X1	12255.000	15.000	1920.000	2045.000	655.000	655.000	655.000	0.0	0.0	0.0
GR	33.100	1766.000	34.100	1808.000	33.400	1866.000	33.400	1885.000	20.600	1914.000
GR	20.000	1920.000	12.400	1966.000	33.900	2000.000	17.900	2014.000	40.000	2040.000
GR	24.700	2080.000	26.800	2085.000	29.000	2394.000	30.000	2440.000	40.000	2930.000
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1920.000	2045.000	0.0

COMPUTED SECTION

X1	13100.000	0.0	0.0	0.0	845.000	845.000	845.000	0.0	1.000	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1860.000	2055.000	0.0

SCALED SECTION D/S OF BEND

X1	14000.000	15.000	1960.000	2040.000	900.000	900.000	900.000	0.0	0.0	0.0

GR	17.300	1983.000	16.900	1988.000	13.900	2000.000	14.900	2012.000	17.200	2025.000	
GR	19.560	2040.000	20.000	2050.000	25.000	2060.000	30.000	2070.000	40.000	2090.000	
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1893.000	2083.000	0.0	

SCALED SECTION D/S OF LR4-S U/S OF BENC

XI	14200.000	12.000	1925.000	2075.000	125.000	250.000	200.000	0.0	0.0	0.0	
GR	40.000	1600.000	30.000	1640.000	25.000	1870.000	20.000	1920.000	19.800	1925.000	
GR	18.600	1840.000	14.200	2000.000	17.560	2060.000	16.800	2075.000	20.000	2080.000	
GR	24.000	2160.000	45.000	2165.000	0.0	0.0	0.0	0.0	0.0	0.0	
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0	
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1950.000	2045.000	0.0	

COMPUTED SECTION D/S FACE OF LR4-S

XI	14300.000	16.000	1983.000	2018.170	50.000	140.000	100.000	0.0	-0.300	0.0	
GR	35.000	1770.000	27.500	1920.000	21.000	1970.000	20.200	1978.000	19.000	1981.000	
GR	17.300	1988.200	14.400	2000.000	15.000	2012.400	16.800	2018.100	17.900	2025.000	
GR	20.200	2030.100	27.600	2070.000	27.900	2120.000	28.100	2170.000	30.000	2230.000	
GR	35.000	2270.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ET	1.050	1.560	2.600	0.0	35.100	2.000	316.000	0.0	14.600	14.300	
	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1950.000	2045.000	0.0	

(F) SURVEYED SECTION U/S FACE OF LR4-S

XI	14340.000	0.0	0.0	0.0	40.000	40.000	40.000	0.0	0.300	0.0	
XS	0.0	0.0	1.000	25.700	0.0	0.0	0.0	0.0	0.0	0.0	
BT	10.000	1450.000	24.800	0.0	1930.000	27.500	0.0	1970.000	27.600	0.0	
BT	1981.000	27.500	2000.000	27.600	27.600	26.600	2010.100	27.700	28.700	2030.100	
BT	27.700	0.0	2070.000	27.600	0.0	2120.000	27.900	0.0	2170.000	28.100	
ET	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1944.000	2104.000	0.0	

(G) SURVEYED SECTION U/S OF LR4-S

XI	14420.000	15.000	1944.000	2051.000	80.000	80.000	80.000	0.0	0.0	0.0	
GR	40.000	1815.000	30.000	1854.000	26.900	1885.000	22.500	1920.000	21.900	1941.000	
GR	20.100	2134.000	19.000	2060.000	20.100	2051.222	19.900	2074.000	20.300	2125.000	
GR	23.400	2134.200	25.000	2140.000	27.100	2177.000	26.100	2225.000	35.000	2475.000	
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0	
ET	3.000	0.112	1970.000	0.065	2025.000	0.112	2195.000	0.0	0.0	0.0	
	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1950.000	2150.000	0.0	

COMPUTED SECTION D/S OF LR5-S

XI	15677.000	23.000	1964.000	2025.000	1257.000	1257.000	1257.000	0.0	0.0	0.0	
GR	35.000	1760.000	29.800	1895.000	28.900	1945.000	29.900	1948.000	27.700	1952.000	
GR	21.000	2038.000	13.000	1987.000	16.100	2000.000	14.800	2011.000	19.700	2025.000	
GR	21.000	2038.000	21.000	2036.000	20.000	2045.000	19.800	2065.000	20.000	2117.000	
GR	28.100	2150.000	31.500	2154.000	32.100	2164.000	30.100	2172.000	28.800	2184.000	
GR	29.000	2190.000	30.000	2230.000	35.000	2240.000	0.0	0.0	0.0	0.0	
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0	
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1950.000	2150.000	0.0	

(H) SURVEYED SECTION D/S FACE OF LR5-S

XI	15697.000	0.0	0.0	0.0	20.000	20.000	20.000	0.0	0.0	0.0	
XS	10.000	0.0	0.0	0.0	0.0	0.0	0.0	27.000	27.000	0.0	
SB	1.250	1.560	2.600	0.0	165.000	15.000	951.000	18.000	15.100	15.100	
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1950.000	2150.000	0.0	

COMPUTED SECTION U/S FACE OF LR5-S

X1	15703.000	0.0	0.0	0.0	6.000	6.000	6.000	0.0	0.0	0.0
X2	0.0	0.0	1.000	25.900	28.100	0.0	0.0	2.000	0.0	0.0
GR	110.000	0.0	0.0	0.0	0.0	0.0	0.0	28.500	21.000	0.0
BT	17.000	1850.000	31.900	0.0	0.0	29.800	0.0	28.500	28.900	0.0
ET	1948.000	29.900	0.0	1952.000	28.600	0.0	1964.000	28.400	25.400	2000.000
BT	28.400	28.300	2035.000	28.400	29.300	2036.000	28.400	25.900	2149.000	28.100
BT	25.600	2150.000	28.100	0.0	2154.000	31.500	0.0	2164.000	32.100	0.0
BT	2172.000	30.100	0.0	2184.000	28.500	0.0	2195.000	29.300	0.0	2600.000
BT	50.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1950.000	2150.000	0.0

COMPUTED SECTION U/S OF LR5-S

X1	15713.000	0.0	0.0	0.0	10.000	10.000	10.000	0.0	0.0	0.0
NT	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	8.410	8.110	1692.000	2032.000	0.0

SCALED SECTION AT WIDENING OF FLOOD PLAIN

X1	16175.000	10.000	1973.000	2031.000	465.000	465.000	462.000	0.0	0.0	0.0
GR	30.000	1630.000	20.200	1684.000	20.000	1690.200	20.200	1725.000	21.000	1850.000
GR	20.500	1973.000	12.700	2000.000	20.200	2031.000	35.000	2065.000	30.000	2071.000
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1972.000	2032.000	0.0

(I) SURVEYED SECTION LR6

X1	16410.000	11.000	1973.000	2031.000	240.000	230.000	235.000	0.0	0.0	0.0
GR	34.300	1811.000	30.900	1831.000	29.800	1881.000	34.000	1931.000	25.100	1963.000
GR	31.100	1971.000	12.200	2000.000	19.700	2031.000	34.000	2069.000	29.100	2073.000
NM	1.000	2081.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NM	5.000	0.112	1973.000	0.050	2031.000	0.112	2100.000	0.050	2150.000	0.112
NM	2365.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1805.000	2160.000	0.0

SCALED SECTION

X1	17680.000	13.000	1973.000	2031.000	1500.000	1170.000	1270.000	0.0	0.0	0.0
GR	35.000	1140.000	30.300	1280.000	25.000	1760.000	21.400	1973.000	15.900	2000.000
GR	21.400	2031.000	14.400	2100.000	17.000	2125.000	21.400	2150.000	25.000	2260.000
GR	30.000	2280.000	34.000	2320.000	34.000	2365.000	34.000	0.0	0.0	0.0
NM	3.000	0.112	1984.000	0.050	2016.000	0.112	2079.000	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1965.000	2050.000	0.0

(J) SURVEYED SECTION D/S OF LR7-S (RTE 495) FULLY EXPANDED

X1	19140.000	10.000	1967.000	2046.000	1460.000	1460.000	1460.000	0.0	0.0	0.0
X2	10.000	0.0	0.0	0.0	0.0	0.0	0.0	65.000	65.000	0.0
GR	35.000	1150.000	30.200	1550.000	26.700	1839.000	29.200	1967.000	19.900	1984.000
GR	19.600	2000.000	19.300	2016.000	32.500	2048.000	33.300	2073.000	34.400	2079.000
NC	0.112	0.112	0.042	0.300	0.500	0.0	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1965.000	2050.000	0.0

COMPUTED SECTION D/S OF RTE 495 FULLY EXPANDED

X1	19225.000	0.0	0.0	0.0	85.000	85.000	85.000	0.0	0.250	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1984.000	2016.000	0.0

SCALED SECTION D/S FACE OF RTE 495 EMBANKMENT

```
X1  19310.000      13.000    1984.000    2016.000      55.000      85.000      85.000        0.0         0.0         0.0
GR      55.000  1930.000      21.000    1980.000      26.400    1964.000     17.600     2000.000     21.400     2016.000
GR      33.000  2040.000      34.900    2065.000      34.600    2070.000     34.900     2075.000     33.000     2074.000
GR      34.000  2085.000      40.000    2116.000      55.000    2150.000        0.0         0.0         0.0        0.0
ET       0.0        0.0         0.0         0.0         0.0         0.0       8.110     1984.000    2016.000       0.0

      COMPUTED SECTION  APPROX MIDPOINT OF CONSTRICTION UNDER RTE 495.

X1  19430.000      0.0         0.0         0.0       120.000     120.000     120.000        0.0         0.450       0.0
ET       0.0        0.0         0.0         0.0         0.0         0.0       8.110     1984.000    2016.000       0.0

      (K) SURVEYED SECTION  U/S FACE  OF  RTE 495 EMBANKMENT  LR7-S

X1  19550.000      0.0         0.0         0.0       120.000     120.000     120.000        0.0         0.450       0.0
ET       0.0        0.0         0.0         0.0         0.0       0.410       8.110     1971.000    2036.000       0.0

      COMPUTED SECTION-ELMIN SURVEYED-D/S TOE OF RIPRAP OBSTRUCTION

X1  19600.000      7.000     1985.000    2015.000      50.000      50.000      50.000        0.0         0.0         0.0
GR      55.000  1930.000      21.000    1980.000      19.000    1985.000     19.000     2000.000     19.000     2015.000
GR      33.000  2040.000      36.000    2065.000         0.0         0.0         0.0        0.0         0.0        0.0
ET       0.0        0.0         0.0         0.0         0.0         0.0       8.110     1971.000    2036.000       0.0

      (L) COMPUTED SECTION-ELMIN SURVEYED-HIGH PT. OF RIPRAP OBSTRUCTION

X1  19606.000      7.000     1985.000    2015.000       6.000       6.000       6.000        0.0         0.0         0.0
GR      55.000  1930.000      21.000    1980.000      21.000    1985.000     21.000     2000.000     21.500     2015.000
GR      33.000  2040.000      36.000    2065.000         0.0         0.0         0.0        0.0         0.0        0.0
ET       0.0        0.0         0.0         0.0         0.0         0.0       8.110     1971.000    2036.000       0.0

      COMPUTED SECTION-ELMIN SURVEYED-U/S TOE OF RIPRAP  OBSTRUCTION

X1  19612.000      7.000     1985.000    2015.000       6.000       6.000       6.000        0.0         0.0         0.0
GR      55.000  1930.000      21.000    1980.000      21.100    1985.000     20.800     2000.000     21.300     2015.000
GR      33.000  2040.000      36.000    2065.000         0.0         0.0         0.0        0.0         0.0        0.0
CN       0.112      0.112       0.244       0.200       0.200       0.200       0.0        0.0         0.0        0.0
GT       0.000   980.000    1640.000    1990.000    3030.000    1990.000    1990.000    1990.000    1990.000    1990.000
ET       0.0        0.0         0.0         0.0         0.0         0.0       8.110     1327.000    2052.000       0.0

      COMPUTED SECTION

X1  20412.000      10.000    1981.000    2020.000      800.000     800.000     800.000        0.0        -0.500       0.0
GR      60.000  320.000      34.000    1970.000      23.000    1835.000     30.000     1970.000     23.400     1981.000
GR      21.700  2000.000     22.800    2020.000      30.200    2030.000     35.000     2080.000     46.000     2096.000
ET       0.0        0.0         0.0         0.0         0.0         0.0       8.110     1348.000    2048.000       0.0

      (M) SURVEYED SECTION LRB

X1  21212.000      0.0         0.0         0.0       800.000     800.000     800.000        0.0         0.500       0.0
ET       0.0        0.0         0.0         0.0         0.0         0.0       8.110     1902.000    2422.000       0.0

      APPROXIMATED SECTION

X1  23012.000      16.000    1982.000    2018.000    1800.000    1800.000    1800.000        0.0         0.0         0.0
GR      60.000  1640.000      48.000    1910.000      40.000    1750.000     35.000     1830.000     22.000     1830.000
GR      35.000  1890.000      30.000    1918.000      24.000    1962.000     24.000     2000.000     22.000     2018.000
GR      30.000  2000.000      30.000    2340.000      56.000    2540.000     40.000     2570.000     45.000     2695.000
GR      50.000  2975.000        0.0         0.0         0.0         0.0       60.000        0.0         0.0         0.0
ET       0.0        0.0         0.0         0.0         0.0         0.0       8.110     1886.000    2051.000       0.0
```

APPROXIMATED SECTION D/S OF LR9-S

XI	23332.000	7.000	1975.000	2025.000	320.000	320.000	320.000	0.0	0.0	0.0
GR	40.000	1555.000	35.000	1835.000	27.000	1975.000	23.500	2000.000	27.000	2025.000
GR	30.000	2040.000	40.000	2095.000	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.125	0.125	0.042	0.360	0.500	0.0	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1992.000	2008.000	0.0

COMPUTED SECTION D/S FACE LR9-S

XI	23432.000	19.000	1992.000	2008.000	100.000	100.000	100.000	0.0	0.0	0.0
XS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GR	50.800	1770.000	45.000	1850.000	40.000	1900.000	30.500	1987.000	30.500	1981.100
GR	26.900	1970.000	22.800	2000.000	22.800	2008.000	29.700	2012.900	29.700	2013.000
GR	22.400	2020.000	30.000	2025.000	30.000	2070.000	32.000	2125.000	32.000	2170.000
GR	35.000	2310.000	40.000	2500.000	45.000	2650.000	50.000	2715.000	0.0	0.0
NC	0.060	11.560	0.0	0.0	16.000	0.0	152.000	0.0	22.800	22.800
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1992.000	2008.000	0.0

(N) SURVEYED SECTION U/S FACE LR9-S

XI	23466.000	0.0	0.0	0.0	34.000	34.000	34.000	0.0	0.0	0.0
XS	0.0	0.0	1.000	32.300	34.400	0.0	0.0	0.0	0.0	0.0
GR	10.000	0.0	0.0	0.0	0.0	0.0	32.300	34.000	0.0	0.0
RT	13.000	1900.000	40.000	0.0	1987.000	32.300	0.0	1987.100	32.300	0.0
RT	1992.000	36.700	32.300	2000.000	36.600	32.300	2008.000	36.400	32.300	2012.900
RT	32.400	0.0	2013.000	34.900	0.0	2025.000	34.500	0.0	2070.000	32.400
RT	0.0	2120.000	34.400	0.0	2170.000	34.900	0.0	2310.000	35.000	0.0
ET	0.0	0.0	0.0	0.0	0.0	8.410	8.110	1770.000	2010.000	0.0

(O) SURVEYED SECTION U/S LR9-S

XI	23566.000	15.000	1990.000	2010.000	100.000	100.000	100.000	0.0	0.0	0.0
GR	50.000	1635.000	40.000	1705.000	32.000	1745.000	25.200	1780.000	25.200	1824.000
GR	25.200	1856.000	26.400	1923.000	25.200	1990.000	19.200	2000.000	25.200	2010.000
GR	30.000	2030.000	35.000	2050.000	40.000	2130.000	45.000	2380.000	50.000	2470.000
NC	0.080	0.080	0.040	0.100	0.300	0.0	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1775.000	2130.000	0.0

SCALED SECTION

XI	24666.000	10.000	1985.000	2015.000	1000.000	1150.000	1100.000	0.0	0.0	0.0
GR	50.000	1525.000	45.000	1665.000	40.000	1650.000	35.000	1665.000	30.000	1755.000
GR	28.400	1985.000	22.400	2000.000	28.400	2015.000	30.000	2175.000	40.000	2195.000
GR	0.000	660.000	1065.000	1275.000	1865.000	1275.000	1275.000	1275.000	1275.000	1275.000
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1588.000	2128.000	0.0

SCALED SECTION

XI	25966.000	9.000	1988.000	2012.000	1200.000	1300.000	1300.000	0.0	0.0	0.0
GR	50.000	1938.000	32.000	1988.000	26.000	2000.000	32.000	2012.000	30.000	2140.000
GR	35.000	2200.000	40.000	2210.000	48.000	2300.000	50.000	2450.000	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1940.000	2080.000	0.0

SCALED SECTION

XI	27116.000	7.000	1989.000	2011.000	1250.000	1100.000	1150.000	0.0	0.0	0.0
GR	50.000	1835.000	35.000	1910.000	34.900	1989.000	28.900	2000.000	34.900	2010.000
GR	35.000	2110.000	50.000	2220.000	0.0	0.0	0.0	0.0	0.0	0.0
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1900.000	2040.000	0.0

(P) SURVEYED SECTION AT DAM LR10

X1	28266.000	15.000	1987.500	2013.500	1200.000	1400.000	1110.000	0.0	0.0	0.0	
GR	45.800	1862.000	42.400	1985.500	35.500	1827.500	34.100	1932.500	33.200	1941.500	
GR	34.100	1873.500	34.700	1985.500	33.500	1847.500	33.700	1600.000	33.500	1611.500	
GR	33.800	2016.500	33.400	2035.000	41.600	2057.500	41.000	1984.500	39.000	2180.000	
ET	0.0	0.0	0.0	0.0	0.0	0.0	8.110	1977.500	2022.500	0.0	

SCALED SECTION AT CITY LIMITS

X1	28406.000	9.000	1965.000	2035.000	130.000	150.000	190.000	0.0	0.0	0.0	
GR	50.000	1872.000	45.000	1965.000	40.000	1945.000	35.000	1965.000	32.000	2000.000	
GR	35.000	2035.000	40.000	2055.000	45.000	2085.000	50.000	2135.000	0.0	0.0	
ET	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

THIS RUN EXECUTED 05/07/81 16.15.30

```
HEC2 RELEASE DATED NOV 76 UPDATED JULY 1979
ERR,  WR    01,02,03
MODIFICATION -  40,51,52,53, *, *, *, *,98
```

T1 HAVERHILL
T2 LITTLE RIVER
T3 ENCROICHMENT ANALYSIS

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q		WSEL	FQ
	0.	6.	0.	0.	0.0	0.0	0.0		0.	1.600	0.0
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW		CHNIM	ITRACE
	2.000	0.0	-1.000	0.0	0.0	0.0	0.0	0.0		0.0	0.0

THIS RUN EXECUTED 05/07/81 16.15.39

```
HEC2 RELEASE DATED NOV 76 UPDATED JULY 1979
ERROR CORR - 01.02.03
MODIFICATION - 50.51.52.53.*.*.*.*.*
```

```
T1      HAVERHILL
T2      LITTLE RIVER
T3      ENCROACHMENT    ANALYSIS
J1  ICHECK      INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ
        0.        7.        0.        0.  0.0           0.0       0.0       0.        1.60C     0.0
J2  NPROF       IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE
    15.000      0.0       -1.000    0.0       0.0       0.0       0.0       0.0       0.0       0.0
```

THIS RUN EXECUTED 05/07/81 16.15.53

HEC2 RELEASE DATED NOV 76 UPDATED JULY 1979
ERROR CODE = 01,02,03
MODIFICATION = 50,51,52,53, *, *, *, *,98

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

ENCROACHMENT ANALYSIS

SUMMARY PRINTOUT TABLE 110

	SECNO	CWSEL	DIFKWS	EG	TOPWID	QLOB	QCH	QROB	PERENC	STENCL	STCHL	STCHR	STENCR
*	8225.000	1.60	0.0	1.75	524.00	960.68	408.64	960.68	0.0	0.0	1984.00	2016.00	0.0
	8225.000	1.60	0.0	1.75	524.00	960.68	408.64	960.68	0.0	0.0	1984.00	2016.00	0.0
	8225.000	1.60	0.0	1.75	524.00	960.68	408.64	960.68	0.0	0.0	1984.00	2016.00	0.0
*	8235.000	4.22	0.0	6.97	33.20	0.0	2330.00	0.0	0.0	0.0	1984.00	2016.00	0.0
*	8235.000	4.22	0.0	6.97	33.20	0.0	2330.00	0.0	0.0	0.0	1984.00	2016.00	0.0
*	8235.000	4.22	0.00	6.97	32.00	0.0	2330.00	0.0	32.00	1984.00	1984.00	2016.00	2016.00
	10000.000	16.47	0.0	17.95	33.20	0.0	2330.00	0.0	0.0	0.0	1983.40	2016.60	0.0
	10000.000	16.47	0.0	17.95	33.20	0.0	2330.00	0.0	0.0	0.0	1983.40	2016.60	0.0
	10000.000	17.00	0.53	18.37	33.20	0.0	2330.00	0.0	33.00	1983.00	1983.40	2016.60	2017.00
	10050.000	17.66	0.0	18.29	50.31	216.79	1986.53	132.98	0.0	0.0	1984.00	2014.00	0.0
	10050.000	17.66	0.0	18.29	50.31	216.79	1986.53	132.98	0.0	0.0	1984.00	2014.00	0.0
	10050.000	18.12	0.46	18.68	50.42	227.31	1961.09	131.60	51.00	1973.00	1984.00	2014.00	2024.00
	10480.000	18.33	0.0	18.67	47.42	0.0	2330.00	0.0	0.0	0.0	1972.00	2020.00	0.0
	10480.000	18.33	0.0	18.67	47.42	0.0	2330.00	0.0	0.0	0.0	1972.00	2020.00	0.0
	10480.000	18.80	0.47	19.00	47.48	0.0	2330.00	0.0	48.00	1972.00	1972.00	2020.00	2020.00
	10530.000	17.82	0.0	19.20	28.00	0.0	2330.00	0.0	0.0	0.0	1986.00	2014.00	0.0
	10530.000	17.85	0.0	19.20	28.00	0.0	2330.00	0.0	0.0	0.0	1986.00	2014.00	0.0
	10530.000	18.23	0.41	19.49	28.00	0.0	2330.00	0.0	28.00	1986.00	1986.00	2014.00	2014.00
	10605.000	17.57	0.0	19.99	28.00	0.0	2330.00	0.0	0.0	0.0	1986.00	2014.00	0.0
	10605.000	17.57	0.0	19.99	28.00	0.0	2330.00	0.0	0.0	0.0	1986.00	2014.00	0.0
	10605.000	18.30	0.73	19.94	28.00	0.0	2330.00	0.0	28.00	1986.00	1986.00	2014.00	2014.00
	10640.000	20.54	0.0	20.69	65.09	0.0	2330.00	0.0	0.0	0.0	1972.90	2038.10	0.0
	10640.000	20.54	0.0	20.69	65.09	0.0	2330.00	0.0	0.0	0.0	1972.90	2038.10	0.0
	10640.000	20.25	-0.29	20.41	65.09	0.0	2330.00	0.0	67.00	1972.00	1972.90	2038.10	2039.00
	10674.000	20.58	0.0	20.70	75.09	0.0	2330.00	0.0	0.0	0.0	1959.90	2035.10	0.0
	10674.000	20.58	0.0	20.70	75.09	0.0	2330.00	0.0	0.0	0.0	1959.90	2035.10	0.0
	10674.000	20.30	-0.29	20.42	75.09	0.0	2330.00	0.0	77.00	1959.00	1959.90	2035.10	2036.00
*	10675.000	22.60	0.0	24.16	75.05	0.0	2330.00	0.0	0.0	0.0	1959.90	2035.10	0.0
*	10675.000	22.60	0.0	24.16	75.05	0.0	2330.00	0.0	0.0	0.0	1959.90	2035.10	0.0
*	10675.000	22.60	0.00	24.16	75.05	0.0	2330.00	0.0	77.00	1959.00	1959.90	2035.10	2036.00

SECND	CWSEL	DIFKWS	EG	TOPWID	QLOB	QCH	QROB	PERENC	STENCL	STCHL	STCHR	STENCR
10676.000	23.76	0.0	24.27	75.08	0.0	2330.00	0.0	0.0	0.0	1959.90	2035.10	0.0
10676.000	23.76	-0.0	24.27	75.08	0.0	2330.00	0.0	0.0	0.0	1959.90	2035.10	0.0
10676.000	23.76	-0.00	24.27	75.08	0.0	2330.00	0.0	77.00	1959.00	1959.90	2035.10	2036.00
10775.000	23.92	-0.0	24.42	75.08	0.0	2330.00	0.0	0.0	0.0	1959.90	2035.10	0.0
10775.000	23.92	-0.00	24.42	75.08	0.0	2330.00	0.0	0.0	1959.00	1959.90	2035.10	0.0
10775.000	23.92	-0.00	24.42	75.08	0.0	2330.00	0.0	77.00	1959.00	1959.90	2035.10	2036.00
11000.000	24.56	0.0	24.62	296.80	0.00	1773.63	556.36	0.0	0.0	1960.00	2030.00	0.0
11000.000	24.57	0.01	24.64	171.87	0.0	1775.96	662.67	0.02	1960.00	1960.00	2030.00	2135.87
11000.000	24.57	0.01	24.66	125.00	0.0	1949.53	380.47	125.00	1960.00	1960.00	2030.00	2085.00
11600.000	24.76	0.0	24.83	149.04	14.56	2283.45	32.00	0.0	0.0	1940.00	2060.00	0.0
11600.000	24.81	0.04	24.87	132.76	0.0	2323.47	6.53	0.02	1940.00	1940.00	2060.00	0.0
11600.000	24.81	0.08	24.90	125.00	0.0	2315.89	14.11	125.00	1940.00	1940.00	2060.00	2074.00
12255.000	25.00	0.0	25.06	151.01	32.09	2292.05	5.86	0.0	0.0	1920.00	2045.00	0.0
12255.000	25.06	0.06	25.13	137.50	0.0	2330.00	0.0	0.02	1920.00	1920.00	2045.00	0.0
12255.000	25.09	0.10	25.16	125.00	0.0	2330.00	0.0	125.00	1920.00	1920.00	2045.00	2045.00
13100.000	25.42	0.0	25.49	144.35	27.58	2297.91	4.51	0.0	0.0	1920.00	2045.00	0.0
13100.000	25.46	0.11	25.59	134.00	0.0	2330.00	0.0	0.01	1920.00	1920.00	2045.00	0.0
13100.000	25.55	0.13	25.63	125.00	0.0	2330.00	0.0	125.00	1920.00	1920.00	2045.00	2045.00
14000.000	25.96	0.0	26.04	276.40	416.52	1815.99	95.19	0.0	0.0	1960.00	2040.00	0.0
14000.000	26.08	0.13	26.16	190.07	149.59	1840.60	79.11	0.02	1868.24	1960.00	2040.00	2082.31
14000.000	26.10	0.14	26.18	193.00	411.98	1838.94	81.06	193.00	1868.00	1960.00	2040.00	2055.00
14200.000	26.07	0.0	26.11	282.62	103.43	2174.89	51.68	0.0	0.0	1925.00	2075.00	0.0
14200.000	26.20	0.12	26.25	197.45	86.93	2213.80	20.27	0.02	1892.84	1925.00	2075.00	2084.30
14200.000	26.22	0.14	26.28	190.00	87.03	2212.51	20.05	190.00	1893.00	1925.00	2075.00	2083.00
14300.000	26.01	0.0	26.27	133.86	266.40	1698.39	348.21	0.0	0.0	1983.00	2018.10	0.0
14300.000	26.13	0.12	26.40	92.00	272.66	1722.67	330.92	99.02	1952.75	1983.00	2018.10	2044.75
14300.000	26.15	0.14	26.41	95.00	262.81	1716.69	330.52	95.00	1950.00	1983.00	2018.10	2045.00
14340.000	27.11	0.0	27.21	144.31	320.94	1642.24	366.82	0.0	0.0	1983.00	2018.10	0.0
14340.000	27.31	0.19	27.43	98.00	292.88	1698.45	341.67	95.02	1952.75	1983.00	2018.10	2045.75
14340.000	27.33	0.21	27.45	98.00	305.38	1683.28	341.34	95.00	1950.00	1983.00	2018.10	2045.00
14420.000	27.36	0.0	27.39	293.69	90.96	1809.29	429.75	0.0	0.0	1944.00	2051.00	0.0
14420.000	27.48	0.12	27.52	161.69	0.0	2031.69	268.31	0.13	1944.00	1944.00	2051.00	2105.00
14420.000	27.50	0.14	27.54	160.00	0.0	2038.87	261.13	160.00	1944.00	1944.00	2051.00	2104.00
15677.000	27.68	0.0	27.74	196.06	18.26	1535.55	776.19	0.0	0.0	1964.00	2025.00	0.0
15677.000	27.87	0.20	27.95	169.36	19.58	1714.66	615.34	0.13	1964.00	1964.00	2025.00	2159.33
15677.000	27.88	0.20	27.95	169.36	19.58	1622.04	784.37	200.00	1950.00	1964.00	2025.00	2150.00
15697.000	27.69	0.0	27.75	196.10	18.39	1535.24	776.36	0.0	0.0	1964.00	2025.00	0.0
15697.000	27.92	0.23	27.98	167.60	19.23	1715.91	784.86	0.13	1964.00	1964.00	2025.00	0.0
15697.000	27.88	0.19	27.94	197.34	19.23	1555.91	784.86	200.00	1950.00	1964.00	2025.00	2150.00
15703.000	27.76	0.0	27.83	184.54	0.0	1543.34	784.66	0.0	0.0	1964.00	2025.00	0.0
15703.000	28.01	0.24	28.07	182.61	0.0	1532.99	797.01	0.13	1964.00	1964.00	2025.00	0.0
15703.000	27.97	0.20	28.03	185.43	0.0	1534.66	795.34	200.00	1950.00	1964.00	2025.00	2150.00

SECNO	CWSEL	DIFKWS	EG	TOPWID	QLOB	QCH	QROB	PERENC	STENCL	STCHL	STCHR	STENCR
15713.000	27.78	0.0	27.84	196.70	18.33	1530.62	780.46	0.0	0.0	1964.00	2025.00	0.0
15713.000	27.87	0.24	28.07	198.22	20.27	1610.83	740.17	0.0	0.0	1964.00	2025.00	0.0
15713.000	27.98	0.20	28.03	197.96	20.24	1621.15	788.24	200.00	1950.00	1964.00	2025.00	2150.00
16175.000	27.93	0.0	27.94	436.74	1385.07	860.34	84.58	0.0	0.0	1973.00	2031.00	0.0
16175.000	28.17	0.24	28.19	336.83	1392.75	937.52	0.0	0.14	1694.37	1973.00	2031.00	2031.00
16175.000	28.13	0.20	28.14	340.00	1348.51	980.28	1.21	348.00	1642.00	1973.00	2031.00	2032.00
16410.000	27.90	0.0	28.04	131.46	79.20	2162.19	88.60	0.0	0.0	1973.00	2031.00	0.0
16410.000	28.11	0.25	28.11	68.00	0.81	2320.92	0.84	0.0	1973.00	1973.00	2031.00	2031.00
16410.000	28.06	0.19	28.26	60.00	0.81	2320.92	0.84	66.00	1973.00	1973.00	2031.00	2032.00
17680.000	28.29	0.0	28.31	829.28	501.59	834.25	994.15	0.0	0.0	1973.00	2031.00	0.0
17680.000	28.63	0.34	28.66	354.79	430.94	961.51	937.65	0.17	1805.79	1973.00	2031.00	2160.26
17680.000	28.56	0.26	28.58	355.00	429.45	964.32	936.24	355.00	1805.00	1973.00	2031.00	2160.26
19140.000	28.44	0.0	28.78	69.77	0.0	2330.00	0.0	0.0	0.0	1967.00	2048.00	0.0
19140.000	28.76	0.32	29.10	71.57	0.0	2330.00	0.0	0.0	1967.00	1967.00	2048.00	2048.00
19140.000	28.69	0.26	29.16	71.57	0.0	2330.00	0.0	65.00	1967.00	1967.00	2048.00	2050.00
19225.000	28.62	0.0	28.94	279.29	61.36	2268.64	0.0	0.0	0.0	1967.00	2048.00	0.0
19225.000	28.99	0.37	29.30	71.02	0.0	2330.00	0.0	0.07	1967.00	1967.00	2048.00	2048.00
19225.000	28.93	0.31	29.25	70.77	0.0	2330.00	0.0	65.00	1965.00	1967.00	2048.00	2050.00
19310.000	28.56	0.0	29.29	57.43	42.13	2199.88	87.99	0.0	0.0	1984.00	2016.00	0.0
19310.000	28.90	0.34	29.72	52.00	0.0	2330.00	0.0	0.06	1984.00	1984.00	2016.00	2016.00
19310.000	28.84	0.28	29.79	52.00	0.0	2330.00	0.0	32.00	1984.00	1984.00	2016.00	2016.00
19430.000	28.78	0.0	29.55	56.64	40.32	2204.54	85.14	0.0	0.0	1984.00	2016.00	0.0
19430.000	29.23	0.44	30.14	53.00	0.0	2330.00	0.0	0.06	1984.00	1984.00	2016.00	2016.00
19430.000	29.27	0.49	30.09	52.00	0.0	2330.00	0.0	32.00	1984.00	1984.00	2016.00	2016.00
19550.000	29.02	0.0	29.84	55.92	36.70	2208.78	82.55	0.0	0.0	1984.00	2016.00	0.0
19550.000	29.74	0.71	30.57	52.00	0.0	2330.00	0.0	0.06	1984.00	1984.00	2016.00	2016.00
19550.000	29.79	0.77	30.62	52.00	0.0	2330.00	0.0	32.00	1984.00	1984.00	2016.00	2016.00
19600.000	29.31	0.0	29.98	60.60	66.09	2122.63	141.28	0.0	0.0	1985.00	2015.00	0.0
19600.000	30.18	0.88	30.74	63.66	74.51	2103.51	151.99	0.0	0.0	1985.00	2015.00	0.0
19600.000	30.15	0.83	30.71	63.48	74.01	2104.22	151.36	65.00	1971.00	1985.00	2015.00	2036.00
19606.000	29.04	0.0	30.28	58.05	92.69	2111.36	125.96	0.0	0.0	1985.00	2015.00	0.0
19606.000	30.00	0.96	30.98	61.77	103.61	2084.66	140.72	0.0	0.0	1985.00	2015.00	0.0
19606.000	29.92	0.92	30.92	61.70	103.50	2086.16	140.09	65.00	1971.00	1985.00	2015.00	2036.00
19612.000	29.39	0.0	30.39	59.63	89.46	2113.47	126.87	0.0	0.0	1985.00	2015.00	0.0
19612.000	30.30	0.91	31.01	62.66	98.22	2093.02	138.76	0.0	0.0	1985.00	2015.00	0.0
19612.000	30.16	0.77	30.98	62.54	97.89	2093.86	138.28	65.00	1971.00	1985.00	2015.00	2036.00
20412.000	30.88	0.0	30.91	688.85	1202.27	763.49	24.24	0.0	0.0	1981.00	2020.00	0.0
20412.000	31.38	0.49	31.38	714.89	1238.63	727.17	25.01	0.0	0.0	1981.00	2020.00	0.0
20412.000	31.36	0.47	31.38	714.89	1239.09	727.20	25.01	725.00	1327.00	1981.00	2020.00	2052.00
21212.000	31.04	0.0	31.08	666.27	1173.88	792.94	23.17	0.0	0.0	1981.00	2020.00	0.0
21212.000	31.51	0.46	31.53	696.79	1211.62	755.74	24.04	0.0	0.0	1981.00	2020.00	0.0
21212.000	31.48	0.44	31.51	695.00	1209.54	756.91	24.55	700.00	1348.00	1981.00	2020.00	2048.00

	SECNO	CWSEL	DIFKWS	EG	TOPWID	QLOB	QCH	QROB	PERENC	STENCL	STCHL	STCHR	STENCR
	23012.000	31.66	0.0	31.74	503.06	265.65	870.62	853.73	0.0	0.0	1982.00	2018.00	0.0
	23013.000	31.98	0.32	32.05	517.23	268.74	934.86	886.40	0.0	0.0	1982.00	2018.00	0.0
	23012.000	31.96	0.30	32.03	516.37	268.57	836.92	884.51	520.00	1902.00	1982.00	2018.00	2422.00
	23332.000	31.79	0.0	32.14	158.79	193.67	1733.83	62.50	0.0	0.0	1975.00	2025.00	0.0
	23332.000	32.07	0.28	32.43	164.91	201.74	1716.93	64.44	0.0	0.0	1975.00	2025.00	0.0
	23332.000	32.05	0.26	32.38	163.93	200.47	1716.93	64.13	165.00	1880.00	1975.00	2025.00	2051.00
*	23432.000	30.58	0.0	34.52	16.00	0.0	1990.00	0.0	0.0	0.0	1992.00	2008.00	0.0
*	23432.000	30.59	0.01	34.52	16.00	0.0	1990.00	0.0	0.0	0.0	1992.00	2008.00	0.0
	23432.000	30.63	0.05	34.51	16.00	0.0	1990.00	0.0	16.00	1992.00	1992.00	2008.00	2008.00
	23466.000	31.24	0.0	34.60	16.00	0.0	1990.00	0.0	0.0	0.0	1992.00	2008.00	0.0
	23466.000	31.27	0.03	34.59	16.00	0.0	1990.00	0.0	0.0	0.0	1992.00	2008.00	0.0
	23466.000	31.63	0.39	34.58	16.00	0.0	1990.00	0.0	16.00	1992.00	1992.00	2008.00	2008.00
	23566.000	35.61	0.0	35.62	339.14	1402.51	495.06	92.43	0.0	0.0	1990.00	2010.00	0.0
	23566.000	35.63	0.02	35.64	259.07	1225.44	464.56	0.0	0.12	1770.93	1990.00	2010.00	2010.00
	23566.000	35.67	0.07	35.69	240.00	1527.52	462.48	0.0	240.00	1770.00	1990.00	2010.00	2010.00
	24666.000	35.71	0.0	35.72	508.49	931.93	455.37	602.70	0.0	0.0	1985.00	2015.00	0.0
	24666.000	35.76	0.05	35.77	563.10	956.76	534.47	625.29	0.17	1775.85	1985.00	2015.00	2132.04
	24666.000	35.80	0.09	35.82	395.00	925.73	534.98	580.79	359.00	1775.00	1985.00	2015.00	2130.00
	25966.000	35.85	0.0	35.89	224.38	11.56	416.34	847.10	0.0	0.0	1988.00	2012.00	0.0
	25966.000	35.95	0.10	36.02	144.90	0.0	490.66	784.34	0.22	1988.00	1988.00	2012.00	2132.50
	25966.000	35.99	0.15	36.07	140.00	0.0	505.83	769.17	140.00	1988.00	1988.00	2012.00	2128.50
	27116.000	36.72	0.0	37.09	221.26	261.24	684.55	329.21	0.0	0.0	1989.00	2011.00	0.0
	27116.000	37.17	0.44	37.20	80.00	220.26	729.57	284.19	0.36	1968.48	1989.00	2011.00	2028.96
	27116.000	37.29	0.57	37.37	140.00	220.42	743.26	312.31	140.00	1968.00	1989.00	2011.00	2028.00
	28266.000	38.71	0.0	38.80	154.42	951.36	532.85	190.79	0.0	0.0	1987.50	2013.50	0.0
	28266.000	39.61	0.90	39.73	99.58	549.88	655.11	70.00	0.22	1923.60	1987.50	2013.50	2031.18
	28266.000	39.04	0.32	39.12	140.00	550.65	537.26	187.09	140.00	1900.00	1987.50	2013.50	2040.00
	28406.000	38.77	0.0	38.94	100.16	23.42	1226.16	23.42	0.0	0.0	1965.00	2035.00	0.0
	28406.000	39.49	0.72	39.63	79.00	0.0	1274.00	0.0	0.03	1969.00	1965.00	2035.00	2035.00
	28406.000	38.99	0.22	39.34	47.00	0.0	1275.00	0.0	45.00	1977.50	1965.00	2035.00	2022.50

SUMMARY OF ERRORS

CAUTION SECNO= 8225.000 PROFILE= 1 BRIDGE DECK DEFINITION ERROR

CAUTION SECNO= 8235.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8235.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8235.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION SECNO= 8235.000 PROFILE= 2 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8235.000 PROFILE= 2 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8235.000 PROFILE= 2 20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION SECNO= 8235.000 PROFILE= 3 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8235.000 PROFILE= 3 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8235.000 PROFILE= 3 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=10675.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO=10675.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=10675.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

FLOODWAY DATA
PROFILE NO. 2

ENCROACHMENT ANALYSIS

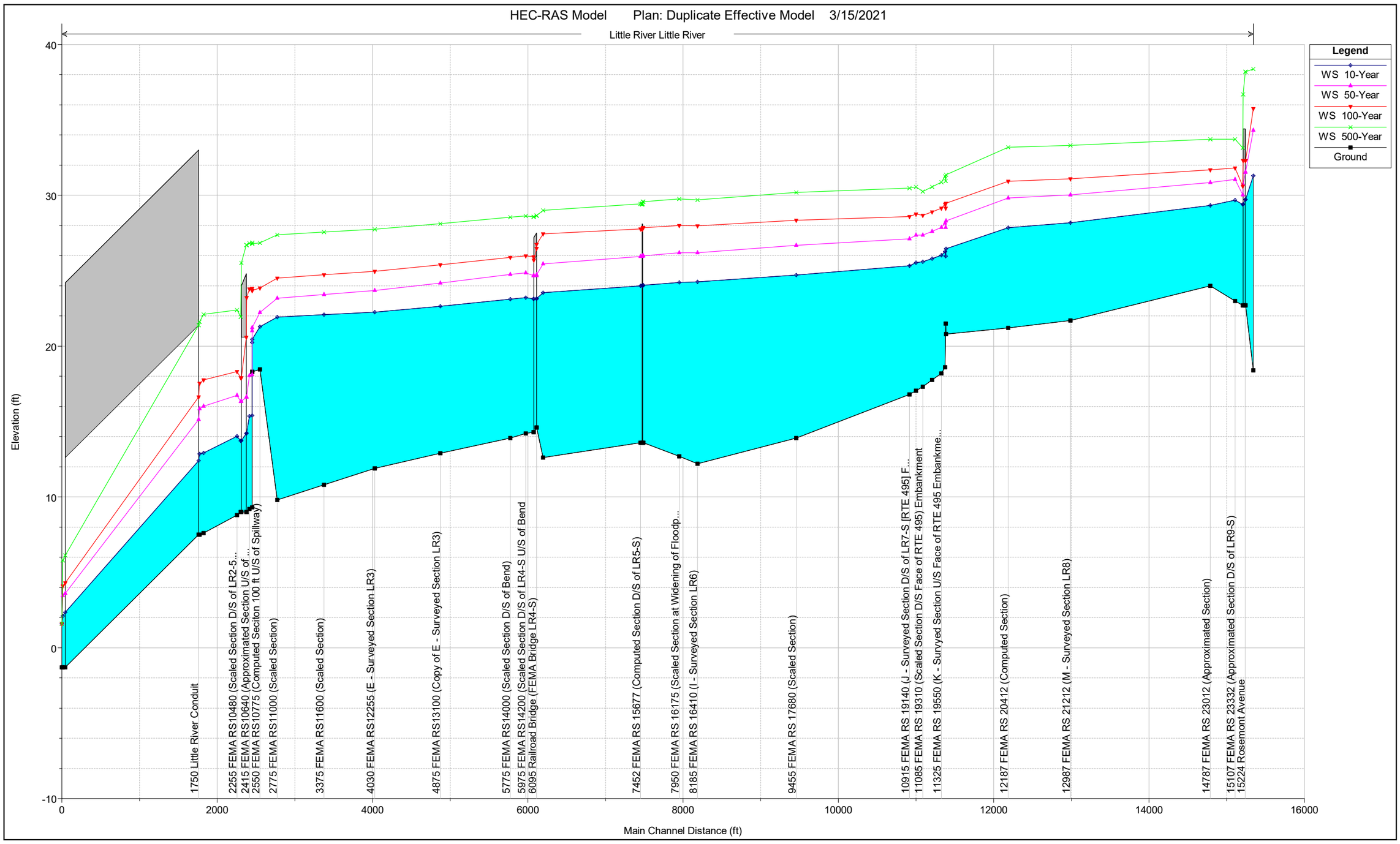
STATION	FLOODWAY WIDTH (FT)	FLOODWAY SECTION AREA	MEAN VELOCITY	WATER SURFACE ELEVATION WITH FLOODWAY	WITHOUT FLOODWAY	DIFFERENCE
8225.000	524.	780.	3.0	1.6	1.6	0.0
8235.000	32.	175.	13.3	4.2	4.2	0.0
10000.000	33.	138.	7.8	16.5	16.5	0.0
10040.000	50.	584.	6.1	17.2	17.2	0.0
10480.000	47.	441.	5.3	18.2	18.2	0.0
10530.000	28.	247.	12.4	17.8	17.8	0.0
10605.000	28.	187.	12.5	17.8	17.8	0.0
10640.000	65.	737.	3.2	17.9	17.9	0.0
10674.000	79.	847.	3.8	20.2	20.2	0.0
10675.000	79.	232.	16.0	52.6	52.6	0.0
10676.000	79.	410.	9.1	52.6	52.6	0.0
10775.000	76.	410.	5.7	53.8	53.8	0.0
11000.000	176.	1397.	1.7	53.8	53.8	0.0
11600.000	121.	1266.	1.8	54.8	54.8	0.0
12255.000	138.	1116.	1.9	55.4	55.4	0.0
13100.000	150.	1048.	1.9	55.6	55.6	0.0
14005.000	160.	1260.	1.8	56.1	56.0	0.1
14200.000	191.	1687.	1.4	56.2	56.0	0.1
14300.000	92.	700.	3.3	56.1	56.0	0.1
14350.000	92.	771.	3.0	57.1	57.1	0.0
14450.000	161.	1566.	1.5	57.5	57.4	0.1
16577.000	133.	1236.	1.6	57.8	57.7	0.1
16697.000	168.	1569.	1.5	57.9	57.7	0.2
16793.000	186.	1557.	1.5	57.9	57.8	0.1
16715.000	186.	1591.	1.5	58.0	57.8	0.2
16775.000	337.	2604.	0.8	58.0	57.8	0.2
16910.000	69.	758.	0.8	58.1	57.9	0.2
17680.000	358.	2702.	0.9	58.1	57.9	0.2
18150.000	77.	505.	4.4	58.6	58.3	0.3
18225.000	71.	516.	4.3	58.6	58.4	0.2
19310.000	32.	332.	7.5	58.9	58.5	0.4
19430.000	32.	332.	7.5	58.9	58.5	0.4
19480.000	32.	321.	7.8	59.3	58.8	0.5
19560.000	64.	520.	4.8	59.3	58.8	0.5
19606.000	64.	508.	4.9	59.7	59.0	0.7
19615.000	63.	416.	6.0	60.0	59.0	1.0
19715.000	70.	416.	6.0	59.2	58.4	0.8
57515.000	767.	3284.	0.6	31.4	30.9	0.5
57715.000	760.	3016.	0.7	31.4	30.9	0.5
58015.000	617.	1825.	0.7	32.0	31.5	0.5
58335.000	165.	698.	1.4	32.0	31.7	0.3
58435.000	16.	136.	14.7	32.1	31.8	0.3
58466.000	16.	136.	14.7	31.9	31.5	0.4
58566.000	230.	2615.	0.8	32.5	32.5	0.0
58666.000	350.	2605.	0.8	32.5	32.5	0.0
59066.000	149.	757.	1.7	35.9	35.8	0.1
27116.000	86.	267.	2.2	36.1	35.8	0.3
28266.000	100.	607.	2.1	36.1	35.7	0.4
28406.000	70.	434.	2.9	39.7	38.8	0.9

FLOODWAY DATA
PROFILE NO. 3 ENCROACHMENT ANALYSIS

STATION	FLOODWAY WIDTH (FT)	FLOODWAY SECTION AREA	FLOODWAY MEAN VELOCITY	WATER SURFACE ELEVATION WITH FLOODWAY	WITHOUT FLOODWAY	DIFFERENCE
8225.000	*24.	780.	3.0	1.6	1.6	0.0
8236.000	33.	175.	13.3	4.2	4.2	0.0
10000.000	35.	248.	9.4	17.5	16.5	0.9
10007.000	E1.	407.	5.7	18.2	17.7	0.5
10486.000	51.	456.	5.1	18.6	18.2	0.4
10530.000	26.	259.	9.0	18.2	17.8	0.4
10605.000	28.	476.	10.3	18.3	17.6	0.7
10640.000	68.	719.	3.4	20.3	20.4	-0.2
10674.000	76.	825.	2.8	20.4	20.6	-0.2
10675.000	75.	253.	10.0	25.6	25.6	0.0
10676.000	75.	410.	5.7	25.6	25.6	0.0
10678.000	75.	411.	5.7	23.9	23.9	0.0
11000.000	125.	1148.	1.8	24.6	24.6	0.0
11600.000	136.	1266.	1.8	24.9	24.8	0.1
12586.000	126.	1151.	1.9	25.1	25.0	0.1
13100.000	126.	1053.	2.1	25.5	25.4	0.1
14000.000	196.	1293.	1.8	26.1	26.0	0.1
14200.000	196.	1684.	1.4	26.2	26.1	0.1
14300.000	99.	714.	3.5	26.2	26.1	0.1
14320.000	99.	788.	3.0	26.2	26.1	0.1
14420.000	160.	1590.	1.5	27.2	27.1	0.1
15677.000	197.	1543.	1.6	27.9	27.7	0.2
16007.000	197.	1624.	1.6	27.9	27.7	0.2
16703.000	189.	1524.	1.6	28.0	27.8	0.2
16713.000	198.	1563.	1.6	28.0	27.8	0.2
16176.000	340.	2817.	0.9	28.1	27.9	0.2
16410.000	60.	761.	3.9	28.2	27.9	0.2
16680.000	357.	2628.	0.8	28.6	28.3	0.3
16154.000	71.	920.	3.3	28.8	28.4	0.3
16225.000	71.	612.	4.5	28.9	28.6	0.3
16310.000	35.	330.	7.3	28.8	28.5	0.3
16430.000	36.	310.	7.8	29.3	28.8	0.3
16480.000	38.	316.	7.3	29.7	29.0	0.7
16600.000	63.	605.	4.4	30.1	29.5	0.6
16606.000	62.	383.	6.9	29.6	29.0	0.6
16615.000	60.	417.	6.6	30.2	29.4	0.8
20411.000	720.	3266.	0.6	31.6	31.4	0.2
21215.000	698.	3997.	0.7	31.4	31.0	0.4
23010.000	216.	1012.	2.1	32.0	31.7	0.3
23335.000	164.	640.	3.1	32.1	31.8	0.3
23432.000	16.	126.	15.8	30.6	30.6	0.0
23466.000	16.	126.	15.8	30.6	30.6	0.0
23566.000	240.	2535.	0.8	34.7	33.9	0.6
24666.000	150.	2456.	0.8	35.8	35.7	0.1
25966.000	140.	734.	1.7	36.9	36.7	0.1
27116.000	140.	367.	3.5	37.3	36.7	0.6
28026.000	140.	733.	1.7	37.0	36.7	0.3
28406.000	140.	271.	4.7	39.0	38.8	0.2

ATTACHMENT 6 - DUPLICATE EFFECTIVE MODEL HEC-RAS PROFILE AND OUTPUT SUMMARY

HEC-RAS Model Plan: Duplicate Effective Model 3/15/2021



HEC-RAS Plan: DuplicateEffModel River: Little River Reach: Little River

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Max Chl Dpth	Vel Chnl
			(cfs)	(ft)	(ft)	(ft)	(ft/s)
Little River	15341	10-Year	980.00	18.40	31.31	12.91	1.47
Little River	15341	50-Year	1640.00	18.40	34.31	15.91	1.61
Little River	15341	100-Year	1990.00	18.40	35.75	17.35	1.66
Little River	15341	500-Year	3030.00	18.40	38.37	19.97	1.97
Little River	15241	10-Year	980.00	22.70	29.73	7.03	8.81
Little River	15241	50-Year	1640.00	22.70	31.54	8.84	11.70
Little River	15241	100-Year	1990.00	22.70	32.30	9.60	13.05
Little River	15241	500-Year	3030.00	22.70	38.18	15.48	4.81
Little River	15224		Bridge				
Little River	15207	10-Year	980.00	22.70	29.40	6.70	9.24
Little River	15207	50-Year	1640.00	22.70	30.03	7.33	14.12
Little River	15207	100-Year	1990.00	22.70	30.61	7.91	15.88
Little River	15207	500-Year	3030.00	22.70	33.15	10.45	18.25
Little River	15107	10-Year	980.00	23.00	29.68	6.68	3.97
Little River	15107	50-Year	1640.00	23.00	31.06	8.06	4.86
Little River	15107	100-Year	1990.00	23.00	31.81	8.81	5.09
Little River	15107	500-Year	3030.00	23.00	33.71	10.71	5.61
Little River	14787	10-Year	980.00	24.00	29.32	5.32	3.43
Little River	14787	50-Year	1640.00	24.00	30.84	6.84	3.54
Little River	14787	100-Year	1990.00	24.00	31.69	7.69	3.35
Little River	14787	500-Year	3030.00	24.00	33.73	9.73	3.17
Little River	12987	10-Year	980.00	21.70	28.17	6.47	2.42
Little River	12987	50-Year	1640.00	21.70	30.04	8.34	2.40
Little River	12987	100-Year	1990.00	21.70	31.09	9.39	2.26
Little River	12987	500-Year	3030.00	21.70	33.31	11.61	2.23
Little River	12187	10-Year	980.00	21.20	27.86	6.66	2.28
Little River	12187	50-Year	1640.00	21.20	29.83	8.63	2.23
Little River	12187	100-Year	1990.00	21.20	30.94	9.74	2.10
Little River	12187	500-Year	3030.00	21.20	33.20	12.00	2.09
Little River	11387	10-Year	1160.00	20.80	26.45	5.65	6.67
Little River	11387	50-Year	1920.00	20.80	28.31	7.51	8.05
Little River	11387	100-Year	2330.00	20.80	29.48	8.68	8.30
Little River	11387	500-Year	3520.00	20.80	31.36	10.56	10.03
Little River	11381	10-Year	1160.00	21.50	25.96	4.46	8.27
Little River	11381	50-Year	1920.00	21.50	27.87	6.37	9.32
Little River	11381	100-Year	2330.00	21.50	29.15	7.65	9.24
Little River	11381	500-Year	3520.00	21.50	30.95	9.45	11.04
Little River	11375	10-Year	1160.00	18.60	26.26	7.66	5.02
Little River	11375	50-Year	1920.00	18.60	28.17	9.57	6.45
Little River	11375	100-Year	2330.00	18.60	29.41	10.81	6.80
Little River	11375	500-Year	3520.00	18.60	31.26	12.66	8.56
Little River	11325	10-Year	1160.00	18.20	26.03	7.83	5.62
Little River	11325	50-Year	1920.00	18.20	27.87	9.67	7.08
Little River	11325	100-Year	2330.00	18.20	29.14	10.94	7.34
Little River	11325	500-Year	3520.00	18.20	30.87	12.67	9.21

HEC-RAS Plan: DuplicateEffModel River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Max Chl Dpth	Vel Chnl
			(cfs)	(ft)	(ft)	(ft)	(ft/s)
Little River	11205	10-Year	1160.00	17.75	25.80	8.05	5.42
Little River	11205	50-Year	1920.00	17.75	27.60	9.85	6.91
Little River	11205	100-Year	2330.00	17.75	28.90	11.15	7.17
Little River	11205	500-Year	3520.00	17.75	30.56	12.81	9.09
Little River	11085	10-Year	1160.00	17.30	25.59	8.29	5.22
Little River	11085	50-Year	1920.00	17.30	27.35	10.05	6.74
Little River	11085	100-Year	2330.00	17.30	28.68	11.38	6.98
Little River	11085	500-Year	3520.00	17.30	30.26	12.96	8.95
Little River	11000	10-Year	1160.00	17.05	25.54	8.49	3.90
Little River	11000	50-Year	1920.00	17.05	27.36	10.31	4.72
Little River	11000	100-Year	2330.00	17.05	28.76	11.71	4.50
Little River	11000	500-Year	3520.00	17.05	30.56	13.51	4.69
Little River	10915	10-Year	1160.00	16.80	25.34	8.54	3.87
Little River	10915	50-Year	1920.00	16.80	27.11	10.31	4.72
Little River	10915	100-Year	2330.00	16.80	28.59	11.79	4.27
Little River	10915	500-Year	3520.00	16.80	30.47	13.67	3.78
Little River	9455	10-Year	1160.00	13.90	24.72	10.82	1.46
Little River	9455	50-Year	1920.00	13.90	26.69	12.79	1.52
Little River	9455	100-Year	2330.00	13.90	28.36	14.46	1.34
Little River	9455	500-Year	3520.00	13.90	30.19	16.29	1.48
Little River	8185	10-Year	1160.00	12.20	24.25	12.05	2.35
Little River	8185	50-Year	1920.00	12.20	26.18	13.98	3.09
Little River	8185	100-Year	2330.00	12.20	27.97	15.77	3.10
Little River	8185	500-Year	3520.00	12.20	29.70	17.50	3.91
Little River	7950	10-Year	1160.00	12.70	24.22	11.52	1.29
Little River	7950	50-Year	1920.00	12.70	26.19	13.49	1.41
Little River	7950	100-Year	2330.00	12.70	28.00	15.30	1.28
Little River	7950	500-Year	3520.00	12.70	29.77	17.07	1.54
Little River	7488	10-Year	1160.00	13.60	24.03	10.43	1.91
Little River	7488	50-Year	1920.00	13.60	25.99	12.39	2.28
Little River	7488	100-Year	2330.00	13.60	27.86	14.26	2.16
Little River	7488	500-Year	3520.00	13.60	29.58	15.98	2.67
Little River	7478	10-Year	1160.00	13.60	24.02	10.42	1.92
Little River	7478	50-Year	1920.00	13.60	25.99	12.39	2.29
Little River	7478	100-Year	2330.00	13.60	27.85	14.25	2.16
Little River	7478	500-Year	3520.00	13.60	29.57	15.97	2.67
Little River	7475		Bridge				
Little River	7472	10-Year	1160.00	13.60	24.01	10.41	1.92
Little River	7472	50-Year	1920.00	13.60	25.95	12.35	2.30
Little River	7472	100-Year	2330.00	13.60	27.77	14.17	2.18
Little River	7472	500-Year	3520.00	13.60	29.44	15.84	2.71
Little River	7452	10-Year	1160.00	13.60	24.00	10.40	1.92
Little River	7452	50-Year	1920.00	13.60	25.94	12.34	2.30
Little River	7452	100-Year	2330.00	13.60	27.76	14.16	2.18

HEC-RAS Plan: DuplicateEffModel River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Max Chl Dpth	Vel Chnl
			(cfs)	(ft)	(ft)	(ft)	(ft/s)
Little River	7452	500-Year	3520.00	13.60	29.42	15.82	2.72
Little River	6195	10-Year	1160.00	12.60	23.55	10.95	1.33
Little River	6195	50-Year	1920.00	12.60	25.46	12.86	1.62
Little River	6195	100-Year	2330.00	12.60	27.44	14.84	1.52
Little River	6195	500-Year	3520.00	12.60	29.00	16.40	1.92
Little River	6115	10-Year	1160.00	14.60	23.15	8.55	4.43
Little River	6115	50-Year	1920.00	14.60	24.74	10.14	6.00
Little River	6115	100-Year	2330.00	14.60	26.75	12.15	5.93
Little River	6115	500-Year	3520.00	14.60	28.65	14.05	5.14
Little River	6095		Bridge				
Little River	6075	10-Year	1160.00	14.30	23.13	8.83	4.26
Little River	6075	50-Year	1920.00	14.30	24.68	10.38	5.84
Little River	6075	100-Year	2330.00	14.30	25.92	11.62	4.77
Little River	6075	500-Year	3520.00	14.30	28.57	14.27	4.97
Little River	5975	10-Year	1160.00	14.20	23.21	9.01	1.11
Little River	5975	50-Year	1920.00	14.20	24.87	10.67	1.44
Little River	5975	100-Year	2330.00	14.20	25.99	11.79	1.52
Little River	5975	500-Year	3520.00	14.20	28.64	14.44	1.69
Little River	5775	10-Year	1160.00	13.90	23.12	9.22	1.87
Little River	5775	50-Year	1920.00	13.90	24.75	10.85	2.35
Little River	5775	100-Year	2330.00	13.90	25.89	11.99	2.38
Little River	5775	500-Year	3520.00	13.90	28.55	14.65	2.46
Little River	4875	10-Year	1160.00	12.90	22.64	9.74	1.68
Little River	4875	50-Year	1920.00	12.90	24.18	11.28	2.16
Little River	4875	100-Year	2330.00	12.90	25.38	12.48	2.23
Little River	4875	500-Year	3520.00	12.90	28.12	15.22	2.48
Little River	4030	10-Year	1160.00	11.90	22.25	10.35	1.51
Little River	4030	50-Year	1920.00	11.90	23.68	11.78	2.01
Little River	4030	100-Year	2330.00	11.90	24.96	13.06	2.08
Little River	4030	500-Year	3520.00	11.90	27.76	15.86	2.33
Little River	3375	10-Year	1160.00	10.80	22.08	11.28	1.25
Little River	3375	50-Year	1920.00	10.80	23.43	12.63	1.75
Little River	3375	100-Year	2330.00	10.80	24.73	13.93	1.84
Little River	3375	500-Year	3520.00	10.80	27.56	16.76	2.10
Little River	2775	10-Year	1160.00	9.80	21.92	12.12	1.68
Little River	2775	50-Year	1920.00	9.80	23.17	13.37	2.29
Little River	2775	100-Year	2330.00	9.80	24.51	14.71	2.29
Little River	2775	500-Year	3520.00	9.80	27.38	17.58	2.40
Little River	2550	10-Year	1160.00	18.45	21.29	2.84	5.45
Little River	2550	50-Year	1920.00	18.45	22.23	3.78	6.76
Little River	2550	100-Year	2330.00	18.45	23.85	5.40	5.75
Little River	2550	500-Year	3520.00	18.45	26.85	8.40	5.39
Little River	2451	10-Year	1160.00	18.30	20.45	2.15	7.20
Little River	2451	50-Year	1920.00	18.30	21.23	2.93	8.74

HEC-RAS Plan: DuplicateEffModel River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Max Chl Dpth	Vel Chnl
			(cfs)	(ft)	(ft)	(ft)	(ft/s)
Little River	2451	100-Year	2330.00	18.30	23.70	5.40	5.75
Little River	2451	500-Year	3520.00	18.30	26.78	8.48	5.32
Little River	2450	10-Year	1160.00	18.30	20.25	1.95	7.93
Little River	2450	50-Year	1920.00	18.30	21.02	2.72	9.40
Little River	2450	100-Year	2330.00	18.30	23.69	5.39	5.76
Little River	2450	500-Year	3520.00	18.30	26.78	8.48	5.32
Little River	2449	10-Year	1160.00	9.30	15.40	6.10	2.53
Little River	2449	50-Year	1920.00	9.30	18.11	8.81	2.90
Little River	2449	100-Year	2330.00	9.30	23.83	14.53	2.14
Little River	2449	500-Year	3520.00	9.30	26.87	17.57	2.63
Little River	2415	10-Year	1160.00	9.20	15.36	6.16	2.90
Little River	2415	50-Year	1920.00	9.20	18.06	8.86	3.33
Little River	2415	100-Year	2330.00	9.20	23.80	14.60	2.45
Little River	2415	500-Year	3520.00	9.20	26.83	17.63	3.06
Little River	2380	10-Year	1160.00	9.00	14.23	5.23	7.92
Little River	2380	50-Year	1920.00	9.00	16.62	7.62	9.00
Little River	2380	100-Year	2330.00	9.00	23.22	14.22	5.85
Little River	2380	500-Year	3520.00	9.00	26.70	17.70	4.16
Little River	2342.5		Bridge				
Little River	2305	10-Year	1160.00	9.00	13.71	4.71	8.80
Little River	2305	50-Year	1920.00	9.00	16.33	7.33	9.36
Little River	2305	100-Year	2330.00	9.00	17.91	8.91	9.34
Little River	2305	500-Year	3520.00	9.00	21.94	12.94	9.72
Little River	2255	10-Year	1160.00	8.80	14.03	5.23	4.78
Little River	2255	50-Year	1920.00	8.80	16.73	7.93	5.20
Little River	2255	100-Year	2330.00	8.80	18.32	9.52	5.24
Little River	2255	500-Year	3520.00	8.80	22.40	13.60	5.47
Little River	1825	10-Year	1160.00	7.60	12.93	5.33	7.04
Little River	1825	50-Year	1920.00	7.60	16.01	8.41	6.89
Little River	1825	100-Year	2330.00	7.60	17.76	10.16	6.64
Little River	1825	500-Year	3520.00	7.60	22.10	14.50	6.33
Little River	1775 FEMA Section A	10-Year	1160.00	7.50	12.86	5.36	6.56
Little River	1775 FEMA Section A	50-Year	1920.00	7.50	15.86	8.36	6.95
Little River	1775 FEMA Section A	100-Year	2330.00	7.50	17.53	10.03	7.02
Little River	1775 FEMA Section A	500-Year	3520.00	7.50	21.62	14.12	7.53
Little River	1750		Bridge				
Little River	0010	10-Year	1160.00	-1.30	2.11	3.41	10.41
Little River	0010	50-Year	1920.00	-1.30	3.46	4.76	12.30
Little River	0010	100-Year	2330.00	-1.30	4.10	5.40	13.13
Little River	0010	500-Year	3520.00	-1.30	5.80	7.10	15.05
Little River	0	10-Year	1160.00	-1.30	1.60	2.90	2.23
Little River	0	50-Year	1920.00	-1.30	1.60	2.90	3.69
Little River	0	100-Year	2330.00	-1.30	1.60	2.90	4.48
Little River	0	500-Year	3520.00	-1.30	1.60	2.90	6.77

ATTACHMENT 7 - HYDRAULIC CROSS SECTION LOCATION PLANS INCLUDING BATHYMETRIC TOPOGRAPHIC INFORMATION (SPOT ELEVATIONS) OBTAINED FROM FIELD INVESTIGATIONS

LEGEND

FEMA MODEL CROSS–SECTION

F&O ADDED MODEL CROSS–SECTION

FIG. 1E

FIG. 1D

FIG. 1B

FIG. 1C

FIG. 1A

PROJ. No.: 20170390U20

DATE: OCTOBER 2020

TOWN OF HAVERHILL

CROSS SECTION LOCATION MAP
INDEX PLAN

HAVERHILL MASSACHUSETTS

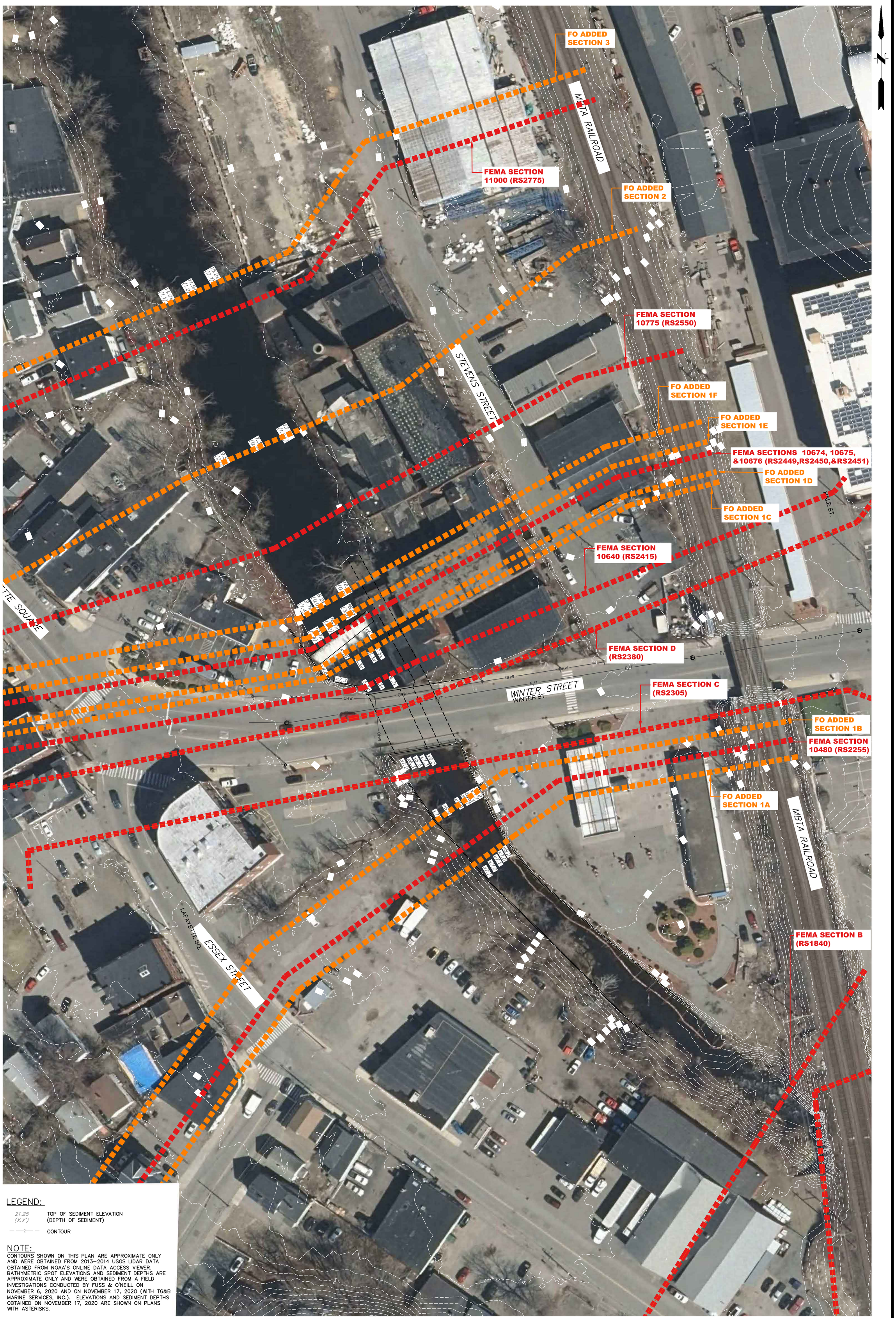
FUSS & O'NEILL
317 IRON HORSE WAY, SUITE 204
PROVIDENCE, RI 02908
401.861.3070
www.fando.com

SCALE:
HORZ.: 1"= 600'
VERT.:
DATUM:
HORZ.:
VERT.:

600 300 0 600
GRAPHIC SCALE

No.	DATE	DESCRIPTION	DESIGNER	REVIEWER

File Path: J:\DWG\P2017\0390\U20\CivilPlan\20170390U20_EXC01.dwg Layout: FIG 1A Plotted: Tue, April 06, 2021 - 8:18 AM User: sarruda
MS VIEW: LAYER STATE: Plotter: NONE CTB File: FO.STB



LEGEND:

21.25 (X.X')	TOP OF SEDIMENT ELEVATION (DEPTH OF SEDIMENT)
— —2— —	CONTOUR

NOTE:

CONTOURS SHOWN ON THIS PLAN ARE APPROXIMATE ONLY AND WERE OBTAINED FROM 2013–2014 USGS LIDAR DATA OBTAINED FROM NOAA'S ONLINE DATA ACCESS VIEWER. BATHYMETRIC SPOT ELEVATIONS AND SEDIMENT DEPTHS ARE APPROXIMATE ONLY AND WERE OBTAINED FROM A FIELD INVESTIGATIONS CONDUCTED BY FUSS & O'NEILL ON NOVEMBER 6, 2020 AND ON NOVEMBER 17, 2020 (WITH TG&B MARINE SERVICES, INC.). ELEVATIONS AND SEDIMENT DEPTHS OBTAINED ON NOVEMBER 17, 2020 ARE SHOWN ON PLANS WITH ASTERISKS.

PROJ. No.: 20170390U20
DATE: OCTOBER 2020

FIG. 1B

TOWN OF HAVERHILL

CROSS SECTION LOCATION MAP NO. 1

HAVERHILL MASSACHUSETTS

FUSS & O'NEILL
317 IRON HORSE WAY, SUITE 204
PROVIDENCE, RI 02908
401.861.3070
www.fando.com

SCALE:
HORZ.: 1"= 40'
VERT.:
DATUM:
HORZ.: NAD83
VERT.: NAVD88
40 20 0 40
GRAPHIC SCALE

No.	DATE	DESCRIPTION	DESIGNER	REVIEWER

File Path: J:\DWG\P20170390U20\Civil\Plan\20170390U20_EXC01.dwg Layout: FIG 1B Plotted: Tue, April 06, 2021 - 9:21 AM User: sarruda
MS VIEW: LAYER STATE: Plotter: NONE CTB File: FO.STB



File Path: J:\DWG\P20170390U20\CivilPlan\20170390U20_EXC01.dwg Layout: FIG 1C Plotted: Tue, April 06, 2021 - 8:40 AM User: sarruda
MS VIEW: LAYER STATE: Plotter: NONE CTB File: FO.STB

PROJ. No.: 20170390U20
DATE: OCTOBER 2020

FIG. 1C

TOWN OF HAVERHILL

CROSS SECTION LOCATION MAP NO. 2

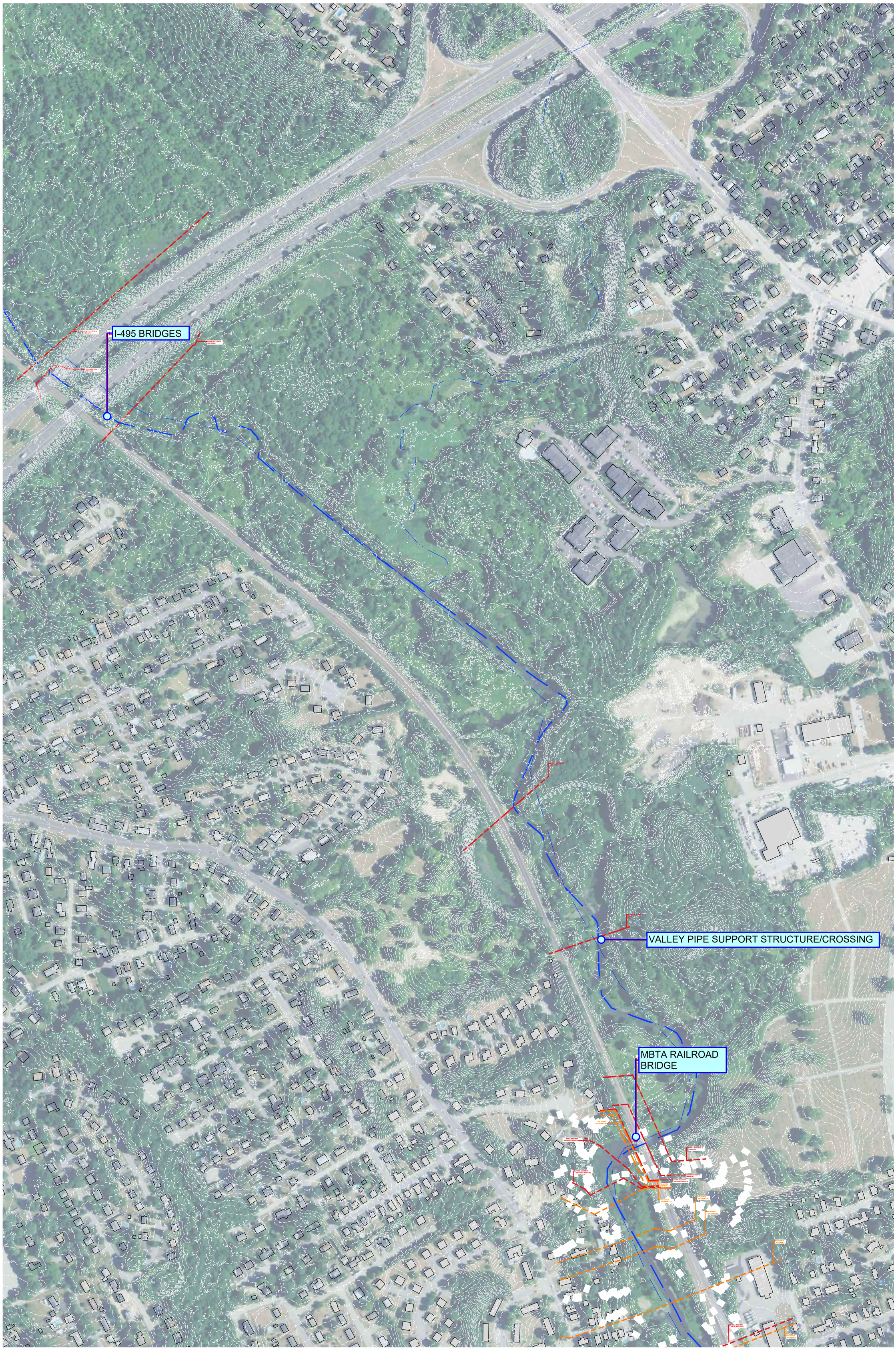
HAVERHILL MASSACHUSETTS

FUSS & O'NEILL
317 IRON HORSE WAY, SUITE 204
PROVIDENCE, RI 02908
401.861.3070
www.fando.com

SCALE:
HORZ.: 1"= 200'
VERT.:
DATUM:
HORZ.: NAD83
VERT.: NAVD88

200 100 0 200
GRAPHIC SCALE

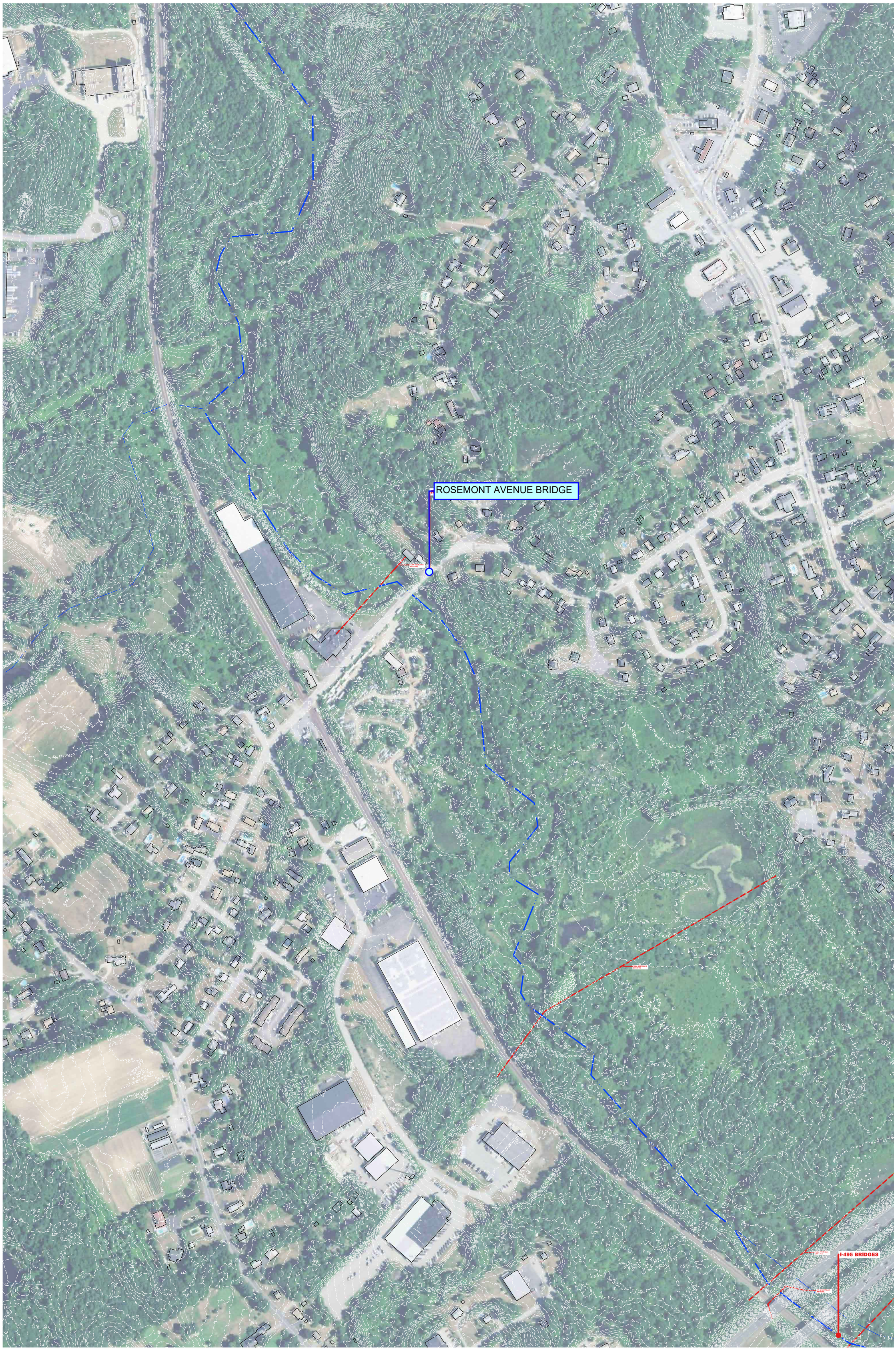
No.	DATE	DESCRIPTION	DESIGNER	REVIEWER



PROJ. No.: 20170390U20	TOWN OF HAVERHILL	FUSS & O'NEILL	SCALE:	
DATE: OCTOBER 2020	CROSS SECTION LOCATION MAP NO. 3	317 IRON HORSE WAY, SUITE 204	HORZ.: 1"= 200'	
FIG. 1D	HAVERHILL MASSACHUSETTS	PROVIDENCE, RI 02908	VERT.:	
		401.861.3070	DATUM:	
		www.fando.com	HORZ.: NAD83	
			VERT.: NAVD88	
			200 100 0 200	
			GRAPHIC SCALE	

No.	DATE	DESCRIPTION	DESIGNER	REVIEWER

File Path: J:\DWG\P2017\0390U20\Civil\Plan\20170390U20_EXC01.dwg Layout: FIG 1D Plotted: Tue, April 06, 2021 - 8:55 AM User: sarruda
MS VIEW: LAYER STATE: Plotter: NONE CTB File: FO.STB



PROJ. No.: 20170390U20	TOWN OF HAVERHILL	FUSS & O'NEILL	SCALE:	
DATE: OCTOBER 2020	CROSS SECTION LOCATION MAP NO. 4	317 IRON HORSE WAY, SUITE 204 PROVIDENCE, RI 02908 401.861.3070 www.fando.com	HORZ.: 1"= 200'	
FIG. 1E	HAVERHILL MASSACHUSETTS		VERT.:	
			DATUM:	
			HORZ.: NAD83	
			VERT.: NAVD88	
			200 100 0 200 GRAPHIC SCALE	

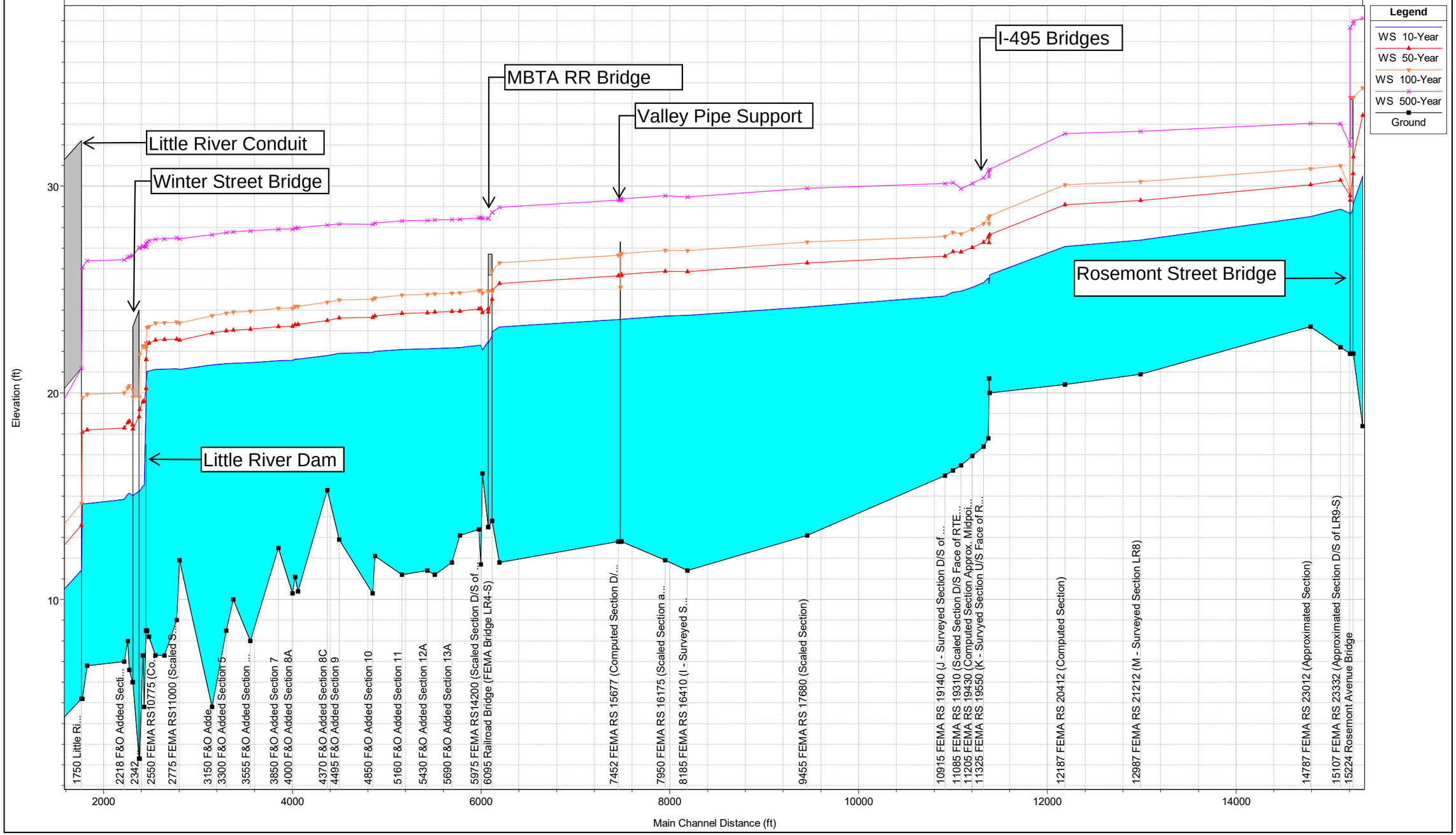
No.	DATE	DESCRIPTION	DESIGNER	REVIEWER

File Path: J:\DWG\P2017\0390U20\Civil\Plan\20170390U20_EXC01.dwg Layout: FIG 1E Plotted: Tue, April 06, 2021 - 8:59 AM User: sarruda
MS VIEW: | LAYER STATE: | Plotter: NONE CTB File: FO.STB

ATTACHMENT 8 - PRE-DAM REMOVAL MODEL HEC-RAS PROFILE AND OUTPUT SUMMARY (FLOOD FLOWS)

HEC-RAS Model Plan: FO PreConditions Model 3/23/2021

Little River Little River



HEC-RAS Plan: FO PreCondit River: Little River Reach: Little River

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	15341	10-Year	980.00	18.40	30.48	1.71	299.57
Little River	15341	50-Year	1640.00	18.40	33.43	1.80	321.70
Little River	15341	100-Year	1990.00	18.40	34.75	1.86	338.32
Little River	15341	500-Year	3030.00	18.40	38.13	2.01	404.08
Little River	15241	10-Year	980.00	21.90	29.17	8.16	35.83
Little River	15241	50-Year	1640.00	21.90	31.43	10.21	181.62
Little River	15241	100-Year	1990.00	21.90	34.29	6.12	368.30
Little River	15241	500-Year	3030.00	21.90	37.99	4.33	542.92
Little River	15224		Bridge				
Little River	15207	10-Year	980.00	21.90	28.68	8.78	25.00
Little River	15207	50-Year	1640.00	21.90	29.53	12.96	56.47
Little River	15207	100-Year	1990.00	21.90	29.81	15.13	73.51
Little River	15207	500-Year	3030.00	21.90	31.99	17.75	220.02
Little River	15107	10-Year	980.00	22.20	28.88	3.96	110.29
Little River	15107	50-Year	1640.00	22.20	30.28	4.83	142.42
Little River	15107	100-Year	1990.00	22.20	30.98	5.12	158.40
Little River	15107	500-Year	3030.00	22.20	33.02	5.51	205.46
Little River	14787	10-Year	980.00	23.20	28.53	3.42	273.13
Little River	14787	50-Year	1640.00	23.20	30.07	3.50	468.45
Little River	14787	100-Year	1990.00	23.20	30.85	3.39	502.61
Little River	14787	500-Year	3030.00	23.20	33.04	3.10	598.98
Little River	12987	10-Year	980.00	20.90	27.39	2.41	443.36
Little River	12987	50-Year	1640.00	20.90	29.30	2.36	604.70
Little River	12987	100-Year	1990.00	20.90	30.23	2.29	665.41
Little River	12987	500-Year	3030.00	20.90	32.65	2.17	824.46
Little River	12187	10-Year	980.00	20.40	27.08	2.27	459.99
Little River	12187	50-Year	1640.00	20.40	29.10	2.19	624.49
Little River	12187	100-Year	1990.00	20.40	30.07	2.13	687.62
Little River	12187	500-Year	3030.00	20.40	32.55	2.04	850.29
Little River	11387	10-Year	1160.00	20.00	25.71	6.60	48.65
Little River	11387	50-Year	1920.00	20.00	27.65	7.88	56.04
Little River	11387	100-Year	2330.00	20.00	28.55	8.44	59.47
Little River	11387	500-Year	3520.00	20.00	30.81	9.76	68.05
Little River	11381	10-Year	1160.00	20.70	25.26	8.08	46.57
Little River	11381	50-Year	1920.00	20.70	27.27	9.01	54.31
Little River	11381	100-Year	2330.00	20.70	28.19	9.47	57.86
Little River	11381	500-Year	3520.00	20.70	30.47	10.63	66.67
Little River	11375	10-Year	1160.00	17.80	25.55	4.96	50.37
Little River	11375	50-Year	1920.00	17.80	27.55	6.31	57.28
Little River	11375	100-Year	2330.00	17.80	28.47	6.91	60.46
Little River	11375	500-Year	3520.00	17.80	30.75	8.34	68.34

HEC-RAS Plan: FO PreCondit River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	11325	10-Year	1160.00	17.40	25.33	5.53	45.58
Little River	11325	50-Year	1920.00	17.40	27.28	6.89	52.54
Little River	11325	100-Year	2330.00	17.40	28.18	7.48	55.75
Little River	11325	500-Year	3520.00	17.40	30.41	8.91	63.72
Little River	11205	10-Year	1160.00	16.95	25.11	5.33	46.39
Little River	11205	50-Year	1920.00	16.95	27.03	6.71	53.27
Little River	11205	100-Year	2330.00	16.95	27.92	7.31	56.45
Little River	11205	500-Year	3520.00	16.95	30.14	8.76	64.35
Little River	11085	10-Year	1160.00	16.50	24.91	5.12	47.31
Little River	11085	50-Year	1920.00	16.50	26.81	6.52	54.08
Little River	11085	100-Year	2330.00	16.50	27.69	7.14	57.22
Little River	11085	500-Year	3520.00	16.50	29.88	8.60	65.04
Little River	11000	10-Year	1160.00	16.25	24.87	3.81	56.93
Little River	11000	50-Year	1920.00	16.25	26.82	4.52	133.16
Little River	11000	100-Year	2330.00	16.25	27.76	4.68	270.43
Little River	11000	500-Year	3520.00	16.25	30.18	4.27	538.11
Little River	10915	10-Year	1160.00	16.00	24.68	3.77	57.18
Little River	10915	50-Year	1920.00	16.00	26.60	4.49	137.55
Little River	10915	100-Year	2330.00	16.00	27.56	4.50	278.25
Little River	10915	500-Year	3520.00	16.00	30.12	3.29	554.41
Little River	9455	10-Year	1160.00	13.10	24.16	1.38	496.21
Little River	9455	50-Year	1920.00	13.10	26.29	1.40	708.72
Little River	9455	100-Year	2330.00	13.10	27.30	1.40	809.57
Little River	9455	500-Year	3520.00	13.10	29.89	1.37	1024.79
Little River	8185	10-Year	1160.00	11.40	23.75	2.26	81.57
Little River	8185	50-Year	1920.00	11.40	25.86	2.93	108.96
Little River	8185	100-Year	2330.00	11.40	26.87	3.20	125.56
Little River	8185	500-Year	3520.00	11.40	29.48	3.68	217.92
Little River	7950	10-Year	1160.00	11.90	23.72	1.20	417.65
Little River	7950	50-Year	1920.00	11.90	25.87	1.29	430.54
Little River	7950	100-Year	2330.00	11.90	26.90	1.34	435.60
Little River	7950	500-Year	3520.00	11.90	29.54	1.45	447.00
Little River	7488	10-Year	1160.00	12.80	23.57	1.80	174.34
Little River	7488	50-Year	1920.00	12.80	25.72	2.11	188.44
Little River	7488	100-Year	2330.00	12.80	26.74	2.24	195.15
Little River	7488	500-Year	3520.00	12.80	29.38	2.50	326.07
Little River	7478	10-Year	1160.00	12.80	23.56	1.80	174.30
Little River	7478	50-Year	1920.00	12.80	25.71	2.13	188.40
Little River	7478	100-Year	2330.00	12.80	26.73	2.26	195.10
Little River	7478	500-Year	3520.00	12.80	29.38	2.50	325.91

HEC-RAS Plan: FO PreCondit River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	7475		Bridge				
Little River	7472	10-Year	1160.00	12.80	23.55	1.81	174.24
Little River	7472	50-Year	1920.00	12.80	25.67	2.14	188.13
Little River	7472	100-Year	2330.00	12.80	26.66	2.26	194.62
Little River	7472	500-Year	3520.00	12.80	29.32	2.51	324.13
Little River	7452	10-Year	1160.00	12.80	23.54	1.81	174.17
Little River	7452	50-Year	1920.00	12.80	25.66	2.13	188.07
Little River	7452	100-Year	2330.00	12.80	26.65	2.27	194.56
Little River	7452	500-Year	3520.00	12.80	29.31	2.52	323.82
Little River	6195	10-Year	1160.00	11.80	23.18	1.23	234.87
Little River	6195	50-Year	1920.00	11.80	25.29	1.49	271.40
Little River	6195	100-Year	2330.00	11.80	26.28	1.59	288.67
Little River	6195	500-Year	3520.00	11.80	28.98	1.76	396.78
Little River	6115	10-Year	1160.00	13.80	22.96	3.52	100.48
Little River	6115	50-Year	1920.00	13.80	24.96	4.42	126.72
Little River	6115	100-Year	2330.00	13.80	25.90	4.81	139.00
Little River	6115	500-Year	3520.00	13.80	28.74	4.48	336.03
Little River	6095		Bridge				
Little River	6075	10-Year	1160.00	13.50	22.49	3.62	98.24
Little River	6075	50-Year	1920.00	13.50	24.08	4.76	119.07
Little River	6075	100-Year	2330.00	13.50	24.92	5.20	130.15
Little River	6075	500-Year	3520.00	13.50	28.43	4.48	336.01
Little River	6015	10-Year	1160.00	16.10	22.06	4.98	126.48
Little River	6015	50-Year	1920.00	16.10	23.88	5.00	288.84
Little River	6015	100-Year	2330.00	16.10	24.83	4.58	326.13
Little River	6015	500-Year	3520.00	16.10	28.45	3.00	432.24
Little River	5995	10-Year	1160.00	11.70	22.30	1.15	339.89
Little River	5995	50-Year	1920.00	11.70	24.07	1.39	366.77
Little River	5995	100-Year	2330.00	11.70	24.96	1.48	376.81
Little River	5995	500-Year	3520.00	11.70	28.47	1.43	481.11
Little River	5975	10-Year	1160.00	13.40	22.29	1.13	203.30
Little River	5975	50-Year	1920.00	13.40	24.06	1.44	228.03
Little River	5975	100-Year	2330.00	13.40	24.94	1.56	266.49
Little River	5975	500-Year	3520.00	13.40	28.46	1.58	438.66
Little River	5775	10-Year	1160.00	13.10	22.19	2.03	219.20
Little River	5775	50-Year	1920.00	13.10	23.95	2.33	237.39
Little River	5775	100-Year	2330.00	13.10	24.84	2.43	264.16
Little River	5775	500-Year	3520.00	13.10	28.40	2.20	399.50
Little River	5690	10-Year	1160.00	11.80	22.17	1.18	221.38
Little River	5690	50-Year	1920.00	11.80	23.93	1.42	232.63

HEC-RAS Plan: FO PreCondit River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	5690	100-Year	2330.00	11.80	24.82	1.51	243.63
Little River	5690	500-Year	3520.00	11.80	28.39	1.47	346.35
Little River	5510	10-Year	1160.00	11.20	22.15	0.87	197.99
Little River	5510	50-Year	1920.00	11.20	23.91	1.15	206.63
Little River	5510	100-Year	2330.00	11.20	24.79	1.27	221.81
Little River	5510	500-Year	3520.00	11.20	28.37	1.35	353.43
Little River	5430	10-Year	1160.00	11.40	22.12	1.19	145.99
Little River	5430	50-Year	1920.00	11.40	23.87	1.59	162.28
Little River	5430	100-Year	2330.00	11.40	24.75	1.75	170.78
Little River	5430	500-Year	3520.00	11.40	28.33	1.86	355.20
Little River	5160	10-Year	1160.00	11.20	22.09	0.80	274.73
Little River	5160	50-Year	1920.00	11.20	23.84	1.01	287.12
Little River	5160	100-Year	2330.00	11.20	24.72	1.09	300.12
Little River	5160	500-Year	3520.00	11.20	28.32	1.12	470.35
Little River	4875	10-Year	1160.00	12.10	22.00	1.63	135.62
Little River	4875	50-Year	1920.00	12.10	23.72	2.06	141.34
Little River	4875	100-Year	2330.00	12.10	24.59	2.23	144.26
Little River	4875	500-Year	3520.00	12.10	28.21	2.27	357.82
Little River	4850	10-Year	1160.00	10.30	21.96	2.01	98.67
Little River	4850	50-Year	1920.00	10.30	23.65	2.64	112.35
Little River	4850	100-Year	2330.00	10.30	24.52	2.89	119.16
Little River	4850	500-Year	3520.00	10.30	28.15	2.96	359.54
Little River	4495	10-Year	1160.00	12.90	21.91	0.80	290.42
Little River	4495	50-Year	1920.00	12.90	23.62	0.99	305.30
Little River	4495	100-Year	2330.00	12.90	24.50	1.06	317.18
Little River	4495	500-Year	3520.00	12.90	28.16	1.06	520.50
Little River	4370	10-Year	1160.00	15.30	21.79	2.29	190.47
Little River	4370	50-Year	1920.00	15.30	23.50	2.50	309.52
Little River	4370	100-Year	2330.00	15.30	24.39	2.50	373.76
Little River	4370	500-Year	3520.00	15.30	28.12	1.90	615.05
Little River	4060	10-Year	1160.00	10.40	21.63	1.57	121.90
Little River	4060	50-Year	1920.00	10.40	23.31	2.10	139.58
Little River	4060	100-Year	2330.00	10.40	24.19	2.30	151.13
Little River	4060	500-Year	3520.00	10.40	27.98	2.32	398.03
Little River	4030	10-Year	1160.00	11.10	21.63	1.47	137.72
Little River	4030	50-Year	1920.00	11.10	23.30	1.90	143.29
Little River	4030	100-Year	2330.00	11.10	24.18	2.07	150.68
Little River	4030	500-Year	3520.00	11.10	27.98	2.09	467.73
Little River	4000	10-Year	1160.00	10.30	21.57	2.14	122.44
Little River	4000	50-Year	1920.00	10.30	23.22	2.79	145.30
Little River	4000	100-Year	2330.00	10.30	24.10	3.01	155.24

HEC-RAS Plan: FO PreCondit River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	4000	500-Year	3520.00	10.30	27.92	2.90	255.26
Little River	3850	10-Year	1160.00	12.50	21.55	1.21	165.02
Little River	3850	50-Year	1920.00	12.50	23.20	1.57	196.83
Little River	3850	100-Year	2330.00	12.50	24.08	1.71	217.08
Little River	3850	500-Year	3520.00	12.50	27.92	1.69	384.81
Little River	3555	10-Year	1160.00	8.00	21.46	1.46	118.70
Little River	3555	50-Year	1920.00	8.00	23.07	1.98	155.48
Little River	3555	100-Year	2330.00	8.00	23.94	2.18	180.06
Little River	3555	500-Year	3520.00	8.00	27.83	2.15	380.02
Little River	3375	10-Year	1160.00	10.00	21.43	1.22	138.11
Little River	3375	50-Year	1920.00	10.00	23.03	1.67	144.98
Little River	3375	100-Year	2330.00	10.00	23.90	1.85	148.70
Little River	3375	500-Year	3520.00	10.00	27.80	1.88	495.63
Little River	3300	10-Year	1160.00	8.50	21.41	1.33	113.15
Little River	3300	50-Year	1920.00	8.50	23.00	1.84	120.13
Little River	3300	100-Year	2330.00	8.50	23.86	2.04	123.73
Little River	3300	500-Year	3520.00	8.50	27.76	2.18	373.29
Little River	3150	10-Year	1160.00	4.80	21.35	1.72	75.16
Little River	3150	50-Year	1920.00	4.80	22.89	2.46	97.03
Little River	3150	100-Year	2330.00	4.80	23.73	2.78	112.33
Little River	3150	500-Year	3520.00	4.80	27.65	2.96	233.57
Little River	2805	10-Year	1160.00	11.90	21.14	2.42	88.38
Little River	2805	50-Year	1920.00	11.90	22.55	3.25	118.06
Little River	2805	100-Year	2330.00	11.90	23.37	3.52	145.52
Little River	2805	500-Year	3520.00	11.90	27.46	3.14	312.95
Little River	2775	10-Year	1160.00	9.00	21.16	1.67	218.73
Little River	2775	50-Year	1920.00	9.00	22.60	2.21	262.09
Little River	2775	100-Year	2330.00	9.00	23.43	2.38	286.81
Little River	2775	500-Year	3520.00	9.00	27.50	2.15	409.12
Little River	2645	10-Year	1160.00	7.30	21.14	1.20	119.15
Little River	2645	50-Year	1920.00	7.30	22.57	1.70	125.22
Little River	2645	100-Year	2330.00	7.30	23.39	1.90	126.48
Little River	2645	500-Year	3520.00	7.30	27.46	2.02	271.64
Little River	2550	10-Year	1160.00	7.30	21.13	1.20	119.06
Little River	2550	50-Year	1920.00	7.30	22.55	1.70	125.19
Little River	2550	100-Year	2330.00	7.30	23.37	1.90	126.44
Little River	2550	500-Year	3520.00	7.30	27.44	2.03	269.72
Little River	2480	10-Year	1160.00	8.20	21.05	2.10	76.52
Little River	2480	50-Year	1920.00	8.20	22.41	2.91	84.23
Little River	2480	100-Year	2330.00	8.20	23.20	3.20	88.68
Little River	2480	500-Year	3520.00	8.20	27.38	2.64	508.18

HEC-RAS Plan: FO PreCondit River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	2461	10-Year	1160.00	8.50	21.04	1.98	54.01
Little River	2461	50-Year	1920.00	8.50	22.39	2.91	56.18
Little River	2461	100-Year	2330.00	8.50	23.16	3.31	57.77
Little River	2461	500-Year	3520.00	8.50	27.31	3.16	390.86
Little River	2451	10-Year	1160.00	8.50	20.44	5.26	75.10
Little River	2451	50-Year	1920.00	8.50	21.61	6.22	75.11
Little River	2451	100-Year	2330.00	8.50	22.41	6.32	75.11
Little River	2451	500-Year	3520.00	8.50	27.20	3.86	288.43
Little River	2450		Inl Struct				
Little River	2449	10-Year	1160.00	8.50	19.44	7.94	75.09
Little River	2449	50-Year	1920.00	8.50	20.22	9.40	75.10
Little River	2449	100-Year	2330.00	8.50	22.15	6.67	75.11
Little River	2449	500-Year	3520.00	8.50	27.07	4.43	275.11
Little River	2430	10-Year	1160.00	4.80	15.52	1.95	68.64
Little River	2430	50-Year	1920.00	4.80	19.59	2.18	70.79
Little River	2430	100-Year	2330.00	4.80	22.27	2.17	73.80
Little River	2430	500-Year	3520.00	4.80	27.10	2.33	382.95
Little River	2420	10-Year	1160.00	7.30	15.49	2.21	71.22
Little River	2420	50-Year	1920.00	7.30	19.58	2.34	74.54
Little River	2420	100-Year	2330.00	7.30	22.26	2.27	76.76
Little River	2420	500-Year	3520.00	7.30	27.10	2.41	357.31
Little River	2415	10-Year	1160.00	7.30	15.48	2.36	65.06
Little River	2415	50-Year	1920.00	7.30	19.56	2.54	65.10
Little River	2415	100-Year	2330.00	7.30	22.24	2.50	65.12
Little River	2415	500-Year	3520.00	7.30	27.06	2.78	264.77
Little River	2380	10-Year	1160.00	2.30	15.25	4.05	45.89
Little River	2380	50-Year	1920.00	2.30	19.21	4.83	45.94
Little River	2380	100-Year	2330.00	2.30	21.87	4.94	45.97
Little River	2380	500-Year	3520.00	2.30	27.01	3.43	283.72
Little River	2342.5		Bridge				
Little River	2305	10-Year	1160.00	6.00	15.03	5.06	45.89
Little River	2305	50-Year	1920.00	6.00	18.46	5.90	45.93
Little River	2305	100-Year	2330.00	6.00	20.13	6.26	45.95
Little River	2305	500-Year	3520.00	6.00	26.64	3.06	604.81
Little River	2273	10-Year	1160.00	6.60	15.14	3.09	54.55
Little River	2273	50-Year	1920.00	6.60	18.63	3.35	59.49
Little River	2273	100-Year	2330.00	6.60	20.33	3.44	62.45
Little River	2273	500-Year	3520.00	6.60	26.60	2.87	313.84
Little River	2255	10-Year	1160.00	8.00	15.09	3.52	47.07

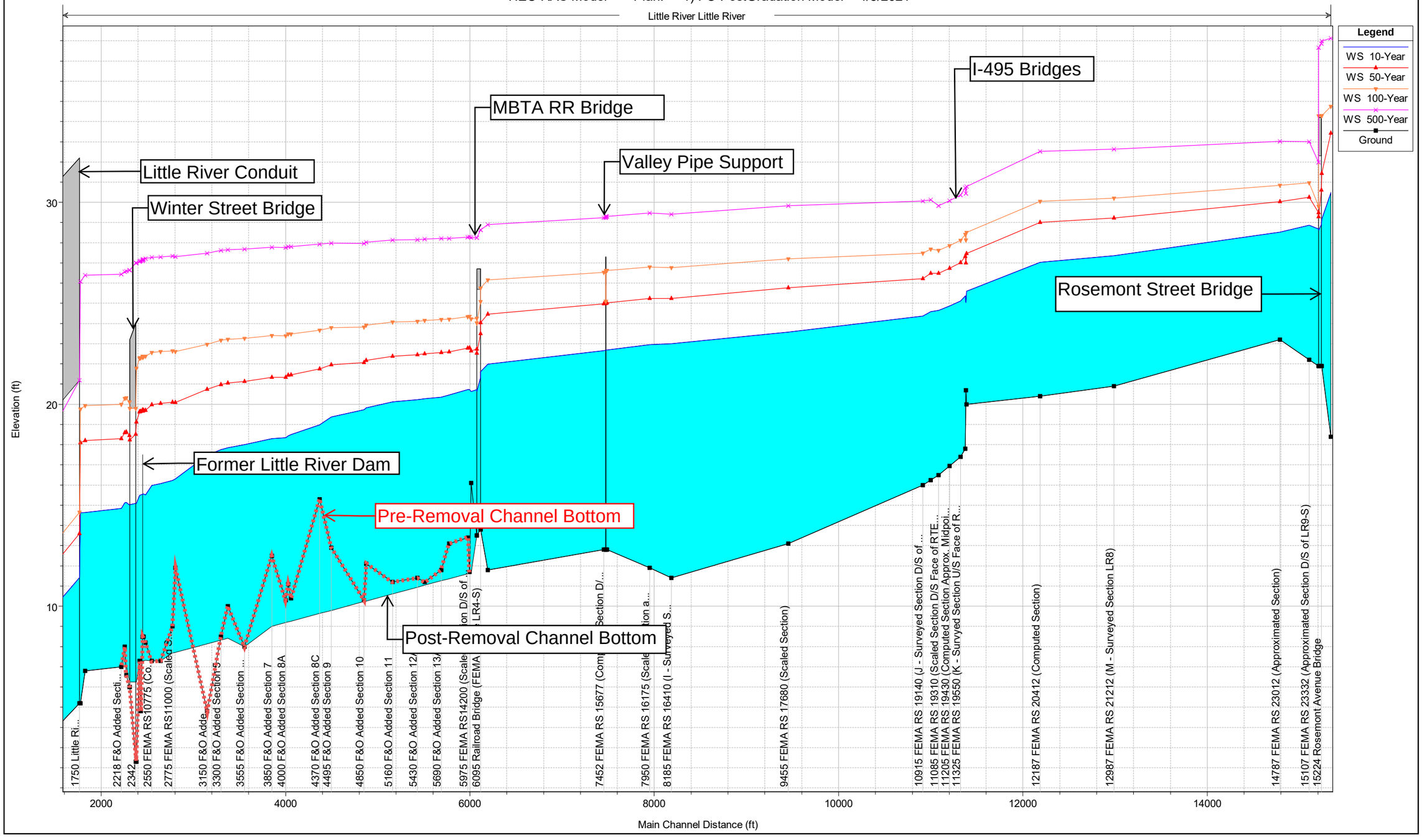
HEC-RAS Plan: FO PreCondit River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	2255	50-Year	1920.00	8.00	18.56	3.89	47.59
Little River	2255	100-Year	2330.00	8.00	20.25	4.05	53.00
Little River	2255	500-Year	3520.00	8.00	26.56	3.36	239.29
Little River	2218	10-Year	1160.00	7.00	14.85	4.99	34.36
Little River	2218	50-Year	1920.00	7.00	18.30	5.38	38.29
Little River	2218	100-Year	2330.00	7.00	19.99	5.52	43.48
Little River	2218	500-Year	3520.00	7.00	26.44	4.30	289.49
Little River	1825	10-Year	1160.00	6.80	14.64	4.51	44.20
Little River	1825	50-Year	1920.00	6.80	18.20	4.75	54.38
Little River	1825	100-Year	2330.00	6.80	19.93	4.80	60.09
Little River	1825	500-Year	3520.00	6.80	26.40	4.12	79.95
Little River	1775 FEMA Section A	10-Year	1160.00	5.20	14.62	4.24	39.49
Little River	1775 FEMA Section A	50-Year	1920.00	5.20	18.09	4.93	42.32
Little River	1775 FEMA Section A	100-Year	2330.00	5.20	19.77	5.24	43.68
Little River	1775 FEMA Section A	500-Year	3520.00	5.20	26.09	5.38	48.83
Little River	1750		Bridge				
Little River	0010	10-Year	1160.00	-3.30	1.03	14.14	360.14
Little River	0010	50-Year	1920.00	-3.30	1.90	17.39	535.00
Little River	0010	100-Year	2330.00	-3.30	2.33	18.77	619.45
Little River	0010	500-Year	3520.00	-3.30	3.26	22.78	806.71
Little River	0	10-Year	1160.00	-3.30	1.60	1.49	664.57
Little River	0	50-Year	1920.00	-3.30	1.60	2.46	664.57
Little River	0	100-Year	2330.00	-3.30	1.60	2.99	664.57
Little River	0	500-Year	3520.00	-3.30	-0.89	33.20	226.32

ATTACHMENT 9 - POST-CONDITION MODEL HEC-RAS PROFILE AND OUTPUT SUMMARY (FLOOD FLOWS)

HEC-RAS Model Plan: 1) FO PostGradation Model 4/5/2021

Little River Little River



HEC-RAS Plan: FO PostGradation Model River: Little River Reach: Little River

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	15341	10-Year	980.00	18.40	30.47	1.71	299.55
Little River	15341	50-Year	1640.00	18.40	33.43	1.80	321.71
Little River	15341	100-Year	1990.00	18.40	34.75	1.86	338.29
Little River	15341	500-Year	3030.00	18.40	38.13	2.01	404.08
Little River	15241	10-Year	980.00	21.90	29.16	8.16	35.63
Little River	15241	50-Year	1640.00	21.90	31.43	10.21	181.87
Little River	15241	100-Year	1990.00	21.90	34.29	6.13	368.22
Little River	15241	500-Year	3030.00	21.90	37.99	4.33	542.92
Little River	15224		Bridge				
Little River	15207	10-Year	980.00	21.90	28.68	8.79	25.00
Little River	15207	50-Year	1640.00	21.90	29.50	13.02	54.38
Little River	15207	100-Year	1990.00	21.90	29.80	15.16	72.54
Little River	15207	500-Year	3030.00	21.90	31.99	17.75	220.02
Little River	15107	10-Year	980.00	22.20	28.87	3.97	110.15
Little River	15107	50-Year	1640.00	22.20	30.25	4.87	141.68
Little River	15107	100-Year	1990.00	22.20	30.97	5.13	158.16
Little River	15107	500-Year	3030.00	22.20	33.01	5.53	205.12
Little River	14787	10-Year	980.00	23.20	28.52	3.43	272.66
Little River	14787	50-Year	1640.00	23.20	30.03	3.55	466.59
Little River	14787	100-Year	1990.00	23.20	30.84	3.40	502.04
Little River	14787	500-Year	3030.00	23.20	33.03	3.11	598.30
Little River	12987	10-Year	980.00	20.90	27.35	2.44	440.35
Little River	12987	50-Year	1640.00	20.90	29.22	2.41	599.33
Little River	12987	100-Year	1990.00	20.90	30.21	2.30	664.11
Little River	12987	500-Year	3030.00	20.90	32.63	2.18	823.22
Little River	12187	10-Year	980.00	20.40	27.04	2.30	456.02
Little River	12187	50-Year	1640.00	20.40	29.01	2.24	618.31
Little River	12187	100-Year	1990.00	20.40	30.04	2.14	686.18
Little River	12187	500-Year	3030.00	20.40	32.53	2.04	848.98
Little River	11387	10-Year	1160.00	20.00	25.60	6.75	48.22
Little River	11387	50-Year	1920.00	20.00	27.47	8.10	55.34
Little River	11387	100-Year	2330.00	20.00	28.51	8.48	59.32
Little River	11387	500-Year	3520.00	20.00	30.78	9.80	67.93
Little River	11381	10-Year	1160.00	20.70	25.04	8.52	45.71
Little River	11381	50-Year	1920.00	20.70	27.01	9.42	53.29
Little River	11381	100-Year	2330.00	20.70	28.14	9.54	57.65
Little River	11381	500-Year	3520.00	20.70	30.43	10.68	66.51
Little River	11375	10-Year	1160.00	17.80	25.37	5.09	49.75
Little River	11375	50-Year	1920.00	17.80	27.32	6.49	56.50
Little River	11375	100-Year	2330.00	17.80	28.42	6.94	60.30
Little River	11375	500-Year	3520.00	17.80	30.72	8.37	68.21

HEC-RAS Plan: FO PostGradation Model River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	11325	10-Year	1160.00	17.40	25.12	5.72	44.84
Little River	11325	50-Year	1920.00	17.40	27.02	7.13	51.62
Little River	11325	100-Year	2330.00	17.40	28.12	7.53	55.56
Little River	11325	500-Year	3520.00	17.40	30.37	8.95	63.57
Little River	11205	10-Year	1160.00	16.95	24.87	5.54	45.55
Little River	11205	50-Year	1920.00	16.95	26.74	6.97	52.22
Little River	11205	100-Year	2330.00	16.95	27.86	7.37	56.24
Little River	11205	500-Year	3520.00	16.95	30.09	8.80	64.18
Little River	11085	10-Year	1160.00	16.50	24.65	5.34	46.36
Little River	11085	50-Year	1920.00	16.50	26.48	6.80	52.91
Little River	11085	100-Year	2330.00	16.50	27.62	7.19	56.99
Little River	11085	500-Year	3520.00	16.50	29.83	8.64	64.86
Little River	11000	10-Year	1160.00	16.25	24.59	4.02	55.74
Little River	11000	50-Year	1920.00	16.25	26.48	4.78	83.02
Little River	11000	100-Year	2330.00	16.25	27.69	4.74	260.33
Little River	11000	500-Year	3520.00	16.25	30.13	4.32	533.64
Little River	10915	10-Year	1160.00	16.00	24.37	4.00	55.85
Little River	10915	50-Year	1920.00	16.00	26.22	4.79	81.59
Little River	10915	100-Year	2330.00	16.00	27.48	4.59	266.78
Little River	10915	500-Year	3520.00	16.00	30.07	3.35	549.69
Little River	9455	10-Year	1160.00	13.10	23.58	1.59	444.39
Little River	9455	50-Year	1920.00	13.10	25.77	1.56	657.05
Little River	9455	100-Year	2330.00	13.10	27.21	1.42	800.55
Little River	9455	500-Year	3520.00	13.10	29.83	1.38	1022.62
Little River	8185	10-Year	1160.00	11.40	23.01	2.49	77.97
Little River	8185	50-Year	1920.00	11.40	25.24	3.14	99.05
Little River	8185	100-Year	2330.00	11.40	26.76	3.23	123.21
Little River	8185	500-Year	3520.00	11.40	29.41	3.71	214.47
Little River	7950	10-Year	1160.00	11.90	22.95	1.45	410.21
Little River	7950	50-Year	1920.00	11.90	25.24	1.44	427.38
Little River	7950	100-Year	2330.00	11.90	26.79	1.36	435.08
Little River	7950	500-Year	3520.00	11.90	29.47	1.46	447.00
Little River	7488	10-Year	1160.00	12.80	22.70	2.13	168.64
Little River	7488	50-Year	1920.00	12.80	25.03	2.33	183.94
Little River	7488	100-Year	2330.00	12.80	26.63	2.27	194.41
Little River	7488	500-Year	3520.00	12.80	29.31	2.52	323.70
Little River	7478	10-Year	1160.00	12.80	22.69	2.13	168.58
Little River	7478	50-Year	1920.00	12.80	25.02	2.35	183.88
Little River	7478	100-Year	2330.00	12.80	26.62	2.29	194.37
Little River	7478	500-Year	3520.00	12.80	29.31	2.52	323.54

HEC-RAS Plan: FO PostGradation Model River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	7475		Bridge				
Little River	7472	10-Year	1160.00	12.80	22.67	2.14	168.47
Little River	7472	50-Year	1920.00	12.80	25.00	2.36	183.71
Little River	7472	100-Year	2330.00	12.80	26.55	2.30	193.90
Little River	7472	500-Year	3520.00	12.80	29.25	2.54	321.34
Little River	7452	10-Year	1160.00	12.80	22.65	2.15	168.36
Little River	7452	50-Year	1920.00	12.80	24.98	2.35	183.62
Little River	7452	100-Year	2330.00	12.80	26.54	2.30	193.83
Little River	7452	500-Year	3520.00	12.80	29.24	2.54	320.98
Little River	6195	10-Year	1160.00	11.80	22.00	1.53	211.54
Little River	6195	50-Year	1920.00	11.80	24.47	1.67	257.13
Little River	6195	100-Year	2330.00	11.80	26.15	1.62	286.36
Little River	6195	500-Year	3520.00	11.80	28.89	1.78	392.21
Little River	6115	10-Year	1160.00	13.80	21.62	4.44	82.95
Little River	6115	50-Year	1920.00	13.80	24.04	4.98	114.64
Little River	6115	100-Year	2330.00	13.80	25.76	4.89	137.14
Little River	6115	500-Year	3520.00	13.80	28.64	4.55	330.99
Little River	6095		Bridge				
Little River	6075	10-Year	1160.00	13.50	20.72	5.00	75.19
Little River	6075	50-Year	1920.00	13.50	22.74	5.76	101.56
Little River	6075	100-Year	2330.00	13.50	24.27	5.64	121.54
Little River	6075	500-Year	3520.00	13.50	28.24	4.62	325.96
Little River	6015	10-Year	1160.00	11.66	20.63	3.45	56.20
Little River	6015	50-Year	1920.00	11.66	22.63	4.38	146.70
Little River	6015	100-Year	2330.00	11.66	24.24	4.01	317.05
Little River	6015	500-Year	3520.00	11.66	28.26	2.83	430.93
Little River	5995	10-Year	1160.00	11.63	20.72	1.57	294.79
Little River	5995	50-Year	1920.00	11.63	22.79	1.73	347.46
Little River	5995	100-Year	2330.00	11.63	24.35	1.62	369.95
Little River	5995	500-Year	3520.00	11.63	28.29	1.46	479.67
Little River	5975	10-Year	1160.00	11.61	20.72	1.32	181.31
Little River	5975	50-Year	1920.00	11.61	22.79	1.58	210.23
Little River	5975	100-Year	2330.00	11.61	24.34	1.57	236.99
Little River	5975	500-Year	3520.00	11.61	28.28	1.54	429.99
Little River	5775	10-Year	1160.00	11.36	20.46	3.08	201.32
Little River	5775	50-Year	1920.00	11.36	22.59	2.97	223.36
Little River	5775	100-Year	2330.00	11.36	24.21	2.65	240.39
Little River	5775	500-Year	3520.00	11.36	28.22	2.23	392.72
Little River	5690	10-Year	1160.00	11.26	20.36	1.86	206.90
Little River	5690	50-Year	1920.00	11.26	22.56	1.78	223.85

HEC-RAS Plan: FO PostGradation Model River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	5690	100-Year	2330.00	11.26	24.19	1.63	235.55
Little River	5690	500-Year	3520.00	11.26	28.21	1.49	346.14
Little River	5510	10-Year	1160.00	11.04	20.28	1.16	184.96
Little River	5510	50-Year	1920.00	11.04	22.50	1.36	199.74
Little River	5510	100-Year	2330.00	11.04	24.16	1.35	209.99
Little River	5510	500-Year	3520.00	11.04	28.19	1.37	351.32
Little River	5430	10-Year	1160.00	10.94	20.24	1.54	128.61
Little River	5430	50-Year	1920.00	10.94	22.45	1.85	149.05
Little River	5430	100-Year	2330.00	10.94	24.11	1.85	164.55
Little River	5430	500-Year	3520.00	10.94	28.15	1.88	349.60
Little River	5160	10-Year	1160.00	10.61	20.13	1.20	250.97
Little River	5160	50-Year	1920.00	10.61	22.38	1.25	276.79
Little River	5160	100-Year	2330.00	10.61	24.07	1.18	289.42
Little River	5160	500-Year	3520.00	10.61	28.14	1.13	468.71
Little River	4875	10-Year	1160.00	10.26	19.83	2.40	118.43
Little River	4875	50-Year	1920.00	10.26	22.17	2.46	136.21
Little River	4875	100-Year	2330.00	10.26	23.92	2.32	142.02
Little River	4875	500-Year	3520.00	10.26	28.03	2.24	332.17
Little River	4850	10-Year	1160.00	10.23	19.73	2.94	79.46
Little River	4850	50-Year	1920.00	10.23	22.06	3.27	99.54
Little River	4850	100-Year	2330.00	10.23	23.82	3.13	113.71
Little River	4850	500-Year	3520.00	10.23	27.96	3.02	302.47
Little River	4495	10-Year	1160.00	9.79	19.37	1.40	262.64
Little River	4495	50-Year	1920.00	9.79	21.95	1.24	290.68
Little River	4495	100-Year	2330.00	9.79	23.79	1.12	306.83
Little River	4495	500-Year	3520.00	9.79	27.98	1.06	400.64
Little River	4370	10-Year	1160.00	9.64	18.99	3.54	89.64
Little River	4370	50-Year	1920.00	9.64	21.76	2.99	189.60
Little River	4370	100-Year	2330.00	9.64	23.67	2.51	322.61
Little River	4370	500-Year	3520.00	9.64	27.94	1.85	605.05
Little River	4060	10-Year	1160.00	9.26	18.51	2.25	88.59
Little River	4060	50-Year	1920.00	9.26	21.46	2.40	119.43
Little River	4060	100-Year	2330.00	9.26	23.49	2.30	141.30
Little River	4060	500-Year	3520.00	9.26	27.82	2.25	381.35
Little River	4030	10-Year	1160.00	9.22	18.43	2.64	111.57
Little River	4030	50-Year	1920.00	9.22	21.44	2.36	137.10
Little River	4030	100-Year	2330.00	9.22	23.48	2.16	143.89
Little River	4030	500-Year	3520.00	9.22	27.81	2.07	443.85
Little River	4000	10-Year	1160.00	9.19	18.34	2.99	64.04
Little River	4000	50-Year	1920.00	9.19	21.33	3.21	116.50
Little River	4000	100-Year	2330.00	9.19	23.39	3.00	147.06

HEC-RAS Plan: FO PostGradation Model River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	4000	500-Year	3520.00	9.19	27.76	2.80	249.25
Little River	3850	10-Year	1160.00	9.00	18.29	1.51	141.60
Little River	3850	50-Year	1920.00	9.00	21.33	1.57	163.46
Little River	3850	100-Year	2330.00	9.00	23.41	1.50	201.74
Little River	3850	500-Year	3520.00	9.00	27.78	1.50	374.18
Little River	3555	10-Year	1160.00	8.00	18.01	2.53	86.24
Little River	3555	50-Year	1920.00	8.00	21.13	2.52	114.69
Little River	3555	100-Year	2330.00	8.00	23.26	2.35	160.73
Little River	3555	500-Year	3520.00	8.00	27.69	2.18	376.30
Little River	3375	10-Year	1160.00	8.42	17.85	1.92	122.78
Little River	3375	50-Year	1920.00	8.42	21.05	1.93	136.49
Little River	3375	100-Year	2330.00	8.42	23.21	1.84	145.77
Little River	3375	500-Year	3520.00	8.42	27.66	1.82	482.16
Little River	3300	10-Year	1160.00	8.33	17.75	2.30	93.27
Little River	3300	50-Year	1920.00	8.33	20.98	2.30	111.11
Little River	3300	100-Year	2330.00	8.33	23.16	2.18	120.83
Little River	3300	500-Year	3520.00	8.33	27.62	2.20	358.24
Little River	3150	10-Year	1160.00	8.14	17.47	3.12	56.77
Little River	3150	50-Year	1920.00	8.14	20.74	3.37	69.82
Little River	3150	100-Year	2330.00	8.14	22.98	3.24	98.56
Little River	3150	500-Year	3520.00	8.14	27.48	3.18	227.29
Little River	2805	10-Year	1160.00	7.72	16.31	4.55	55.95
Little River	2805	50-Year	1920.00	7.72	20.09	3.83	75.14
Little River	2805	100-Year	2330.00	7.72	22.61	3.35	119.82
Little River	2805	500-Year	3520.00	7.72	27.31	2.95	303.64
Little River	2775	10-Year	1160.00	7.68	16.23	3.87	70.76
Little River	2775	50-Year	1920.00	7.68	20.10	3.08	187.07
Little River	2775	100-Year	2330.00	7.68	22.65	2.55	263.38
Little River	2775	500-Year	3520.00	7.68	27.35	2.15	404.52
Little River	2645	10-Year	1160.00	7.30	16.08	2.38	82.82
Little River	2645	50-Year	1920.00	7.30	20.04	2.27	112.46
Little River	2645	100-Year	2330.00	7.30	22.60	2.05	125.27
Little River	2645	500-Year	3520.00	7.30	27.30	2.05	256.76
Little River	2550	10-Year	1160.00	7.30	15.97	2.42	82.41
Little River	2550	50-Year	1920.00	7.30	19.98	2.29	97.74
Little River	2550	100-Year	2330.00	7.30	22.57	2.06	125.22
Little River	2550	500-Year	3520.00	7.30	27.28	2.05	254.77
Little River	2480	10-Year	1160.00	7.32	15.52	4.62	46.25
Little River	2480	50-Year	1920.00	7.32	19.70	3.92	68.82
Little River	2480	100-Year	2330.00	7.32	22.38	3.35	84.10
Little River	2480	500-Year	3520.00	7.32	27.22	2.65	490.06

HEC-RAS Plan: FO PostGradation Model River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	2461	10-Year	1160.00	7.30	15.56	3.14	48.48
Little River	2461	50-Year	1920.00	7.30	19.70	3.32	52.24
Little River	2461	100-Year	2330.00	7.30	22.37	3.23	56.14
Little River	2461	500-Year	3520.00	7.30	27.16	3.08	376.75
Little River	2451	10-Year	1160.00	7.29	15.57	1.87	75.06
Little River	2451	50-Year	1920.00	7.29	19.71	2.06	75.10
Little River	2451	100-Year	2330.00	7.29	22.38	2.06	75.12
Little River	2451	500-Year	3520.00	7.29	27.17	2.19	285.48
Little River	2450		Inl Struct				
Little River	2449	10-Year	1160.00	7.28	15.54	1.87	75.06
Little River	2449	50-Year	1920.00	7.28	19.67	2.06	75.10
Little River	2449	100-Year	2330.00	7.28	22.33	2.06	75.12
Little River	2449	500-Year	3520.00	7.28	27.11	2.29	279.21
Little River	2430	10-Year	1160.00	7.26	15.51	2.11	68.44
Little River	2430	50-Year	1920.00	7.26	19.65	2.29	70.83
Little River	2430	100-Year	2330.00	7.26	22.31	2.26	73.84
Little River	2430	500-Year	3520.00	7.26	27.10	2.41	382.68
Little River	2420	10-Year	1160.00	7.25	15.50	2.21	71.22
Little River	2420	50-Year	1920.00	7.25	19.64	2.32	74.59
Little River	2420	100-Year	2330.00	7.25	22.30	2.27	76.78
Little River	2420	500-Year	3520.00	7.25	27.10	2.41	357.67
Little River	2415	10-Year	1160.00	7.24	15.49	2.35	65.06
Little River	2415	50-Year	1920.00	7.24	19.62	2.52	65.10
Little River	2415	100-Year	2330.00	7.24	22.28	2.49	65.12
Little River	2415	500-Year	3520.00	7.24	27.06	2.77	265.13
Little River	2380	10-Year	1160.00	6.25	15.09	4.96	45.89
Little River	2380	50-Year	1920.00	6.25	19.12	5.54	45.94
Little River	2380	100-Year	2330.00	6.25	21.78	5.53	45.97
Little River	2380	500-Year	3520.00	6.25	27.00	3.59	282.76
Little River	2342.5		Bridge				
Little River	2305	10-Year	1160.00	6.25	15.02	5.09	45.89
Little River	2305	50-Year	1920.00	6.25	18.45	5.93	45.93
Little River	2305	100-Year	2330.00	6.25	20.12	6.29	45.95
Little River	2305	500-Year	3520.00	6.25	26.64	3.09	604.52
Little River	2273	10-Year	1160.00	7.07	15.13	3.15	54.54
Little River	2273	50-Year	1920.00	7.07	18.62	3.38	59.48
Little River	2273	100-Year	2330.00	7.07	20.32	3.47	62.43
Little River	2273	500-Year	3520.00	7.07	26.60	2.89	313.83
Little River	2255	10-Year	1160.00	7.05	15.13	3.08	47.14

HEC-RAS Plan: FO PostGradation Model River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	2255	50-Year	1920.00	7.05	18.60	3.55	47.62
Little River	2255	100-Year	2330.00	7.05	20.29	3.75	53.20
Little River	2255	500-Year	3520.00	7.05	26.57	3.23	239.76
Little River	2218	10-Year	1160.00	7.00	14.85	4.99	34.36
Little River	2218	50-Year	1920.00	7.00	18.30	5.38	38.29
Little River	2218	100-Year	2330.00	7.00	19.99	5.52	43.48
Little River	2218	500-Year	3520.00	7.00	26.44	4.30	289.49
Little River	1825	10-Year	1160.00	6.80	14.64	4.51	44.20
Little River	1825	50-Year	1920.00	6.80	18.20	4.75	54.38
Little River	1825	100-Year	2330.00	6.80	19.93	4.80	60.09
Little River	1825	500-Year	3520.00	6.80	26.40	4.12	79.95
Little River	1775 FEMA Section A	10-Year	1160.00	5.20	14.62	4.24	39.49
Little River	1775 FEMA Section A	50-Year	1920.00	5.20	18.09	4.93	42.32
Little River	1775 FEMA Section A	100-Year	2330.00	5.20	19.77	5.24	43.68
Little River	1775 FEMA Section A	500-Year	3520.00	5.20	26.09	5.38	48.83
Little River	1750		Bridge				
Little River	0010	10-Year	1160.00	-3.30	0.61	14.09	274.73
Little River	0010	50-Year	1920.00	-3.30	1.48	17.36	449.45
Little River	0010	100-Year	2330.00	-3.30	1.90	18.75	533.83
Little River	0010	500-Year	3520.00	-3.30	2.88	22.52	731.32
Little River	0	10-Year	1160.00	-3.30	1.60	1.49	664.57
Little River	0	50-Year	1920.00	-3.30	1.60	2.46	664.57
Little River	0	100-Year	2330.00	-3.30	1.60	2.99	664.57
Little River	0	500-Year	3520.00	-3.30	-0.88	32.56	229.04

ATTACHMENT 10 - SEDIMENT SIEVE AND MOBILITY ANALYSIS RESULTS



MAP REFERENCE

THIS MAP WAS PREPARED FROM USGS COLOR ORTHO IMAGERY (2019)

SOURCE: OFFICE OF GEOGRAPHIC AND ENVIRONMENTAL INFORMATION (MASSGIS), COMMONWEALTH OF MASSACHUSETTS EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS

LEGEND

TRANSECT

SCALE:
HORZ.: 1" = 500'
VERT.:
DATUM:
HORZ.:
VERT.:
0 250 500
GRAPHIC SCALE

FUSS & O'NEILL
1550 MAIN STREET, SUITE 400
SPRINGFIELD, MA 01103
413.452.0445
www.fando.com

CITY OF HAVERHILL

TRANSECT LOCATION MAP

LITTLE RIVER DAM

HAVERHILL MASSACHUSETTS

PROJ. No.: 20170390.U20
DATE: NOVEMBER 2020

FIGURE 2

File Path: J:\DWG\P20170390\U20\Environmental\20170390.U20_STP.dwg Layout: 08.5X11-P Plotted: Thu, December 10, 2020 - 9:21 AM User: sdevincentis
Plotter: DWG TO PDF.PC3 CTB File: FO.STB
LAYER STATE:
MS VIEW:

THIELSCH ENGINEERING

195 Frances Avenue
Cranston RI, 02910
Phone: (401)-467-6454
Fax: (401)-467-2398
thielsch.com
Let's Build a Solid Foundation

Client Information:
Fuss & O'Neil
North Quincy, MA
PM: Matt Kissane
Assigned By: Matt Kissane
Collected By: Client

Project Information:
MVP Action Grant RY21
Haverhill, MA
F&ON Project Number: 201703901.V20
Summary Page: 1 of 1
Report Date: 11.23.2020

LABORATORY TESTING DATA SHEET, Report No.: 7420-L-155

Source	Sample No.	Depth (Ft)	Laboratory No.	Identification Tests								Proctor / CBR / Permeability Tests								Laboratory Log and Soil Description
				As Received Water Content %	LL %	PL %	Gravel %	Sand %	Fines %	Org. %	G_s	Dry unit wt. pcf	Test Water Content %	γ_d MAX (pcf) W_{opt} (%)	γ_d MAX (pcf) W_{opt} (%) (Corr.)	Target Test Setup as % of Proctor	CBR @ 0.1"	CBR @ 0.2"	Permeability cm/sec	
				D2216	D4318		D6913			D2974	D854			D1557						
Boring	1543201117-02	-	20-S-3562	106.9			9.4	67.3	23.3											Brown silty sand
Boring	1543201117-03	-	20-S-3563	50.1			22.0	71.3	6.7											Brown poorly graded sand with silt and gravel
Boring	1543201117-04	-	20-S-3564	91.0			2.3	53.0	44.7											Brown silty sand

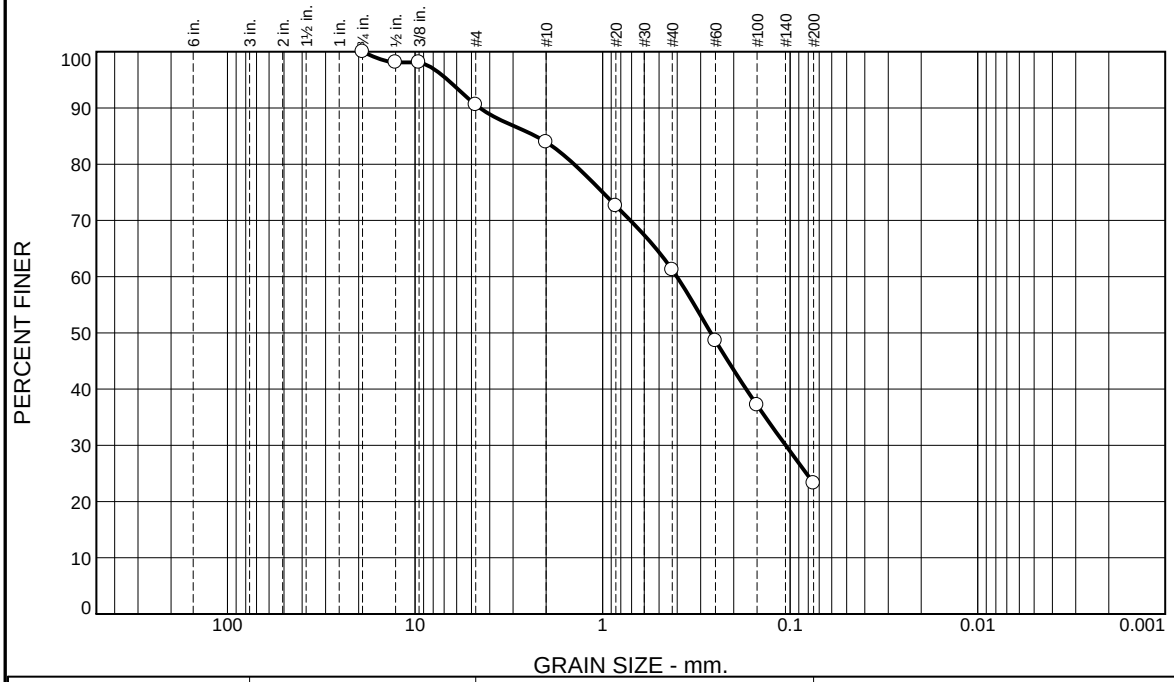
Date Received: *11.19.2020*

Reviewed By: SAH

Date Reviewed: *11.23.2020*

This report only relates to items inspect and/or tested. No warranty, expressed or implied, is made.
This report shall not be reproduced, except in full, without prior written approval from the Agency, as defined in ASTM E329.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	9.4	6.7	22.7	37.9	23.3	

Test Results (C136 & ASTM C 117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.75"	100.0		
0.5"	98.1		
0.375"	98.1		
#4	90.6		
#10	83.9		
#20	72.6		
#40	61.2		
#60	48.6		
#100	37.1		
#200	23.3		

* (no specification provided)

Material Description

Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 4.5071 D_{85}= 2.2730 D_{60}= 0.4016
D_{50}= 0.2647 D_{30}= 0.1056 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 11.19.2020 **Date Tested:** 11.23.2020

Tested By: AV

Checked By: Steven Accetta

Title: Laboratory Coordinator

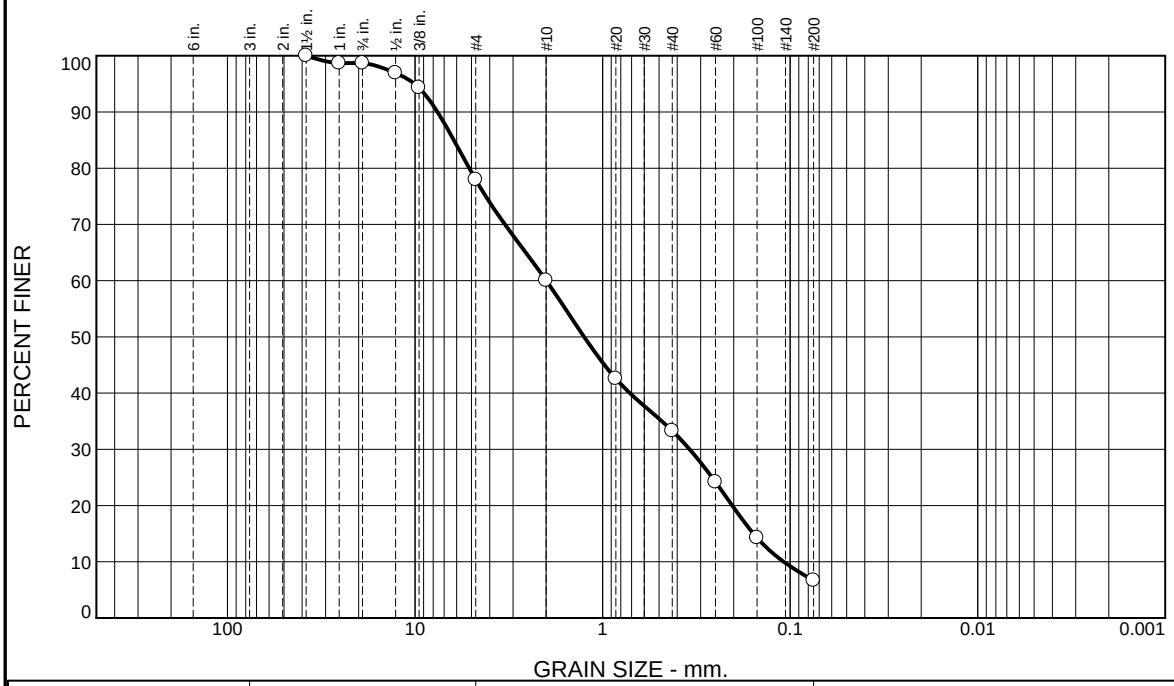
Source of Sample: Borings **Date Sampled:**
Sample Number: 1543201117-02

Thielsch Engineering Inc.

Cranston, RI

Client: Fuss & O'Neil
Project: MVP Action Grant RY21
Haverhill, MA
Project No: 20170390.V20 **Figure** 20-S-3562

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	1.3	20.7	18.0	26.7	26.6	6.7	

Test Results (C136 & ASTM C 117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100.0		
1"	98.7		
0.75"	98.7		
0.5"	96.9		
0.375"	94.3		
#4	78.0		
#10	60.0		
#20	42.6		
#40	33.3		
#60	24.2		
#100	14.3		
#200	6.7		

* (no specification provided)

Material Description

Brown poorly graded sand with silt and gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 7.5833 D_{85}= 6.2094 D_{60}= 1.9954
D_{50}= 1.2535 D_{30}= 0.3433 D_{15}= 0.1567
D_{10}= 0.1083 C_u= 18.42 C_c= 0.55

Remarks

Date Received: 11.19.2020 **Date Tested:** 11.23.2020

Tested By: AV

Checked By: Rebecca Roth

Title: Laboratory Coordinator

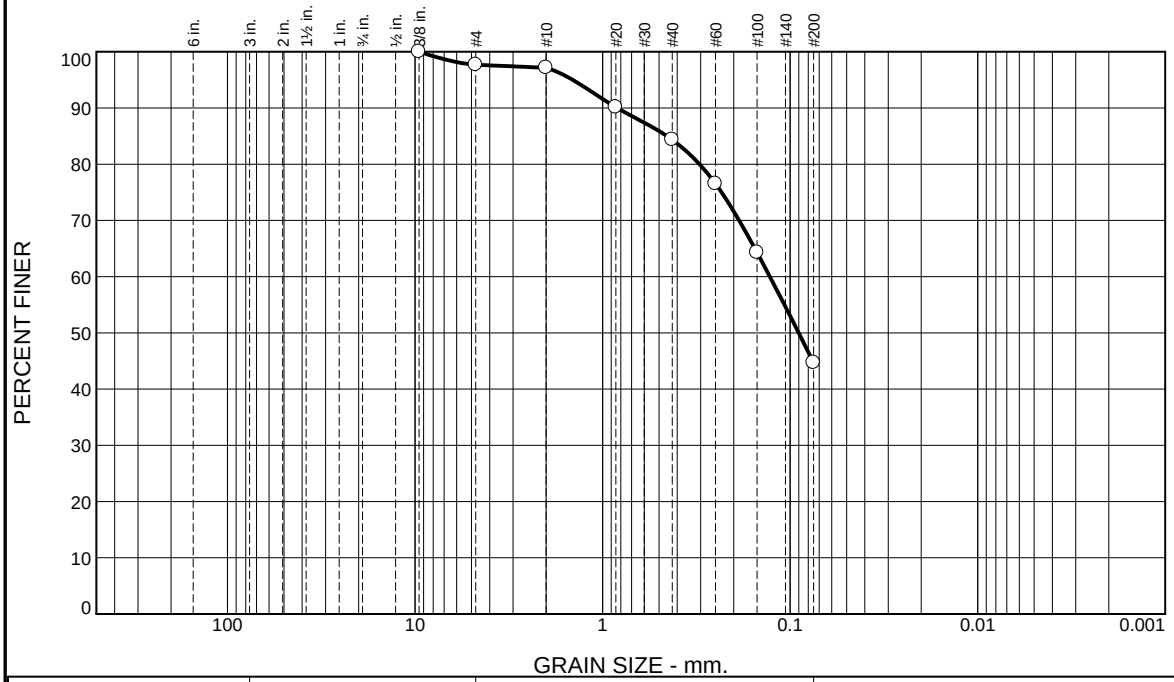
Source of Sample: Borings **Date Sampled:**
Sample Number: 1543201117-03

Thielsch Engineering Inc.

Cranston, RI

Client: Fuss & O'Neil
Project: MVP Action Grant RY21
Haverhill, MA
Project No: 20170390.V20 **Figure** 20-S-3563

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.3	0.5	12.9	39.6	44.7	

Test Results (C136 & ASTM C 117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.375"	100.0		
#4	97.7		
#10	97.2		
#20	90.1		
#40	84.3		
#60	76.5		
#100	64.3		
#200	44.7		

* (no specification provided)

Material Description

Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.8363 D_{85}= 0.4536 D_{60}= 0.1282
D_{50}= 0.0901 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 11.19.2020 **Date Tested:** 11.23.2020

Tested By: AV

Checked By: Rebecca Roth

Title: Laboratory Coordinator

Source of Sample: Borings **Date Sampled:**
Sample Number: 1543201117-04

Thielsch Engineering Inc.

Cranston, RI

Client: Fuss & O'Neil
Project: MVP Action Grant RY21
Haverhill, MA
Project No: 20170390.V20 **Figure** 20-S-3564

Little River Dam Removal
Sediment Mobility Calculations
April 6, 2021

Location	Description	Average Hydr Depth (feet)	Average n-value	Average d50 Sed. (mm)	Average D50 sed ft
Transect 1: RS 2450 - RS 2480	Sample 02	0.56	0.05061111	0.2647	0.00086848
Transect 2: RS 3850 - RS 4000	Sample 03	0.67	0.065	1.2535	0.00411273
Transect 3: RS 5510	Sample 04	0.72	0.03	0.0901	0.00029562

Table 7: Post Dam Removal Flow Depths and Critical Flow Velocities (for report)

nsection Loca	Post Dam Removal Channel Depths (feet)				Post Dam Removal Critical Flow Velocities (fps)			
	Base Condition (Low) Flow Condition	10-Year Flood	50-Year Flood	100-Year Flood	Base Condition (Low) Flow Condition	10-Year Flood	50-Year Flood	100-Year Flood
1	0.56	7.10	10.19	12.06	0.10	0.15	0.16	0.16
2	0.67	5.75	8.23	10.30	0.17	0.24	0.25	0.26
3	0.72	5.45	7.68	9.33	0.07	0.10	0.10	0.11

Table 8: Post Dam Removal Flow Depths and Critical Flow Velocities (for report)

nsection Loca	Post Dam Removal Computed Average Flow Velocities (fps)				Potential for Sediment Mobility			
	Base Condition (Low) Flow Condition	10-Year Flood	50-Year Flood	100-Year Flood	Base Condition (Low) Flow Condition	10-Year Flood	50-Year Flood	100-Year Flood
1	0.57	3.21	3.1	2.88	High	High	High	High
2	0.59	2.25	2.39	2.25	High	High	High	High
3	0.53	1.16	1.36	1.35	High	High	High	High

River	Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Hydr Depth C (ft)	Max Chl Dpth (ft)
Little River	Little River	5510	10-Year	1160	11.04	20.28	1.16	5.45	9.24
Little River	Little River	5510	50-Year	1920	11.04	22.5	1.36	7.68	11.46
Little River	Little River	5510	100-Year	2330	11.04	24.16	1.35	9.33	13.12
Little River	Little River	5510	Base Conditio	9.8	11.04	12.48	0.53	0.72	1.44
Little River	Little River	4000	10-Year	1160	9.19	18.34	2.99	6.06	9.15
Little River	Little River	4000	50-Year	1920	9.19	21.33	3.21	8.49	12.14
Little River	Little River	4000	100-Year	2330	9.19	23.39	3	10.55	14.2
Little River	Little River	4000	Base Conditio	9.8	9.19	10.45	0.55	0.69	1.26
Little River	Little River	3850	10-Year	1160	9	18.29	1.51	5.43	9.29
Little River	Little River	3850	50-Year	1920	9	21.33	1.57	7.97	12.33
Little River	Little River	3850	100-Year	2330	9	23.41	1.5	10.04	14.41
Little River	Little River	3850	Base Conditio	9.8	9	10.28	0.63	0.64	1.28
Little River	Little River	2480	10-Year	1160	7.32	15.52	4.62	5.43	8.2
Little River	Little River	2480	50-Year	1920	7.32	19.7	3.92	7.11	12.38
Little River	Little River	2480	100-Year	2330	7.32	22.38	3.35	8.26	15.06
Little River	Little River	2480	Base Conditio	9.8	7.32	7.89	1.06	0.54	0.57
Little River	Little River	2461	10-Year	1160	7.3	15.56	3.14	7.62	8.26
Little River	Little River	2461	50-Year	1920	7.3	19.7	3.32	11.06	12.4
Little River	Little River	2461	100-Year	2330	7.3	22.37	3.23	12.86	15.07
Little River	Little River	2461	Base Conditio	9.8	7.3	7.87	0.42	0.57	0.57
Little River	Little River	2451	10-Year	1160	7.29	15.57	1.87	8.26	8.28
Little River	Little River	2451	50-Year	1920	7.29	19.71	2.06	12.4	12.42
Little River	Little River	2451	100-Year	2330	7.29	22.38	2.06	15.07	15.09
Little River	Little River	2451	Base Conditio	9.8	7.29	7.87	0.23	0.57	0.58

ATTACHMENT 11 - PRE- VERSUS POST-DAM REMOVAL HEC-RAS SUMMARY PROFILE AND RESULTS (FOR BASE FLOW CONDITIONS)

HEC-RAS Model Plan: 1) FO PostGradation Model 4/5/2021 2) FO PreCondit 3/23/2021

Little River Little River

Legend

WS Base Condition - FO PostGradation Model

WS Base Condition - FO PreCondit

Ground

Little River Conduit

Winter Street Bridge

MBTA RR Bridge

Valley Pipe Support

Rosemont Street Bridge

I-495 Bridges

Elevation (ft)

40
30
20
10
0
-10

0
2000
4000
6000
8000
10000
12000
14000
16000

Main Channel Distance (ft)

1750 Little River Conduit
2218 F&O Added Section 1A
2342.5 Winter Street Bridge (FEMA LR2-S)...
2550 FEMA RS10775 (Computed Section 100 ft ...
2775 FEMA RS11000 (Scaled Section)
3150 F&O Added Section 4
3300 F&O Added Section 5
3555 F&O Added Section 6
3850 F&O Added Section 7
4000 F&O Added Section 8A
4370 F&O Added Section 8C
4850 F&O Added Section 10
5160 F&O Added Section 11
5430 F&O Added Section 12A
5690 F&O Added Section 13A
5975 FEMA RS14200 (Scaled Section D/S of LR4-S U/S of...
6195 FEMA RS 14420 (G - Surveyed Section U/S of LR4-S)...
7452 FEMA RS 15677 (Computed Section D/S of LR5-S)
7950 FEMA RS 16175 (Scaled Section at Widening of Floo...
8185 FEMA RS 16410 (I - Surveyed Section LR6)
9455 FEMA RS 17680 (Scaled Section)
10915 FEMA RS 19140 (J - Surveyed Section D/S of LR7-S [RTE 495]...
11085 FEMA RS 19310 (Scaled Section D/S Face of RTE 495) Embankme...
11325 FEMA RS 19550 (K - Surveyed Section U/S Face of RTE 495 Embank...
12187 FEMA RS 20412 (Computed Section)
12987 FEMA RS 21212 (M - Surveyed Section LR8)
14787 FEMA RS 23012 (Approximated Section)
15107 FEMA RS 23332 (Approximated Section D/S of LR9-S)
15341 FEMA RS 23566 (O - Surveyed Section U/S LR9-S)

HEC-RAS River: Little River Reach: Little River Profile: Base Condition

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Max Chl Dpth	Vel Chnl	Top Width
				(cfs)	(ft)	(ft)	(ft)	(ft/s)	(ft)
Little River	15341	Base Condition	FO PostGradation Model	9.80	18.40	24.10	5.70	0.17	75.83
Little River	15341	Base Condition	FO PreCondit	9.80	18.40	24.10	5.70	0.17	75.83
Little River	15241	Base Condition	FO PostGradation Model	9.80	21.90	24.10	2.20	0.28	18.87
Little River	15241	Base Condition	FO PreCondit	9.80	21.90	24.10	2.20	0.28	18.87
Little River	15224			Bridge					
Little River	15207	Base Condition	FO PostGradation Model	9.80	21.90	24.10	2.20	0.29	18.87
Little River	15207	Base Condition	FO PreCondit	9.80	21.90	24.10	2.20	0.29	18.87
Little River	15107	Base Condition	FO PostGradation Model	9.80	22.20	24.09	1.89	0.44	23.61
Little River	15107	Base Condition	FO PreCondit	9.80	22.20	24.09	1.89	0.44	23.61
Little River	14787	Base Condition	FO PostGradation Model	9.80	23.20	23.93	0.73	1.03	26.16
Little River	14787	Base Condition	FO PreCondit	9.80	23.20	23.93	0.73	1.03	26.16
Little River	12987	Base Condition	FO PostGradation Model	9.80	20.90	21.80	0.90	0.55	35.63
Little River	12987	Base Condition	FO PreCondit	9.80	20.90	21.80	0.90	0.55	35.63
Little River	12187	Base Condition	FO PostGradation Model	9.80	20.40	21.26	0.86	0.60	34.82
Little River	12187	Base Condition	FO PreCondit	9.80	20.40	21.26	0.86	0.60	34.82
Little River	11387	Base Condition	FO PostGradation Model	9.80	20.00	20.99	0.99	0.41	31.95
Little River	11387	Base Condition	FO PreCondit	9.80	20.00	20.99	0.99	0.41	31.95
Little River	11381	Base Condition	FO PostGradation Model	9.80	20.70	20.91	0.21	2.00	30.41
Little River	11381	Base Condition	FO PreCondit	9.80	20.70	20.91	0.21	2.00	30.41
Little River	11375	Base Condition	FO PostGradation Model	9.80	17.80	18.65	0.85	0.70	25.61
Little River	11375	Base Condition	FO PreCondit	9.80	17.80	18.65	0.85	0.70	25.63
Little River	11325	Base Condition	FO PostGradation Model	9.80	17.40	18.54	1.14	1.47	11.75
Little River	11325	Base Condition	FO PreCondit	9.80	17.40	18.54	1.14	1.46	11.77
Little River	11205	Base Condition	FO PostGradation Model	9.80	16.95	18.09	1.14	1.47	11.73
Little River	11205	Base Condition	FO PreCondit	9.80	16.95	18.10	1.15	1.44	11.85
Little River	11085	Base Condition	FO PostGradation Model	9.80	16.50	17.66	1.16	1.41	11.99
Little River	11085	Base Condition	FO PreCondit	9.80	16.50	17.82	1.32	1.09	13.61
Little River	11000	Base Condition	FO PostGradation Model	9.80	16.25	17.41	1.16	1.26	13.40
Little River	11000	Base Condition	FO PreCondit	9.80	16.25	17.73	1.48	0.77	17.14
Little River	10915	Base Condition	FO PostGradation Model	9.80	16.00	16.91	0.91	2.03	10.57
Little River	10915	Base Condition	FO PreCondit	9.80	16.00	17.68	1.68	0.60	19.45
Little River	9455	Base Condition	FO PostGradation Model	9.80	13.10	15.13	2.03	0.61	15.73
Little River	9455	Base Condition	FO PreCondit	9.80	13.10	17.66	4.56	0.11	51.89
Little River	8185	Base Condition	FO PostGradation Model	9.80	11.40	15.03	3.63	0.19	28.11
Little River	8185	Base Condition	FO PreCondit	9.80	11.40	17.66	6.26	0.06	48.40
Little River	7950	Base Condition	FO PostGradation Model	9.80	11.90	15.02	3.12	0.26	24.15
Little River	7950	Base Condition	FO PreCondit	9.80	11.90	17.66	5.76	0.08	44.53
Little River	7488	Base Condition	FO PostGradation Model	9.80	12.80	14.95	2.15	0.41	28.19
Little River	7488	Base Condition	FO PreCondit	9.80	12.80	17.66	4.86	0.07	48.44
Little River	7478	Base Condition	FO PostGradation Model	9.80	12.80	14.95	2.15	0.41	28.11
Little River	7478	Base Condition	FO PreCondit	9.80	12.80	17.66	4.86	0.07	48.44
Little River	7475			Bridge					
Little River	7472	Base Condition	FO PostGradation Model	9.80	12.80	14.94	2.14	0.41	28.01
Little River	7472	Base Condition	FO PreCondit	9.80	12.80	17.66	4.86	0.07	48.44
Little River	7452	Base Condition	FO PostGradation Model	9.80	12.80	14.94	2.14	0.42	27.84
Little River	7452	Base Condition	FO PreCondit	9.80	12.80	17.66	4.86	0.07	48.44
Little River	6195	Base Condition	FO PostGradation Model	9.80	11.80	14.86	3.06	0.15	43.63
Little River	6195	Base Condition	FO PreCondit	9.80	11.80	17.65	5.85	0.04	83.53
Little River	6115	Base Condition	FO PostGradation Model	9.80	13.80	14.83	1.03	1.11	17.20
Little River	6115	Base Condition	FO PreCondit	9.80	13.80	17.65	3.85	0.11	41.33

HEC-RAS River: Little River Reach: Little River Profile: Base Condition (Continued)

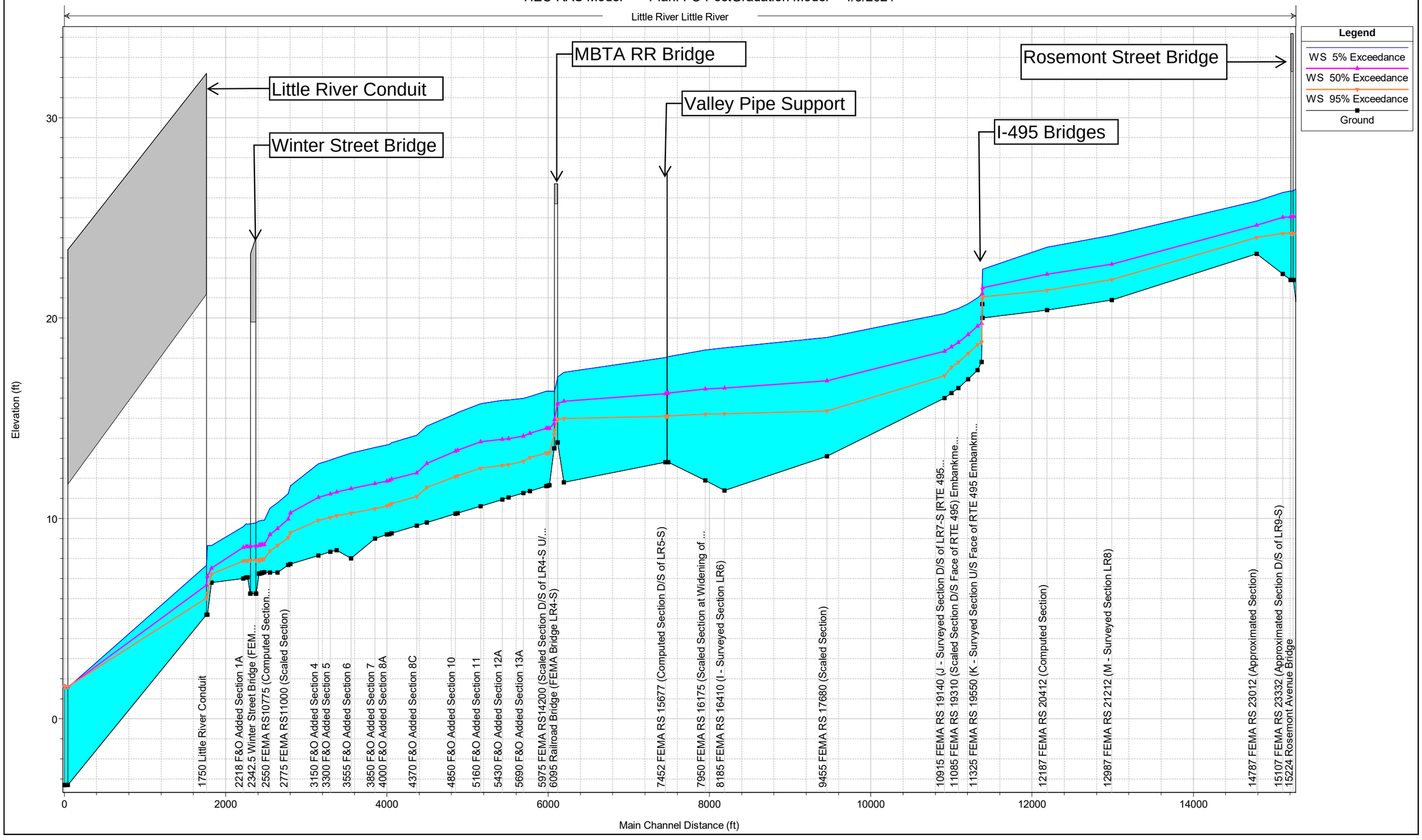
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Max Chl Dpth	Vel Chnl	Top Width
				(cfs)	(ft)	(ft)	(ft)	(ft/s)	(ft)
Little River	6095			Bridge					
Little River	6075	Base Condition	FO PostGradation Model	9.80	13.50	14.12	0.62	3.08	10.32
Little River	6075	Base Condition	FO PreCondit	9.80	13.50	17.65	4.15	0.10	43.53
Little River	6015	Base Condition	FO PostGradation Model	9.80	11.66	13.09	1.43	0.21	32.93
Little River	6015	Base Condition	FO PreCondit	9.80	16.10	17.65	1.55	0.23	35.70
Little River	5995	Base Condition	FO PostGradation Model	9.80	11.63	13.09	1.46	0.22	47.16
Little River	5995	Base Condition	FO PreCondit	9.80	11.70	17.65	5.95	0.03	98.11
Little River	5975	Base Condition	FO PostGradation Model	9.80	11.61	13.08	1.47	0.38	34.76
Little River	5975	Base Condition	FO PreCondit	9.80	13.40	17.65	4.25	0.03	132.43
Little River	5775	Base Condition	FO PostGradation Model	9.80	11.36	12.85	1.49	1.27	10.33
Little River	5775	Base Condition	FO PreCondit	9.80	13.10	17.65	4.55	0.07	59.99
Little River	5690	Base Condition	FO PostGradation Model	9.80	11.26	12.67	1.41	0.67	20.83
Little River	5690	Base Condition	FO PreCondit	9.80	11.80	17.65	5.85	0.04	78.92
Little River	5510	Base Condition	FO PostGradation Model	9.80	11.04	12.48	1.44	0.53	25.57
Little River	5510	Base Condition	FO PreCondit	9.80	11.20	17.65	6.45	0.02	174.72
Little River	5430	Base Condition	FO PostGradation Model	9.80	10.94	12.45	1.51	0.30	43.23
Little River	5430	Base Condition	FO PreCondit	9.80	11.40	17.65	6.25	0.02	105.60
Little River	5160	Base Condition	FO PostGradation Model	9.80	10.61	12.31	1.70	0.72	16.09
Little River	5160	Base Condition	FO PreCondit	9.80	11.20	17.65	6.45	0.02	183.18
Little River	4875	Base Condition	FO PostGradation Model	9.80	10.26	11.94	1.68	0.73	15.98
Little River	4875	Base Condition	FO PreCondit	9.80	12.10	17.65	5.55	0.04	80.33
Little River	4850	Base Condition	FO PostGradation Model	9.80	10.23	11.90	1.67	0.78	15.06
Little River	4850	Base Condition	FO PreCondit	9.80	10.30	17.65	7.35	0.04	64.15
Little River	4495	Base Condition	FO PostGradation Model	9.80	9.79	11.37	1.58	0.73	17.01
Little River	4495	Base Condition	FO PreCondit	9.80	12.90	17.65	4.75	0.03	214.49
Little River	4370	Base Condition	FO PostGradation Model	9.80	9.64	10.95	1.31	1.67	8.97
Little River	4370	Base Condition	FO PreCondit	9.80	15.30	17.65	2.35	0.13	65.60
Little River	4060	Base Condition	FO PostGradation Model	9.80	9.26	10.56	1.30	0.41	33.91
Little River	4060	Base Condition	FO PreCondit	9.80	10.40	17.65	7.25	0.03	83.06
Little River	4030	Base Condition	FO PostGradation Model	9.80	9.22	10.50	1.28	1.27	12.07
Little River	4030	Base Condition	FO PreCondit	9.80	11.10	17.65	6.55	0.03	97.85
Little River	4000	Base Condition	FO PostGradation Model	9.80	9.19	10.45	1.26	0.55	25.88
Little River	4000	Base Condition	FO PreCondit	9.80	10.30	17.65	7.35	0.04	61.63
Little River	3850	Base Condition	FO PostGradation Model	9.80	9.00	10.28	1.28	0.63	24.34
Little River	3850	Base Condition	FO PreCondit	9.80	12.50	17.65	5.15	0.03	136.99
Little River	3555	Base Condition	FO PostGradation Model	9.80	8.00	10.07	2.07	0.48	19.60
Little River	3555	Base Condition	FO PreCondit	9.80	8.00	17.65	9.65	0.02	83.57
Little River	3375	Base Condition	FO PostGradation Model	9.80	8.42	9.95	1.53	0.61	20.88
Little River	3375	Base Condition	FO PreCondit	9.80	10.00	17.65	7.65	0.02	121.93
Little River	3300	Base Condition	FO PostGradation Model	9.80	8.33	9.86	1.53	0.67	19.01
Little River	3300	Base Condition	FO PreCondit	9.80	8.50	17.65	9.15	0.02	92.70
Little River	3150	Base Condition	FO PostGradation Model	9.80	8.14	9.72	1.58	0.53	23.45
Little River	3150	Base Condition	FO PreCondit	9.80	4.80	17.65	12.85	0.02	57.25
Little River	2805	Base Condition	FO PostGradation Model	9.80	7.72	9.14	1.42	1.38	10.02
Little River	2805	Base Condition	FO PreCondit	9.80	11.90	17.65	5.75	0.04	62.54
Little River	2775	Base Condition	FO PostGradation Model	9.80	7.68	8.90	1.22	1.61	10.02
Little River	2775	Base Condition	FO PreCondit	9.80	9.00	17.65	8.65	0.03	113.54
Little River	2645	Base Condition	FO PostGradation Model	9.80	7.30	8.51	1.21	0.63	25.45
Little River	2645	Base Condition	FO PreCondit	9.80	7.30	17.65	10.35	0.02	88.83
Little River	2550	Base Condition	FO PostGradation Model	9.80	7.30	8.26	0.96	1.01	20.13
Little River	2550	Base Condition	FO PreCondit	9.80	7.30	17.65	10.35	0.02	88.83

HEC-RAS River: Little River Reach: Little River Profile: Base Condition (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Max Chl Dpth	Vel Chnl	Top Width
				(cfs)	(ft)	(ft)	(ft)	(ft/s)	(ft)
Little River	2480	Base Condition	FO PostGradation Model	9.80	7.32	7.89	0.57	1.06	17.23
Little River	2480	Base Condition	FO PreCondit	9.80	8.20	17.65	9.45	0.03	56.86
Little River	2461	Base Condition	FO PostGradation Model	9.80	7.30	7.87	0.57	0.42	41.51
Little River	2461	Base Condition	FO PreCondit	9.80	8.50	17.65	9.15	0.02	50.12
Little River	2451	Base Condition	FO PostGradation Model	9.80	7.29	7.87	0.58	0.23	75.00
Little River	2451	Base Condition	FO PreCondit	9.80	8.50	17.62	9.12	1.06	75.07
Little River	2450			Inl Struct					
Little River	2449	Base Condition	FO PostGradation Model	9.80	7.28	7.86	0.58	0.23	75.00
Little River	2449	Base Condition	FO PreCondit	9.80	8.50	17.58	9.08	1.72	75.07
Little River	2430	Base Condition	FO PostGradation Model	9.80	7.26	7.86	0.60	0.25	65.25
Little River	2430	Base Condition	FO PreCondit	9.80	4.80	8.18	3.38	0.10	66.15
Little River	2420	Base Condition	FO PostGradation Model	9.80	7.25	7.84	0.59	0.94	34.44
Little River	2420	Base Condition	FO PreCondit	9.80	7.30	8.18	0.88	0.42	46.86
Little River	2415	Base Condition	FO PostGradation Model	9.80	7.24	7.79	0.55	1.56	25.02
Little River	2415	Base Condition	FO PreCondit	9.80	7.30	8.18	0.88	0.53	45.22
Little River	2380	Base Condition	FO PostGradation Model	9.80	6.25	7.81	1.56	0.32	25.18
Little River	2380	Base Condition	FO PreCondit	9.80	2.30	8.18	5.88	0.11	27.91
Little River	2342.5			Bridge					
Little River	2305	Base Condition	FO PostGradation Model	9.80	6.25	7.80	1.55	0.38	25.56
Little River	2305	Base Condition	FO PreCondit	9.80	6.00	8.18	2.18	0.26	27.91
Little River	2273	Base Condition	FO PostGradation Model	9.80	7.07	7.78	0.71	0.93	24.41
Little River	2273	Base Condition	FO PreCondit	9.80	6.60	8.18	1.58	0.35	37.23
Little River	2255	Base Condition	FO PostGradation Model	9.80	7.05	7.79	0.74	0.29	46.10
Little River	2255	Base Condition	FO PreCondit	9.80	8.00	8.11	0.11	1.91	46.02
Little River	2218	Base Condition	FO PostGradation Model	9.80	7.00	7.78	0.78	0.71	25.53
Little River	2218	Base Condition	FO PreCondit	9.80	7.00	7.78	0.78	0.71	25.53
Little River	1825	Base Condition	FO PostGradation Model	9.80	6.80	7.16	0.36	2.45	21.89
Little River	1825	Base Condition	FO PreCondit	9.80	6.80	7.16	0.36	2.45	21.89
Little River	1775 FEMA Section A	Base Condition	FO PostGradation Model	9.80	5.20	6.18	0.98	1.93	10.40
Little River	1775 FEMA Section A	Base Condition	FO PreCondit	9.80	5.20	6.18	0.98	1.93	10.40
Little River	1750			Bridge					
Little River	0010	Base Condition	FO PostGradation Model	9.80	-3.30	1.60	4.90	0.09	473.78
Little River	0010	Base Condition	FO PreCondit	9.80	-3.30	1.60	4.90	0.10	473.78
Little River	0	Base Condition	FO PostGradation Model	9.80	-3.30	1.60	4.90	0.01	664.57
Little River	0	Base Condition	FO PreCondit	9.80	-3.30	1.60	4.90	0.01	664.57

ATTACHMENT 12 - POST-DAM REMOVAL HEC-RAS RESULTS FOR FISH PASSAGE ASSESSMENT

HEC-RAS Model Plan: FO PostGradation Model 4/5/2021



HEC-RAS Plan: FO PostGradation Model River: Little River Reach: Little River

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Max Chl Dpth
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	15341	5% Exceedance	201.70	18.40	26.54	1.04	8.14
Little River	15341	50% Exceedance	56.30	18.40	25.09	0.58	6.69
Little River	15341	95% Exceedance	13.30	18.40	24.23	0.21	5.83
Little River	15241	5% Exceedance	201.70	21.90	26.37	2.79	4.47
Little River	15241	50% Exceedance	56.30	21.90	25.06	1.12	3.16
Little River	15241	95% Exceedance	13.30	21.90	24.23	0.36	2.33
Little River	15224		Bridge				
Little River	15207	5% Exceedance	201.70	21.90	26.33	2.82	4.43
Little River	15207	50% Exceedance	56.30	21.90	25.06	1.12	3.16
Little River	15207	95% Exceedance	13.30	21.90	24.23	0.36	2.33
Little River	15107	5% Exceedance	201.70	22.20	26.26	1.96	4.06
Little River	15107	50% Exceedance	56.30	22.20	25.02	1.13	2.82
Little River	15107	95% Exceedance	13.30	22.20	24.22	0.52	2.02
Little River	14787	5% Exceedance	201.70	23.20	25.84	2.20	2.64
Little River	14787	50% Exceedance	56.30	23.20	24.63	1.64	1.43
Little River	14787	95% Exceedance	13.30	23.20	24.02	1.09	0.82
Little River	12987	5% Exceedance	201.70	20.90	24.12	1.84	3.22
Little River	12987	50% Exceedance	56.30	20.90	22.69	1.08	1.79
Little River	12987	95% Exceedance	13.30	20.90	21.91	0.61	1.01
Little River	12187	5% Exceedance	201.70	20.40	23.53	1.91	3.13
Little River	12187	50% Exceedance	56.30	20.40	22.19	1.08	1.79
Little River	12187	95% Exceedance	13.30	20.40	21.38	0.65	0.98
Little River	11387	5% Exceedance	201.70	20.00	22.43	2.95	2.43
Little River	11387	50% Exceedance	56.30	20.00	21.52	1.41	1.52
Little River	11387	95% Exceedance	13.30	20.00	21.05	0.52	1.05
Little River	11381	5% Exceedance	201.70	20.70	21.86	5.98	1.16
Little River	11381	50% Exceedance	56.30	20.70	21.22	3.94	0.52
Little River	11381	95% Exceedance	13.30	20.70	20.93	2.42	0.23
Little River	11375	5% Exceedance	201.70	17.80	21.17	2.23	3.37
Little River	11375	50% Exceedance	56.30	17.80	19.74	1.23	1.94
Little River	11375	95% Exceedance	13.30	17.80	18.79	0.76	0.99
Little River	11325	5% Exceedance	201.70	17.40	21.01	3.06	3.61
Little River	11325	50% Exceedance	56.30	17.40	19.60	2.26	2.20
Little River	11325	95% Exceedance	13.30	17.40	18.67	1.60	1.27
Little River	11205	5% Exceedance	201.70	16.95	20.70	2.86	3.75
Little River	11205	50% Exceedance	56.30	16.95	19.16	2.23	2.21
Little River	11205	95% Exceedance	13.30	16.95	18.23	1.57	1.28
Little River	11085	5% Exceedance	201.70	16.50	20.48	2.59	3.98
Little River	11085	50% Exceedance	56.30	16.50	18.77	2.11	2.27
Little River	11085	95% Exceedance	13.30	16.50	17.80	1.53	1.30
Little River	11000	5% Exceedance	201.70	16.25	20.37	2.21	4.12
Little River	11000	50% Exceedance	56.30	16.25	18.56	1.82	2.31
Little River	11000	95% Exceedance	13.30	16.25	17.54	1.39	1.29

HEC-RAS Plan: FO PostGradation Model River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Max Chl Dpth
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	10915	5% Exceedance	201.70	16.00	20.23	2.12	4.23
Little River	10915	50% Exceedance	56.30	16.00	18.35	1.77	2.35
Little River	10915	95% Exceedance	13.30	16.00	17.11	1.86	1.11
Little River	9455	5% Exceedance	201.70	13.10	19.03	1.23	5.93
Little River	9455	50% Exceedance	56.30	13.10	16.86	1.01	3.76
Little River	9455	95% Exceedance	13.30	13.10	15.35	0.68	2.25
Little River	8185	5% Exceedance	201.70	11.40	18.52	1.03	7.12
Little River	8185	50% Exceedance	56.30	11.40	16.51	0.56	5.11
Little River	8185	95% Exceedance	13.30	11.40	15.22	0.24	3.82
Little River	7950	5% Exceedance	201.70	11.90	18.40	1.24	6.50
Little River	7950	50% Exceedance	56.30	11.90	16.45	0.70	4.55
Little River	7950	95% Exceedance	13.30	11.90	15.21	0.31	3.31
Little River	7488	5% Exceedance	201.70	12.80	18.07	1.32	5.27
Little River	7488	50% Exceedance	56.30	12.80	16.25	0.80	3.45
Little River	7488	95% Exceedance	13.30	12.80	15.12	0.46	2.32
Little River	7478	5% Exceedance	201.70	12.80	18.06	1.32	5.26
Little River	7478	50% Exceedance	56.30	12.80	16.24	0.80	3.44
Little River	7478	95% Exceedance	13.30	12.80	15.11	0.47	2.31
Little River	7475		Bridge				
Little River	7472	5% Exceedance	201.70	12.80	18.04	1.33	5.24
Little River	7472	50% Exceedance	56.30	12.80	16.23	0.81	3.43
Little River	7472	95% Exceedance	13.30	12.80	15.11	0.47	2.31
Little River	7452	5% Exceedance	201.70	12.80	18.03	1.33	5.23
Little River	7452	50% Exceedance	56.30	12.80	16.22	0.81	3.42
Little River	7452	95% Exceedance	13.30	12.80	15.10	0.47	2.30
Little River	6195	5% Exceedance	201.70	11.80	17.29	0.94	5.49
Little River	6195	50% Exceedance	56.30	11.80	15.85	0.48	4.05
Little River	6195	95% Exceedance	13.30	11.80	14.99	0.18	3.19
Little River	6115	5% Exceedance	201.70	13.80	17.06	2.89	3.26
Little River	6115	50% Exceedance	56.30	13.80	15.74	1.88	1.94
Little River	6115	95% Exceedance	13.30	13.80	14.95	1.20	1.15
Little River	6095		Bridge				
Little River	6075	5% Exceedance	201.70	13.50	16.35	3.58	2.85
Little River	6075	50% Exceedance	56.30	13.50	14.73	4.47	1.23
Little River	6075	95% Exceedance	13.30	13.50	14.19	3.37	0.69
Little River	6015	5% Exceedance	201.70	11.66	16.35	1.25	4.69
Little River	6015	50% Exceedance	56.30	11.66	14.50	0.60	2.84
Little River	6015	95% Exceedance	13.30	11.66	13.27	0.26	1.61
Little River	5995	5% Exceedance	201.70	11.63	16.36	0.75	4.73
Little River	5995	50% Exceedance	56.30	11.63	14.50	0.46	2.87
Little River	5995	95% Exceedance	13.30	11.63	13.27	0.25	1.64

HEC-RAS Plan: FO PostGradation Model River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Max Chl Dpth
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	5975	5% Exceedance	201.70	11.61	16.35	0.76	4.74
Little River	5975	50% Exceedance	56.30	11.61	14.49	0.58	2.88
Little River	5975	95% Exceedance	13.30	11.61	13.26	0.41	1.65
Little River	5775	5% Exceedance	201.70	11.36	16.08	2.54	4.72
Little River	5775	50% Exceedance	56.30	11.36	14.24	1.96	2.88
Little River	5775	95% Exceedance	13.30	11.36	13.03	1.38	1.67
Little River	5690	5% Exceedance	201.70	11.26	15.99	1.26	4.73
Little River	5690	50% Exceedance	56.30	11.26	14.11	0.94	2.85
Little River	5690	95% Exceedance	13.30	11.26	12.85	0.71	1.59
Little River	5510	5% Exceedance	201.70	11.04	15.91	0.77	4.87
Little River	5510	50% Exceedance	56.30	11.04	13.98	0.60	2.94
Little River	5510	95% Exceedance	13.30	11.04	12.68	0.56	1.64
Little River	5430	5% Exceedance	201.70	10.94	15.89	0.73	4.95
Little River	5430	50% Exceedance	56.30	10.94	13.95	0.46	3.01
Little River	5430	95% Exceedance	13.30	10.94	12.65	0.32	1.71
Little River	5160	5% Exceedance	201.70	10.61	15.73	1.63	5.12
Little River	5160	50% Exceedance	56.30	10.61	13.82	1.15	3.21
Little River	5160	95% Exceedance	13.30	10.61	12.51	0.78	1.90
Little River	4875	5% Exceedance	201.70	10.26	15.28	1.68	5.02
Little River	4875	50% Exceedance	56.30	10.26	13.40	1.20	3.14
Little River	4875	95% Exceedance	13.30	10.26	12.13	0.80	1.87
Little River	4850	5% Exceedance	201.70	10.23	15.23	1.79	5.00
Little River	4850	50% Exceedance	56.30	10.23	13.36	1.27	3.13
Little River	4850	95% Exceedance	13.30	10.23	12.09	0.85	1.86
Little River	4495	5% Exceedance	201.70	9.79	14.61	1.60	4.82
Little River	4495	50% Exceedance	56.30	9.79	12.74	1.20	2.95
Little River	4495	95% Exceedance	13.30	9.79	11.54	0.80	1.75
Little River	4370	5% Exceedance	201.70	9.64	14.15	2.89	4.51
Little River	4370	50% Exceedance	56.30	9.64	12.27	2.37	2.63
Little River	4370	95% Exceedance	13.30	9.64	11.09	1.84	1.45
Little River	4060	5% Exceedance	201.70	9.26	13.78	1.19	4.52
Little River	4060	50% Exceedance	56.30	9.26	11.96	0.72	2.70
Little River	4060	95% Exceedance	13.30	9.26	10.73	0.45	1.47
Little River	4030	5% Exceedance	201.70	9.22	13.69	2.13	4.47
Little River	4030	50% Exceedance	56.30	9.22	11.89	1.67	2.67
Little River	4030	95% Exceedance	13.30	9.22	10.67	1.34	1.45
Little River	4000	5% Exceedance	201.70	9.19	13.66	1.55	4.47
Little River	4000	50% Exceedance	56.30	9.19	11.86	0.94	2.67
Little River	4000	95% Exceedance	13.30	9.19	10.63	0.59	1.44
Little River	3850	5% Exceedance	201.70	9.00	13.55	1.02	4.55
Little River	3850	50% Exceedance	56.30	9.00	11.74	0.78	2.74
Little River	3850	95% Exceedance	13.30	9.00	10.48	0.64	1.48
Little River	3555	5% Exceedance	201.70	8.00	13.25	1.54	5.25

HEC-RAS Plan: FO PostGradation Model River: Little River Reach: Little River (Continued)

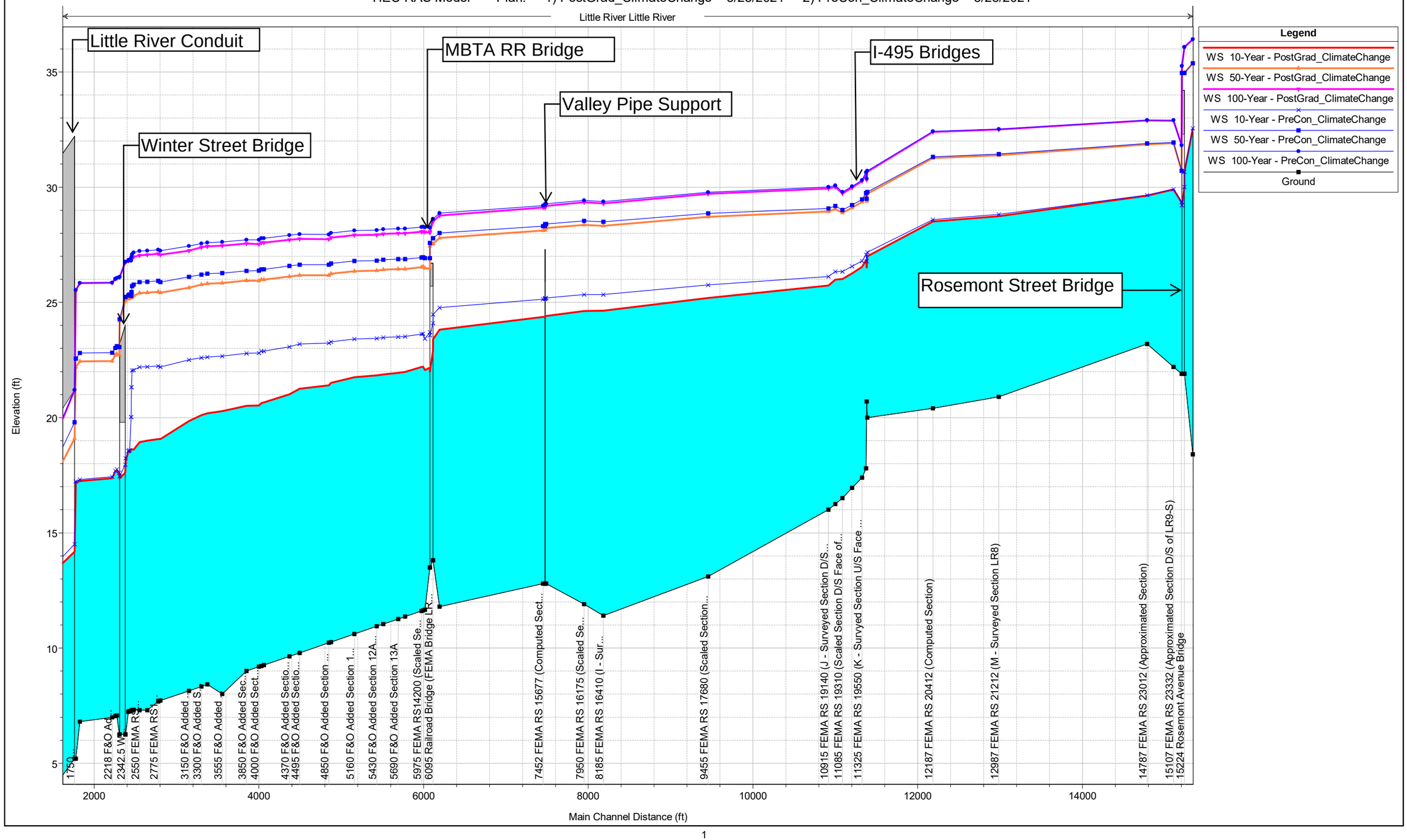
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Max Chl Dpth
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	3555	50% Exceedance	56.30	8.00	11.49	0.97	3.49
Little River	3555	95% Exceedance	13.30	8.00	10.26	0.55	2.26
Little River	3375	5% Exceedance	201.70	8.42	13.03	1.39	4.61
Little River	3375	50% Exceedance	56.30	8.42	11.31	0.98	2.89
Little River	3375	95% Exceedance	13.30	8.42	10.13	0.66	1.71
Little River	3300	5% Exceedance	201.70	8.33	12.92	1.54	4.59
Little River	3300	50% Exceedance	56.30	8.33	11.21	1.09	2.88
Little River	3300	95% Exceedance	13.30	8.33	10.05	0.73	1.72
Little River	3150	5% Exceedance	201.70	8.14	12.73	1.54	4.59
Little River	3150	50% Exceedance	56.30	8.14	11.05	0.92	2.91
Little River	3150	95% Exceedance	13.30	8.14	9.91	0.57	1.77
Little River	2805	5% Exceedance	201.70	7.72	11.64	3.73	3.92
Little River	2805	50% Exceedance	56.30	7.72	10.28	2.43	2.56
Little River	2805	95% Exceedance	13.30	7.72	9.30	1.52	1.58
Little River	2775	5% Exceedance	201.70	7.68	11.24	3.88	3.56
Little River	2775	50% Exceedance	56.30	7.68	9.97	2.61	2.29
Little River	2775	95% Exceedance	13.30	7.68	9.04	1.74	1.36
Little River	2645	5% Exceedance	201.70	7.30	10.79	1.75	3.49
Little River	2645	50% Exceedance	56.30	7.30	9.50	1.11	2.20
Little River	2645	95% Exceedance	13.30	7.30	8.64	0.70	1.34
Little River	2550	5% Exceedance	201.70	7.30	10.52	1.99	3.22
Little River	2550	50% Exceedance	56.30	7.30	9.19	1.50	1.89
Little River	2550	95% Exceedance	13.30	7.30	8.38	1.10	1.08
Little River	2480	5% Exceedance	201.70	7.32	9.90	3.92	2.58
Little River	2480	50% Exceedance	56.30	7.32	8.70	2.30	1.38
Little River	2480	95% Exceedance	13.30	7.32	7.99	1.22	0.67
Little River	2461	5% Exceedance	201.70	7.30	9.91	1.83	2.61
Little River	2461	50% Exceedance	56.30	7.30	8.69	0.98	1.39
Little River	2461	95% Exceedance	13.30	7.30	7.97	0.48	0.67
Little River	2451	5% Exceedance	201.70	7.29	9.91	1.03	2.62
Little River	2451	50% Exceedance	56.30	7.29	8.68	0.54	1.39
Little River	2451	95% Exceedance	13.30	7.29	7.96	0.27	0.67
Little River	2450		Inl Struct				
Little River	2449	5% Exceedance	201.70	7.28	9.90	1.02	2.62
Little River	2449	50% Exceedance	56.30	7.28	8.68	0.54	1.40
Little River	2449	95% Exceedance	13.30	7.28	7.96	0.26	0.68
Little River	2430	5% Exceedance	201.70	7.26	9.89	1.17	2.63
Little River	2430	50% Exceedance	56.30	7.26	8.67	0.61	1.41
Little River	2430	95% Exceedance	13.30	7.26	7.96	0.29	0.70
Little River	2420	5% Exceedance	201.70	7.25	9.87	1.50	2.62
Little River	2420	50% Exceedance	56.30	7.25	8.66	1.05	1.41
Little River	2420	95% Exceedance	13.30	7.25	7.94	0.96	0.69

HEC-RAS Plan: FO PostGradation Model River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Max Chl Dpth
			(cfs)	(ft)	(ft)	(ft/s)	(ft)
Little River	2415	5% Exceedance	201.70	7.24	9.87	1.58	2.63
Little River	2415	50% Exceedance	56.30	7.24	8.65	1.16	1.41
Little River	2415	95% Exceedance	13.30	7.24	7.90	1.43	0.66
Little River	2380	5% Exceedance	201.70	6.25	9.79	2.36	3.54
Little River	2380	50% Exceedance	56.30	6.25	8.64	1.06	2.39
Little River	2380	95% Exceedance	13.30	6.25	7.91	0.40	1.66
Little River	2342.5		Bridge				
Little River	2305	5% Exceedance	201.70	6.25	9.73	2.54	3.48
Little River	2305	50% Exceedance	56.30	6.25	8.62	1.16	2.37
Little River	2305	95% Exceedance	13.30	6.25	7.91	0.46	1.66
Little River	2273	5% Exceedance	201.70	7.07	9.72	2.16	2.65
Little River	2273	50% Exceedance	56.30	7.07	8.59	1.38	1.52
Little River	2273	95% Exceedance	13.30	7.07	7.88	1.01	0.81
Little River	2255	5% Exceedance	201.70	7.05	9.73	1.63	2.68
Little River	2255	50% Exceedance	56.30	7.05	8.60	0.79	1.55
Little River	2255	95% Exceedance	13.30	7.05	7.89	0.34	0.84
Little River	2218	5% Exceedance	201.70	7.00	9.59	3.10	2.59
Little River	2218	50% Exceedance	56.30	7.00	8.56	1.60	1.56
Little River	2218	95% Exceedance	13.30	7.00	7.88	0.81	0.88
Little River	1825	5% Exceedance	201.70	6.80	8.65	4.13	1.85
Little River	1825	50% Exceedance	56.30	6.80	7.53	3.94	0.73
Little River	1825	95% Exceedance	13.30	6.80	7.22	2.57	0.42
Little River	1775 FEMA Section A	5% Exceedance	201.70	5.20	8.64	2.68	3.44
Little River	1775 FEMA Section A	50% Exceedance	56.30	5.20	7.11	2.30	1.91
Little River	1775 FEMA Section A	95% Exceedance	13.30	5.20	6.29	2.11	1.09
Little River	1750		Bridge				
Little River	0010	5% Exceedance	201.70	-3.30	1.58	1.77	4.88
Little River	0010	50% Exceedance	56.30	-3.30	1.60	0.49	4.90
Little River	0010	95% Exceedance	13.30	-3.30	1.60	0.12	4.90
Little River	0	5% Exceedance	201.70	-3.30	1.60	0.26	4.90
Little River	0	50% Exceedance	56.30	-3.30	1.60	0.07	4.90
Little River	0	95% Exceedance	13.30	-3.30	1.60	0.02	4.90

ATTACHMENT 13 - CLIMATE CHANGE PRE- VERSUS POST-DAM REMOVAL HEC-RAS SUMMARY PROFILES AND RESULTS

HEC-RAS Model Plan: 1) PostGrad_ClimateChange 3/25/2021 2) PreCon_ClimateChange 3/25/2021



HEC-RAS River: Little River Reach: Little River

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area	Top Width
				(cfs)	(ft)	(ft)	(ft/s)	(sq ft)	(ft)
Little River	15341	10-Year	PostGrad_ClimateChange	1450.00	18.40	32.55	1.79	2282.13	315.11
Little River	15341	10-Year	PreCon_ClimateChange	1450.00	18.40	32.55	1.79	2283.03	315.13
Little River	15341	50-Year	PostGrad_ClimateChange	2427.00	18.40	35.38	2.11	3213.44	350.54
Little River	15341	50-Year	PreCon_ClimateChange	2427.00	18.40	35.38	2.11	3213.44	350.54
Little River	15341	100-Year	PostGrad_ClimateChange	2945.00	18.40	36.41	2.30	3584.50	370.60
Little River	15341	100-Year	PreCon_ClimateChange	2945.00	18.40	36.41	2.30	3584.50	370.60
Little River	15241	10-Year	PostGrad_ClimateChange	1450.00	21.90	30.67	9.87	188.56	128.86
Little River	15241	10-Year	PreCon_ClimateChange	1450.00	21.90	30.67	9.87	188.70	129.21
Little River	15241	50-Year	PostGrad_ClimateChange	2427.00	21.90	34.95	6.24	1437.51	399.77
Little River	15241	50-Year	PreCon_ClimateChange	2427.00	21.90	34.95	6.24	1437.51	399.77
Little River	15241	100-Year	PostGrad_ClimateChange	2945.00	21.90	36.07	5.99	1913.88	452.49
Little River	15241	100-Year	PreCon_ClimateChange	2945.00	21.90	36.07	5.99	1913.88	452.49
Little River	15224			Bridge					
Little River	15207	10-Year	PostGrad_ClimateChange	1450.00	21.90	29.33	11.78	154.11	45.15
Little River	15207	10-Year	PreCon_ClimateChange	1450.00	21.90	29.36	11.74	154.78	46.65
Little River	15207	50-Year	PostGrad_ClimateChange	2427.00	21.90	30.70	16.45	189.55	131.33
Little River	15207	50-Year	PreCon_ClimateChange	2427.00	21.90	30.70	16.45	189.55	131.33
Little River	15207	100-Year	PostGrad_ClimateChange	2945.00	21.90	31.81	17.58	218.28	208.71
Little River	15207	100-Year	PreCon_ClimateChange	2945.00	21.90	31.81	17.58	218.28	208.71
Little River	15107	10-Year	PostGrad_ClimateChange	1450.00	22.20	29.89	4.64	438.17	133.43
Little River	15107	10-Year	PreCon_ClimateChange	1450.00	22.20	29.92	4.62	441.53	134.01
Little River	15107	50-Year	PostGrad_ClimateChange	2427.00	22.20	31.91	5.29	753.50	179.75
Little River	15107	50-Year	PreCon_ClimateChange	2427.00	22.20	31.94	5.26	759.63	180.53
Little River	15107	100-Year	PostGrad_ClimateChange	2945.00	22.20	32.89	5.47	940.52	202.27
Little River	15107	100-Year	PreCon_ClimateChange	2945.00	22.20	32.90	5.46	944.06	202.67
Little River	14787	10-Year	PostGrad_ClimateChange	1450.00	23.20	29.63	3.58	1071.18	448.84
Little River	14787	10-Year	PreCon_ClimateChange	1450.00	23.20	29.66	3.54	1086.75	450.37
Little River	14787	50-Year	PostGrad_ClimateChange	2427.00	23.20	31.86	3.20	2182.65	547.05
Little River	14787	50-Year	PreCon_ClimateChange	2427.00	23.20	31.90	3.17	2202.97	548.69
Little River	14787	100-Year	PostGrad_ClimateChange	2945.00	23.20	32.90	3.10	2772.34	592.59
Little River	14787	100-Year	PreCon_ClimateChange	2945.00	23.20	32.91	3.09	2783.14	593.39
Little River	12987	10-Year	PostGrad_ClimateChange	1450.00	20.90	28.74	2.41	1774.95	558.65
Little River	12987	10-Year	PreCon_ClimateChange	1450.00	20.90	28.81	2.37	1816.84	565.01
Little River	12987	50-Year	PostGrad_ClimateChange	2427.00	20.90	31.38	2.19	3504.13	741.30
Little River	12987	50-Year	PreCon_ClimateChange	2427.00	20.90	31.43	2.17	3540.44	744.50
Little River	12987	100-Year	PostGrad_ClimateChange	2945.00	20.90	32.50	2.17	4372.17	814.50
Little River	12987	100-Year	PreCon_ClimateChange	2945.00	20.90	32.52	2.16	4390.33	815.96
Little River	12187	10-Year	PostGrad_ClimateChange	1450.00	20.40	28.51	2.25	1928.64	581.67
Little River	12187	10-Year	PreCon_ClimateChange	1450.00	20.40	28.60	2.20	1979.74	589.13
Little River	12187	50-Year	PostGrad_ClimateChange	2427.00	20.40	31.26	2.04	3785.99	765.83
Little River	12187	50-Year	PreCon_ClimateChange	2427.00	20.40	31.31	2.02	3825.99	769.25
Little River	12187	100-Year	PostGrad_ClimateChange	2945.00	20.40	32.39	2.03	4696.79	840.24
Little River	12187	100-Year	PreCon_ClimateChange	2945.00	20.40	32.42	2.02	4716.46	841.77
Little River	11387	10-Year	PostGrad_ClimateChange	1717.00	20.00	26.99	7.80	279.09	53.53
Little River	11387	10-Year	PreCon_ClimateChange	1717.00	20.00	27.17	7.58	288.79	54.22
Little River	11387	50-Year	PostGrad_ClimateChange	2842.00	20.00	29.71	8.91	438.52	63.86
Little River	11387	50-Year	PreCon_ClimateChange	2842.00	20.00	29.79	8.83	443.96	64.19
Little River	11387	100-Year	PostGrad_ClimateChange	3448.00	20.00	30.67	9.71	501.28	67.50
Little River	11387	100-Year	PreCon_ClimateChange	3448.00	20.00	30.70	9.67	503.95	67.65
Little River	11381	10-Year	PostGrad_ClimateChange	1717.00	20.70	26.51	9.21	233.07	51.37
Little River	11381	10-Year	PreCon_ClimateChange	1717.00	20.70	26.78	8.77	247.11	52.42
Little River	11381	50-Year	PostGrad_ClimateChange	2842.00	20.70	29.39	9.79	397.17	62.50
Little River	11381	50-Year	PreCon_ClimateChange	2842.00	20.70	29.50	9.66	403.68	62.90
Little River	11381	100-Year	PostGrad_ClimateChange	3448.00	20.70	30.32	10.60	456.94	66.09
Little River	11381	100-Year	PreCon_ClimateChange	3448.00	20.70	30.37	10.54	460.17	66.27
Little River	11375	10-Year	PostGrad_ClimateChange	1717.00	17.80	26.83	6.16	356.37	54.80
Little River	11375	10-Year	PreCon_ClimateChange	1717.00	17.80	27.06	5.99	369.00	55.59
Little River	11375	50-Year	PostGrad_ClimateChange	2842.00	17.80	29.65	7.46	524.84	64.54
Little River	11375	50-Year	PreCon_ClimateChange	2842.00	17.80	29.75	7.40	530.89	64.87
Little River	11375	100-Year	PostGrad_ClimateChange	3448.00	17.80	30.60	8.28	587.67	67.82
Little River	11375	100-Year	PreCon_ClimateChange	3448.00	17.80	30.65	8.25	590.65	67.97

HEC-RAS River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area	Top Width
				(cfs)	(ft)	(ft)	(ft/s)	(sq ft)	(ft)
Little River	11325	10-Year	PostGrad_ClimateChange	1717.00	17.40	26.54	6.81	294.20	49.90
Little River	11325	10-Year	PreCon_ClimateChange	1717.00	17.40	26.80	6.56	307.48	50.84
Little River	11325	50-Year	PostGrad_ClimateChange	2842.00	17.40	29.36	8.00	449.05	59.96
Little River	11325	50-Year	PreCon_ClimateChange	2842.00	17.40	29.46	7.91	455.38	60.34
Little River	11325	100-Year	PostGrad_ClimateChange	3448.00	17.40	30.26	8.86	504.57	63.18
Little River	11325	100-Year	PreCon_ClimateChange	3448.00	17.40	30.31	8.81	507.74	63.36
Little River	11205	10-Year	PostGrad_ClimateChange	1717.00	16.95	26.26	6.65	302.90	50.52
Little River	11205	10-Year	PreCon_ClimateChange	1717.00	16.95	26.56	6.38	318.19	51.58
Little River	11205	50-Year	PostGrad_ClimateChange	2842.00	16.95	29.11	7.83	461.28	60.69
Little River	11205	50-Year	PreCon_ClimateChange	2842.00	16.95	29.22	7.74	468.30	61.10
Little River	11205	100-Year	PostGrad_ClimateChange	3448.00	16.95	29.98	8.71	515.64	63.81
Little River	11205	100-Year	PreCon_ClimateChange	3448.00	16.95	30.04	8.66	519.18	64.01
Little River	11085	10-Year	PostGrad_ClimateChange	1717.00	16.50	26.01	6.47	312.95	51.22
Little River	11085	10-Year	PreCon_ClimateChange	1717.00	16.50	26.34	6.19	330.31	52.42
Little River	11085	50-Year	PostGrad_ClimateChange	2842.00	16.50	28.88	7.66	474.81	61.48
Little River	11085	50-Year	PreCon_ClimateChange	2842.00	16.50	29.01	7.56	482.53	61.93
Little River	11085	100-Year	PostGrad_ClimateChange	3448.00	16.50	29.72	8.55	527.94	64.49
Little River	11085	100-Year	PreCon_ClimateChange	3448.00	16.50	29.78	8.50	531.84	64.71
Little River	11000	10-Year	PostGrad_ClimateChange	1717.00	16.25	25.99	4.63	370.89	61.70
Little River	11000	10-Year	PreCon_ClimateChange	1717.00	16.25	26.34	4.37	392.64	63.18
Little River	11000	50-Year	PostGrad_ClimateChange	2842.00	16.25	29.05	4.41	1096.25	438.30
Little River	11000	50-Year	PreCon_ClimateChange	2842.00	16.25	29.18	4.29	1153.72	449.95
Little River	11000	100-Year	PostGrad_ClimateChange	3448.00	16.25	30.01	4.34	1560.49	523.55
Little River	11000	100-Year	PreCon_ClimateChange	3448.00	16.25	30.07	4.28	1592.77	528.81
Little River	10915	10-Year	PostGrad_ClimateChange	1717.00	16.00	25.74	4.63	370.50	61.67
Little River	10915	10-Year	PreCon_ClimateChange	1717.00	16.00	26.12	4.35	394.76	66.76
Little River	10915	50-Year	PostGrad_ClimateChange	2842.00	16.00	28.94	3.80	1159.20	451.04
Little River	10915	50-Year	PreCon_ClimateChange	2842.00	16.00	29.08	3.65	1223.89	463.77
Little River	10915	100-Year	PostGrad_ClimateChange	3448.00	16.00	29.95	3.40	1657.75	539.25
Little River	10915	100-Year	PreCon_ClimateChange	3448.00	16.00	30.01	3.34	1693.00	544.82
Little River	9455	10-Year	PostGrad_ClimateChange	1717.00	13.10	25.19	1.59	2091.84	599.29
Little River	9455	10-Year	PreCon_ClimateChange	1717.00	13.10	25.76	1.40	2449.26	656.22
Little River	9455	50-Year	PostGrad_ClimateChange	2842.00	13.10	28.71	1.34	4819.58	951.15
Little River	9455	50-Year	PreCon_ClimateChange	2842.00	13.10	28.86	1.30	4966.60	966.49
Little River	9455	100-Year	PostGrad_ClimateChange	3448.00	13.10	29.71	1.38	5806.49	1018.21
Little River	9455	100-Year	PreCon_ClimateChange	3448.00	13.10	29.78	1.37	5879.18	1020.78
Little River	8185	10-Year	PostGrad_ClimateChange	1717.00	11.40	24.64	3.01	631.02	89.61
Little River	8185	10-Year	PreCon_ClimateChange	1717.00	11.40	25.34	2.78	697.77	100.70
Little River	8185	50-Year	PostGrad_ClimateChange	2842.00	11.40	28.32	3.35	1080.23	166.91
Little River	8185	50-Year	PreCon_ClimateChange	2842.00	11.40	28.50	3.29	1110.04	176.92
Little River	8185	100-Year	PostGrad_ClimateChange	3448.00	11.40	29.29	3.68	1262.21	208.38
Little River	8185	100-Year	PreCon_ClimateChange	3448.00	11.40	29.37	3.65	1279.33	212.46
Little River	7950	10-Year	PostGrad_ClimateChange	1717.00	11.90	24.63	1.45	2221.67	424.36
Little River	7950	10-Year	PreCon_ClimateChange	1717.00	11.90	25.34	1.27	2527.22	427.91
Little River	7950	50-Year	PostGrad_ClimateChange	2842.00	11.90	28.37	1.34	3843.66	442.88
Little River	7950	50-Year	PreCon_ClimateChange	2842.00	11.90	28.54	1.31	3920.19	443.73
Little River	7950	100-Year	PostGrad_ClimateChange	3448.00	11.90	29.35	1.45	4279.80	447.00
Little River	7950	100-Year	PreCon_ClimateChange	3448.00	11.90	29.43	1.43	4315.79	447.00
Little River	7488	10-Year	PostGrad_ClimateChange	1717.00	12.80	24.41	2.30	1041.36	179.85
Little River	7488	10-Year	PreCon_ClimateChange	1717.00	12.80	25.19	2.04	1183.77	184.96
Little River	7488	50-Year	PostGrad_ClimateChange	2842.00	12.80	28.22	2.29	1777.39	219.84
Little River	7488	50-Year	PreCon_ClimateChange	2842.00	12.80	28.40	2.25	1818.36	234.77
Little River	7488	100-Year	PostGrad_ClimateChange	3448.00	12.80	29.19	2.50	2036.29	318.74
Little River	7488	100-Year	PreCon_ClimateChange	3448.00	12.80	29.27	2.48	2063.37	322.36
Little River	7478	10-Year	PostGrad_ClimateChange	1717.00	12.80	24.40	2.31	1028.13	179.79
Little River	7478	10-Year	PreCon_ClimateChange	1717.00	12.80	25.18	2.05	1164.87	184.92
Little River	7478	50-Year	PostGrad_ClimateChange	2842.00	12.80	28.22	2.29	1776.42	219.48
Little River	7478	50-Year	PreCon_ClimateChange	2842.00	12.80	28.40	2.25	1817.38	234.42
Little River	7478	100-Year	PostGrad_ClimateChange	3448.00	12.80	29.18	2.50	2034.76	318.33
Little River	7478	100-Year	PreCon_ClimateChange	3448.00	12.80	29.27	2.48	2061.86	322.19
Little River	7475			Bridge					

HEC-RAS River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area	Top Width
				(cfs)	(ft)	(ft)	(ft/s)	(sq ft)	(ft)
Little River	7472	10-Year	PostGrad_ClimateChange	1717.00	12.80	24.38	2.32	1025.41	179.69
Little River	7472	10-Year	PreCon_ClimateChange	1717.00	12.80	25.15	2.06	1160.09	184.75
Little River	7472	50-Year	PostGrad_ClimateChange	2842.00	12.80	28.13	2.32	1756.35	211.77
Little River	7472	50-Year	PreCon_ClimateChange	2842.00	12.80	28.32	2.27	1798.70	227.73
Little River	7472	100-Year	PostGrad_ClimateChange	3448.00	12.80	29.12	2.52	2015.41	313.14
Little River	7472	100-Year	PreCon_ClimateChange	3448.00	12.80	29.21	2.49	2042.95	320.04
Little River	7452	10-Year	PostGrad_ClimateChange	1717.00	12.80	24.37	2.32	1034.49	179.60
Little River	7452	10-Year	PreCon_ClimateChange	1717.00	12.80	25.14	2.05	1175.81	184.68
Little River	7452	50-Year	PostGrad_ClimateChange	2842.00	12.80	28.12	2.32	1754.44	211.02
Little River	7452	50-Year	PreCon_ClimateChange	2842.00	12.80	28.31	2.27	1796.77	227.03
Little River	7452	100-Year	PostGrad_ClimateChange	3448.00	12.80	29.11	2.52	2012.39	312.33
Little River	7452	100-Year	PreCon_ClimateChange	3448.00	12.80	29.20	2.50	2039.96	319.69
Little River	6195	10-Year	PostGrad_ClimateChange	1717.00	11.80	23.81	1.65	1332.73	245.82
Little River	6195	10-Year	PreCon_ClimateChange	1717.00	11.80	24.78	1.43	1577.46	262.49
Little River	6195	50-Year	PostGrad_ClimateChange	2842.00	11.80	27.80	1.62	2460.83	339.15
Little River	6195	50-Year	PreCon_ClimateChange	2842.00	11.80	28.01	1.58	2534.77	348.61
Little River	6195	100-Year	PostGrad_ClimateChange	3448.00	11.80	28.77	1.77	2813.58	385.87
Little River	6195	100-Year	PreCon_ClimateChange	3448.00	11.80	28.87	1.75	2851.42	390.94
Little River	6115	10-Year	PostGrad_ClimateChange	1717.00	13.80	23.39	4.88	447.62	106.19
Little River	6115	10-Year	PreCon_ClimateChange	1717.00	13.80	24.47	4.20	523.45	120.34
Little River	6115	50-Year	PostGrad_ClimateChange	2842.00	13.80	27.54	4.35	1100.71	274.32
Little River	6115	50-Year	PreCon_ClimateChange	2842.00	13.80	27.78	4.19	1167.34	286.58
Little River	6115	100-Year	PostGrad_ClimateChange	3448.00	13.80	28.51	4.55	1392.58	324.60
Little River	6115	100-Year	PreCon_ClimateChange	3448.00	13.80	28.62	4.47	1428.09	330.19
Little River	6095			Bridge					
Little River	6075	10-Year	PostGrad_ClimateChange	1717.00	13.50	22.17	5.64	382.89	94.11
Little River	6075	10-Year	PreCon_ClimateChange	1717.00	13.50	23.71	4.47	490.77	114.24
Little River	6075	50-Year	PostGrad_ClimateChange	2842.00	13.50	26.47	4.85	931.58	151.32
Little River	6075	50-Year	PreCon_ClimateChange	2842.00	13.50	26.92	4.55	1017.61	241.59
Little River	6075	100-Year	PostGrad_ClimateChange	3448.00	13.50	28.02	4.68	1331.68	314.77
Little River	6075	100-Year	PreCon_ClimateChange	3448.00	13.50	28.24	4.53	1401.69	326.04
Little River	6015	10-Year	PostGrad_ClimateChange	1717.00	11.66	22.06	4.25	442.94	126.38
Little River	6015	10-Year	PreCon_ClimateChange	1717.00	16.10	23.42	5.13	510.38	256.84
Little River	6015	50-Year	PostGrad_ClimateChange	2842.00	11.66	26.49	3.14	1697.22	402.60
Little River	6015	50-Year	PreCon_ClimateChange	2842.00	16.10	26.92	3.30	1698.28	410.10
Little River	6015	100-Year	PostGrad_ClimateChange	3448.00	11.66	28.05	2.88	2346.39	429.37
Little River	6015	100-Year	PreCon_ClimateChange	3448.00	16.10	28.25	3.04	2260.33	430.84
Little River	5995	10-Year	PostGrad_ClimateChange	1717.00	11.63	22.21	1.72	1317.24	338.48
Little River	5995	10-Year	PreCon_ClimateChange	1717.00	11.70	23.63	1.34	1813.56	360.37
Little River	5995	50-Year	PostGrad_ClimateChange	2842.00	11.63	26.54	1.45	2955.14	468.83
Little River	5995	50-Year	PreCon_ClimateChange	2842.00	11.70	26.96	1.38	3152.13	471.30
Little River	5995	100-Year	PostGrad_ClimateChange	3448.00	11.63	28.08	1.46	3685.05	477.95
Little River	5995	100-Year	PreCon_ClimateChange	3448.00	11.70	28.28	1.43	3778.58	479.57
Little River	5975	10-Year	PostGrad_ClimateChange	1717.00	11.61	22.20	1.53	1190.48	202.04
Little River	5975	10-Year	PreCon_ClimateChange	1717.00	13.40	23.63	1.37	1384.66	221.96
Little River	5975	50-Year	PostGrad_ClimateChange	2842.00	11.61	26.53	1.49	2289.66	344.01
Little River	5975	50-Year	PreCon_ClimateChange	2842.00	13.40	26.95	1.50	2331.99	364.71
Little River	5975	100-Year	PostGrad_ClimateChange	3448.00	11.61	28.07	1.54	2877.64	419.48
Little River	5975	100-Year	PreCon_ClimateChange	3448.00	13.40	28.27	1.58	2854.67	429.23
Little River	5775	10-Year	PostGrad_ClimateChange	1717.00	11.36	21.98	3.05	753.89	217.07
Little River	5775	10-Year	PreCon_ClimateChange	1717.00	13.10	23.51	2.26	1077.95	232.92
Little River	5775	50-Year	PostGrad_ClimateChange	2842.00	11.36	26.45	2.28	1896.74	325.46
Little River	5775	50-Year	PreCon_ClimateChange	2842.00	13.10	26.88	2.17	2019.59	341.83
Little River	5775	100-Year	PostGrad_ClimateChange	3448.00	11.36	28.00	2.25	2448.19	384.49
Little River	5775	100-Year	PreCon_ClimateChange	3448.00	13.10	28.20	2.21	2505.34	392.13
Little River	5690	10-Year	PostGrad_ClimateChange	1717.00	11.26	21.94	1.81	961.07	219.79
Little River	5690	10-Year	PreCon_ClimateChange	1717.00	11.80	23.50	1.36	1295.89	229.86
Little River	5690	50-Year	PostGrad_ClimateChange	2842.00	11.26	26.44	1.48	2068.86	339.30
Little River	5690	50-Year	PreCon_ClimateChange	2842.00	11.80	26.87	1.41	2199.24	341.12
Little River	5690	100-Year	PostGrad_ClimateChange	3448.00	11.26	28.00	1.50	2601.46	345.86
Little River	5690	100-Year	PreCon_ClimateChange	3448.00	11.80	28.20	1.48	2654.54	346.12

HEC-RAS River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area	Top Width
				(cfs)	(ft)	(ft)	(ft/s)	(sq ft)	(ft)
Little River	5510	10-Year	PostGrad_ClimateChange	1717.00	11.04	21.88	1.33	1302.37	196.40
Little River	5510	10-Year	PreCon_ClimateChange	1717.00	11.20	23.47	1.08	1619.05	204.50
Little River	5510	50-Year	PostGrad_ClimateChange	2842.00	11.04	26.42	1.31	2318.69	331.48
Little River	5510	50-Year	PreCon_ClimateChange	2842.00	11.20	26.85	1.26	2460.73	336.31
Little River	5510	100-Year	PostGrad_ClimateChange	3448.00	11.04	27.97	1.37	2848.24	348.77
Little River	5510	100-Year	PreCon_ClimateChange	3448.00	11.20	28.17	1.35	2915.88	351.14
Little River	5430	10-Year	PostGrad_ClimateChange	1717.00	10.94	21.83	1.80	968.46	143.25
Little River	5430	10-Year	PreCon_ClimateChange	1717.00	11.40	23.44	1.49	1193.87	158.27
Little River	5430	50-Year	PostGrad_ClimateChange	2842.00	10.94	26.38	1.80	1736.63	246.33
Little River	5430	50-Year	PreCon_ClimateChange	2842.00	11.40	26.81	1.74	1832.26	272.90
Little River	5430	100-Year	PostGrad_ClimateChange	3448.00	10.94	27.93	1.88	2193.60	340.86
Little River	5430	100-Year	PreCon_ClimateChange	3448.00	11.40	28.14	1.86	2245.87	349.14
Little River	5160	10-Year	PostGrad_ClimateChange	1717.00	10.61	21.75	1.25	1387.80	270.95
Little River	5160	10-Year	PreCon_ClimateChange	1717.00	11.20	23.41	0.96	1833.50	284.07
Little River	5160	50-Year	PostGrad_ClimateChange	2842.00	10.61	26.36	1.10	2754.01	360.97
Little River	5160	50-Year	PreCon_ClimateChange	2842.00	11.20	26.80	1.05	2901.98	385.15
Little River	5160	100-Year	PostGrad_ClimateChange	3448.00	10.61	27.92	1.13	3384.81	446.68
Little River	5160	100-Year	PreCon_ClimateChange	3448.00	11.20	28.12	1.12	3462.33	468.58
Little River	4875	10-Year	PostGrad_ClimateChange	1717.00	10.26	21.51	2.47	701.48	134.01
Little River	4875	10-Year	PreCon_ClimateChange	1717.00	12.10	23.29	1.96	899.14	139.94
Little River	4875	50-Year	PostGrad_ClimateChange	2842.00	10.26	26.25	2.16	1387.20	170.78
Little River	4875	50-Year	PreCon_ClimateChange	2842.00	12.10	26.69	2.14	1419.32	179.23
Little River	4875	100-Year	PostGrad_ClimateChange	3448.00	10.26	27.81	2.25	1718.18	300.74
Little River	4875	100-Year	PreCon_ClimateChange	3448.00	12.10	28.01	2.27	1736.28	329.75
Little River	4850	10-Year	PostGrad_ClimateChange	1717.00	10.23	21.40	3.22	539.97	93.79
Little River	4850	10-Year	PreCon_ClimateChange	1717.00	10.30	23.24	2.49	724.16	108.99
Little River	4850	50-Year	PostGrad_ClimateChange	2842.00	10.23	26.17	2.94	1083.32	159.27
Little River	4850	50-Year	PreCon_ClimateChange	2842.00	10.30	26.63	2.81	1162.95	195.97
Little River	4850	100-Year	PostGrad_ClimateChange	3448.00	10.23	27.74	3.03	1431.24	284.70
Little River	4850	100-Year	PreCon_ClimateChange	3448.00	10.30	27.95	2.96	1491.41	301.63
Little River	4495	10-Year	PostGrad_ClimateChange	1717.00	9.79	21.25	1.27	1354.73	286.79
Little River	4495	10-Year	PreCon_ClimateChange	1717.00	12.90	23.20	0.94	1848.22	301.56
Little River	4495	50-Year	PostGrad_ClimateChange	2842.00	9.79	26.18	1.03	2883.89	348.10
Little River	4495	50-Year	PreCon_ClimateChange	2842.00	12.90	26.63	1.00	2968.00	361.45
Little River	4495	100-Year	PostGrad_ClimateChange	3448.00	9.79	27.75	1.06	3469.41	394.15
Little River	4495	100-Year	PreCon_ClimateChange	3448.00	12.90	27.96	1.06	3473.81	400.21
Little River	4370	10-Year	PostGrad_ClimateChange	1717.00	9.64	21.01	3.14	589.81	171.84
Little River	4370	10-Year	PreCon_ClimateChange	1717.00	15.30	23.08	2.46	880.25	277.44
Little River	4370	50-Year	PostGrad_ClimateChange	2842.00	9.64	26.12	1.99	2170.42	463.64
Little River	4370	50-Year	PreCon_ClimateChange	2842.00	15.30	26.58	1.99	2246.06	499.47
Little River	4370	100-Year	PostGrad_ClimateChange	3448.00	9.64	27.71	1.88	3007.25	587.56
Little River	4370	100-Year	PreCon_ClimateChange	3448.00	15.30	27.92	1.93	2984.54	603.67
Little River	4060	10-Year	PostGrad_ClimateChange	1717.00	9.26	20.66	2.39	722.66	107.85
Little River	4060	10-Year	PreCon_ClimateChange	1717.00	10.40	22.89	1.97	917.02	135.66
Little River	4060	50-Year	PostGrad_ClimateChange	2842.00	9.26	25.99	2.17	1495.90	198.52
Little River	4060	50-Year	PreCon_ClimateChange	2842.00	10.40	26.44	2.21	1514.50	242.67
Little River	4060	100-Year	PostGrad_ClimateChange	3448.00	9.26	27.59	2.26	1940.44	358.49
Little River	4060	100-Year	PreCon_ClimateChange	3448.00	10.40	27.78	2.33	1930.59	377.58
Little River	4030	10-Year	PostGrad_ClimateChange	1717.00	9.22	20.63	2.41	718.72	134.42
Little River	4030	10-Year	PreCon_ClimateChange	1717.00	11.10	22.89	1.80	982.75	141.91
Little River	4030	50-Year	PostGrad_ClimateChange	2842.00	9.22	25.99	2.01	1519.81	184.79
Little River	4030	50-Year	PreCon_ClimateChange	2842.00	11.10	26.43	1.98	1569.28	247.12
Little River	4030	100-Year	PostGrad_ClimateChange	3448.00	9.22	27.59	2.08	1995.22	411.38
Little River	4030	100-Year	PreCon_ClimateChange	3448.00	11.10	27.78	2.09	2029.54	438.69
Little River	4000	10-Year	PostGrad_ClimateChange	1717.00	9.19	20.52	3.20	546.83	96.65
Little River	4000	10-Year	PreCon_ClimateChange	1717.00	10.30	22.81	2.64	752.74	141.15
Little River	4000	50-Year	PostGrad_ClimateChange	2842.00	9.19	25.93	2.74	1337.22	193.71
Little River	4000	50-Year	PreCon_ClimateChange	2842.00	10.30	26.37	2.78	1351.48	206.70
Little River	4000	100-Year	PostGrad_ClimateChange	3448.00	9.19	27.53	2.80	1686.15	242.24
Little River	4000	100-Year	PreCon_ClimateChange	3448.00	10.30	27.72	2.90	1656.81	247.93
Little River	3850	10-Year	PostGrad_ClimateChange	1717.00	9.00	20.51	1.56	1100.79	157.52
Little River	3850	10-Year	PreCon_ClimateChange	1717.00	12.50	22.79	1.49	1179.59	187.06

HEC-RAS River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area	Top Width
				(cfs)	(ft)	(ft)	(ft/s)	(sq ft)	(ft)
Little River	3850	50-Year	PostGrad_ClimateChange	2842.00	9.00	25.94	1.43	2174.95	244.84
Little River	3850	50-Year	PreCon_ClimateChange	2842.00	12.50	26.37	1.60	1981.47	272.58
Little River	3850	100-Year	PostGrad_ClimateChange	3448.00	9.00	27.55	1.50	2655.66	357.66
Little River	3850	100-Year	PreCon_ClimateChange	3448.00	12.50	27.72	1.69	2414.00	370.00
Little River	3555	10-Year	PostGrad_ClimateChange	1717.00	8.00	20.28	2.55	674.86	104.52
Little River	3555	10-Year	PreCon_ClimateChange	1717.00	8.00	22.67	1.86	962.80	144.13
Little River	3555	50-Year	PostGrad_ClimateChange	2842.00	8.00	25.84	2.16	1565.82	238.06
Little River	3555	50-Year	PreCon_ClimateChange	2842.00	8.00	26.28	2.06	1696.37	340.28
Little River	3555	100-Year	PostGrad_ClimateChange	3448.00	8.00	27.46	2.19	2116.00	370.41
Little River	3555	100-Year	PreCon_ClimateChange	3448.00	8.00	27.63	2.15	2179.25	374.74
Little River	3375	10-Year	PostGrad_ClimateChange	1717.00	8.42	20.18	1.93	904.00	132.79
Little River	3375	10-Year	PreCon_ClimateChange	1717.00	10.00	22.63	1.56	1146.52	143.26
Little River	3375	50-Year	PostGrad_ClimateChange	2842.00	8.42	25.81	1.76	1838.55	304.82
Little River	3375	50-Year	PreCon_ClimateChange	2842.00	10.00	26.24	1.79	1883.17	345.96
Little River	3375	100-Year	PostGrad_ClimateChange	3448.00	8.42	27.43	1.83	2456.36	459.93
Little River	3375	100-Year	PreCon_ClimateChange	3448.00	10.00	27.59	1.89	2438.40	475.70
Little River	3300	10-Year	PostGrad_ClimateChange	1717.00	8.33	20.11	2.32	740.34	106.95
Little River	3300	10-Year	PreCon_ClimateChange	1717.00	8.50	22.60	1.71	1014.74	118.48
Little River	3300	50-Year	PostGrad_ClimateChange	2842.00	8.33	25.77	2.09	1419.75	133.30
Little River	3300	50-Year	PreCon_ClimateChange	2842.00	8.50	26.21	2.02	1485.04	211.06
Little River	3300	100-Year	PostGrad_ClimateChange	3448.00	8.33	27.38	2.20	1812.63	334.03
Little River	3300	100-Year	PreCon_ClimateChange	3448.00	8.50	27.55	2.18	1863.74	351.61
Little River	3150	10-Year	PostGrad_ClimateChange	1717.00	8.14	19.85	3.34	513.80	62.97
Little River	3150	10-Year	PreCon_ClimateChange	1717.00	4.80	22.51	2.28	777.29	90.06
Little River	3150	50-Year	PostGrad_ClimateChange	2842.00	8.14	25.63	3.07	1093.07	161.85
Little River	3150	50-Year	PreCon_ClimateChange	2842.00	4.80	26.10	2.75	1238.91	175.78
Little River	3150	100-Year	PostGrad_ClimateChange	3448.00	8.14	27.25	3.19	1398.36	218.54
Little River	3150	100-Year	PreCon_ClimateChange	3448.00	4.80	27.44	2.96	1507.94	225.79
Little River	2805	10-Year	PostGrad_ClimateChange	1717.00	7.72	19.07	4.01	428.22	69.49
Little River	2805	10-Year	PreCon_ClimateChange	1717.00	11.90	22.20	3.05	587.92	106.03
Little River	2805	50-Year	PostGrad_ClimateChange	2842.00	7.72	25.42	2.94	1190.98	192.90
Little River	2805	50-Year	PreCon_ClimateChange	2842.00	11.90	25.88	3.08	1179.99	201.22
Little River	2805	100-Year	PostGrad_ClimateChange	3448.00	7.72	27.07	2.97	1576.95	288.20
Little River	2805	100-Year	PreCon_ClimateChange	3448.00	11.90	27.24	3.16	1526.02	299.13
Little River	2775	10-Year	PostGrad_ClimateChange	1717.00	7.68	19.07	3.28	622.51	156.08
Little River	2775	10-Year	PreCon_ClimateChange	1717.00	9.00	22.24	2.09	1222.11	251.22
Little River	2775	50-Year	PostGrad_ClimateChange	2842.00	7.68	25.46	2.15	2233.51	347.89
Little River	2775	50-Year	PreCon_ClimateChange	2842.00	9.00	25.93	2.09	2352.61	361.87
Little River	2775	100-Year	PostGrad_ClimateChange	3448.00	7.68	27.11	2.16	2847.33	397.32
Little River	2775	100-Year	PreCon_ClimateChange	3448.00	9.00	27.29	2.16	2872.66	402.68
Little River	2645	10-Year	PostGrad_ClimateChange	1717.00	7.30	18.99	2.30	745.75	93.97
Little River	2645	10-Year	PreCon_ClimateChange	1717.00	7.30	22.22	1.58	1105.54	124.67
Little River	2645	50-Year	PostGrad_ClimateChange	2842.00	7.30	25.42	1.92	1513.89	130.01
Little River	2645	50-Year	PreCon_ClimateChange	2842.00	7.30	25.89	1.85	1574.89	130.86
Little River	2645	100-Year	PostGrad_ClimateChange	3448.00	7.30	27.06	2.04	1782.71	233.63
Little River	2645	100-Year	PreCon_ClimateChange	3448.00	7.30	27.24	2.02	1826.27	250.99
Little River	2550	10-Year	PostGrad_ClimateChange	1717.00	7.30	18.93	2.32	739.46	93.72
Little River	2550	10-Year	PreCon_ClimateChange	1717.00	7.30	22.19	1.58	1102.99	124.64
Little River	2550	50-Year	PostGrad_ClimateChange	2842.00	7.30	25.40	1.93	1511.10	129.97
Little River	2550	50-Year	PreCon_ClimateChange	2842.00	7.30	25.87	1.85	1572.40	130.83
Little River	2550	100-Year	PostGrad_ClimateChange	3448.00	7.30	27.04	2.05	1777.82	231.61
Little River	2550	100-Year	PreCon_ClimateChange	3448.00	7.30	27.22	2.02	1821.25	249.05
Little River	2480	10-Year	PostGrad_ClimateChange	1717.00	7.32	18.61	4.11	417.88	62.60
Little River	2480	10-Year	PreCon_ClimateChange	1717.00	8.20	22.07	2.72	632.03	82.32
Little River	2480	50-Year	PostGrad_ClimateChange	2842.00	7.32	25.29	2.87	1081.73	193.72
Little River	2480	50-Year	PreCon_ClimateChange	2842.00	8.20	25.77	2.79	1138.93	197.49
Little River	2480	100-Year	PostGrad_ClimateChange	3448.00	7.32	26.97	2.71	1614.19	461.10
Little River	2480	100-Year	PreCon_ClimateChange	3448.00	8.20	27.15	2.70	1663.90	482.33
Little River	2461	10-Year	PostGrad_ClimateChange	1717.00	7.30	18.62	3.29	521.99	51.26
Little River	2461	10-Year	PreCon_ClimateChange	1717.00	8.50	22.05	2.68	641.66	55.49
Little River	2461	50-Year	PostGrad_ClimateChange	2842.00	7.30	25.24	3.15	961.52	164.88
Little River	2461	50-Year	PreCon_ClimateChange	2842.00	8.50	25.70	3.23	982.94	200.47

HEC-RAS River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area	Top Width
				(cfs)	(ft)	(ft)	(ft/s)	(sq ft)	(ft)
Little River	2461	100-Year	PostGrad_ClimateChange	3448.00	7.30	26.91	3.13	1391.04	352.57
Little River	2461	100-Year	PreCon_ClimateChange	3448.00	8.50	27.08	3.22	1390.45	369.14
Little River	2451	10-Year	PostGrad_ClimateChange	1717.00	7.29	18.63	2.02	850.33	75.09
Little River	2451	10-Year	PreCon_ClimateChange	1717.00	8.50	21.32	5.99	286.55	75.10
Little River	2451	50-Year	PostGrad_ClimateChange	2842.00	7.29	25.25	2.09	1426.54	196.71
Little River	2451	50-Year	PreCon_ClimateChange	2842.00	8.50	25.44	4.54	699.69	203.58
Little River	2451	100-Year	PostGrad_ClimateChange	3448.00	7.29	26.92	2.20	1802.19	260.74
Little River	2451	100-Year	PreCon_ClimateChange	3448.00	8.50	26.96	3.99	1046.88	264.78
Little River	2450			Inl Struct					
Little River	2449	10-Year	PostGrad_ClimateChange	1717.00	7.28	18.59	2.02	848.69	75.09
Little River	2449	10-Year	PreCon_ClimateChange	1717.00	8.50	20.03	9.05	189.65	75.09
Little River	2449	50-Year	PostGrad_ClimateChange	2842.00	7.28	25.20	2.11	1420.72	198.14
Little River	2449	50-Year	PreCon_ClimateChange	2842.00	8.50	25.29	4.78	670.54	201.34
Little River	2449	100-Year	PostGrad_ClimateChange	3448.00	7.28	26.86	2.28	1799.30	259.45
Little River	2449	100-Year	PreCon_ClimateChange	3448.00	8.50	26.81	4.53	1019.03	255.83
Little River	2430	10-Year	PostGrad_ClimateChange	1717.00	7.26	18.56	2.26	761.40	69.94
Little River	2430	10-Year	PreCon_ClimateChange	1717.00	4.80	18.58	2.13	807.61	69.96
Little River	2430	50-Year	PostGrad_ClimateChange	2842.00	7.26	25.18	2.27	1322.45	194.08
Little River	2430	50-Year	PreCon_ClimateChange	2842.00	4.80	25.34	2.17	1398.51	208.23
Little River	2430	100-Year	PostGrad_ClimateChange	3448.00	7.26	26.85	2.41	1778.95	357.57
Little River	2430	100-Year	PreCon_ClimateChange	3448.00	4.80	26.85	2.34	1824.47	357.73
Little River	2420	10-Year	PostGrad_ClimateChange	1717.00	7.25	18.56	2.30	746.56	73.69
Little River	2420	10-Year	PreCon_ClimateChange	1717.00	7.30	18.56	2.30	746.24	73.69
Little River	2420	50-Year	PostGrad_ClimateChange	2842.00	7.25	25.18	2.26	1321.33	186.28
Little River	2420	50-Year	PreCon_ClimateChange	2842.00	7.30	25.33	2.24	1348.99	198.67
Little River	2420	100-Year	PostGrad_ClimateChange	3448.00	7.25	26.85	2.41	1750.58	334.01
Little River	2420	100-Year	PreCon_ClimateChange	3448.00	7.30	26.84	2.42	1748.01	333.52
Little River	2415	10-Year	PostGrad_ClimateChange	1717.00	7.24	18.54	2.48	691.79	65.09
Little River	2415	10-Year	PreCon_ClimateChange	1717.00	7.30	18.55	2.48	691.08	65.09
Little River	2415	50-Year	PostGrad_ClimateChange	2842.00	7.24	25.16	2.53	1131.53	103.85
Little River	2415	50-Year	PreCon_ClimateChange	2842.00	7.30	25.30	2.51	1146.68	116.39
Little River	2415	100-Year	PostGrad_ClimateChange	3448.00	7.24	26.81	2.76	1418.65	243.84
Little River	2415	100-Year	PreCon_ClimateChange	3448.00	7.30	26.80	2.77	1416.15	243.37
Little River	2380	10-Year	PostGrad_ClimateChange	1717.00	6.25	18.06	5.41	317.10	45.92
Little River	2380	10-Year	PreCon_ClimateChange	1717.00	2.30	18.23	4.64	369.67	45.93
Little River	2380	50-Year	PostGrad_ClimateChange	2842.00	6.25	25.05	3.53	875.84	162.00
Little River	2380	50-Year	PreCon_ClimateChange	2842.00	2.30	25.23	3.30	954.05	181.39
Little River	2380	100-Year	PostGrad_ClimateChange	3448.00	6.25	26.74	3.63	1262.20	269.15
Little River	2380	100-Year	PreCon_ClimateChange	3448.00	2.30	26.75	3.46	1313.81	269.86
Little River	2342.5			Bridge					
Little River	2305	10-Year	PostGrad_ClimateChange	1717.00	6.25	17.53	5.76	297.93	45.92
Little River	2305	10-Year	PreCon_ClimateChange	1717.00	6.00	17.61	5.69	301.52	45.92
Little River	2305	50-Year	PostGrad_ClimateChange	2842.00	6.25	22.73	4.12	703.42	45.98
Little River	2305	50-Year	PreCon_ClimateChange	2842.00	6.00	23.07	3.99	720.40	45.99
Little River	2305	100-Year	PostGrad_ClimateChange	3448.00	6.25	26.09	3.38	1620.11	540.69
Little River	2305	100-Year	PreCon_ClimateChange	3448.00	6.00	26.10	3.34	1623.40	541.12
Little River	2273	10-Year	PostGrad_ClimateChange	1717.00	7.07	17.69	3.35	512.65	58.19
Little River	2273	10-Year	PreCon_ClimateChange	1717.00	6.60	17.76	3.29	522.55	58.30
Little River	2273	50-Year	PostGrad_ClimateChange	2842.00	7.07	22.76	3.44	833.41	71.52
Little River	2273	50-Year	PreCon_ClimateChange	2842.00	6.60	23.10	3.32	863.42	72.95
Little River	2273	100-Year	PostGrad_ClimateChange	3448.00	7.07	26.06	3.05	1337.25	311.14
Little River	2273	100-Year	PreCon_ClimateChange	3448.00	6.60	26.06	3.04	1343.59	311.15
Little River	2255	10-Year	PostGrad_ClimateChange	1717.00	7.05	17.67	3.46	496.42	47.49
Little River	2255	10-Year	PreCon_ClimateChange	1717.00	8.00	17.69	3.79	453.06	47.46
Little River	2255	50-Year	PostGrad_ClimateChange	2842.00	7.05	22.71	3.80	768.00	65.47
Little River	2255	50-Year	PreCon_ClimateChange	2842.00	8.00	23.02	3.94	743.71	67.02
Little River	2255	100-Year	PostGrad_ClimateChange	3448.00	7.05	26.03	3.39	1202.37	218.01
Little River	2255	100-Year	PreCon_ClimateChange	3448.00	8.00	26.01	3.55	1154.46	217.42
Little River	2218	10-Year	PostGrad_ClimateChange	1717.00	7.00	17.37	5.33	322.18	36.76
Little River	2218	10-Year	PreCon_ClimateChange	1717.00	7.00	17.44	5.29	324.80	36.83

HEC-RAS River: Little River Reach: Little River (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area	Top Width
				(cfs)	(ft)	(ft)	(ft/s)	(sq ft)	(ft)
Little River	2218	50-Year	PostGrad_ClimateChange	2842.00	7.00	22.46	5.36	543.45	51.77
Little River	2218	50-Year	PreCon_ClimateChange	2842.00	7.00	22.82	5.19	562.08	53.05
Little River	2218	100-Year	PostGrad_ClimateChange	3448.00	7.00	25.86	4.64	886.88	222.12
Little River	2218	100-Year	PreCon_ClimateChange	3448.00	7.00	25.86	4.64	886.88	222.12
Little River	1825	10-Year	PostGrad_ClimateChange	1717.00	6.80	17.24	4.74	403.64	51.47
Little River	1825	10-Year	PreCon_ClimateChange	1717.00	6.80	17.32	4.70	407.56	51.70
Little River	1825	50-Year	PostGrad_ClimateChange	2842.00	6.80	22.45	4.59	714.27	67.47
Little River	1825	50-Year	PreCon_ClimateChange	2842.00	6.80	22.81	4.44	738.71	68.43
Little River	1825	100-Year	PostGrad_ClimateChange	3448.00	6.80	25.84	4.21	958.60	77.46
Little River	1825	100-Year	PreCon_ClimateChange	3448.00	6.80	25.84	4.21	958.60	77.46
Little River	1775 FEMA Section A	10-Year	PostGrad_ClimateChange	1717.00	5.20	17.16	4.79	358.28	41.56
Little River	1775 FEMA Section A	10-Year	PreCon_ClimateChange	1717.00	5.20	17.24	4.76	360.78	41.62
Little River	1775 FEMA Section A	50-Year	PostGrad_ClimateChange	2842.00	5.20	22.20	5.41	525.58	45.66
Little River	1775 FEMA Section A	50-Year	PreCon_ClimateChange	2842.00	5.20	22.57	5.29	537.64	45.96
Little River	1775 FEMA Section A	100-Year	PostGrad_ClimateChange	3448.00	5.20	25.53	5.42	635.94	48.37
Little River	1775 FEMA Section A	100-Year	PreCon_ClimateChange	3448.00	5.20	25.53	5.42	635.94	48.37
Little River	1750			Bridge					
Little River	0010	10-Year	PostGrad_ClimateChange	1717.00	-3.30	8.50	5.06	339.92	1859.82
Little River	0010	10-Year	PreCon_ClimateChange	1717.00	-3.30	8.48	5.29	325.15	1856.13
Little River	0010	50-Year	PostGrad_ClimateChange	2842.00	-3.30	8.11	8.69	327.30	1782.10
Little River	0010	50-Year	PreCon_ClimateChange	2842.00	-3.30	8.05	9.14	311.11	1769.68
Little River	0010	100-Year	PostGrad_ClimateChange	3448.00	-3.30	2.83	22.29	155.09	721.28
Little River	0010	100-Year	PreCon_ClimateChange	3448.00	-3.30	3.21	22.54	153.27	797.33
Little River	0	10-Year	PostGrad_ClimateChange	1717.00	-3.30	8.70	0.27	10421.96	1912.14
Little River	0	10-Year	PreCon_ClimateChange	1717.00	-3.30	8.70	0.27	10421.96	1912.14
Little River	0	50-Year	PostGrad_ClimateChange	2842.00	-3.30	8.70	0.44	10421.96	1912.14
Little River	0	50-Year	PreCon_ClimateChange	2842.00	-3.30	8.70	0.44	10421.96	1912.14
Little River	0	100-Year	PostGrad_ClimateChange	3448.00	-3.30	8.70	0.53	10421.96	1912.14
Little River	0	100-Year	PreCon_ClimateChange	3448.00	-3.30	8.70	0.53	10421.96	1912.14