M-2 CLOMR Application Narrative

NH Route 119 Bridge Replacement
Project No. 12210c
Hinsdale, NH

August, 2019

I. Introduction

The project involves replacement of the NH 119 highway bridge from Hinsdale NH to Brattleboro VT. The proposed bridge is 4700 ft. upstream from a railroad bridge, and 6 miles upstream from the Vernon Dam. The bridge is 26 miles downstream from the Bellows Fall Dam. The Connecticut River is "regulated" or controlled by several dams. The Vernon Dam increased the normal Connecticut River water surface in the vicinity of the bridge when it was constructed in 1908. Whereas, the two existing bridges that span channels either side of Hinsdale Island were built in 1920 and rehabilitated in 1988. The main channel piers for the new bridge will be located 1000 ft. downstream from existing bridge #041/040, and Pier 6 of the new bridge will be located in the secondary river channel 200 ft. downstream of bridge #042/044. The new bridge will have six (6) piers in the river, one (1) dry pier, and abutments on the dry banks. The FEMA Flood Insurance Studies (FIS) were completed by ENSR, International Corp. in November 2003[1]. Both hydrologic and hydraulic studies were performed by ENSR. Prior to theses studies the effective 100 yr. water surface stage at NH 119 was elevation 232.5. The study lowered the elevation to 231.0 (Table 6, pg. 4-10 ENSR Hydraulic Report, Technical Study Data Notebook Section 2.2). Hinsdale and Brattleboro use the same ENSR model in their respective FIS reports. The regulatory floodplain maps for each community end at the cooperate limits which is the western low water line of the river at the state boundary.

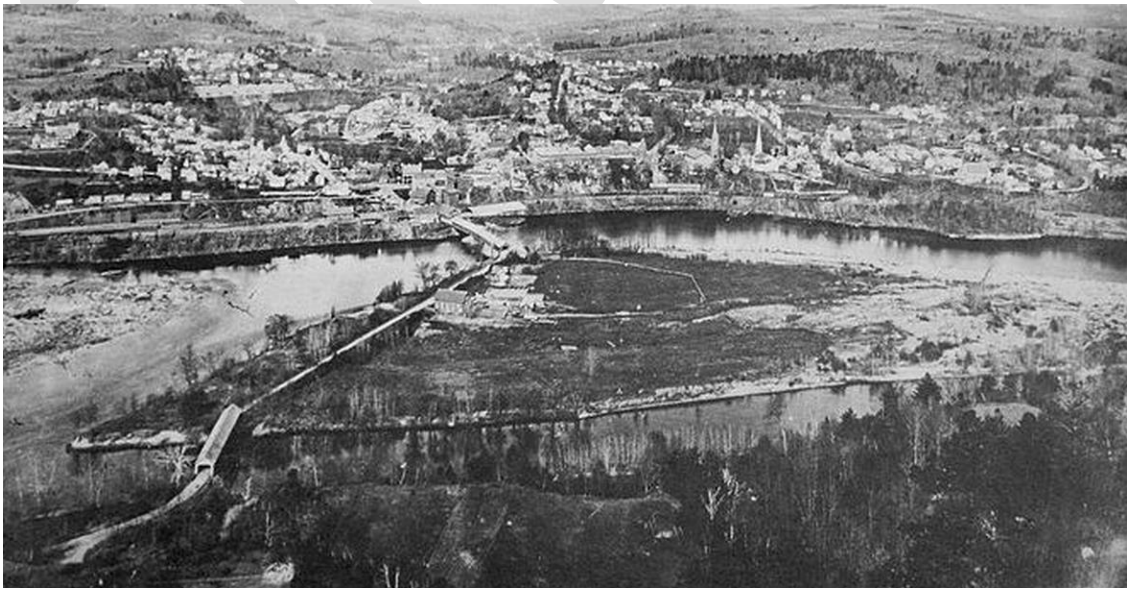

Fig. 1: circa. 1897 prior to the Vernon Dam which was built in 1908

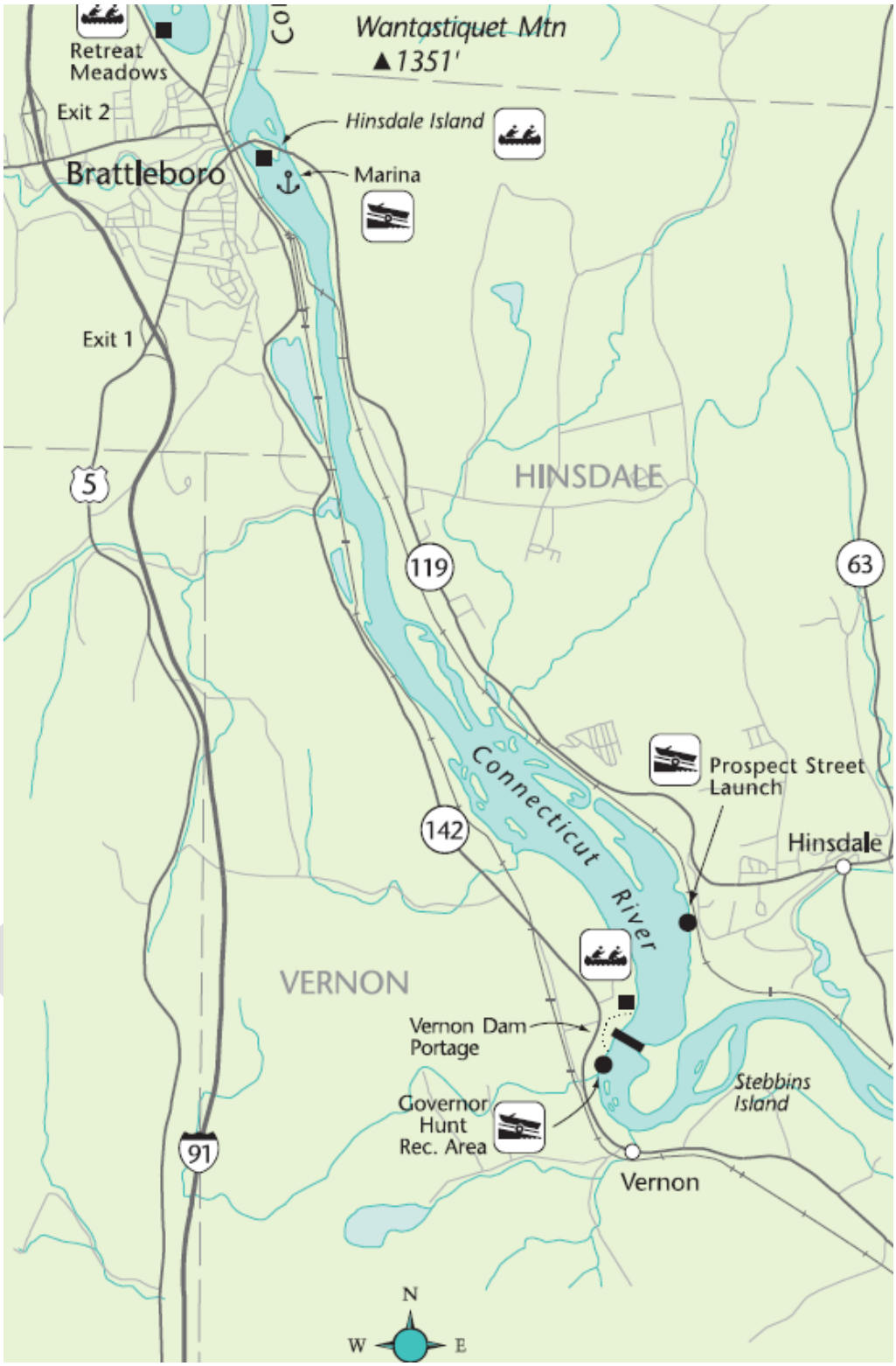

Fig 2: Hydraulic locus map – proposed bridge is just downstream of Hinsdale Island

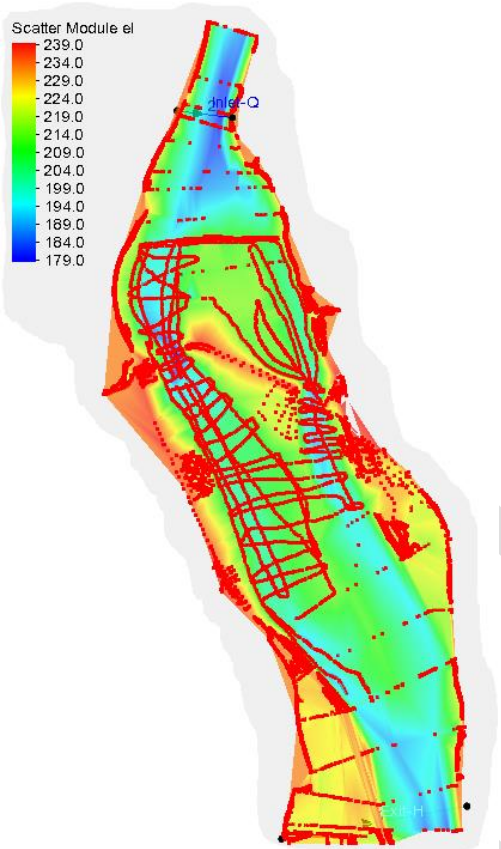

Fig 3. Red points represent merged data from NHDOT 2018 survey, NFIP X-Sects., and lidar

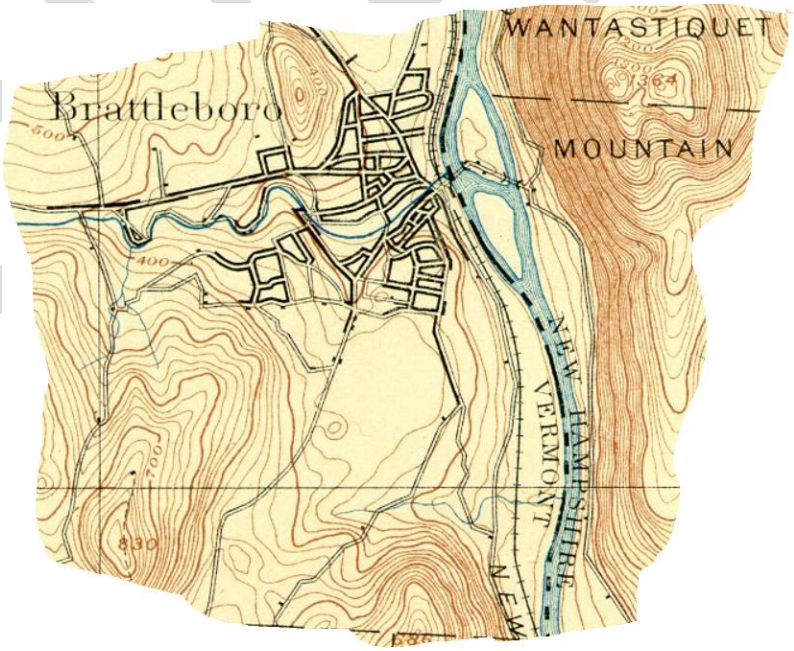

Fig 4. Historic USGS Quad circa 1893 (reprint 1916)

II. Study Area

In accordance with the Federal Emergency Management Agency National Flood Insurance Program (FEMA-NFIP) - the project must limit any increase in the 100 yr. flood elevation caused by encroachments in the floodplain fringe and floodway. The state of NH is a community in the NFIP similar to municipalities. Communities are responsible for prohibiting encroachments including fill, new construction, and substantial improvements within the floodway unless hydrologic and hydraulic analyses show it will not increase flooding levels above target elevations. A "No-Rise" Certification is used when water stages in the new models increase less than 0.1 ft. A CLOMR is required for work in a regulated floodway when water stages are predicted to be more than 0.1 ft. for the 100 yr. profile as is the case for this project. The hydraulic models for the project tie into existing cross sections within the tolerances specified in FEMA guidelines. Brattleboro and Hinsdale corporate limits extend to the low water line of the Connecticut River which is a dynamic line that is represented as a snap shot in time for the FEMA maps. The future LOMR will also be a snap shot in time regarding the regulatory flood maps and the state line. In fact, all plans depict the state line as a snap shot in time unless the Supreme Court line established in the 1930s is altered by legal procedures.

The Hydraulics Section obtained the effective model and then developed a duplicate effective model from the end of the natural constriction in the Connecticut River 2000 ft. upstream to the manmade constriction in the river 4500 ft. downstream. A corrected existing conditions model was created that includes new topography for the river between cross section S and T where the bridges are. Finally the proposed conditions model was created to incorporate the new bridge geometry. A separate model was then developed with plans and profiles for floodway encroachments.

The 2018 NHDOT survey data was combined with 2003 ENSR river geometry and lidar acquired in 2017 above elevation 222 (See **Fig. 5**). Two new cross sections in the vicinity of the proposed bridge were coded in to the models. FEMA cross sections S and T were then updated with the new survey data. The HEC RAS models will be used for a Letter of Map Revision (LOMR) once asbuilts of the new bridge are available.

The proposed model predicts a slight increase of 0.15 ft. in the water surface at effective cross section "T" upstream from the existing bridges. (Sta. 33.3 in **Fig. 5**, aka River Station 33,956.3) The ENSR models show water surfaces to the 0.01 ft., but the VT community FIS table shows the floodway elevation to the nearest 0.1 ft. Energy loss through each existing bridge is slightly different, but the methods used for multiple bridge openings with "stagnation points" iteratively arrive at an average solution within specified tolerance for the cross section T stage.

The models used in addition to a standalone floodway model are:

- Effective model obtained from FEMA
- Duplicate effective model that includes only relevant cross sections near the project.

- Corrected effective model that includes updated topography and bathymetry
- Proposed model that includes the new bridge geometry.

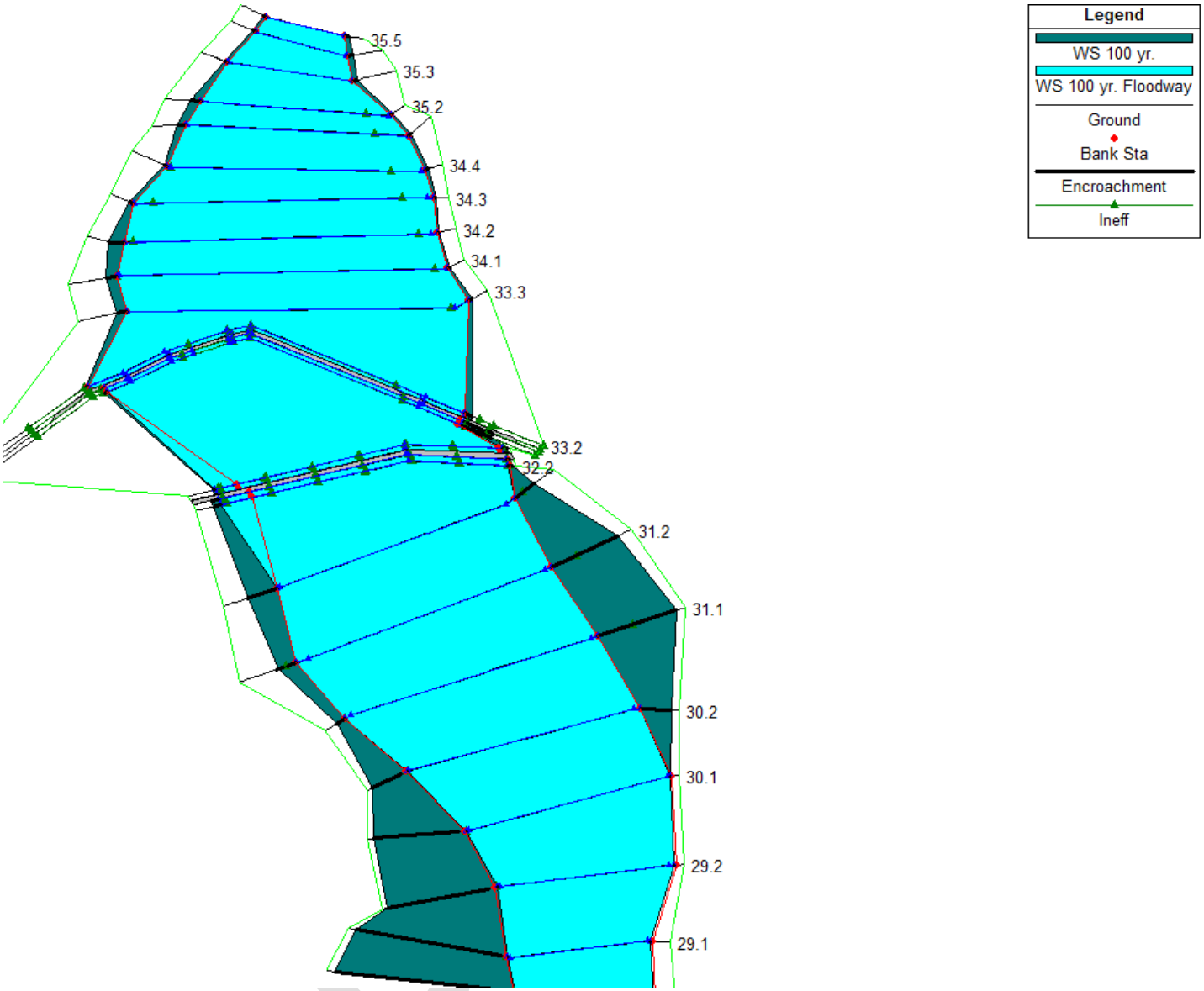

Fig. 5 Depicts the proposed 100 yr. floodway with two new cross sections near new bridge

III. Hydrologic Analysis

The effective FIS reports and supporting models were obtained from the FEMA Engineering Library. The NHDOT Hydraulics Section found the ENSR hydrologic analysis sufficient for bridge design. It was verified that Great Rivers Hydro, LLC used the same FEMA estimates for a recent analysis of the 100 yr. discharge over the Vernon Dam. The 100 yr. design flow is 120,500 cfs. at the confluence of the Connecticut River with Whetstone Brook just upstream from the existing bridge. The 500 yr. flow is 134,700 cfs. FEMA provided the hydrologic report

prepared by ENSR in 2003 that was used in the effective 1d steady state HEC RAS models. ENSR used Bulletin 17b methods. Future hydrologic study of the Connecticut River will likely use Bulletin 17c methods (revised 2018).

A. Drainage Area – Watershed Characteristics

The drainage area is 6,180 sq. miles. The width and depth of flow of the Connecticut River varies as it collects runoff from tributaries from the western slopes of the White Mountains and the eastern slopes of the Green Mountains. Mean daily flows are available from USGS gages and dams located along the river. There are 148 tributaries of the Connecticut River, and 38 are rivers. Land cover was deforested in the 1800s with higher runoff and erosion; however, modern development increased the percent of impervious area in the watershed. Climate change is evident in the form of earlier spring runoffs and more frequent hydrologic events like rain with snow melt in the winter season rather than larger snow melt events near the end of winter.

B. Flood Records and Observations

Much reworking of the river has occurred by nature and by railroad and highway construction. Historic photos are available on the Brattleboro Historical Society website. For historic water records the Hydraulics Section reviewed the Department of the Interior Census Office publication Part I of Water-Power of the United States in 1885. Low flows were estimated to be on an average of 0.540 cfs / sq. mile for the years 1872 -1874 when the landscape was largely deforested (0.54 x 6,180 sq. miles = 3337 cfs). Today typical daily flows based on Great River Hydro, LLC observations below the Vernon Dam are less than 10,000 cfs. Spring flows approach 100k.

C. Flood Discharges

The effective FEMA flood profiles used in the model are shown in **Table 1**:

Location	Watershed (Sq. Mi.)	10 yr. (cfs)	50 yr.	100 yr.	500 yr.
Conn. Riv. @ Whetstone	6,180	94,500	114,500	120,500	134,700

IV. **Hydraulic Analysis of 100 yr. floodplain and floodway** (NAVD 88 vertical datum)

A. Methodology

The extents of the model(s) are between the river constrictions upstream and downstream from the project. The river stationing shown in **Fig. 5**, pg. 5 was used to distinguish this study from the effective study. Effective river stations are included in the description field for the proposed, duplicate effective and existing models. **Fig 6** on pg. 7 shows the river profiles from downstream of the RR Bridge to upstream of the Highway Bridges for NH 119. **Table 2** is from the ENSR

Hydraulic Report **(**pg. 18) whereas **Table 3** on pg. 9 of this narrative is directly from the effective model.

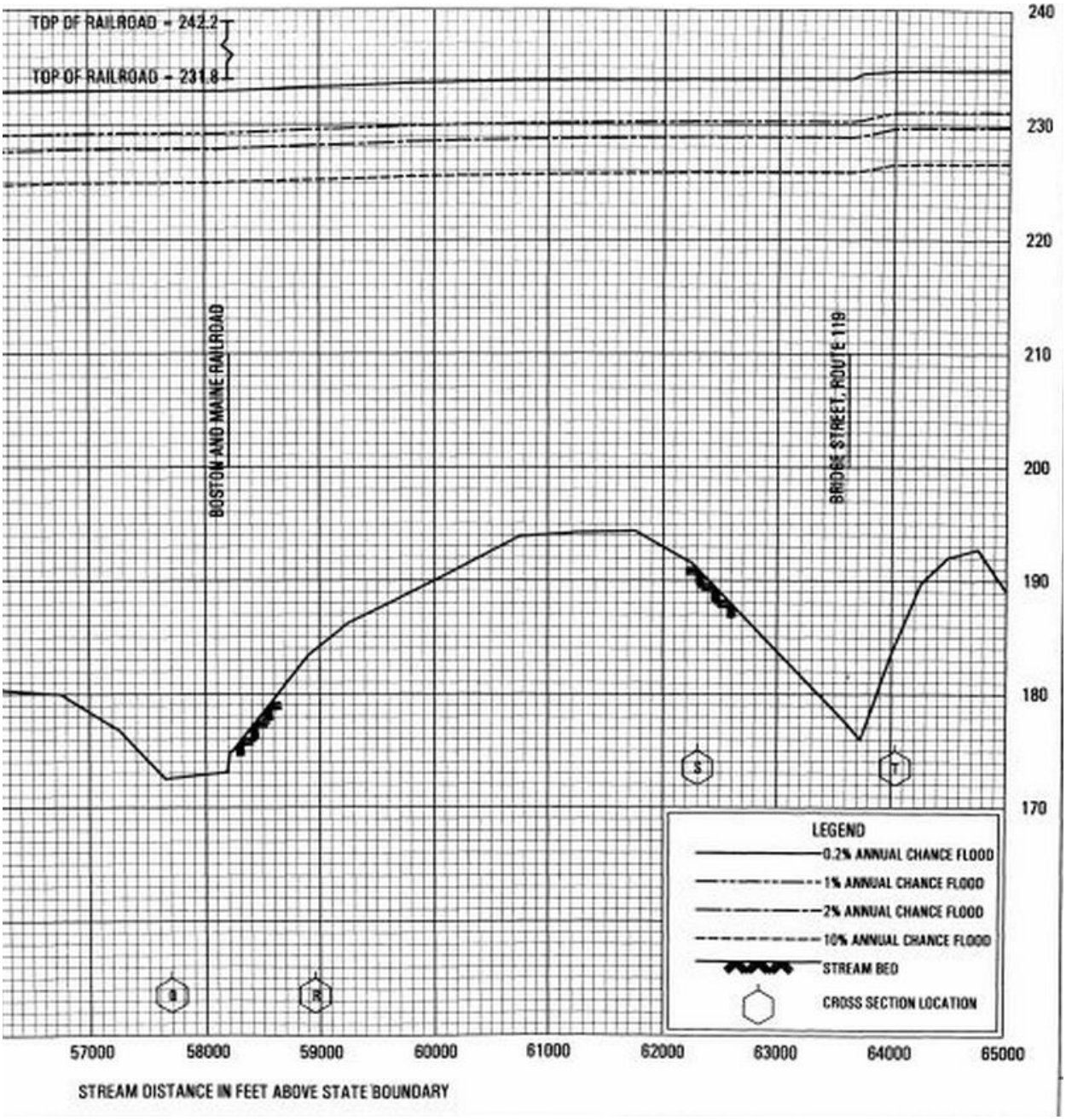

Fig. 6 FEMA river profile and regulatory water surfaces (see pg. 112 of FIS)

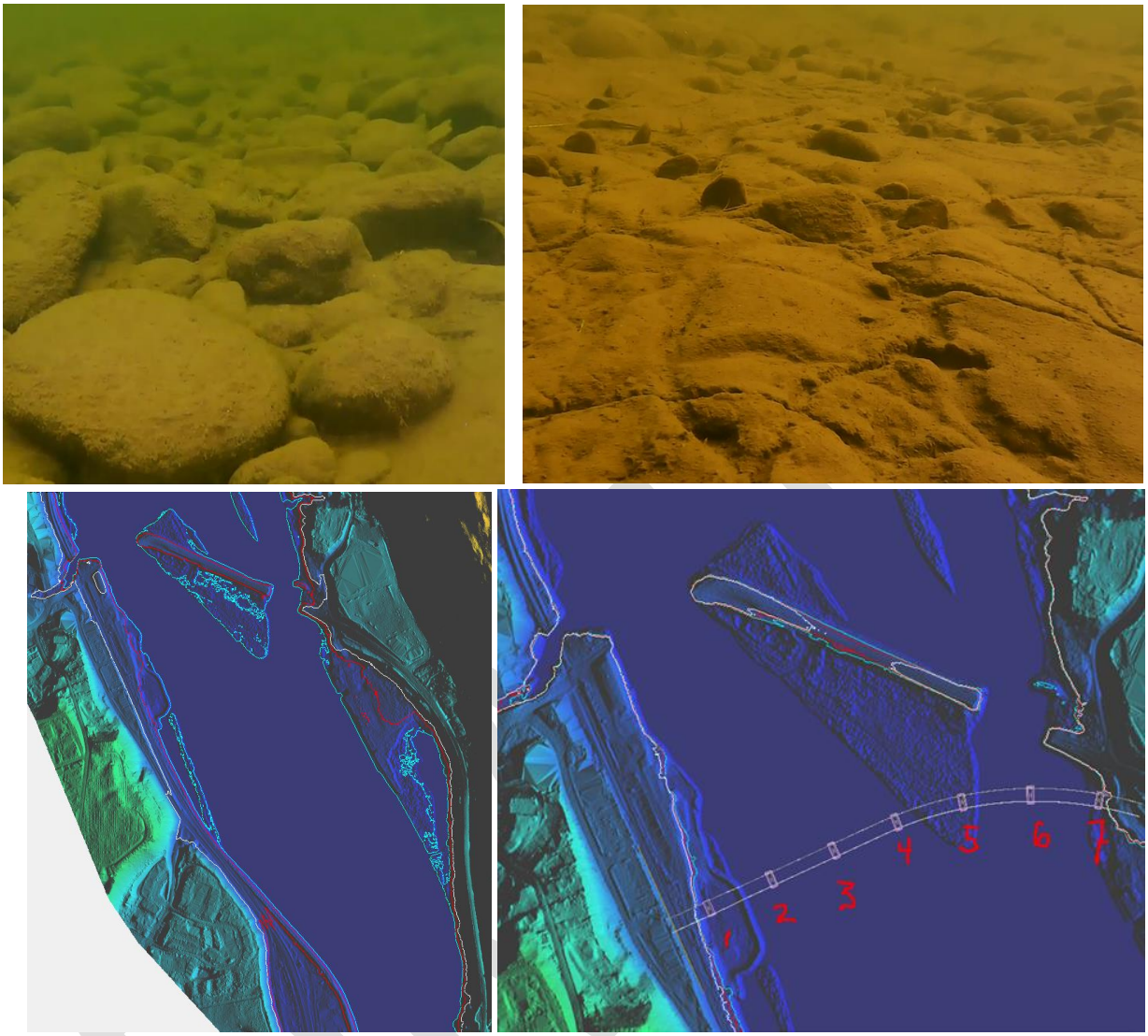

Fig. 7 Top left photo is near future Pier #6, and right photo is between Pier #3 & #4 HEC RAS piers are numbered automatically in reverse to the labeling shown here.

Table 2: Cross Section ID N = T (both @ River Sta. 33956) which = Sta. 33.3 in **Fig. 5**

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Table 3: Open Water Flood Profile Table

River Station	Cross Section ID	Annual Chance Flood Stage			
		0.1	0.2	0.01	0.002
(ft)		(ft)	(ft)	(ft)	(ft)
251	A	220.76	223.87	225.84	230.47
1,310	B	221.06	224.17	226.11	230.69
4,501	C	221.5	224.57	226.46	230.95
6,123	D	221.63	224.69	226.56	231.03
8,732	E	222.07	225.02	226.78	231.15
11,765	F	222.33	225.23	226.95	231.25
12,753	G	222.38	225.26	226.97	231.25
16,222	H	223	225.85	227.48	231.62
17,722	I	223.31	226.18	227.79	231.88
22,721	J	224.18	227.03	228.56	232.42
27,620	K	224.95	227.87	229.23	232.93
28,875	L	225.23	228.22	229.59	233.28
32,225	M	225.86	228.92	230.29	233.94
33,956	N	226.52	229.67	231.04	234.64

Table 3: Regulatory Floodplain and Floodway from Effective HEC RAS Model

	HEC-RAS Plan: Floodway River: CT Reach: 1											
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
T 1	33956.3	100_Year	20300.00	183.25	231.04	208.57	231.21	0.000141	3.30	36547.21	1805.62	0.12
1	33956.3	Floodway-Prev	20300.00	183.25	231.46	208.57	231.63	0.000132	3.24	37263.27	1807.32	0.12
1	33956.3	Floodway	20300.00	183.25	231.40	208.58	231.57	0.000136	3.27	36773.63	1731.82	0.12
1	33702.25	100_Year	20500.00	175.98	230.42	204.06	231.02	0.000504	6.19	19598.87	1609.04	0.21
1	33702.25	Floodway-Prev	20500.00	175.98	230.87	204.06	231.45	0.000477	6.09	19934.57	1610.67	0.20
1	33702.25	Floodway	20500.00	175.98	230.80	204.06	231.39	0.000505	6.11	19714.89	1572.03	0.20
1	33646.7		Mult Open									
1	33595.37	100_Year	20500.00	177.26	230.27	204.68	230.89	0.000217	6.35	19178.67	1479.93	0.20
1	33595.37	Floodway-Prev	20500.00	177.26	230.72	204.68	231.32	0.000208	6.27	19457.39	1517.63	0.19
1	33595.37	Floodway	20500.00	177.26	230.65	204.68	231.26	0.000215	6.29	19264.92	1374.18	0.19
S 1	32224.63	100_Year	20500.00	191.54	230.29	210.22	230.48	0.000100	3.59	34428.60	1648.01	0.13
1	32224.63	Floodway-Prev	20500.00	191.54	230.74	210.22	230.93	0.000094	3.52	35141.92	1660.01	0.12
1	32224.63	Floodway	20500.00	191.54	230.66	210.22	230.86	0.000101	3.63	33214.87	1349.48	0.13
1	31721.38	100_Year	20500.00	194.37	230.24	210.03	230.42	0.000117	3.44	35160.54	1894.65	0.12
1	31721.38	Floodway-Prev	20500.00	194.37	230.69	210.03	230.87	0.000113	3.41	35329.79	1444.05	0.12
1	31721.38	Floodway	20500.00	194.37	230.62	210.04	230.80	0.000114	3.42	35225.65	1444.05	0.12

The proposed bridge and the existing bridges are located between FEMA cross sections S and T. The Base Flood Elevation (BFE) is 230.3 at S and 231.0 at T. The effective floodway elevation at T is 231.4. The average 100 yr. velocity in the effective FEMA model at X-Section 'S' near the proposed bridge is 3.6 fps.

The NHDOT downstream model boundary is at FEMA cross section R (known water surface of 229.59 w/out floodway and 229.99 w/floodway).

The Connecticut River floodway was originally determined by "detailed methods" as part of the FIS report dated October 15, 1980 for Hinsdale. Environmental Engineers, Inc. completed the work for FEMA in December 1978 (Contract No. H-4590). ENSR updated the hydrologic and hydraulic models in 2003 which resulted in a lower floodway.

The Vermont NFIP work was completed in November 1983 by Dufresne-Henry, Inc. for FEMA under contract No. EMW-C-0683. The Vermont FIS for Windam County was published December 4, 1985. Brattleboro Vermont currently uses the same 2003 ENSR study for their NFIP community panels. Hinsdale and Brattleboro use the same effective FEMA models.

The ENSR model used an open area width of 248.83 ft. for the span w/piers, and a width of 334.5 ft. for the main span across the Connecticut River to the Vermont side. **Fig. 8** depicts the ENSR channel with multiple bridge openings and "stagnation points" that determine the flow split in the effective model

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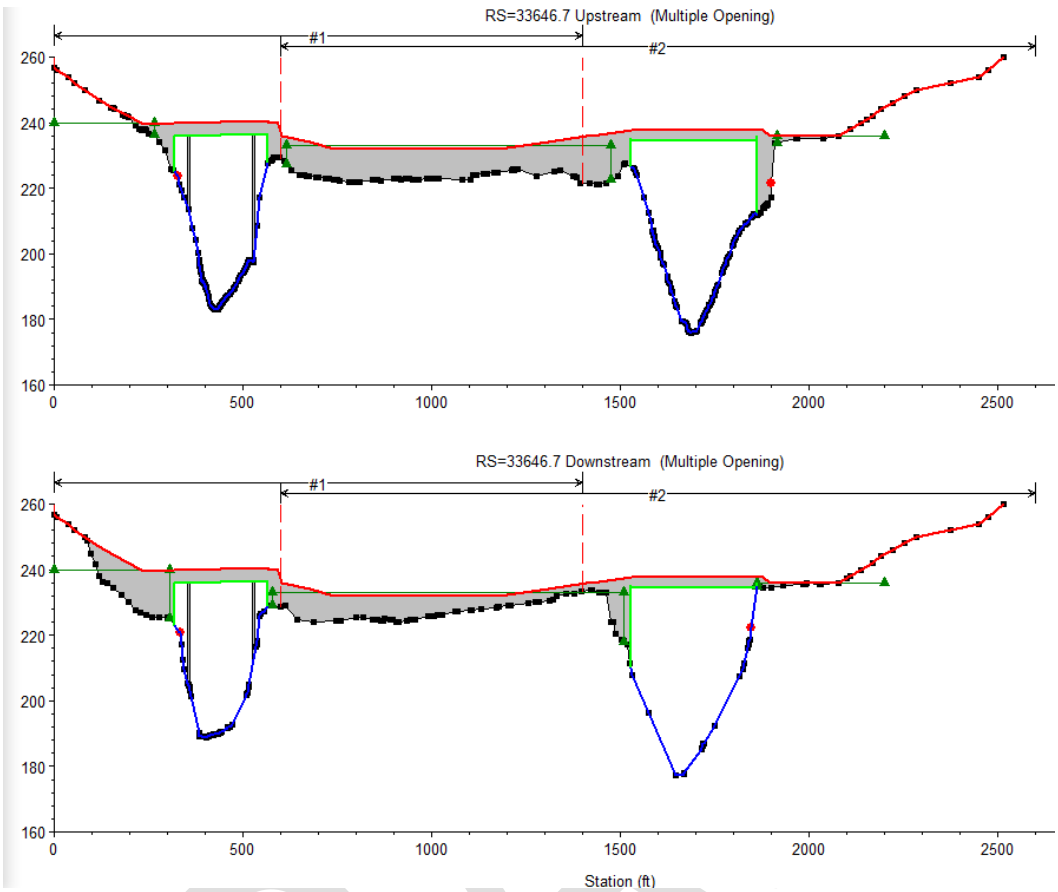

Fig. 8 Existing NH Bridges (041/40 left, 042/44 right)

According to the ENSR Hydraulic Report, the floodway encroachment geometry did not allow for equal conveyance on each side of the floodplain. Fixed encroachment stations were manually set in the floodway model using Method 1 as detailed in the HEC RAS manual. Method 4 was first used for the new river stations immediately upstream and downstream of the proposed bridge. Method 1 was then used to set the encroachment station as shown in **Table 4** on pg. 11. **Fig. 9** depicts the proposed new floodway encroachments (effectively blocking flow behind the outer most piers). Using floodway encroachment stations at the river side of the proposed outer piers provides a smooth transition with the existing floodway.

Table 4: Effective floodway encroachments using Method 1

	River Sta	Method	Value 1	Value 2
742	38220.14	1	86.67	753.49
743	37721.32	1	64.1	695.84
744	37220.27	1	40.65	591.19
745	36721.74	1	67.23	525.93
746	36221.87	1	112.93	526.79
747	35946.74	1	98.19	512.86
748	35823	1	179.42	672.03
749	35623.39	1	231.03	875.04
750	35372.16	1	95.6	1059
751	35220.55	1	180.45	1295.4
752	34942.69	1	92.84	1392.67
753	34723.12	1	73.91	1584.71
754	34461.38	1	99.15	1674.28
755	34222.13	1	102.84	1764.35
T 756	33956.3	1	122.35	1854.17
757	33702.25	1	327.37	1899.4
758	33646.7 MO			
759	33595.37	1	320.4	1847.04
S 760	32224.63	1	279.53	1629.01
761	31721.38	1	479.11	1923.16
762	31228.44	1	480.73	1870.83
763	30721.83	1	193.57	1442.01
764	30222.44	1	45.31	1141.89
765	29721.41	1	51.83	950.66
766	29220.52	1	99.54	825.32
767	28874.51	1	109.37	807.47

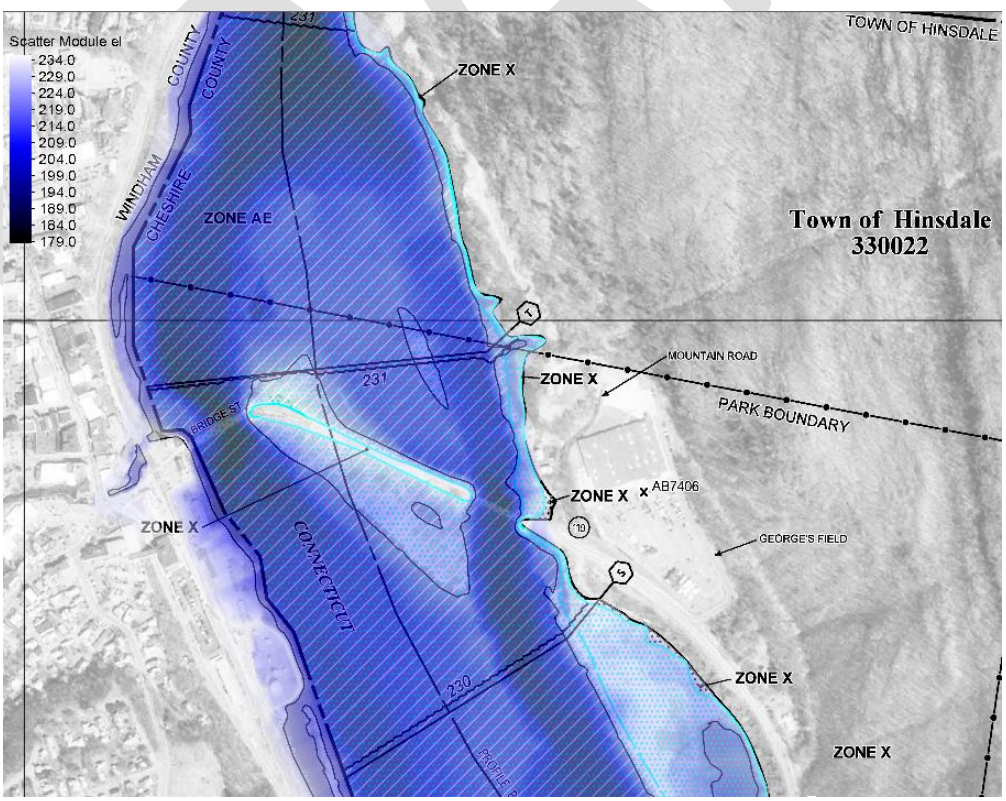

Fig. 7 Effective FEMA cross sections T & S

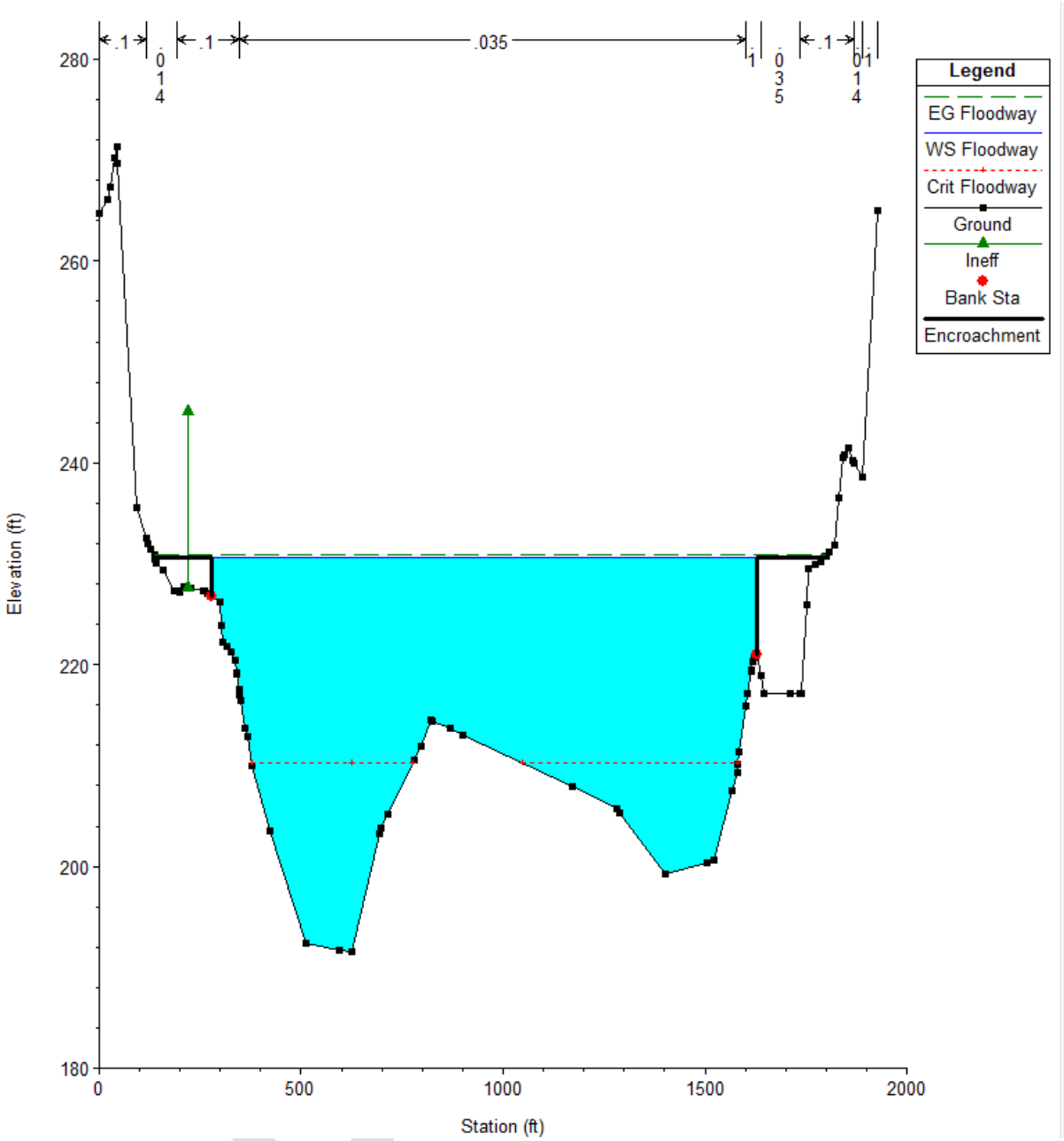

Fig 9.1 Effective Floodway @ X-Sect 'S'

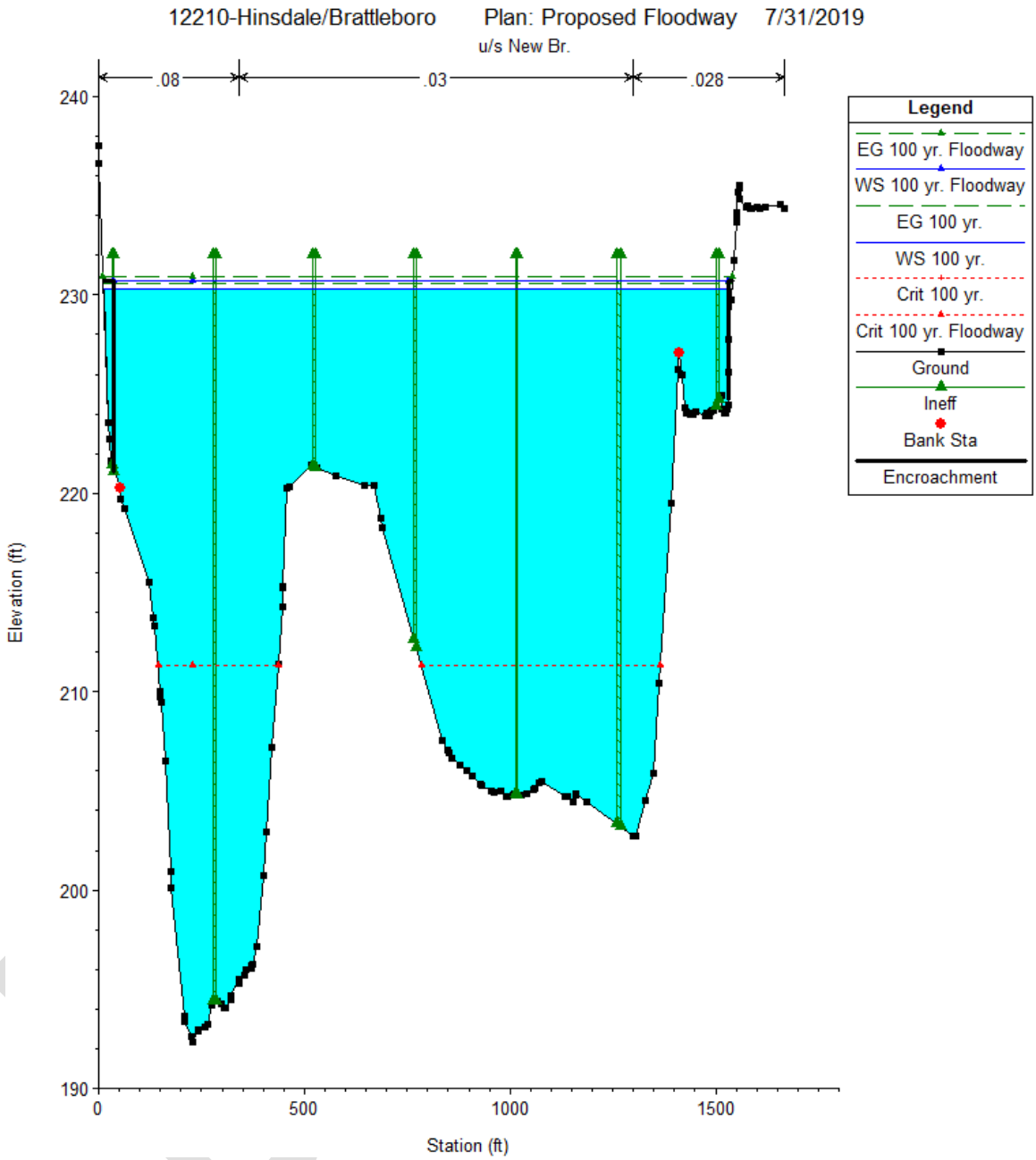

Fig. 9.2 Proposed Floodway @ New Bridge

C. <u>NHDOT Proposed Design Summary</u>

The proposed bridge will carry NH 119 across the Connecticut River between Hinsdale, NH and Brattleboro, VT. The realignment of the roadway will bypass the existing roadway which currently crosses from NH to Hinsdale Island and then from the island to VT. The new bridge downstream from the two existing bridges will span the river. Both existing bridges will remain in place after completion of the new bridge. Roadway pavement along the old alignment will be removed, but not the pavement on the existing bridges.

VI. CLOMR Conclusion

The proposed increase to the Connecticut River Regulatory Floodplain and Floodway resulting from construction of the new bridge is slightly more than the No-Rise certification threshold of 0.1 ft. The increase is a result of energy loss from flow around the piers which produces slightly higher water surfaces in the Connecticut River upstream from the new bridge. The proposed revisions to the regulatory floodplain and floodway are summarized in **Table 5** and in the tables included in appendix A. The Department obtained bathymetry (single echo beam soundings) for part of the model extents. The CLOMR models compare well with the effective FEMA models completed by ENSR. The community panel maps will only need to be revised to show the merging of the floodway under the proposed bridge (see **Fig. 5**).

The LOMR models will include the most current bathymetry and survey measurements from the project files after construction of the proposed bridge. The NH Department of Transportation maintains good communication with the communities, the Vermont Department of Transportation, and with the respective NFIP floodplain coordinators for NH & VT.

Table 5: Floodway Data Table Summaries – refer to tables in the appendix for more detail

Cross Sect. ID	River Station	Floodway Width (ft.)	Section Area (ft^2)	Mean Velocity (fps)	Regulatory ft. NAVD	Without Floodway ft. NAVD	Floodway	Increase
S	32224.63	1349.48	33214.87	3.59	230.29	230.29	230.66	0.37
T	33956.3	1731.82	36773.63	3.27	231.04	231.04	231.4	0.36
Proposed T	33956.3 aka 33.3	1731.82	36925.91	3.26	231.16	231.16	231.52	0.36

HEC-RAS Plan: Proposed River: CT Reach: 12210R

	Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
T	12210R	33.3	100 yr.	120500.00	183.25	231.16	208.61	231.33	0.000139	3.29	36755.96	1806.12	0.12
	12210R	33.3	100 yr. Floodway	120500.00	183.25	231.52	208.60	231.68	0.000134	3.26	36961.17	1731.82	0.12
	12210R	33.2	100 yr.	120500.00	175.98	230.55	204.07	231.15	0.000496	6.16	19697.01	1609.52	0.21
	12210R	33.2	100 yr. Floodway	120500.00	175.98	230.92	204.07	231.51	0.000498	6.09	19800.95	1572.03	0.20
	12210R	33.15		Mult Open									
	12210R	33.1	100 yr.	120500.00	177.26	230.43	204.68	231.05	0.000214	6.32	19277.04	1495.06	0.19
	12210R	33.1	100 yr. Floodway	120500.00	177.26	230.80	204.69	231.41	0.000212	6.26	19353.48	1379.19	0.19
	12210R	32.3	100 yr.	120500.00	192.32	230.31	211.31	230.56	0.000227	4.07	30029.68	1527.21	0.15
	12210R	32.3	100 yr. Floodway	120500.00	192.32	230.69	211.31	230.93	0.000215	4.00	30467.54	1493.00	0.15
	12210R	32.25		Bridge									
	12210R	32.2	100 yr.	120500.00	190.27	230.29		230.53	0.000106	3.93	31427.20	1558.29	0.14
	12210R	32.2	100 yr. Floodway	120500.00	190.27	230.67		230.90	0.000101	3.88	31737.64	1493.00	0.14
S	12210R	32.1	100 yr.	120500.00	191.54	230.29	210.22	230.49	0.000100	3.59	34432.14	1648.07	0.13
	12210R	32.1	100 yr. Floodway	120500.00	191.54	230.66	210.21	230.87	0.000101	3.63	33216.45	1349.48	0.13

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The NHDOT Hydraulics Section calculated a proposed floodway water surface of 231.52 at river station T. The proposed 100 yr. river stage without the floodway is 231.16 which is 0.36 ft lower than the proposed floodway. FEMA Floodways today must be calculated using 1d cross sections. The effective FIS model uses expansion and contraction coefficients that are typically used for bridge sections. The hydraulics section used the same coefficients as the regulatory model. The modeled regulatory floodplain includes both sides of the corporate limits for New Hampshire and Vermont. A 2d hydraulic model does not require expansion and contraction coefficients. The flow split is calculated using the river bathymetry and mesh parameters. The Department appreciates that future FEMA studies may use different methods for floodplain mapping in the future. The data provided herewith will be useful for future floodway and floodplain modeling and management in both communities.

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