Great Brook
Bridge Alternatives Analysis

Plainfield, Vermont
February 15, 2016

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1.0 INTRODUCTION

1.1 Background

This report documents an alternatives analysis for improving the Mill Street Bridge (Bridge #1) and the Brook Road Bridge (Bridge #2) on Great Brook in Plainfield, Vermont, which are prone to flooding and clogging with woody debris and sediment. The bridges have been damaged several times, and the frequency of damages seems to be increasing with increasing floods in the past 5 years. This study focuses on approximately 2,900 feet of Great Brook from near Cameron Road downstream to the confluence with the Winooski River.

This study included collection and review of past flood data collected by the town and others, channel assessment, field survey, aerial survey completed by University of Vermont (UVM) with an unmanned aerial vehicle (UAV), hydraulic modeling, the alternatives analysis, and concept design.

1.2 Flood History

The Great Brook watershed has experienced several damaging floods in recent history (Table 1). The professional and citizen scientists that live in the town of Plainfield have been collecting valuable data on rainfall, flood levels, flow estimates, fluvial geomorphology, and woody debris through the study reach since the 1990s (e.g., Barg and Springston, 2001; Springston, 2015). The data collected were essential to validate the hydraulic conditions leading to damages at the bridges.

TABLE 1
Recent Flood History

Event	Estimated Recurrence Interval	
	Years	%
July, 2015	10	10
Irene, August 2011	25-50	2-4
May, 2011	100-500	0.2-1
Floyd, 1999	10	10

The most recent damaging flood took place during this study on the evening of July 17 where the Brook Road Bridge was partially clogged, flow jumped the banks, local homes were damaged, and a section of the road next to the bridge was destroyed. This storm was estimated to have a 10% annual exceedance probability, or was estimated to be a 10-year flood. Following the UVM wood study, we now know that almost all of the small piles of woody debris moved during this flood, and large piles grew larger. The key observation during this flood was that the Brook Road Bridge was filled with floodwater with only 15 pieces of wood lodged under the Brook Road Bridge. The Brook Road Bridge is hydraulically undersized. Refer to the *Great Brook Flood Notes (July 19, 2015)* memorandum dated July 27, 2015 (Appendix A).

1.3 Bridges

The Mill Street Bridge and the Brook Road Bridge are concrete structures with solid concrete railings (i.e., parapets) (Figures 1 and 2). The Mill Street Bridge was reportedly built in 1929, and the Brook Road Bridge was reportedly built in 1920.

Figure 1: Mill Street Bridge Looking Downstream

Figure 2: Brook Road Bridge Looking Downstream

The opening at the Mill Street Bridge is approximately 30 feet wide providing approximately 7.5 feet of vertical clearance between the channel bottom and concrete support beams. The approach channel is lined with dry-stacked stone masonry and concrete block walls tying into concrete wingwalls at the opening. The exit channel includes a concrete retaining wall and multistory building on river left (facing downstream) and a wingwall on river right. The channel leading into and out of the bridge is aligned with the opening and confined.

The opening at the Brook Road Bridge is approximately 24 feet wide and 7 feet tall between the channel bottom and concrete support beams. The approach channel makes a sharp 90° bend just upstream of the bridge opening. A concrete block and dry-stacked stone wall and wingwall exist on river right (inside of the meander bend) while the channel bank on the outside of the bend has been armored with riprap. A concrete retaining wall and a multistory building exist downstream of the bridge on river left. A wingwall and channel bank armoring exist on river right immediately downstream of the bridge. The channel alignment upstream of the Brook Road Bridge tends to force flow toward the outside of the bend creating a greater potential for debris jamming.

Both subject bridges are not designed to the most current standards (Schiff et al., 2014) and have deficiencies in terms of hydraulic capacity and debris transport. The conveyance of flood flows, woody debris, and sediment is impeded at the Brook Road Bridge because of the following:

- It is hydraulically undersized (Figure 3).
- It is located at a break in channel slope.
- It has a nonuniform flow and a hydraulic jump (Figure 4).
- It is located on the outside of a channel meander bend.
- It is backwatered during the 10-year flood and larger.
- It is prone to debris jams.

The Mill Street Bridge has better conveyance than the Brook Road Bridge, but it is also prone to flooding because of the following:

- It is undersized and
- It is backwatered during the 25-year flood and larger.

The more uniform local channel slope, straighter channel approach to the bridge, and the resulting more uniform flood flow makes the Mill Street Bridge less prone to debris jams than the Brook Road Bridge.

Figure 3: Upstream Face of the Brook Road Bridge Full (Springston, 2011)

Figure 4: Hydraulic Roller Downstream of Brook Road Bridge (Springston, 2011)

1.4 Structure Geomorphic Compatibility

Geomorphic compatibility screening (Schiff et al., 2008) is a tool used to indicate how well a structure fits the channel that it crosses. The geomorphic compatibility score is made up of five variables:

- Percent bankfull width (structure width/bankfull channel width x 100)
- Sediment and debris continuity: upstream deposits and downstream scour
- Structure slope versus channel slope, and break in valley slope
- Approach angle
- Bank armoring and erosion upstream and downstream

Both of the subject bridges were found to be mostly incompatible with current channel form and process and have a moderate to high risk of structure failure. "Re-design and replacement planning should be initiated to improve geomorphic compatibility" (Schiff et al., 2008).

Percent bankfull width measurements show that the Brook Road Bridge width is only 49% of the channel width while the Mill Street Bridge width is 71% of the channel width (Figure 5). The bridges are fundamentally undersized relative to the Great Brook channel.

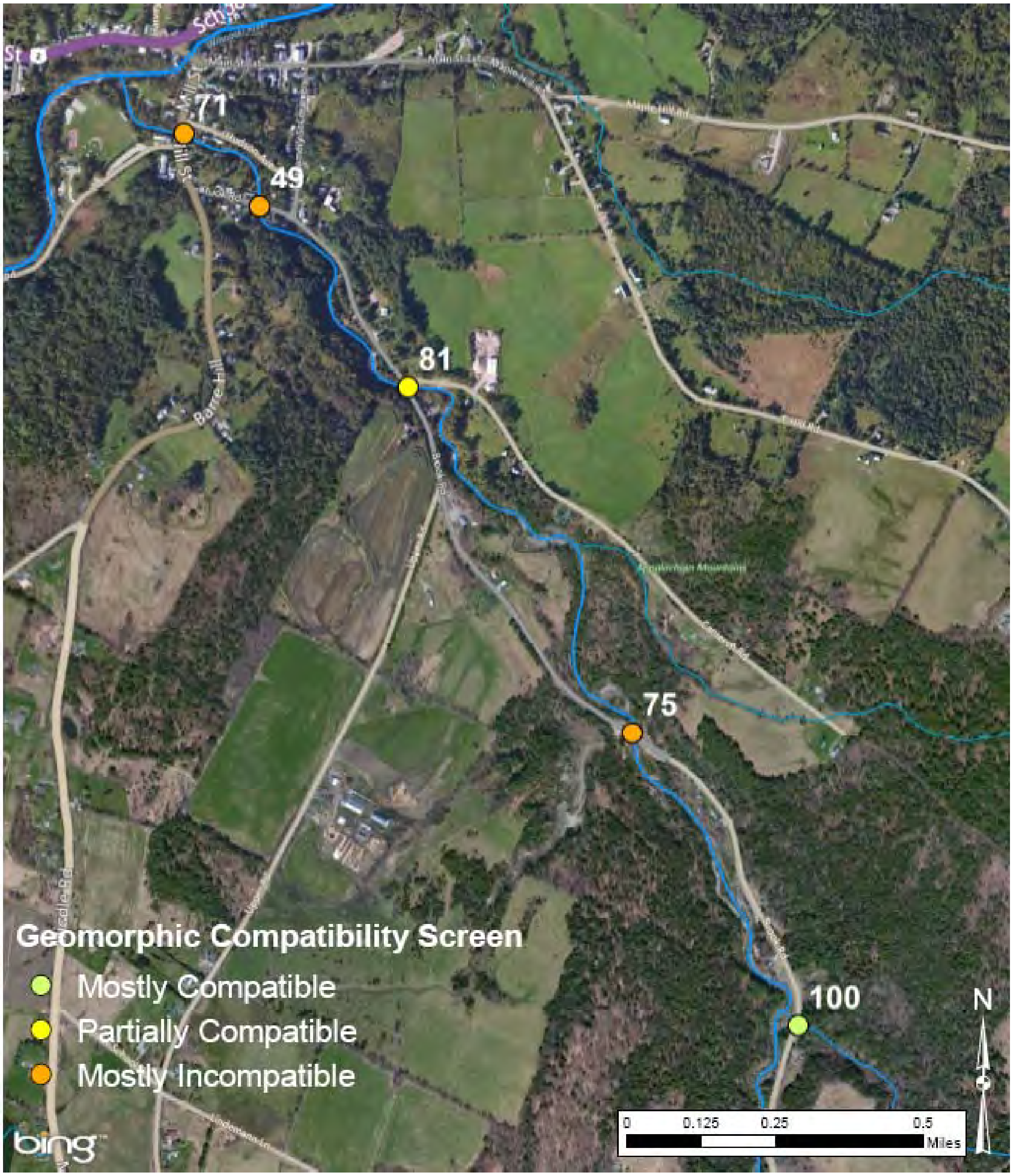

Figure 5: Geomorphic Compatibility Screening on Lower Great Brook

1.5 Channel Geomorphology

A geomorphic assessment (BCE, 2013) and river corridor planning (BCE, 2014) were completed during the past decade, and current field observations indicate that the results of that assessment primarily remain valid today. The channel bankfull width in the study area (M3.01B) is 36 feet, and the bankfull channel depth is 2.5 feet. The channel is dominated by riffle-pool bed features with high sediment bedload and woody debris movement during flooding (Figure 6). The channel sediment is gravel, with cobble and some boulders.

The channel has undergone historic downcutting (i.e., incision) due to encroachments such as Brook Road that artificially narrow the valley through which Great Brook flows. This narrowing leads to high velocities and more erosion. Major aggradation takes place in other areas where the local channel slope decreases or the channel is constricted by either natural or man-made features. Large sediment bars and unstable steep riffles exist in the study area.

The 2012 assessment indicated that the channel was in evolution stage II (F), which means the channel is tending to cut down into its floodplain and widen. This trajectory has been seen during recent floods where the channel cuts down initiating landslides along the steep valley walls and where the channel widens and damages Brook Road. This evolutionary track of downcutting and widening remains today and is anticipated to continue over the long term setting the stage for ongoing conflicts along Great Brook.

The summary of the past and current geomorphic assessment is that the channel is highly sensitive to change when disturbed, such as from a flood.

Figure 6: Great Brook (Milone & MacBroom, Inc., 2015)

1.6 Landslides

Channel downcutting has initiated landslides through the erosion of the bottom of steep valley walls during flooding and subsequent slope failure (Figure 7). Springston and Thomas (2014) studied the landslides along Great Brook and identified 47 active landslides, 3 inactive landslides, 7 bank erosion sites, and 15 sites with gullying on the slopes. The study showed that most landslides are in the lower reaches of Great Brook approaching the village (Figure 8). Gullies are common throughout the watershed.

The 2014 study notes that additional landslides can be expected to occur after future large floods. This prediction has come true in that fresh landslide areas were observed following the July 2015 flood. The most common landslide activity observed in 2015 was the extension of an existing slide area. Some new slides did appear.

As with the geomorphic assessment, the landslide study notes that the constrictions at undersized bridges, floodplain encroachments from roads and houses, past channelization, and removing of hydraulic roughness during flood recovery efforts where large woody debris and boulders are cleared from the channel lead to future flood risks.

Figure 7: Landslide on Great Brook (Milone & MacBroom, Inc., 2015)

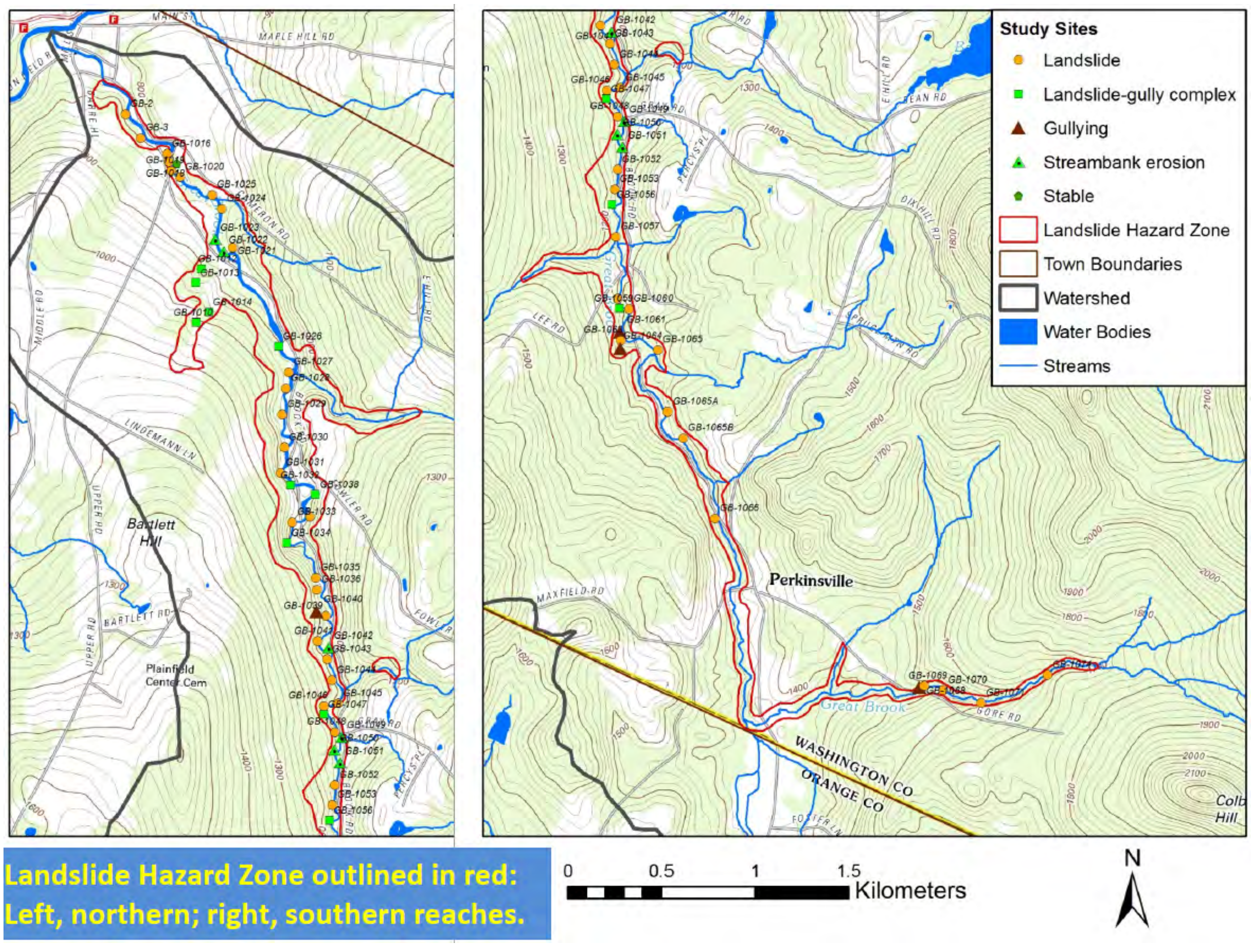

Figure 8: Landslide Mapping on Great Brook (Springston and Thomas, 2014)

2.0 LARGE WOODY DEBRIS

2.1 Observations

Current observation of large woody debris in the channel illustrates that wood is regularly entering the project area from nearby landslides or upstream areas; accumulating in piles in locations with snags, constrictions, or sheltered hydraulics; and leaving the study area after passing under the two subject bridges. Recent field observations reveal large and small accumulations as well as different levels of burial in the channel sediment (i.e., embeddedness).

Observations immediately after the July 2015 flood, estimated to be a 10-year flood, revealed 15 large logs wedged under the river left third of the Brook Road Bridge. The July 2015 flood observations (See Appendix A) suggested that a lot of wood came down Great Brook and thus made it through the subject bridges since only a small amount of wood was held up at the bridges. A large tree was located on the bank downstream of the Mill Street Bridge that was reportedly not there prior to the flood. The observations suggest that some wood is making its way through the system during smaller floods.

A large woody debris survey was conducted by Springston, Cogbill, and Strong on May 16, 2015 that was repeated on June 11, 2015 after a bankfull flood that took place on May 31, 2015. The observations indicated that five of fifteen non-anchored large wood elements moved during the event. Three pieces of wood were transported downstream, two shifted their location, and three new pieces emerged. These observations illustrate that wood enters, moves, accumulates, and leaves stretches of Great Brook during even small and moderate floods – a finding that was confirmed by the University of Vermont study described below.

Observations before and after the July 2015 flood highlighted the reasons the Brook Road Bridge cannot effectively pass debris. A rule of thumb for bridge and culvert design is that at least 20% of the height of the structure should be left open during the design flood so that wood can pass through (Furniss et al., 1998). This common design criterion clearly does not exist at Brook Road. Wood hits the roof and concrete railing of the structure, so it does not even pass during a 10-year flood.

The local hydraulics on the sharp bend in the river are forcing wood to the western side of the channel and prohibiting it from cleanly passing through the structure. Other bridges on Great Brook such as Mill Street and near Cameron Road have straighter approaches and did not trap any wood during the 2015 flood. These bridges are also larger. The flood level was reported to be 1 to 1.5 feet from the top of the Mill Street Bridge, which passed some large trees.

Rill erosion on the compacted, gray, silty material on the steep slope failures appeared to perforate the surface material. Combined with the erosion at the bottom of the slope, additional slope failures are likely to persist on Great Brook for a long time. Observations suggest that a regular supply of wood is in store for the long term on Great Brook.

2.2 University of Vermont Study (O'Neil-Dunne and Ahles, 2015)

The UVM has performed a novel study of the large woody debris transport in Great Brook using high-resolution photography and survey from a UAV. The patterns of wood transport and storage were investigated by counting the amount of wood in the aerial photographs before and after the July 2015 flood (Figure 9). The results show a highly dynamic wood load during the 10-year flood. The data suggest that small wood piles (i.e., those with less than five trees) are regularly being generated and flushed through the system (Figure 10). Large amounts of wood are thus likely passing through the Brook Road Bridge and the Mill Street Bridge and exiting the system since there were only relatively small accumulations in these areas compared to the wood generation and movement during floods.

Figure 9: A Comparison of UAV Photographs Showing Wood Removal on Great Brook Approximately 300 feet Downstream of the Cameron Road Bridge (O'Neil-Dunne and Ahles, 2015)

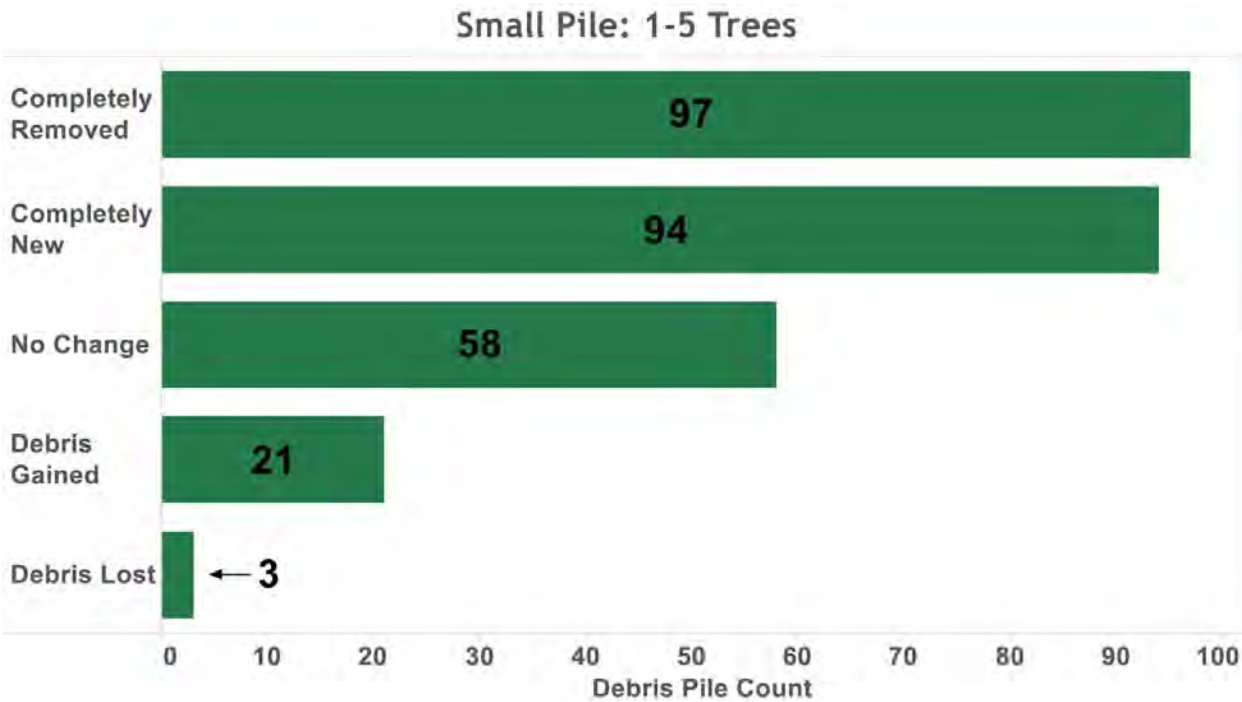

Figure 10: Changes of Small Wood Piles Due to the 2015 Flood on Great Brook (O'Neil-Dunne and Ahles, 2015)

The number of new large wood piles is about equal to the number of existing piles that are unchanged for the 10-year flood (Figure 11). During this flood, large piles of wood were not flushed out of the system as appeared to happen to small piles. This is likely due to the moderate size of the flood. Larger piles, and thus more wood, would likely move during a larger flood such as Irene or the May 2011 flood.

The UVM study indicates that wood is delivered to the channel at the 10-year or larger flood, and wood transport takes place. Given the large source of wood in the forested watershed and the steep valley walls that are prone to landslides, stopping the input of wood into Great Brook is not likely possible. Widespread tree removal around the channel to minimize inputs would increase peak flows and destabilize valley walls, which would increase flood hazards. Widespread tree removal near the channel would also lead to severe water quality and habitat impacts to the channel. The key design objective for the bridges is to create the conditions to pass wood through the system.

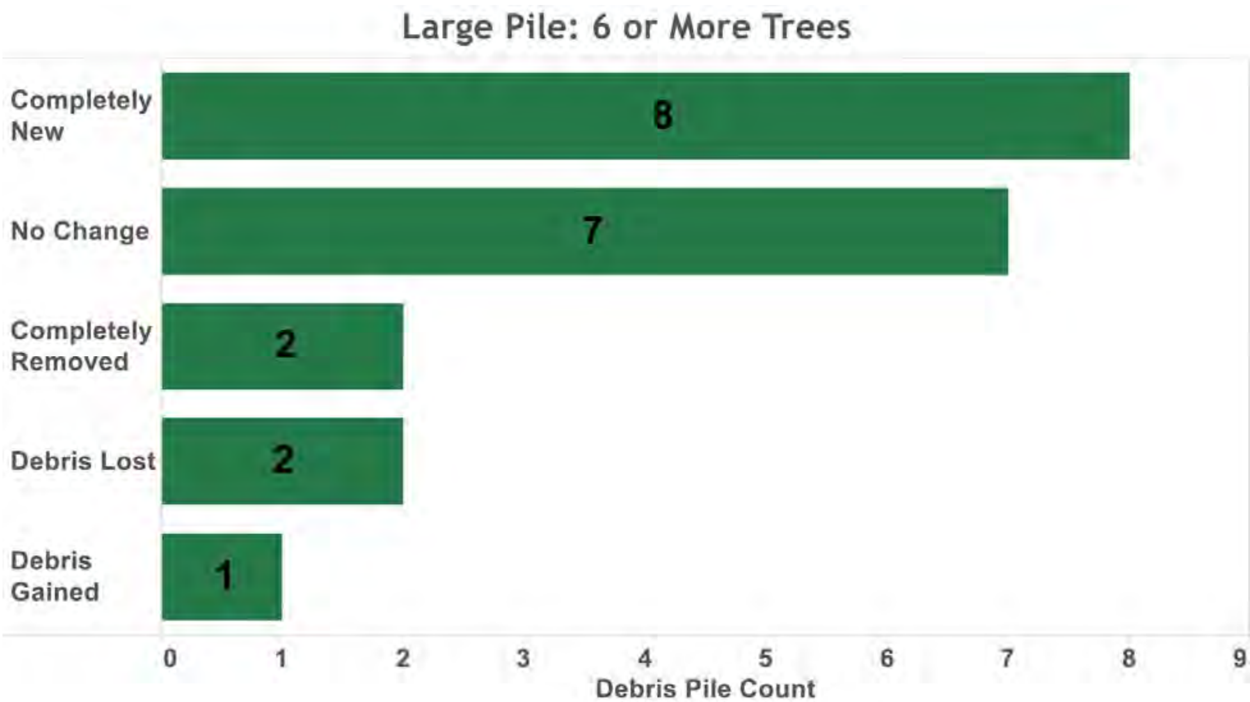

Figure 11: Changes of Large Wood Piles Due to the 2015 Flood on Great Brook (O'Neil-Dunne and Ahles, 2015)

2.3 A Note on Large Wood

It is important to note that large pieces of wood and jams play important roles in stabilizing channels (USACE and BOR, 2015), especially those like Great Brook that are dynamic and prone to incision. Wood also serves as part of the foundation of the aquatic food web (Allan, 1995) and thus has a strong influence on habitat and fisheries. The removal of large woody debris needs to be minimized to control impacts to the channel and to not create additional flood hazards (Schiff et al., 2014).

3.0 HYDROLOGY

3.1 Design Flows

Peak flow rate estimates in cubic feet per second (cfs) used for this analysis (Table 2) were determined from past floods.

TABLE 2
Peak Flow Estimates

Event	Estimated Peak Flow (cfs)	Estimated Recurrence Interval	
		Years	%
Floyd, 1999	1,025	10	10
July 2015	1,055	10	10
Irene, August 2011	1,500	25-50	2-4
May 2011	2,520	100-500	0.2-1

Other flows between 500 cfs and 2,600 cfs were also inserted into the model to investigate the hydraulic performance of the bridges.

3.2 Methods Summary

The flows from Hurricane Floyd (Floyd) and July 2015 were estimated from past stream gauging performed by the Plainfield Conservation Commission. The gauge was installed at the concrete pipe crossing ("the dam") on Great Brook adjacent to the town recreation fields and operated between 1997 and 2001 (Springston, 2002). Data were plotted to develop a rating curve to estimate flows for various flood depths. The peak flow estimate for Floyd was obtained from the flood hydrograph. The peak flow for the July 2015 flood was estimated from surveyed high water marks and conversion to a flow using the gauge rating curve.

For the floods that were too large to estimate using the gauge rating curve (i.e., May 2011 and Irene), high water marks were surveyed, and the slope-area method was performed by George Springston to estimate the flow rate.

Statistical analysis of data from nearby or similar United States Geological Survey (USGS) stream flow gauge stations and regression-based flow estimates (Olson, 2002; Jacobs, 2010; Olson, 2014) were used to check the order of magnitude of the observed or calculated peak flow rates and estimate the annual exceedance probability (or recurrence interval) of the floods (Table 3, and See Table 2).

TABLE 3
Regression and Scaled Peak Flow Estimates (cfs)

	Recurrence Interval							
Source / Method	**1-yr**	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**	**500-yr**
USGS VT StreamStats at Great Brook Project Site (Olson, 2014)	n/a	521	812	1,040	1,370	1,650	1,960	2,810
Regression Equations for Steep Gradient Streams (Jacobs, 2010)	n/a	348	549	733	991	1,197	1,425	2,168
Gage Analysis (Scaled from USGS 01142500, Ayers Brook) (USGS, 1982)	188	421	661	870	1,202	1,507	1,868	2,987

4.0 HYDRAULIC MODELING

4.1 Model Introduction

Hydraulic modeling was performed to predict flood depth and velocity for existing conditions and the alternatives analysis. Hydrologic Engineering Center *River Analysis System* (HEC-RAS) (USACE, 2010) was used for this study to compute flood profiles for multiple flow conditions, including both subcritical (i.e., slow, tranquil, and deep) and supercritical (i.e., fast, turbulent, and shallow) flow. The basic computational procedure of RAS is the solution of the one-dimensional energy equation. Energy losses are evaluated by friction (Manning's Equation) and the contraction/expansion coefficient multiplied by the change in velocity head. The momentum equation is used in situations where the water surface profile is rapidly varied.

4.2 Model Setup

Survey

Field survey of channel cross sections, channel profile, some floodplain, and some nearby infrastructure was conducted in June, July, and August 2015 by Little River Survey of Stowe, Vermont. The survey cross sections were located to define the subject bridges, identify changes in the channel shape or slope, and compare to past survey.

Reference locations used for past survey were resurveyed to tie survey to the same vertical datum (NAVD88). New reference locations were installed for future survey. High water marks or debris accumulation lines that were left after the July 2015 flood were also surveyed.

Aerial survey completed by the UVM UAV was used to identify floodplain elevations. The UVM data were corrected for trees and buildings and brought onto the vertical datum using reference locations surveyed by both the ground survey crew and the UAV.

Geometry

Great Brook was modeled as a single reach extending from a point just downstream of the Brook Road Bridge near Cameron Road (Bridge #3) to the confluence with the Winooski River (length ~ 0.6 miles). The study reach includes the two subject stream crossings at Mill Street and Brook Road, including wingwalls and retaining walls.

The hydraulic roughness (i.e., Manning's N) is determined at each location by the substrate on the channel bed, the surface of structures, the type of vegetation present on the channel banks, and the land cover on the floodplains. Higher N values indicate more hydraulic roughness that slows flow and dissipates energy. N values used to define the roughness in the channel ranged from 0.040 to 0.050, representing a cobble and gravel stream with some boulders and debris. N values used on the overbank areas and floodplains ranged from 0.06 to 0.08 in developed areas to 0.10 in forested areas.

Contraction and expansion coefficients are specified at each cross section and are used to estimate energy loss due to the contraction and expansion of flow. At normal cross section locations, a coefficient of 0.1 was used for contraction and 0.3 for expansion. At bridge locations, the contraction coefficient was increased to 0.3 to 0.5, and the expansion coefficient varied from 0.5 to 0.7 given that the bridges are narrower than the channel.

Model Analysis and Boundary Conditions

The hydraulic model was performed in steady state mode, meaning one estimated peak flow value was used to evaluate the flood conditions for each storm event without variation over time. The model was executed using a mixed-flow regime, which allows the computation of both subcritical and supercritical flood profiles.

The upstream and downstream boundary conditions were set to normal flow associated with a channel slope of 0.012 feet/feet (1.2%).

4.3 Model Validation

Model validation was conducted to check the performance of the model to represent flood levels from a past flood flow. The input parameters of the base model, such as Manning's N values, contraction and expansion coefficients, and the bridge modeling approach were adjusted to match the conditions during the past floods. The Tropical Storm Irene (Irene) flood was used to validate the model. The results of the validation show that the difference between observed and modeled flood levels is ±0.5 feet (Figure 12). This level of accuracy is suitable for the current analysis.

Another check on the model was performed using the high water marks on the concrete pipe housing adjacent to town recreation fields. Again the modeled flood levels were within 0.5 feet of the surveyed flood level.

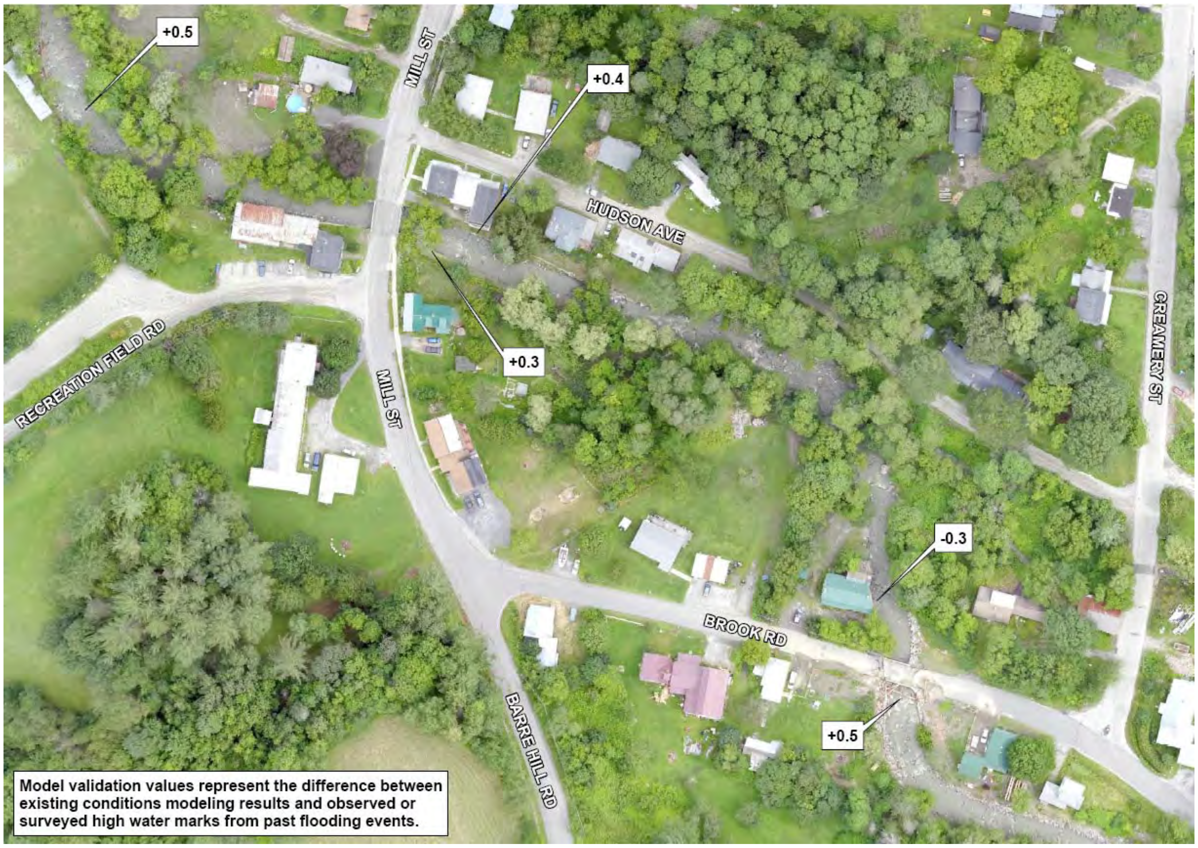

Figure 12: Model Validation Results

4.4 Existing Conditions Hydraulic Evaluation

The validated existing conditions model was first utilized to evaluate the Brook Road Bridge, the Mill Street Bridge, the Great Brook channel, and the floodplain (Appendix B).

Brook Road Bridge

The modeling results indicate that a backwater (i.e., where water slows and ponds due to downstream blockage) condition exists upstream of the Brook Road Bridge due to the narrow bridge opening relative to the bankfull channel width. In addition, the bridge is located at a break in channel slope when compared to the slope approaching and exiting the bridge. The channel profile indicates that there is an accumulation of sediment located approximately 120 feet upstream of the bridge. There is a near 90° channel bend leading into the bridge opening that creates alignment issues with the bridge as well.

The hydraulic modeling results at the Brook Road Bridge indicate that the existing opening can pass approximately 800 cfs without debris jamming or sediment accumulation upstream. The bridge will pass approximately 1,000 cfs just before the roadway is overtopped. A flood of this size is approximately equal to the 10-year flood and analogous to the July 2015 and Hurricane Floyd floods.

Given the history of woody debris accumulation at the upstream face of the Brook Road Bridge, a model simulation was conducted assuming a 10-foot blockage occurred along the left channel bank during a flood equal to the July 2015 event. Flood levels upstream of the bridge increased by approximately 1.6 feet causing floodwater to overtop the roadway. With a simulated debris jam, the hydraulic results indicate that the bridge opening can pass approximately 600 cfs, and roadway overtopping will occur at 800 cfs.

The modeling results indicate that as flood depths upstream of the bridge increase, the backwater condition extends further upstream of the bridge. The flood depth through and immediately downstream of the bridge is shallow with high velocity resulting in turbulent supercritical flow. The modeling results indicate that a hydraulic jump (i.e., a standing wave) will occur downstream of the bridge that becomes more pronounced as flood flows overtop the roadway.

The results indicate a velocity imbalance at the Brook Road Bridge upstream and downstream of the crossing. The hydraulic modeling indicates that the flood velocity upstream of the bridge is approximately 3.4 feet per second (fps) during the July 2015 flood simulation while the velocity is estimated to be 11.1 fps downstream of the bridge. When a debris jam is simulated, flood velocity increases to approximately 3.7 fps upstream of the bridge due to the narrower partially blocked opening, and velocity downstream of the bridge increases to approximately 14.6 fps causing more turbulent flow and a larger hydraulic jump compared to the unclogged simulation. Debris blockage leads to more turbulent conditions that increase the risk of flood and erosion damages.

Mill Street Bridge

The approach and exit channels at the Mill Street Bridge are aligned with the opening, straight, and lined with retaining walls. The bridge is located on a more uniform channel slope, and no indications of appreciable sediment accumulation are visible in the channel. The Mill Street Bridge is less prone to woody debris jamming given the straighter alignment and wider bridge opening.

The hydraulic modeling results at the Mill Street Bridge indicate that a mild backwater condition exists upstream of the opening. The existing opening can pass approximately 1,500 cfs when there is no debris jam or sediment accumulation upstream while the bridge is capable of passing approximately 1,800 cfs just before the roadway is overtopped by floodwaters. A flood of this size would be approximately equal to a 25-year flood and would be comparable to Tropical Storm Irene.

The modeling indicates that the estimated flood velocity at the Mill Street Bridge is 8.6 fps at the upstream face of the bridge and is 8.9 fps downstream of the bridge during the peak of Irene, indicative of uniform flow. When roadway overtopping occurs, the model results indicate a velocity of 7.1 fps upstream of the bridge and 12.5 fps downstream of the bridge indicating nonuniform and likely more turbulent flow.

Although a woody debris jam is less likely to occur at the Mill Street Bridge, a simulation was conducted assuming approximately 10 feet of the opening was clogged. With a jam, the bridge opening is capable of passing approximately 1,200 cfs, and roadway overtopping will occur at 1,400 cfs.

Channel and Floodplains

The results of the hydraulic modeling indicate that the Great Brook channel within the study area can generally pass flood flows ranging between 1,000 to 1,500 cfs corresponding to a 10-year to 25-year flood. This finding suggests that out-of-bank flows have a 10% chance of occurring each year leading to flood risks for infrastructure and improved property in the village. Floodplain encroachments occupy flood storage area and thus further increase the collective flood risk in the village.

The Federal Emergency Management Agency (FEMA) has designated an area of the floodplain adjacent to Great Brook as an approximate Zone A special flood hazard area that is defined as an area subject to flooding during the 100-year flood. Floodplain boundaries were delineated for the estimated 10-year and 100-year floods along the study reach (Figure 13). The floodplain boundaries are based on the results of the existing conditions hydraulic modeling and drawn on the current topographic mapping from the survey and UAV data collection. The delineated floodplains are for informational purposes only at this time. Additional hydraulic modeling and mapping is needed to refine the initial maps for consideration by FEMA to formally update the regulatory floodplain in Plainfield.

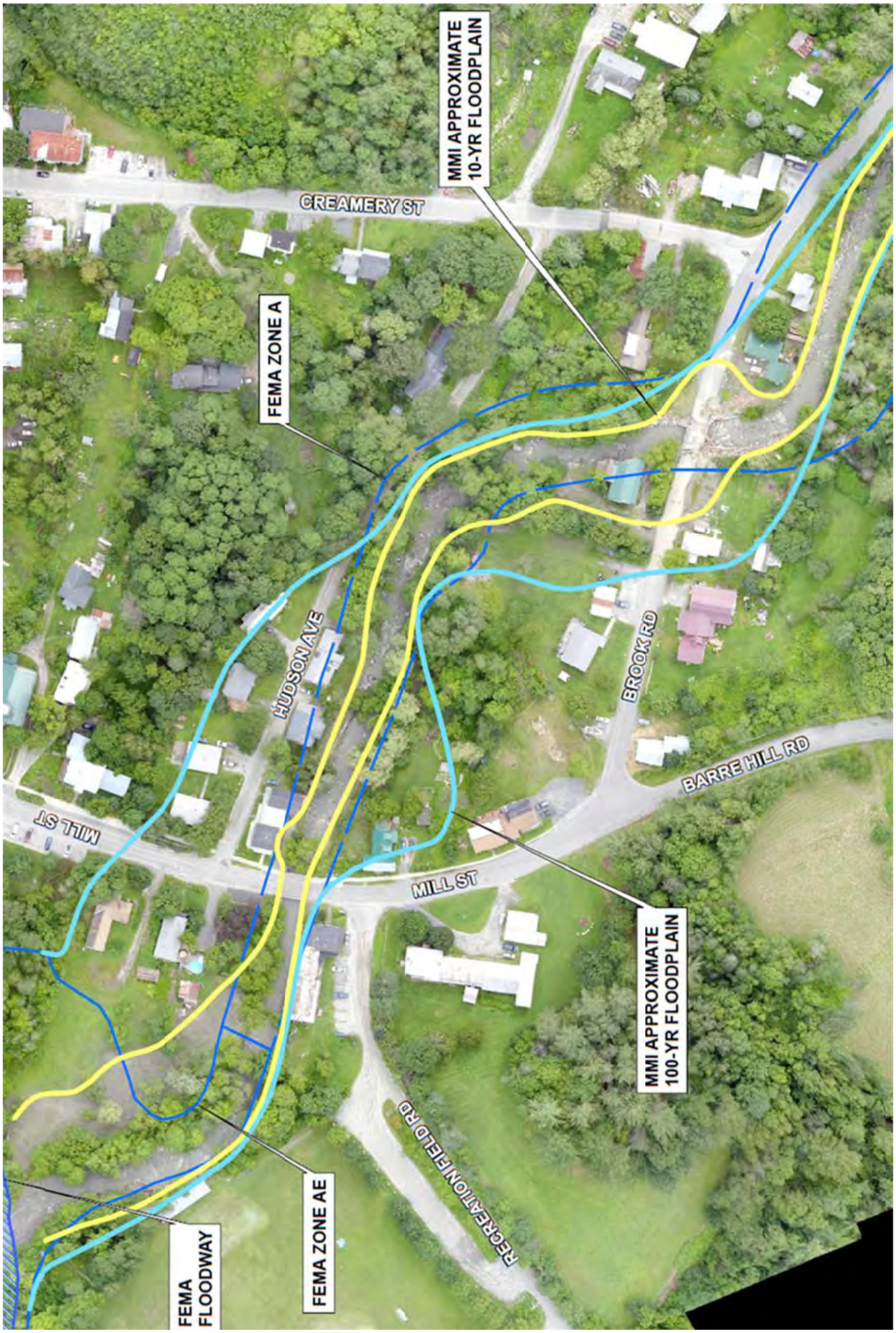

Figure 13: Current Floodplain Mapping.

5.0 ALTERNATIVES ANALYSIS

5.1 Overview

The goal of the alternatives analysis was to reduce damage frequency and increase public safety. Seventeen alternatives were evaluated to meet the following objectives:

- Reduce flood hazards.
- Reduce erosion hazards.
- Increase public safety.
- Naturalize debris and sediment transport.
- Limit water quality and habitat impacts.
- Minimize implementation costs.
- Minimize maintenance costs.

The alternatives generally included changing the size of the bridges, modifying the bridges, removing the bridges, modifying the channel near the bridges, and combinations of bridge and channel changes. An alternatives analysis summary matrix (Figure 14) was developed to compare the alternatives and to assist with selecting a preferred alternative.

A bridge performance summary (Figure 15) was prepared to compare the modeled hydraulic capacity for each alternative. For each modeled flow, a score of pass, caution, or fail was assigned (Table 4).

TABLE 4
Bridge Performance Ratings
(Adapted from TU and SNHPC, 2014)

Score	How Full Opening is (%)	Notes
Pass	< 85	Additional space is available for debris to pass under bridge (Furniss et al., 1998).
Caution	85 – 100	The bridge opening is approaching capacity and could be prone to clogging and damages.
Fail	> 100	The bridge is full with floodwater, and no space exists for debris to pass under the structure. Pressurized flow likely exists.

LEGEND

Excellent	Good	Fair	Poor

	Modeling ID	Description	Reduce Flood Hazards	Reduce Erosion Hazards	Increase Public Safety	Naturalize Debris / Sediment Transport	Limit WQ / Ecological Impacts	Comparative Implementation Cost	Comparative Maintenance Cost	Preferred
Mill St Bridge (Bridge #1)	Exst	No Action - (Maintain Existing Bridge)	Fair	Fair	Fair	Fair	Good	Excellent	Fair	
	Alt A1	Proposed 1.0 x BF Bridge	Good	Good	Good	Good	Good	Fair	Good	√
	Alt A2	Proposed 1.2 x BF Bridge	Good	Excellent	Good	Excellent	Good	Poor	Good	
	Nat	Natural Conditions - Bridge #1 Removed	Fair	Good	Excellent	Fair	Good	Good	Excellent	
	Alt A5	Proposed 1.0 x BF Bridge and Elevate Roadway 1ft	Poor	Good	Fair	Good	Good	Fair	Good	
Brook Rd Bridge (Bridge #2)	Exst	No Action - (Maintain Existing Bridge)	Poor	Poor	Poor	Poor	Fair	Excellent	Poor	
	Alt B3	Existing Bridge with Overflow Culvert	Fair	Poor	Fair	Poor	Fair	Good	Poor	
	Alt B7	Proposed 0.8 x BF Bridge and Elevate Roadway 0.5ft	Fair	Fair	Fair	Fair	Fair	Fair	Fair	
	Alt B1	Proposed 1.0 x BF Bridge and Elevate Roadway 0.5ft	Good	Good	Good	Fair	Good	Fair	Good	
	Alt B8	Proposed 1.0 x BF Bridge with Profile Change	Good	Good	Good	Good	Good	Fair	Good	√
	Alt B4	Proposed 1.2 x BF Bridge with Flood Bench	Excellent	Good	Good	Excellent	Good	Poor	Good	
	Nat	Natural Conditions - Bridge #2 Removed	Fair	Fair	Good	Fair	Fair	Good	Excellent	
	Alt B5	Bridge #2 Removed with BF Channel	Good	Good	Good	Fair	Good	Good	Excellent	
	Alt B6	Bridge #2 Removed with Flood Bench	Excellent	Good	Good	Excellent	Good	Poor	Excellent	
	Alt B2	Weir at Bridge #2	Poor	Fair	Fair	Poor	Fair	Fair	Fair	
Comb.	Alt A3	Proposed Bridge #1 and #2 at 1.0 x BF	Good	Good	Good	Good	Good	Poor	Good	√
	Alt A4	Proposed Bridge #1 and #2 at 1.2 x BF	Good	Good	Good	Excellent	Good	Poor	Good	

Figure 14: Alternatives Matrix

		2-year Flood				10-year Flood Floyd 1999, July 2015						25- to 50-year Flood Irene 2011										100- to 500-year flood May 2011	
	Alternative ↓ / Peak Flow (cfs) →	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	2,600
Mill Street Bridge (Bridge #1)	**Existing Conditions**	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	- With Debris Jam	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	Proposed 1.0 x BF Bridge	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	- With Debris Jam	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	Proposed 1.0 x BF Bridge and Elevate Roadway	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL	FAIL
	- With Debris Jam	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	Proposed 1.2 x BF Bridge	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	CAUTION	CAUTION	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	- With Debris Jam	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	CAUTION	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
Brook Road Bridge (Bridge #2)	**Existing Conditions**	PASS	PASS	PASS	PASS	CAUTION	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	- With Debris Jam	PASS	PASS	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	Existing with Overflow Culvert	PASS	PASS	PASS	PASS	PASS	PASS	PASS	CAUTION	CAUTION	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	- With Debris Jam	PASS	PASS	PASS	CAUTION	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	Proposed 0.8 x BF Bridge	PASS	PASS	PASS	PASS	PASS	PASS	PASS	CAUTION	CAUTION	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	- With Debris Jam	PASS	PASS	PASS	PASS	PASS	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	Proposed 1.0 x BF Bridge	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	CAUTION	CAUTION	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	- With Debris Jam	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	Proposed 1.0 x BF Bridge with Profile Change	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	CAUTION	CAUTION	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	- With Debris Jam	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
	Proposed 1.2 x BF Bridge with Flood Bench	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	CAUTION	CAUTION	CAUTION	CAUTION	FAIL	FAIL	FAIL	FAIL
	- With Debris Jam	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	CAUTION	CAUTION	CAUTION	CAUTION	CAUTION	CAUTION	CAUTION	FAIL	FAIL	FAIL	FAIL	FAIL

LEGEND: Bridge Opening less than 85% Full: PASS   Bridge Opening 85% to 100% Full: CAUTION   Bridge Opening more than 100% Full: FAIL

Figure 15: Bridge Performance Summary

5.2 Brook Road Bridge

A total of 10 alternatives were explored at the Brook Road Bridge (Table 5). Each of the alternatives was modeled with both clear flow (i.e., unobstructed) and a simulated debris jam clogging a portion of the bridge opening.

TABLE 5
List of Alternatives – Brook Road Bridge

Alternative No.	Modeling ID	Description
1	Exst	No action, maintain the existing bridge.
2	Alt B3	Maintain existing bridge and install 6-foot-diameter overflow culvert to the right of bridge opening.
3	Alt B7	Propose 0.8 x BF bridge, elevate roadway by 0.5 feet, and local flood benching.
4	Alt B1	Propose 1.0 x BF bridge, elevate roadway by 0.5 feet, and local flood benching.
5	Alt B8	Propose 1.0 x BF bridge, elevate roadway by 0.5 feet, local flood benching, and remove accumulated sediment just upstream of bridge opening.
6	Alt B4	Propose 1.2 x BF bridge, elevate roadway by 1.0 feet, and create extensive flood benching upstream and downstream of bridge (requiring the relocation of four homes).
7	Nat	Remove existing bridge with no channel modifications.
8	Alt B5	Remove bridge and reshape channel locally to provide a bankfull channel and local flood bench.
9	Alt B6	Remove bridge and create extensive flood benching upstream and downstream (requiring the relocation of four homes).
10	Alt B2	Depress roadway profile by 0.5 feet above the bridge, install breakaway or removable parapets, and allow controlled roadway overtopping.

BF = bankfull channel width

Alternative 1 assumes no action is taken. This alternative is not recommended as existing capacity inadequacies and potential for woody debris jamming would remain. Although the comparative implementation cost would be low, there are limited benefits to this alternative.

Alternative 2 is the installation of a 6-foot-diameter overflow culvert to the river right of the bridge opening. The installation would require the right channel bank to be excavated immediately upstream and downstream of the bridge to connect the overflow culvert to the channel. The modeling results indicate that the culvert will provide limited additional flow capacity during clear flow. This alternative is not recommended as the use of the overflow culvert will leave the bridge and culvert combination prone to clogging and still susceptible to recurring damages.

Alternative 3 proposes a new bridge with a span equal to 80% of the bankfull channel width (~29 feet). Some of the existing land on the river right channel bank upstream and downstream of the bridge would be lowered to create a local flood bench and space for the larger span. In addition, the road would be raised approximately 0.5 feet at the bridge to allow additional clearance through the bridge. The hydraulic modeling indicates that the bridge capacity would increase to approximately 1,400 cfs assuming clear flow and 1,000 cfs with debris jamming under this alternative. The velocity imbalance from upstream to downstream of the bridge is improved providing more uniform flow through the structure and reducing the hydraulic jump downstream. This alternative is not recommended as it is shy of meeting current design standards, and more capacity is possible with a larger structure that will fit at the site.

Alternative 4 is a new bridge with a span equal to 100% of the bankfull channel width (~36 feet). The hydraulic modeling indicates that the bridge capacity will increase to approximately 1,500 cfs assuming clear flow. The larger opening can pass debris more effectively than the existing bridge. The model results show that the bridge would be capable of passing approximately 1,300 cfs when jammed, or nearly the 25-year flood. Flow through the structure becomes more uniform, and the hydraulic jump downstream of the bridge is reduced compared to smaller structures. This alternative is recommended given the performance improvements, the fact that the structure fits in the current crossing location without moving houses, and it meets most of the project objectives.

Alternative 5 adds the removal of the sediment accumulation upstream of the 100% bankfull width bridge to create a more uniform slope approaching the structure. An increase in flood velocity occurs at the location of a sediment accumulation indicating that sediment transport may increase. With the change in hydraulics at the bridge, the hope is that the sediment removal would be a one-time event, and transport would increase in the area reducing (not eliminating) the future risk of debris blockage. This alternative is not recommended until sediment transport modeling takes place during future design to verify the benefits and justify the impacts of sediment removal.

Alternative 6 is a bridge with a width that is 120% of the bankfull channel width (46 feet). To accommodate the wider bridge, a large flood bench would be proposed on both the left and right channel banks upstream and downstream of the bridge. The flood bench would require the relocation of four existing homes. The road would be raised by 1 foot to provide additional clearance through the bridge. Alternative 6 provides the greatest increase in hydraulic capacity and most uniform flow through the structure compared to the other alternatives. The capacity of the bridge assuming clear flow would increase to 2,200 cfs, nearly a 100-year flood. The debris jam simulation indicates that the bridge capacity is only reduced by 100 cfs. A 120% bankfull channel width bridge lowers the risk of clogging with sediment and debris. Implementation cost would be high due to property buyout in addition to bridge replacement costs, and this alternative has a large social impact by displacing four homes. The local residents at the public meeting suggested that this alternative is too extreme from a social perspective at this point. Perhaps if increased flooding does continue as predicted and damages increase, then people will want to move away from this hazardous area, and a larger bridge will be a more realistic option. This alternative is not recommended.

A bridge at Brook Road, even one that is larger and has a greater hydraulic capacity, will continue to have some jamming potential during large floods due primarily to the sharp bend in the approaching channel. Easements or property acquisitions will likely be needed to extend the bridge on both sides of the channel. Due to the potential for remaining debris jamming, buyouts were considered in this analysis along with completely removing the bridge at Brook Road. Moving people and abandoning the crossing location are typically more complicated to implement from a social perspective as they are a big change. However, removal of the bridge without replacement would provide the largest decrease in debris jamming potential in the area. The potential for flood damages to the roadway and nearby private properties would be reduced. Removal of the bridge would avoid replacement costs, significantly reduce future flood damage costs, and avoid long-term maintenance needs.

Alternative 7 assumes that the bridge deck, beams, and parapets are removed, but the bridge abutments and wingwalls remain in place. The primary benefit would be a reduction in clogging potential since there would be no bridge structure to obstruct transport of woody debris. The modeling results indicate that the capacity would increase to approximately 1,500 cfs through the former bridge location; however, the existing flood velocity imbalance from upstream to downstream and turbulent flow conditions would remain, which would allow erosion risks to persist in the area of the former bridge. This alternative is not recommended since the bridge removal alone does not fully reduce risks with the channel remaining confined due to the existing fill. In addition, residents expressed the desire to retain a bridge in this location.

Alternative 8 removes the bridge, re-establishes a bankfull channel at the bridge location, and creates a flood bench to store flood waters and some debris. Modeling results show increased capacity indicating that a 100-year flood would pass through the former bridge location without overtopping the channel banks. Flow is more uniform through the former bridge area. Flood and erosion risks are reduced. This alternative, which would eliminate the bridge and require a change in local traffic patterns, is worth consideration as it fully eliminates the need for future bridge maintenance and flood repairs. At this time this alternative is not recommended as residents expressed the desire to retain a bridge in this location, yet as the project moves into the design phase, the Town should seriously consider removal of a bridge at Brook Road.

Alternative 9 removes the bridge, re-establishes a bankfull channel at the bridge location, and creates a large flood bench. The flood bench would be located on both the left and right channel banks and extend upstream and downstream of the former bridge location. The relocation of four existing homes would be required to implement this alternative. The hydraulic modeling results show the greatest increase in flood capacity and most uniform flow compared to any of the alternatives explored at the Brook Road Bridge. However, implementation cost would be comparatively high due to property buyout requirements. At this time this alternative is not recommended as residents expressed the desire to retain a bridge in this location, and it is not known if the nearby landowners have interest in moving. As the project moves into the design phase, the Town should seriously consider removal of a bridge at Brook Road, and inquire with the local landowners if they have interest in a buyout to be able to move to a safer location.

Alternative 10 explores lowering the roadway profile at the bridge to concentrate flood flows directly over the bridge rather than allowing uncontrolled overtopping. This alternative would require removable or breakaway bridge parapets to reduce the potential for collecting woody debris as the roadway overtops. The modeling results indicate that little to no additional flood capacity would occur after implementing this alternative. Furthermore, fortifying the bridge and embankments to withstand the erosive velocities during overtopping would be extremely difficult in this setting. This alternative is not recommended.

Ballpark cost opinions for each of the Brook Road alternatives are provided that include order-of-magnitude estimates for implementation, flood repairs, and maintenance (Table 6). The cost opinion would be refined during more detailed design phases.

TABLE 6
Ballpark Cost Opinions – Brook Road Bridge

Alternative	Costs ($USD)				
	Implementation*	Flood Repairs†	Maintenance‡	Replacement§	TOTAL
Alt 1 - No Action, Maintain the Existing Bridge	$ -	$ 80,000	$ 20,000	$ 1,600,000	$ 1,700,000
Alt 2 - Maintain the Existing Bridge, Install 6-foot Diameter Overflow Culvert	$ 100,000	$ 80,000	$ 30,000	$ 1,600,000	$ 1,810,000
Alt 3 - Replace Existing Bridge with New 0.8 x Bankfull Width Bridge	$ 1,300,000	$ 60,000	$ 20,000	$ -	$ 1,380,000
Alt 4 - Replace Existing Bridge with New 1.0 x Bankfull Width Bridge and Local Flood Bench	$ 1,600,000	$ 30,000	$ 15,000	$ -	$ 1,645,000
Alt 5 - Replace Existing Bridge with New 1.0 x Bankfull Width Bridge and Sediment Removal	$ 1,600,000	$ 30,000	$ 15,000	$ -	$ 1,645,000
Alt 6 - Replace Existing Bridge with New 1.2 x Bankfull Width Bridge and Extensive Flood Bench	$ 2,600,000	$ 10,000	$ 10,000	$ -	$ 2,620,000
Alt 7 - Remove Existing Bridge with No Channel Modification	$ 50,000	$ 20,000	$ -	$ -	$ 70,000
Alt 8 - Remove Existing Bridge with Bankfull Channel and Local Flood Bench	$ 100,000	$ 10,000	$ -	$ -	$ 110,000
Alt 9 - Remove Existing Bridge with Extensive Flood Bench	$ 900,000	$ 5,000	$ -	$ -	$ 905,000
Alt 10 - Depressed Roadway Profile with Breakaway / Removable Parapets	$ 200,000	$ 80,000	$ 30,000	$ 1,600,000	$ 1,910,000

NOTES

*Includes design, permitting, construction, and a 20% construction contingency.

†Based on past flood damages and estimated liklihood of future flood events.

‡Based on typical maintenance costs over 20 years, which is the estimated life-expectancy of the existing bridges.

§Included in the alternatives when the existing bridge remains as the structure is likely to need replacement in the next 20 years.

5.3 Mill Street Bridge

A total of five alternatives were explored at the Mill Street Bridge (Table 7). Each alternative was modeled assuming clear flow and a simulated debris jam clogging a portion of the bridge opening.

TABLE 7
List of Alternatives – Mill Street Bridge

Alternative No.	Modeling ID	Description
11	Exst	No action; maintain the existing bridge.
12	Alt A1	Propose 1.0 x BF bridge.
13	Alt A2	Propose 1.2 x BF bridge.
14	Nat	Remove existing bridge with no channel modifications.
15	Alt A5	Propose 1.0 x BF bridge; elevate roadway by 1.0 feet.

BF = bankfull channel width

Alternative 11 assumes no action is taken at the Mill Street Bridge. Although the comparative implementation cost would be low, flood and erosion risks would remain due to the existing structure being undersized. This alternative is not recommended.

Alternative 12 proposes a new bridge with a span equal to 100% of the bankfull channel width (~36 feet). To accommodate the wider span, a portion of the existing retaining walls upstream and downstream of the bridge would be rebuilt to match into the new bridge abutment locations. The hydraulic modeling results indicate that the bridge capacity would increase to 1,900 cfs during clear flow, which exceeds the estimated 50-year flood. With a simulated debris jam, the capacity through the bridge reduces to 1,400 cfs. Velocities on both sides of the bridge are similar indicating uniform flow. This alternative is recommended given that it meets most of the project objectives.

Smooth transition into the wider structure must be established to avoid an abrupt increase in cross sectional flow area at the bridge that could lead to excessive local deposition of sediment and large woody debris. The existing walls approaching and leaving the bridge may need to be moved a little to create appropriate transitions. Velocities through the structure should be uniform, with only small increases and decreases to maximize sediment and debris movement during floods.

Alternative 13 is a wider bridge equal to 120% of the bankfull channel width (46 feet). To accommodate the wider bridge, a portion of the existing retaining walls upstream and downstream of the bridge would be rebuilt to match into the new bridge abutment locations, and this alternative would likely result in the loss of useable land on the four properties adjacent to the bridge. The hydraulic modeling results indicate that the bridge capacity would increase to 2,000 cfs assuming clear flow, which exceeds the estimated 50-year flood. With a simulated debris jam, the capacity through the bridge decreases to 1,700 cfs. Velocities on both sides of the bridge are similar indicating uniform flow. Although this alternative has good hydraulic performance, it is not recommended given that there may not be ample space in which to fit the wider span, and the project cost goes up quicker than the hydraulic benefits.

Alternative 14 assumes that the bridge deck, beams, and parapets are removed, but the bridge abutments, wingwalls, and retaining walls remain in place. The primary benefit would be a reduction in clogging potential since there would be no bridge structure to obstruct transport of woody debris. This alternative is not recommended as the public seems to generally feel that a bridge should remain in this location.

Alternative 15 is a wider bridge span equal to 100% of the bankfull width in addition to raising the road 1 foot at the bridge. A portion of the existing retaining walls upstream and downstream of the bridge would be rebuilt to match into the new bridge abutment locations. Nearby driveways would be affected by the change in the road elevation. The higher roadway elevation would increase backwater conditions upstream of the bridge and could direct flood flows further to the north along Mill Street if overtopping was to occur. This alternative is not recommended as it could increase local flood risks.

Ballpark cost opinions for each of the Brook Road alternatives are provided that include order-of-magnitude estimates for implementation, flood repairs, and maintenance (Table 8). The cost opinion would be refined during more detailed design phases.

TABLE 8
Ballpark Cost Opinions – Mill Street Bridge

Alternative	Costs ($USD)				
	Implementation*	Flood Repairs†	Maintenance‡	Replacement§	TOTAL
Alt 11 - No Action, Maintain the Existing Bridge	$ -	$ 40,000	$ 20,000	$ 1,600,000	$ 1,660,000
Alt 12 - Replace Existing Bridge with New 1.0 x Bankfull Width Bridge	$ 1,600,000	$ 30,000	$ 15,000	$ -	$ 1,645,000
Alt 13 - Replace Existing Bridge with New 1.2 x Bankfull Width Bridge	$ 1,900,000	$ 20,000	$ 10,000	$ -	$ 1,930,000
Alt 14 - Remove Existing Bridge with No Channel Modification	$ 50,000	$ 30,000	$ -	$ -	$ 80,000
Alt 15 - Replace Existing Bridge with New 1.0 x Bankfull Width Bridge and Elevate Roadway	$ 1,700,000	$ 40,000	$ 15,000	$ -	$ 1,755,000

NOTES

*Includes design, permitting, construction, and a 20% construction contingency.

†Based on past flood damages and estimated liklihood of future flood events.

‡Based on typical maintenance costs over 20 years, which is the estimated life-expectancy of the existing bridges.

§Included in the alternatives when the existing bridge remains as the structure is likely to need replacement in the next 20 years.

5.4 Combinations

Two alternatives combining changes at the Brook Road and Mill Street Bridges were explored as part of the alternatives analysis to see if the hydraulic changes at one bridge influenced the conditions at the other bridge (Table 9).

TABLE 9
List of Alternatives – Combinations

Alternative No.	Modeling ID	Description
16	Alt A3	Propose 1.0 x BF bridge at Brook Road and Mill Street.
17	Alt A4	Propose 1.2 x BF bridge at Brook Road and Mill Street.

BF = bankfull channel width

The hydraulic modeling results indicate that there is no influence on the Brook Road Bridge due to changes made at the Mill Street Bridge under clear flow, and the opposite scenario applies as well. The findings of the individual alternatives described above at each bridge would thus both take place under the combined alternatives.

The finding of separate benefits at each bridge given their distance apart and the channel slope between the structures (2%) only considers clear flow. It is likely that a wider Brook Road Bridge may lead to more large wood making its way to and through the Mill Street Bridge. We thus recommend that both bridges be replaced and enlarged.

If both bridges will be enlarged, a question arises about which bridge to address first if the ideal scenario where both bridges are replaced near the same time cannot take place. A logical choice is to improve the Brook Road Bridge first since it is the most undersized and has been the most prone to damages during recent floods. A concern does exist about sending more wood to the Mill Street Bridge, but the results of this study suggest that this will only be problematic if an unlikely large flood (i.e., > 50-year event) takes place where the large piles of wood are mobilized, pass through the new Brook Road Bridge, and hit a full Mill Street Bridge. With the large wood study suggesting that a lot of wood does move through both bridges now under smaller floods (i.e., < 10-year event), the presence of some wood storage areas between the bridges, a straight approach to the Mill Street Bridge, and uniform hydraulics at Mill Street, Mill Street is likely to pass even increased amounts of wood until the opening is filled with water.

5.5 The Preferred Alternative

The preferred alternative at the Brook Road Bridge is to replace the structure with a new wider bridge providing a span equal to 100% of the bankfull channel width (Alternative 4). This alternative balances the benefits and performance gains with the spatial requirements associated with a replacement of this size. The hydraulic modeling results indicate that the increased capacity provided at the bridge will lower flood depths upstream of the bridge and provide additional clearance through the bridge for flood events up to the 25-year storm (Table 10, Appendix C).

TABLE 10
Flood Depth and Bridge Clearance Improvement – Brook Road Bridge

Event	Recurrence Interval (years)	Upstream Flood Depth (feet)		Bridge Clearance* (feet)	
		Existing	Preferred	Existing	Preferred
July 2015	10	7.9	5.6	0.0	1.8
Irene, August 2011	25-50	8.9	6.9	0.0	0.7
May, 2011	100-500	11.6	9.8	0.0	0.0

*bridge clearance measured from the flood surface entering the bridge to the bottom of the bridge beams

The modeling results of the preferred alternative show that the difference in estimated velocity from upstream to downstream is reduced compared to existing conditions, indicating more uniform flow through the structure (Table 11, Appendix C). The increase in velocity approaching the bridge indicates an increase in the stream's ability to carry sediment and woody debris. The increase in velocity along with additional clearance through the bridge indicates reduced potential for clogging at the bridge opening.

TABLE 11
Estimated Flood Velocity – Brook Road Bridge

Event	Recurrence Interval (years)	Approach Velocity (fps)		Exit Velocity (fps)	
		Existing	Preferred	Existing	Preferred
July 2015	10	3.4	4.6	11.1	6.8
Irene, August 2011	25-50	4.0	5.1	12.4	7.2
May, 2011	100-500	4.5	5.7	13.9	8.8

Two variations of the preferred alternative were considered. The first variation would be to remove the sediment accumulation located upstream of the bridge to create a more uniform channel slope entering the bridge after bridge replacement. The hydraulic modeling indicates some flood depth improvements extending further upstream of the bridge. Given the high bedload of sediment and wood during flooding, it is likely that the deposit would return. The steep tributary in the area also adds to this sediment buildup. Sediment transport modeling would be needed during future design to verify whether the sediment accumulation would return or whether the transport capacity through this reach would be changed enough with the wider bridge to justify the impacts of sediment removal from the channel.

The preferred alternative at Mill Street is to replace the structure with a new wider bridge providing a span equal to 100% of the bankfull channel width (Alternative 12). Since woody debris clogging at Mill Street is less common, bridge replacement at Mill Street would be less of a priority compared to replacing the Brook Road Bridge. Although bridge replacement at Mill Street would result in performance gains, the improvement is smaller compared to the gains at Brook Road.

The hydraulic modeling results indicate that the increased capacity provided at the bridge will lower flood depths upstream of the bridge and provide additional clearance through the bridge (Table 12, Appendix D). Flood depths may drop up to 2 feet for a storm like Irene.

TABLE 12
Flood Depth and Bridge Clearance Improvement – Mill Street Bridge

Event	Recurrence Interval (years)	Upstream Flood Depth (feet)		Bridge Clearance* (feet)	
		Existing	Preferred	Existing	Preferred
July 2015	10	5.0	4.5	2.6	2.8
Irene, August 2011	25-50	6.4	5.4	1.3	2.0
May, 2011	100-500	9.9	9.1	0.0	0.0

*bridge clearance measured from the flood surface entering the bridge to the bottom of the bridge beams

The preferred alternative modeling results also show how the difference in estimated velocity upstream to downstream of the bridge is reduced when compared to existing conditions indicating more uniform flow through the structure (Table 13, Appendix D). The increase in velocity approaching the bridge indicates an increase in the stream's ability to carry sediment and woody debris. The increase in velocity along with additional clearance through the bridge indicates reduced potential for clogging at the bridge opening.

TABLE 13
Estimated Flood Velocity – Mill Street Bridge

Event	Recurrence Interval (years)	Approach Velocity (fps)		Exit Velocity (fps)	
		Existing	Preferred	Existing	Preferred
July 2015	10	7.8	6.9	9.9	7.6
Irene, August 2011	25-50	8.6	8.2	11.8	9.1
May, 2011	100-500	9.1	7.7	14.0	12.5

6.0 CONCEPT DESIGN

A concept design has been prepared for the Brook Road Bridge (Figure 16, Appendix C) and the Mill Street Bridge (Figure 17, Appendix D) based on the preferred alternatives. The designs increase the bridge spans to the bankfull channel width and widen the channels to create a uniform transition into and out of the structures. The bridge improvements increase hydraulic capacity and improve the transport of large wood and sediment. Flood levels decrease, and velocities through the structures become more uniform. Flood and erosion risks are reduced but not completely eliminated given the confined nature of the Great Brook channel in the village area and the abundance of encroachments in the floodplain.

Plainfield has recently been awarded a 2015 VTrans Bicycle and Pedestrian Program grant for a scoping study to complete the lower village sidewalk network. This study will review specific locations and issues involved in constructing sidewalks in the village, including along Brook Road between Creamery Street and Mill Street. This project is a follow-up to the 2013 Lower Village Traffic-Calming Feasibility Study prepared by Broadreach Associates with funding from Central Vermont Regional Planning Commission, and it advances the 2014 Plainfield Town Plan's call for "building sidewalks on Creamery Street and on Brook Road in the lower village over time as funding becomes available." The hydraulic model indicates that increasing the bridge width by 5 feet (in the direction of flow) in order to accommodate a sidewalk as part of a proposed future bridge over Great Brook does not change the hydraulic improvements identified in this analysis. This finding should be confirmed as the bridge replacement design is advanced.

The following permits will likely be required to implement the bridge replacement projects:

- U.S. Army Corps of Engineers Category 2 Vermont Programmatic General Permit
- Vermont Stream Alteration General Permit
- Clearance from Vermont Division for Historical Resources
- Local Permit for Floodplain and Construction

Possible funding sources to implement these projects include the following:

- Vermont Agency of Transportation Local Transportation Enhancement Grant
- U.S. Fish and Wildlife Service
- FEMA Hazard Mitigation Grant Program
- FEMA Pre-Disaster Mitigation (PDM) Grant
- FEMA Post Disaster Public Assistance Grant
- Vermont Agency of Natural Resources Ecosystem Restoration Program

The following list of project development tasks is provided to begin the necessary data collection and reviews that will be needed to advance design and implement the preferred alternatives.

- Monitor the bridges after large floods for damage.

- Monitor woody debris and sediment buildup at each bridge. If a large deposit forms that impedes flow, clear the debris by passing it through the structure or removing it and placing it in the downstream channel for natural distribution.

- Monitor the wingwalls, retaining walls, and riprap entering and exiting the bridge for scour.

- Conduct topographic field survey at each culvert site to locate property boundaries and right-of-way, topography of the emabankment, and utilities and private property and to create topography at each bridge. The survey will need to be performed by a Vermont Licensed Surveyor for property line and right-of-way work.

- Hire a boring contractor to get four borings drilled at each project site (for a total of eight) – two in each proposed abutment/footing location and two in the road embankment on each side of the bridge. This information will be required for final design.

- Retain a geotechnical engineer to interpret the borings to make design criteria and constructability recommendations.

- Delineate the ordinary high water line and bordering vegetated wetlands, if any, at the project site, which will be required to identify project impacts for a proposed project.

- Submit a request for a review with the Wildlife Diversity Program of Vermont Fish and Wildlife. Contact Steve Parren, Project Coordinator (802-878-1564).

- Submit a project review request to Vermont Division for Historical Resources. Contact either Scott Dillon, Survey Archeologist (802-272-7358), or James Duggan, Historic Preservation Review Coordinator (802-477-2288).

- Once survey and borings are complete, hire a design engineer to perform a bridge type study and complete design of the preferred alternative.

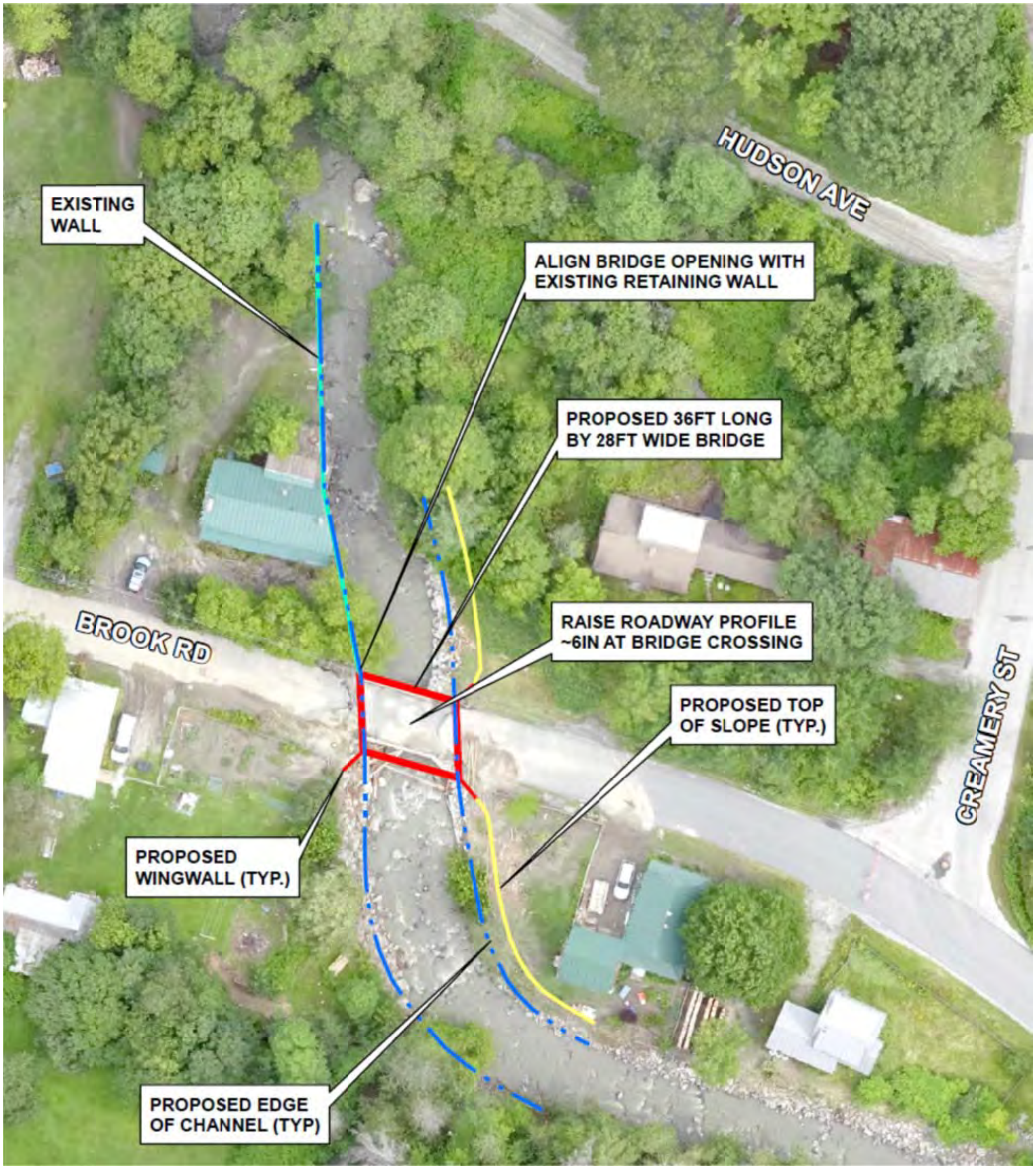

Figure 16: Brook Road Bridge Concept Design

Figure 17: Mill Street Bridge Concept Design

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APPENDIX A

GREAT BROOK FLOOD NOTES (JULY 19, 2015) MEMORANDUM

Memorandum

TO: **Bram Towbin, Town of Plainfield**

FROM: **Roy Schiff, Milone & MacBroom**

DATE: **July 27, 2015**

RE: Great Brook Flood Notes (July 19, 2015)
Great Brook Bridge Alternatives Analysis
MMI# 5315-03

Introduction

On July 19, 2015 an intense rain took place in the headwaters of the Great Brook watershed leading to flooding and damages along the channel and in the floodplain. Thankfully, nobody was injured during the flood, yet substantial damages took place and repairs are under way. The Brook Road Bridge (#2) was overtopped and the road was destroyed on both sides of the structure. Several washouts occurred along roads - upper Brook Road, Gore Road, Gonyeau Road, Lower Road, and Upper Road. A lot of damage took place in the upper watershed near the Barre-Plainfield Town line. So much water and sediment rushed over the steep slopes that sedimentation took place in several areas such as on Brook Road and around houses.

As Milone & MacBroom is currently working on an alternatives analysis to reduce flood and erosion hazards around the bridges on Great Brook in Plainfield Village at Mill Street (#1) and Brook Road (#2), we visited the area on July 20 to observe the flood patterns and mechanisms of damage. We also spoke with members of the Town and public to learn about some of the details of the rains, flood, and damages.

This memorandum contains a summary of several key observations and facts that we learned during the aftermath of the July 19, 2015 flood. The findings focus on the two bridges in the Village.

A 10-year flood

Local gauges indicate that 2.5 inches of rain fell on July 19, 2015, most of it coming between 7:45 pm and 8:45 pm. Most accounts indicate that the flood level peaked between 9:00 and 10:00 pm when the Brook Road culvert was overtopped. Flood levels began slowly receding after 10:00 pm based on accounts of local flood levels.

The flood level did not reach the high water marks recorded during the spring 2011 flood, yet water was not far from this level. Field indicators of the bankfull channel that approximately occurs at the 2-year flood were submerged during the flood. The USGS stream gauge in Montpelier indicated about a 2-year flood took place downstream. The data suggest that the rains translated into approximately the 10-year flood event on Great Brook. Flood frequency estimates suggest that the 10-year flood may have a flow of 500 to 1,000 cubic feet per second.

The Brook Road Bridge (#2) is too small

Accounts of the flood and observations suggest that the Brook Road Bridge in the Village filled with water and overtopped near the peak of the flood. The bridge was reportedly passing flood waters at full capacity without initially being blocked by debris as the flood wave grew. Several large trees were observed downstream following the flood that appeared to have been transported through the Brook Road Bridge.

This observation is important as the bridge is undersized in terms of hydraulic capacity if it cannot pass the 10-year flood. There has been a lot of discussion about debris at the bridge, yet there has been little discussion about hydraulic capacity. This structure is smaller than many of the other bridges that cross Great Brook.

A small debris jam built up at Brook Road

Just after the peak of the flood passed, observers noticed debris build up on the outside of the bend at the Brook Road Bridge. Water was hitting the concrete bridge railing and flowing over the road around both sides of the bridge.

Observations in the morning revealed a blockage of a quarter of the structure on the western side (river left, looking downstream) of the bridge opening. Fifteen (15) logs were counted in place once the flood receded. It does not take a lot of wood to begin to close off the bridge opening at Brook Road.

The debris jam during this flood was smaller than the spring 2011 flood. During spring 2011, the jam grew from the outside of the bend across the structure. The larger flow over a longer duration was delivering more wood to the structure, growing the jam from west to east, and also growing the jam vertically. In 2011, photos suggest that the jam grew so tall on the outside of the bend that water was forced to the east and destroyed the road mostly on the eastern side of the bridge. During this smaller and shorter duration flood, the jam did not grow very tall or wide and water thus went around both sides of the structure destroying the road in both locations.

Why does the Brook Road Bridge trap debris?

A lot of wood came down Great Brook and made it through some of the structures. A little even went through the Brook Road Bridge. Observations after the flood highlighted the reasons the Brook Road Bridge cannot effectively pass debris.

A rule of thumb for bridge and culvert design is that at least 20% of the height of the structure should be left open during the design flood so that wood can pass through. This common design criteria clearly does not exist at Brook Road. Wood hits the roof and concrete railing of the structure so does not pass.

The local hydraulics on the sharp bend in the river are forcing wood to the western side of the channel and prohibiting it from passing through the structure. Other Bridges such as Mill Street and near Cameron Road have straighter approaches and did not trap any wood. These bridges are also larger. The flood level was reported to be 1 to 1.5 feet from the top of the Mill Street Bridge that passed some large trees.

Observations under the Brook Road Bridge as the flood receded during the morning of July 20 revealed a standing wave under the Brook Road Bridge. This hydraulic jump is a place where fast, shallow water hits slower, deeper water. Small logs were observed sitting in the hydraulic roller before eventually moving downstream. This hydraulic feature promotes debris jamming.

Wood generation

Large wood was generated off of existing slope failures that were widened, especially in the upper watershed. Wood in the channel was remobilized during the flood. The wood deposition is more abundant in the upper watershed than from Cameron Road downstream.

Rill erosion on the compacted, gray, silty material on the steep slope failures appeared to perforate the surface material. Combined with the erosion at the bottom of the slope and additional slope failures are likely to persist on Great Brook for a long time.

Washouts

Several washouts took place and most of them occurred from erosion where flow was directed at or along a road by accumulated sediment or wood. In many locations Brook road occupies a quarter to half of the valley floor leading to increased erosional forces as flow is confined into the floodplain. Many of the road washout areas took place in these confined settings.

Next Steps

Several activities are now taking place as part of the Great Brook Bridge Alternatives Analysis that will draw on this information to come up with recommendations for the bridges. A list of tasks under way follows.

1. Topographic survey is being performed by Little River Survey to locate elevations of the channel, floodplain, bridges, high water marks from the flood, buildings, roads, and other relevant information. This information will be used to build and validate the hydraulic model.
2. UVM flew a drone flight over the brook Tuesday July 21st and has another flight planned for Friday July 24th. This information will allow for tracking of large wood and understanding how far the wood moved in the recent flood. We will also try to estimate how much wood was generated.
3. Past hydrology measurements will be extended to cover the elevations observed during the flood to estimate the flow rate during this most recent flood. This information will be used to validate the hydraulic model.
4. The hydraulic model will be used to test alternatives to reduce flood and erosion risks. We will explore removing the Brook Road Bridge, enlarging the Brook Road Bridge, as well as many other options.

APPENDIX B

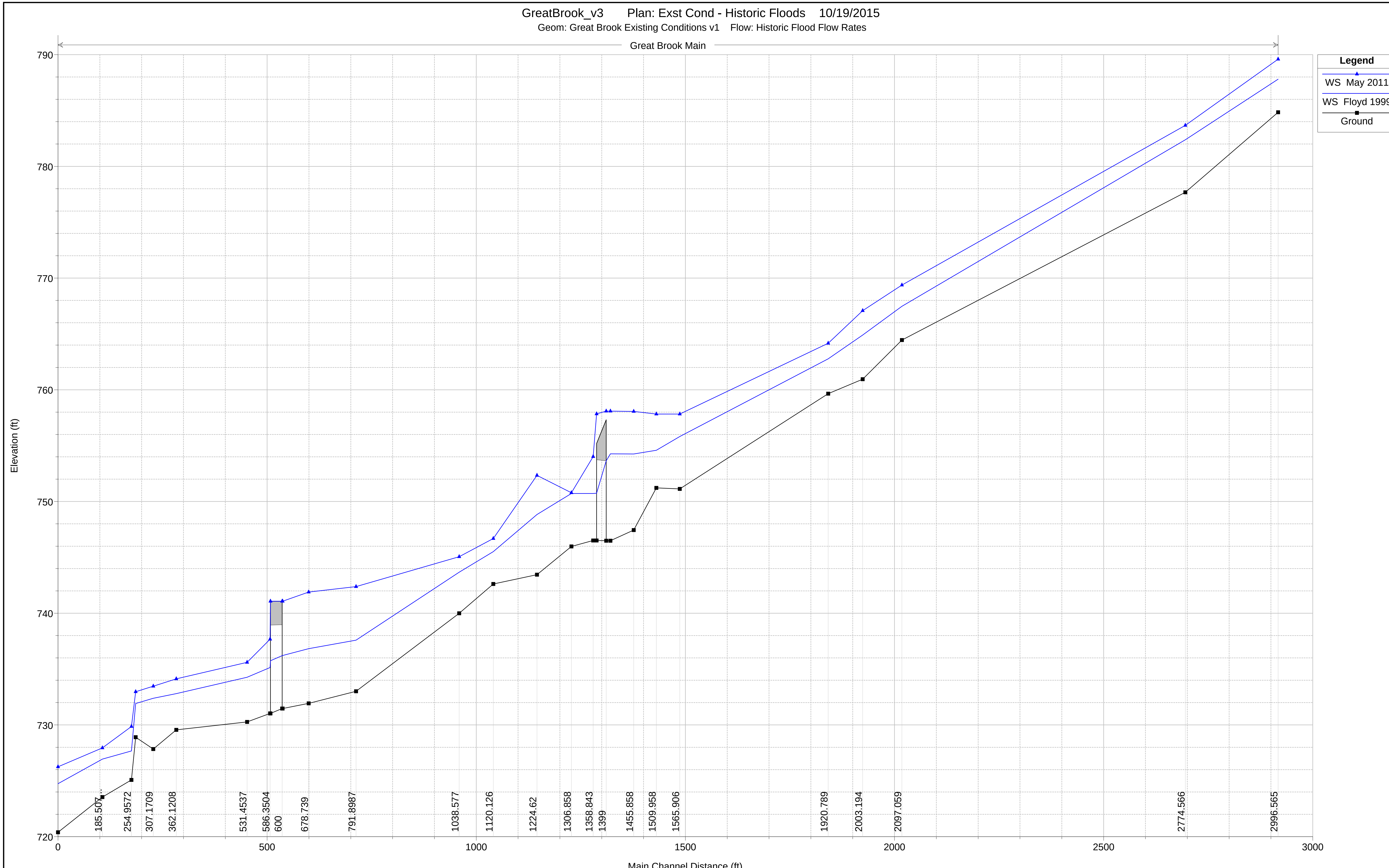
HEC-RAS EXISTING CONDITIONS FLOOD PROFILES AND OUTPUT DATA

HEC-RAS Plan: Ex Cond Hist Q River: Great Brook Reach: Main

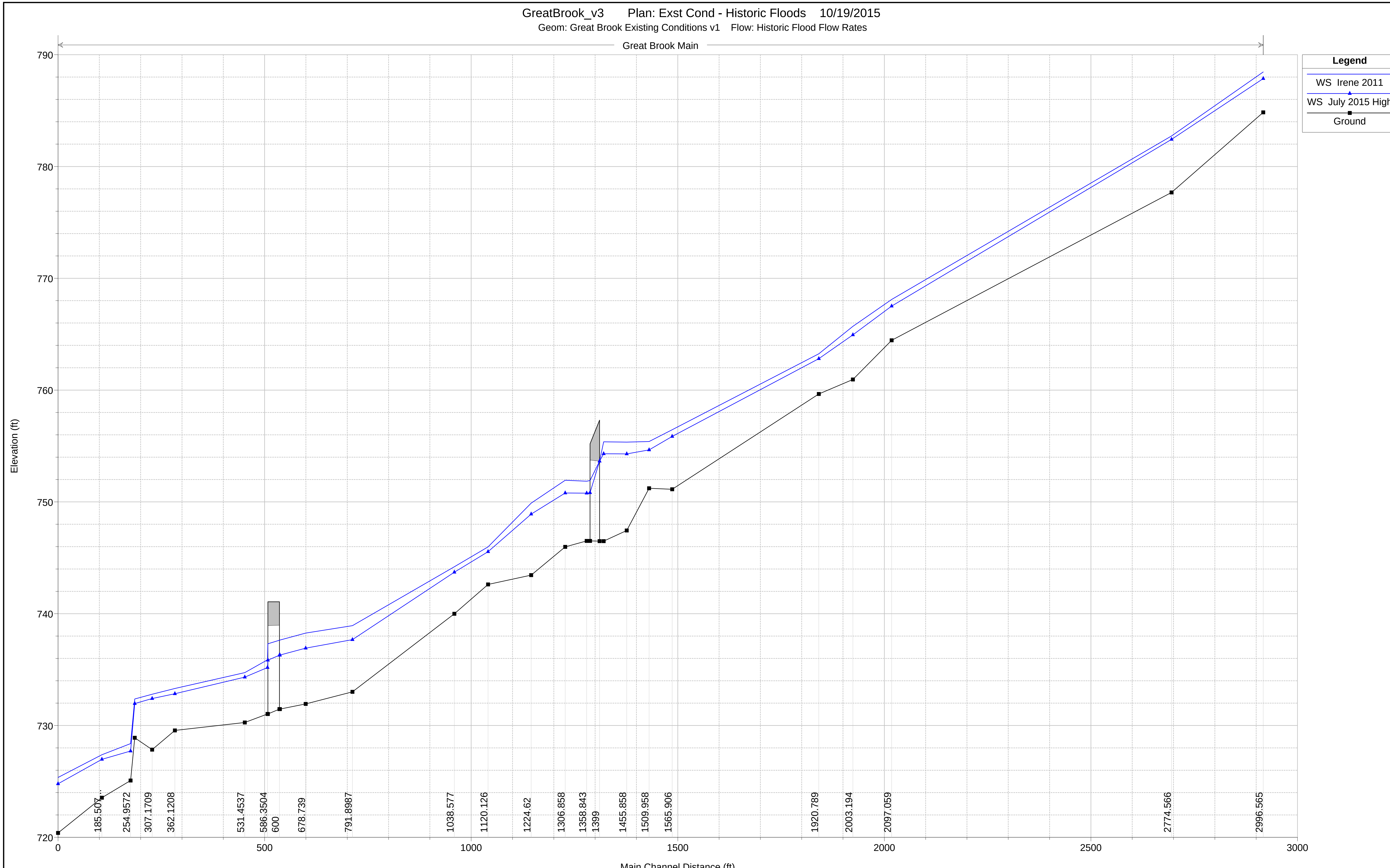
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	2996.565	Floyd 1999	1025.00	784.84	787.81	787.81	788.90	0.024343	8.39	122.19	57.01	1.01
Main	2996.565	May 2011	2520.00	784.84	789.60	789.60	791.51	0.020863	11.11	226.87	60.16	1.01
Main	2996.565	Irene 2011	1500.00	784.84	788.46	788.46	789.83	0.022269	9.40	159.65	58.16	1.00
Main	2996.565	July 2015 High	1055.00	784.84	787.87	787.87	788.96	0.023649	8.40	125.54	57.12	1.00
Main	2774.566	Floyd 1999	1025.00	777.68	782.38	782.22	783.35	0.019710	7.87	130.27	56.35	0.91
Main	2774.566	May 2011	2520.00	777.68	783.67	784.05	785.92	0.030685	12.04	209.92	66.71	1.19
Main	2774.566	Irene 2011	1500.00	777.68	782.73	782.92	784.28	0.028137	9.99	150.32	59.37	1.10
Main	2774.566	July 2015 High	1055.00	777.68	782.42	782.27	783.41	0.019846	7.96	132.62	56.71	0.92
Main	2097.059	Floyd 1999	1025.00	764.45	767.47	767.47	768.46	0.024616	7.97	128.65	65.44	1.00
Main	2097.059	May 2011	2520.00	764.45	769.38	769.11	770.87	0.016502	9.80	257.02	69.65	0.90
Main	2097.059	Irene 2011	1500.00	764.45	768.11	768.06	769.31	0.021404	8.80	170.47	66.84	0.97
Main	2097.059	July 2015 High	1055.00	764.45	767.51	767.51	768.52	0.024468	8.04	131.23	65.53	1.00
Main	2003.194	Floyd 1999	1025.00	760.95	764.90	764.90	766.19	0.023115	9.11	112.45	44.32	1.01
Main	2003.194	May 2011	2520.00	760.95	767.09	767.09	769.12	0.019782	11.45	220.09	54.14	1.00
Main	2003.194	Irene 2011	1500.00	760.95	765.70	765.70	767.27	0.021386	10.03	149.57	47.93	1.00
Main	2003.194	July 2015 High	1055.00	760.95	764.94	764.95	766.26	0.023293	9.22	114.37	44.51	1.01
Main	1920.789	Floyd 1999	1025.00	759.65	762.77	762.92	764.06	0.028965	9.12	112.38	53.16	1.11
Main	1920.789	May 2011	2520.00	759.65	764.17	764.81	766.92	0.034496	13.31	189.28	57.08	1.29
Main	1920.789	Irene 2011	1500.00	759.65	763.25	763.59	765.08	0.032453	10.86	138.14	54.50	1.20
Main	1920.789	July 2015 High	1055.00	759.65	762.81	762.97	764.13	0.028955	9.22	114.47	53.27	1.11
Main	1565.906	Floyd 1999	1025.00	751.13	755.82	755.34	756.90	0.014233	8.34	122.83	37.62	0.81
Main	1565.906	May 2011	2520.00	751.13	757.83	757.83	760.19	0.019692	12.34	204.23	43.42	1.00
Main	1565.906	Irene 2011	1500.00	751.13	756.46	756.23	758.06	0.017867	10.18	147.42	39.46	0.93
Main	1565.906	July 2015 High	1055.00	751.13	755.85	755.40	756.97	0.014591	8.49	124.21	37.72	0.82
Main	1509.958	Floyd 1999	1025.00	751.22	754.58	754.58	755.88	0.022700	9.15	111.99	43.69	1.01
Main	1509.958	May 2011	2520.00	751.22	757.83	756.77	759.10	0.009688	9.06	281.19	69.61	0.72
Main	1509.958	Irene 2011	1500.00	751.22	755.40	755.40	756.97	0.021045	10.06	149.07	47.44	1.00
Main	1509.958	July 2015 High	1055.00	751.22	754.65	754.65	755.96	0.022242	9.17	114.99	44.01	1.00
Main	1455.858	Floyd 1999	1025.00	747.44	754.25	751.82	754.66	0.004218	5.09	201.31	44.01	0.42
Main	1455.858	May 2011	2520.00	747.44	758.07		758.60	0.003233	6.06	481.82	120.35	0.39
Main	1455.858	Irene 2011	1500.00	747.44	755.35	752.76	755.90	0.004840	5.96	251.54	47.79	0.46
Main	1455.858	July 2015 High	1055.00	747.44	754.29	751.89	754.71	0.004363	5.20	203.01	44.14	0.43
Main	1400.035	Floyd 1999	1025.00	746.49	754.27	749.88	754.44	0.001033	3.28	312.43	52.69	0.24
Main	1400.035	May 2011	2520.00	746.49	758.09	752.20	758.40	0.001087	4.55	695.66	206.65	0.26
Main	1400.035	Irene 2011	1500.00	746.49	755.37	750.72	755.63	0.001289	4.03	378.62	68.97	0.27
Main	1400.035	July 2015 High	1055.00	746.49	754.31	749.94	754.48	0.001074	3.35	314.51	52.81	0.24
Main	1399		Bridge									
Main	1358.843	Floyd 1999	1025.00	746.51	750.72	750.62	752.59	0.019815	10.96	93.50	23.40	0.97
Main	1358.843	May 2011	2520.00	746.51	754.02	754.02	757.01	0.019870	13.88	181.60	30.54	1.00
Main	1358.843	Irene 2011	1500.00	746.51	751.85	751.85	754.24	0.020916	12.41	120.86	25.48	1.00
Main	1358.843	July 2015 High	1055.00	746.51	750.79	750.69	752.70	0.020012	11.10	95.01	23.41	0.97
Main	1306.858	Floyd 1999	1025.00	745.98	750.72		751.47	0.006801	6.97	147.15	38.21	0.63
Main	1306.858	May 2011	2520.00	745.98	750.78	752.05	755.18	0.038952	16.82	149.81	38.31	1.50
Main	1306.858	Irene 2011	1500.00	745.98	751.93	750.48	752.85	0.006316	7.70	194.85	40.04	0.61
Main	1306.858	July 2015 High	1055.00	745.98	750.80		751.56	0.006754	7.02	150.34	38.33	0.62
Main	1224.62	Floyd 1999	1025.00	743.45	748.83	748.83	750.52	0.017846	10.42	98.37	29.21	1.00
Main	1224.62	May 2011	2520.00	743.45	752.34	752.34	753.60	0.007054	9.89	445.78	202.35	0.68
Main	1224.62	Irene 2011	1500.00	743.45	749.89	749.89	751.94	0.017233	11.48	130.71	32.01	1.00
Main	1224.62	July 2015 High	1055.00	743.45	748.91	748.91	750.62	0.017790	10.50	100.52	29.40	1.00
Main	1120.126	Floyd 1999	1025.00	742.62	745.51	746.13	747.71	0.043204	11.88	86.28	44.33	1.50
Main	1120.126	May 2011	2520.00	742.62	746.69	748.23	751.66	0.058571	17.88	140.90	48.75	1.85
Main	1120.126	Irene 2011	1500.00	742.62	745.98	746.90	749.02	0.047649	14.01	107.09	46.06	1.62
Main	1120.126	July 2015 High	1055.00	742.62	745.55	746.18	747.80	0.043596	12.04	87.65	44.44	1.51
Main	1038.577	Floyd 1999	1025.00	739.99	743.67	743.79	744.95	0.022574	9.09	112.75	52.56	1.09
Main	1038.577	May 2011	2520.00	739.99	745.06	745.70	747.83	0.027598	13.36	188.60	56.65	1.29
Main	1038.577	Irene 2011	1500.00	739.99	744.20	744.49	745.96	0.024012	10.64	141.01	54.12	1.16
Main	1038.577	July 2015 High	1055.00	739.99	743.71	743.83	745.02	0.022632	9.19	114.74	52.67	1.10
Main	791.8987	Floyd 1999	1025.00	733.01	737.59	737.07	738.69	0.010967	8.43	121.63	34.99	0.80
Main	791.8987	May 2011	2520.00	733.01	742.38	739.77	743.10	0.002769	7.27	512.94	151.82	0.45

HEC-RAS Plan: Ex Cond Hist Q River: Great Brook Reach: Main (Continued)

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)	
Main	791.8987	Irene 2011	1500.00	733.01	738.93	737.97	740.14	0.008448	8.81	171.94	41.71	0.72
Main	791.8987	July 2015 High	1055.00	733.01	737.68	737.13	738.79	0.010791	8.46	124.67	35.13	0.79
Main	678.739	Floyd 1999	1025.00	731.93	736.83		737.64	0.006864	7.23	141.71	31.30	0.60
Main	678.739	May 2011	2520.00	731.93	741.89		742.76	0.003089	7.74	405.22	88.15	0.44
Main	678.739	Irene 2011	1500.00	731.93	738.27		739.26	0.006186	8.00	191.36	37.97	0.58
Main	678.739	July 2015 High	1055.00	731.93	736.92		737.74	0.006845	7.30	144.57	31.30	0.60
Main	616.3432	Floyd 1999	1025.00	731.47	736.21	735.05	737.15	0.007859	7.74	132.38	29.42	0.64
Main	616.3432	May 2011	2520.00	731.47	741.08	737.82	742.37	0.005639	9.14	282.59	97.92	0.53
Main	616.3432	Irene 2011	1500.00	731.47	737.64	736.03	738.79	0.007427	8.60	174.33	29.42	0.62
Main	616.3432	July 2015 High	1055.00	731.47	736.30	735.13	737.25	0.007855	7.82	134.96	29.42	0.64
Main	600		Bridge									
Main	586.3504	Floyd 1999	1025.00	731.03	735.14	734.91	736.62	0.015954	9.75	105.12	29.51	0.91
Main	586.3504	May 2011	2520.00	731.03	737.67	737.67	740.72	0.019270	14.01	179.85	29.51	1.00
Main	586.3504	Irene 2011	1500.00	731.03	735.88	735.88	738.05	0.019274	11.82	126.89	29.51	1.00
Main	586.3504	July 2015 High	1055.00	731.03	735.19	734.97	736.71	0.016185	9.90	106.62	29.51	0.92
Main	531.4537	Floyd 1999	1025.00	730.27	734.27	734.27	735.64	0.017764	9.38	109.33	40.15	1.00
Main	531.4537	May 2011	2520.00	730.27	735.60	736.63	739.22	0.031503	15.26	165.18	43.71	1.38
Main	531.4537	Irene 2011	1500.00	730.27	734.73	735.11	736.86	0.023729	11.72	127.99	41.37	1.17
Main	531.4537	July 2015 High	1055.00	730.27	734.33	734.33	735.72	0.017690	9.45	111.60	40.30	1.00
Main	362.1208	Floyd 1999	1025.00	729.56	732.81	732.31	733.12	0.006655	4.67	265.86	206.81	0.59
Main	362.1208	May 2011	2520.00	729.56	734.13	733.50	734.59	0.005521	5.96	617.92	293.05	0.58
Main	362.1208	Irene 2011	1500.00	729.56	733.31	732.72	733.69	0.006081	5.19	385.84	270.34	0.59
Main	362.1208	July 2015 High	1055.00	729.56	732.84	732.34	733.16	0.006586	4.70	273.50	210.38	0.59
Main	307.1709	Floyd 1999	1025.00	727.84	732.38	731.21	732.82	0.004412	5.59	291.03	268.66	0.52
Main	307.1709	May 2011	2520.00	727.84	733.47	733.25	734.24	0.006869	8.30	592.19	284.96	0.67
Main	307.1709	Irene 2011	1500.00	727.84	732.80	732.49	733.37	0.005418	6.66	404.52	277.06	0.58
Main	307.1709	July 2015 High	1055.00	727.84	732.41	731.25	732.86	0.004496	5.67	298.58	270.15	0.52
Main	264.9572	Floyd 1999	1025.00	728.90	731.92	731.92	732.54	0.010535	7.01	253.82	221.32	0.77
Main	264.9572	May 2011	2520.00	728.90	732.97	732.97	733.87	0.012612	9.39	518.87	259.32	0.88
Main	264.9572	Irene 2011	1500.00	728.90	732.38	732.38	733.06	0.010639	7.74	365.63	253.50	0.79
Main	264.9572	July 2015 High	1055.00	728.90	731.96	731.96	732.58	0.010347	7.01	263.85	227.56	0.76
Main	254.9572	Floyd 1999	1025.00	725.08	727.67	728.90	731.94	0.109178	16.58	61.82	38.94	2.32
Main	254.9572	May 2011	2520.00	725.08	729.86	731.10	733.40	0.036464	15.10	166.89	51.48	1.48
Main	254.9572	Irene 2011	1500.00	725.08	728.38	729.57	732.49	0.078830	16.26	92.23	46.80	2.04
Main	254.9572	July 2015 High	1055.00	725.08	727.72	728.95	731.97	0.106453	16.55	63.73	39.48	2.30
Main	185.5077	Floyd 1999	1025.00	723.54	726.94	727.02	728.02	0.022601	8.33	123.09	64.92	1.07
Main	185.5077	May 2011	2520.00	723.54	727.95	728.64	730.71	0.034377	13.34	188.95	66.46	1.39
Main	185.5077	Irene 2011	1500.00	723.54	727.38	727.60	728.90	0.024551	9.88	151.88	65.60	1.14
Main	185.5077	July 2015 High	1055.00	723.54	726.97	727.06	728.08	0.022733	8.43	125.08	64.97	1.07
Main	79.35866	Floyd 1999	1025.00	720.39	724.74	724.37	725.42	0.012011	6.62	155.90	75.72	0.80
Main	79.35866	May 2011	2520.00	720.39	726.25	725.99	727.51	0.012014	9.06	296.56	111.08	0.86
Main	79.35866	Irene 2011	1500.00	720.39	725.35	725.01	726.20	0.012004	7.39	206.52	89.62	0.82
Main	79.35866	July 2015 High	1055.00	720.39	724.79	724.42	725.48	0.012018	6.67	159.41	76.74	0.80

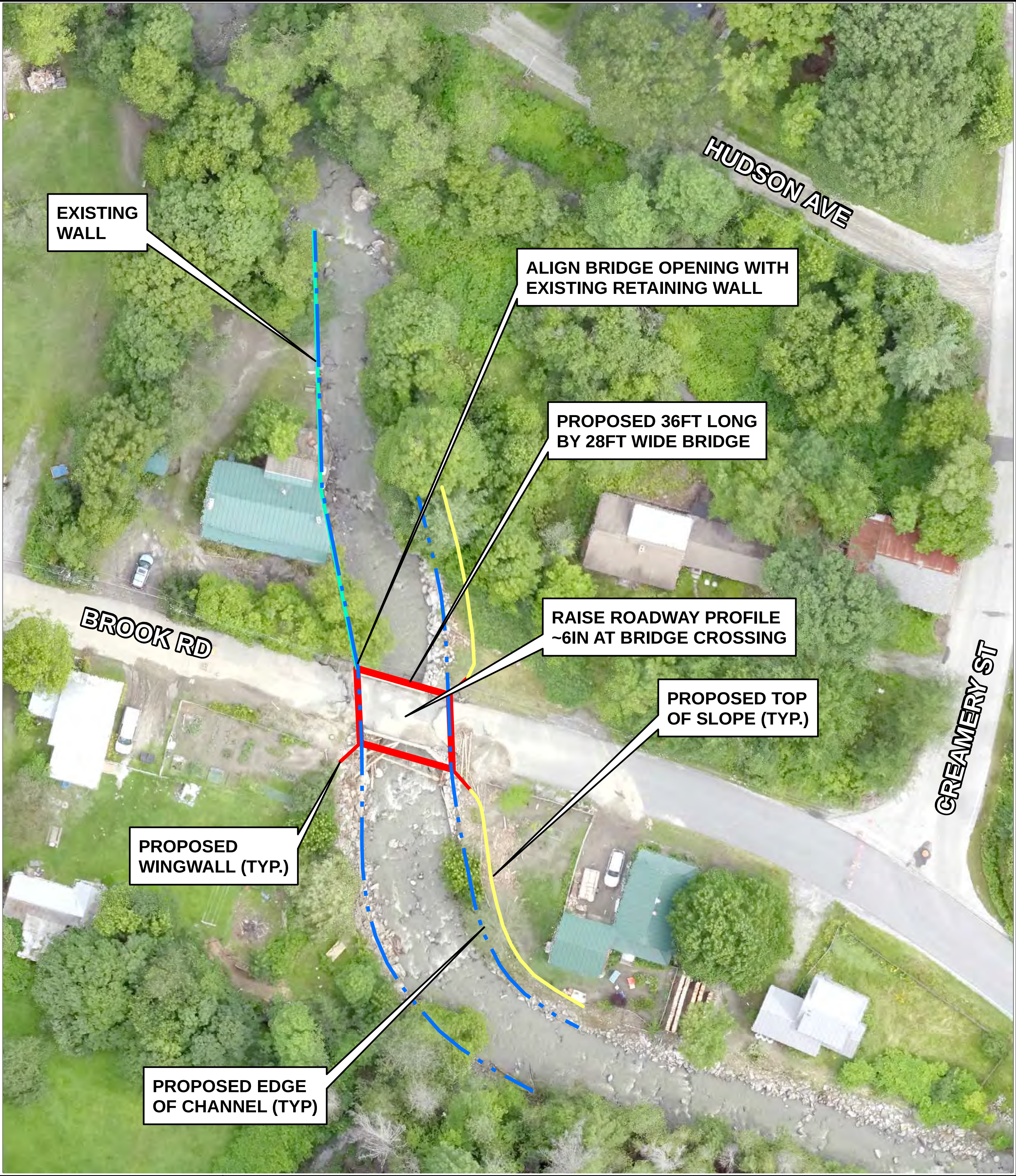


GreatBrook_v3 Plan: Exst Cond - Historic Floods 10/19/2015
Geom: Great Brook Existing Conditions v1 Flow: Historic Flood Flow Rates
Great Brook Main
Legend
WS May 2011
WS Floyd 1999
Ground
Elevation (ft)
790
780
770
760
750
740
730
720
185.507
254.9572
307.1709
362.1208
531.4537
586.3504
600
678.739
791.8987
1038.577
1120.126
1224.62
1306.858
1358.843
1399
1455.858
1509.958
1565.906
1920.789
2003.194
2097.059
2774.566
2996.565
0
500
1000
1500
2000
2500
3000
Main Channel Distance (ft)


GreatBrook_v3 Plan: Exst Cond - Historic Floods 10/19/2015
Geom: Great Brook Existing Conditions v1 Flow: Historic Flood Flow Rates
Great Brook Main
Legend
WS Irene 2011
WS July 2015 High
Ground
Elevation (ft)
790
780
770
760
750
740
730
720
185.507...
254.9572
307.1709
362.1208
531.4537
586.3504
600
678.739
791.8987
1038.577
1120.126
1224.62
1306.858
1358.843
1399
1455.858
1509.958
1565.906
1920.789
2003.194
2097.059
2774.566
2996.565
0
500
1000
1500
2000
2500
3000
Main Channel Distance (ft)

APPENDIX C

BROOK ROAD BRIDGE CONCEPT DESIGN, FLOOD PROFILES AND OUTPUT DATA



SOURCE(S):
UVM SAL - July 25 Data

APPENDIX C: CONCEPT SKETCH
PROPOSED 1.0 x BF BRIDGE AT BROOK ROAD

LOCATION:
Plainfield, VT

N

GREAT BROOK BRIDGES
ALTERNATIVES ANALYSIS

MXD: Y:\5315-03\Maps\GreatBrk_BrookRd_Concept1.mxd

Map By: bmc
MMI#: 5315-03-3
Original: 10/29/2015
Revision: 01/04/2016
Scale: 1 inch = 50 feet

MILONE & MACBROOM
1 South Main Street
Waterbury, VT 05676
802.882.8335
www.miloneandmacbroom.com

HEC-RAS River: Great Brook Reach: Main

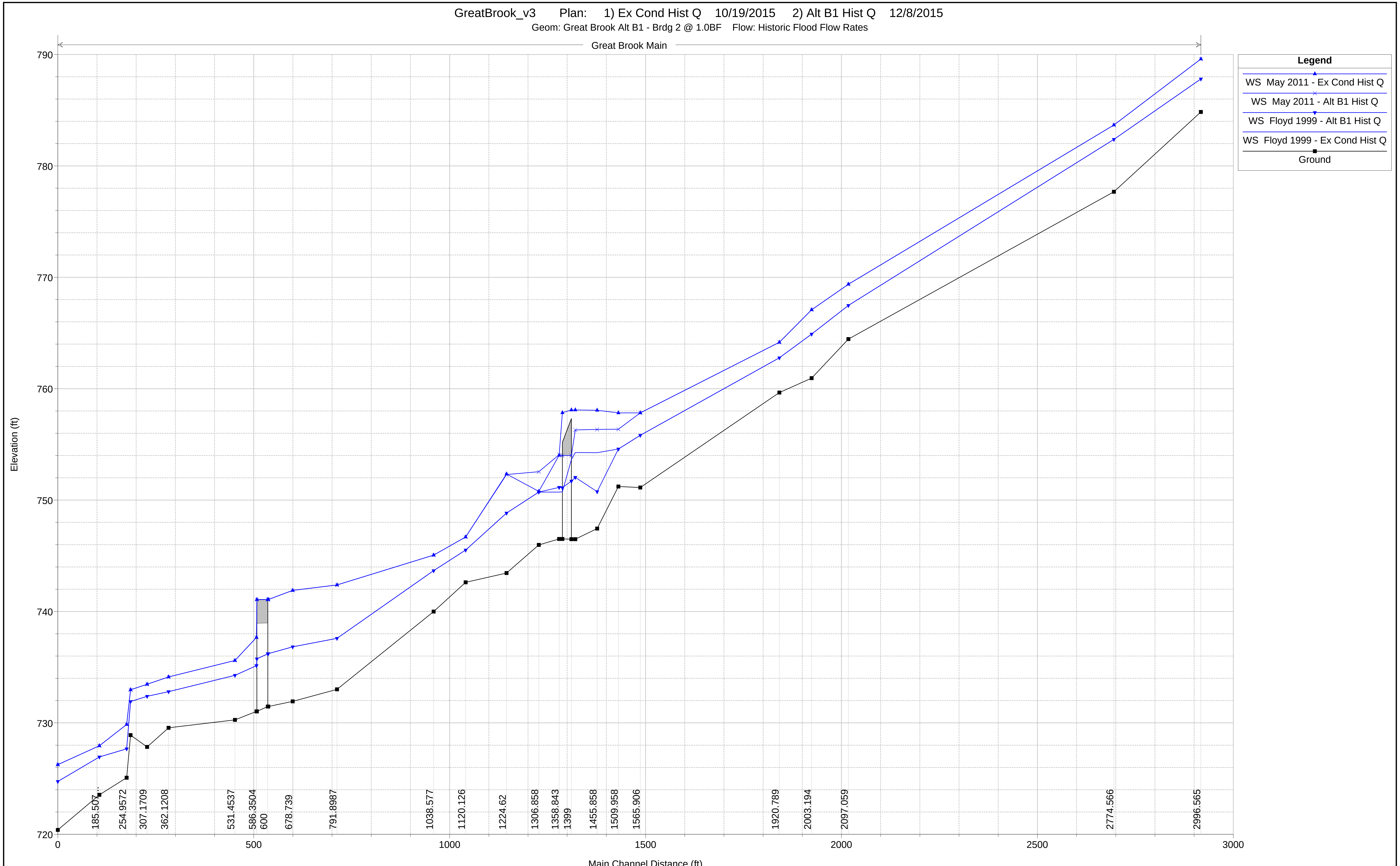
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	2996.565	Floyd 1999	Ex Cond Hist Q	1025.00	784.84	787.81	787.81	788.90	0.024343	8.39	122.19	57.01	1.01
Main	2996.565	Floyd 1999	Alt B1 Hist Q	1025.00	784.84	787.81	787.81	788.90	0.024343	8.39	122.19	57.01	1.01
Main	2996.565	May 2011	Ex Cond Hist Q	2520.00	784.84	789.60	789.60	791.51	0.020863	11.11	226.87	60.16	1.01
Main	2996.565	May 2011	Alt B1 Hist Q	2520.00	784.84	789.60	789.60	791.51	0.020863	11.11	226.87	60.16	1.01
Main	2996.565	Irene 2011	Ex Cond Hist Q	1500.00	784.84	788.46	788.46	789.83	0.022269	9.40	159.65	58.16	1.00
Main	2996.565	Irene 2011	Alt B1 Hist Q	1500.00	784.84	788.46	788.46	789.83	0.022269	9.40	159.65	58.16	1.00
Main	2996.565	July 2015 High	Ex Cond Hist Q	1055.00	784.84	787.87	787.87	788.96	0.023649	8.40	125.54	57.12	1.00
Main	2996.565	July 2015 High	Alt B1 Hist Q	1055.00	784.84	787.87	787.87	788.96	0.023649	8.40	125.54	57.12	1.00
Main	2774.566	Floyd 1999	Ex Cond Hist Q	1025.00	777.68	782.38	782.22	783.35	0.019710	7.87	130.27	56.35	0.91
Main	2774.566	Floyd 1999	Alt B1 Hist Q	1025.00	777.68	782.38	782.22	783.35	0.019710	7.87	130.27	56.35	0.91
Main	2774.566	May 2011	Ex Cond Hist Q	2520.00	777.68	783.67	784.05	785.92	0.030685	12.04	209.92	66.71	1.19
Main	2774.566	May 2011	Alt B1 Hist Q	2520.00	777.68	783.67	784.05	785.92	0.030685	12.04	209.92	66.71	1.19
Main	2774.566	Irene 2011	Ex Cond Hist Q	1500.00	777.68	782.73	782.92	784.28	0.028137	9.99	150.32	59.37	1.10
Main	2774.566	Irene 2011	Alt B1 Hist Q	1500.00	777.68	782.73	782.92	784.28	0.028137	9.99	150.32	59.37	1.10
Main	2774.566	July 2015 High	Ex Cond Hist Q	1055.00	777.68	782.42	782.27	783.41	0.019846	7.96	132.62	56.71	0.92
Main	2774.566	July 2015 High	Alt B1 Hist Q	1055.00	777.68	782.42	782.27	783.41	0.019846	7.96	132.62	56.71	0.92
Main	2097.059	Floyd 1999	Ex Cond Hist Q	1025.00	764.45	767.47	767.47	768.46	0.024616	7.97	128.65	65.44	1.00
Main	2097.059	Floyd 1999	Alt B1 Hist Q	1025.00	764.45	767.47	767.47	768.46	0.024616	7.97	128.65	65.44	1.00
Main	2097.059	May 2011	Ex Cond Hist Q	2520.00	764.45	769.38	769.11	770.87	0.016502	9.80	257.02	69.65	0.90
Main	2097.059	May 2011	Alt B1 Hist Q	2520.00	764.45	769.37	769.11	770.87	0.016503	9.81	257.01	69.65	0.90
Main	2097.059	Irene 2011	Ex Cond Hist Q	1500.00	764.45	768.11	768.06	769.31	0.021404	8.80	170.47	66.84	0.97
Main	2097.059	Irene 2011	Alt B1 Hist Q	1500.00	764.45	768.11	768.06	769.31	0.021402	8.80	170.48	66.84	0.97
Main	2097.059	July 2015 High	Ex Cond Hist Q	1055.00	764.45	767.51	767.51	768.52	0.024468	8.04	131.23	65.53	1.00
Main	2097.059	July 2015 High	Alt B1 Hist Q	1055.00	764.45	767.51	767.51	768.52	0.024468	8.04	131.23	65.53	1.00
Main	2003.194	Floyd 1999	Ex Cond Hist Q	1025.00	760.95	764.90	764.90	766.19	0.023115	9.11	112.45	44.32	1.01
Main	2003.194	Floyd 1999	Alt B1 Hist Q	1025.00	760.95	764.90	764.90	766.19	0.023115	9.11	112.45	44.32	1.01
Main	2003.194	May 2011	Ex Cond Hist Q	2520.00	760.95	767.09	767.09	769.12	0.019782	11.45	220.09	54.14	1.00
Main	2003.194	May 2011	Alt B1 Hist Q	2520.00	760.95	767.09	767.09	769.12	0.019779	11.45	220.10	54.14	1.00
Main	2003.194	Irene 2011	Ex Cond Hist Q	1500.00	760.95	765.70	765.70	767.27	0.021386	10.03	149.57	47.93	1.00
Main	2003.194	Irene 2011	Alt B1 Hist Q	1500.00	760.95	765.70	765.70	767.27	0.021387	10.03	149.57	47.93	1.00
Main	2003.194	July 2015 High	Ex Cond Hist Q	1055.00	760.95	764.94	764.95	766.26	0.023293	9.22	114.37	44.51	1.01
Main	2003.194	July 2015 High	Alt B1 Hist Q	1055.00	760.95	764.94	764.95	766.26	0.023293	9.22	114.37	44.51	1.01
Main	1920.789	Floyd 1999	Ex Cond Hist Q	1025.00	759.65	762.77	762.92	764.06	0.028965	9.12	112.38	53.16	1.11
Main	1920.789	Floyd 1999	Alt B1 Hist Q	1025.00	759.65	762.77	762.92	764.06	0.028965	9.12	112.38	53.16	1.11
Main	1920.789	May 2011	Ex Cond Hist Q	2520.00	759.65	764.17	764.81	766.92	0.034496	13.31	189.28	57.08	1.29
Main	1920.789	May 2011	Alt B1 Hist Q	2520.00	759.65	764.17	764.81	766.92	0.034496	13.31	189.28	57.08	1.29
Main	1920.789	Irene 2011	Ex Cond Hist Q	1500.00	759.65	763.25	763.59	765.08	0.032453	10.86	138.14	54.50	1.20
Main	1920.789	Irene 2011	Alt B1 Hist Q	1500.00	759.65	763.25	763.59	765.08	0.032453	10.86	138.14	54.50	1.20
Main	1920.789	July 2015 High	Ex Cond Hist Q	1055.00	759.65	762.81	762.97	764.13	0.028955	9.22	114.47	53.27	1.11
Main	1920.789	July 2015 High	Alt B1 Hist Q	1055.00	759.65	762.81	762.97	764.13	0.028955	9.22	114.47	53.27	1.11
Main	1565.906	Floyd 1999	Ex Cond Hist Q	1025.00	751.13	755.82	755.34	756.90	0.014233	8.34	122.83	37.62	0.81
Main	1565.906	Floyd 1999	Alt B1 Hist Q	1025.00	751.13	755.82	755.34	756.90	0.014246	8.35	122.79	37.61	0.81
Main	1565.906	May 2011	Ex Cond Hist Q	2520.00	751.13	757.83	757.83	760.19	0.019692	12.34	204.23	43.42	1.00
Main	1565.906	May 2011	Alt B1 Hist Q	2520.00	751.13	757.83	757.83	760.19	0.019688	12.34	204.25	43.42	1.00
Main	1565.906	Irene 2011	Ex Cond Hist Q	1500.00	751.13	756.46	756.23	758.06	0.017867	10.18	147.42	39.46	0.93
Main	1565.906	Irene 2011	Alt B1 Hist Q	1500.00	751.13	756.46	756.23	758.06	0.017804	10.16	147.59	39.47	0.93
Main	1565.906	July 2015 High	Ex Cond Hist Q	1055.00	751.13	755.85	755.40	756.97	0.014591	8.49	124.21	37.72	0.82
Main	1565.906	July 2015 High	Alt B1 Hist Q	1055.00	751.13	755.86	755.40	756.98	0.014462	8.47	124.59	37.75	0.82
Main	1509.958	Floyd 1999	Ex Cond Hist Q	1025.00	751.22	754.58	754.58	755.88	0.022700	9.15	111.99	43.69	1.01
Main	1509.958	Floyd 1999	Alt B1 Hist Q	1025.00	751.22	754.59	754.59	755.88	0.022662	9.15	112.05	43.70	1.01
Main	1509.958	May 2011	Ex Cond Hist Q	2520.00	751.22	757.83	756.77	759.10	0.009688	9.06	281.19	69.61	0.72
Main	1509.958	May 2011	Alt B1 Hist Q	2520.00	751.22	756.36	756.77	758.90	0.026584	12.79	197.04	51.89	1.16
Main	1509.958	Irene 2011	Ex Cond Hist Q	1500.00	751.22	755.40	755.40	756.97	0.021045	10.06	149.07	47.44	1.00
Main	1509.958	Irene 2011	Alt B1 Hist Q	1500.00	751.22	755.38	755.38	756.97	0.021367	10.12	148.29	47.36	1.01
Main	1509.958	July 2015 High	Ex Cond Hist Q	1055.00	751.22	754.65	754.65	755.96	0.022242	9.17	114.99	44.01	1.00
Main	1509.958	July 2015 High	Alt B1 Hist Q	1055.00	751.22	754.64	754.64	755.96	0.022516	9.21	114.51	43.96	1.01
Main	1455.858	Floyd 1999	Ex Cond Hist Q	1025.00	747.44	754.25	751.82	754.66	0.004218	5.09	201.31	44.01	0.42
Main	1455.858	Floyd 1999	Alt B1 Hist Q	1025.00	747.44	750.76	751.61	753.53	0.093350	13.37	76.68	41.88	1.74
Main	1455.858	May 2011	Ex Cond Hist Q	2520.00	747.44	758.07		758.60	0.003233	6.06	481.82	120.35	0.39
Main	1455.858	May 2011	Alt B1 Hist Q	2520.00	747.44	756.35	753.73	757.09	0.005378	6.90	366.65	71.70	0.50
Main	1455.858	Irene 2011	Ex Cond Hist Q	1500.00	747.44	755.35	752.76	755.90	0.004840	5.96	251.54	47.79	0.46
Main	1455.858	Irene 2011	Alt B1 Hist Q	1500.00	747.44	751.33	752.38	754.75	0.085361	14.84	101.07	43.86	1.72
Main	1455.858	July 2015 High	Ex Cond Hist Q	1055.00	747.44	754.29	751.89	754.71	0.004363	5.20	203.01	44.14	0.43
Main	1455.858	July 2015 High	Alt B1 Hist Q	1055.00	747.44	750.79	751.66	753.63	0.093676	13.52	78.03	41.99	1.75
Main	1400.035	Floyd 1999	Ex Cond Hist Q	1025.00	746.49	754.27	749.88	754.44	0.001033	3.28	312.43	52.69	0.24
Main	1400.035	Floyd 1999	Alt B1 Hist Q	1025.00	746.49	752.04	749.88	752.37	0.002851	4.60	223.02	55.37	0.38
Main	1400.035	May 2011	Ex Cond Hist Q	2520.00	746.49	758.09	752.20	758.40	0.001087	4.55	695.66	206.65	0.26
Main	1400.035	May 2011	Alt B1 Hist Q	2520.00	746.49	756.30	751.86	756.79	0.001965	5.65	446.10	84.37	0.35
Main	1400.035	Irene 2011	Ex Cond Hist Q	1500.00	746.49	755.37	750.72	755.63	0.001289	4.03	378.62	68.97	0.27
Main	1400.035	Irene 2011	Alt B1 Hist Q	1500.00	746.49	753.39	750.58	753.80	0.002608	5.14	291.82	59.19	0.38
Main	1400.035	July 2015 High	Ex Cond Hist Q	1055.00	746.49	754.31	749.94	754.48	0.001074	3.35	314.51	52.81	0.24
Main	1400.035	July 2015 High	Alt B1 Hist Q	1055.00	746.49	752.13	749.93	752.46	0.002831	4.64	227.60	55.63	0.38
Main	1399			Bridge									
Main	1358.843	Floyd 1999	Ex Cond Hist Q	1025.00	746.51	750.72	750.62	752.59	0.019815	10.96	93.50	23.40	0.97
Main	1358.843	Floyd 1999	Alt B1 Hist Q	1025.00	746.51	751.14		751.86	0.007972	6.82	150.29	45.88	0.66
Main	1358.843	May 2011	Ex Cond Hist Q	2520.00	746.51	754.02	754.02	757.01	0.019870	13.88	181.60	30.54	1.00
Main	1358.843	May 2011	Alt B1 Hist Q	2520.00	746.51	754.07		755.28	0.006156	8.83	285.32	51.31	0.63

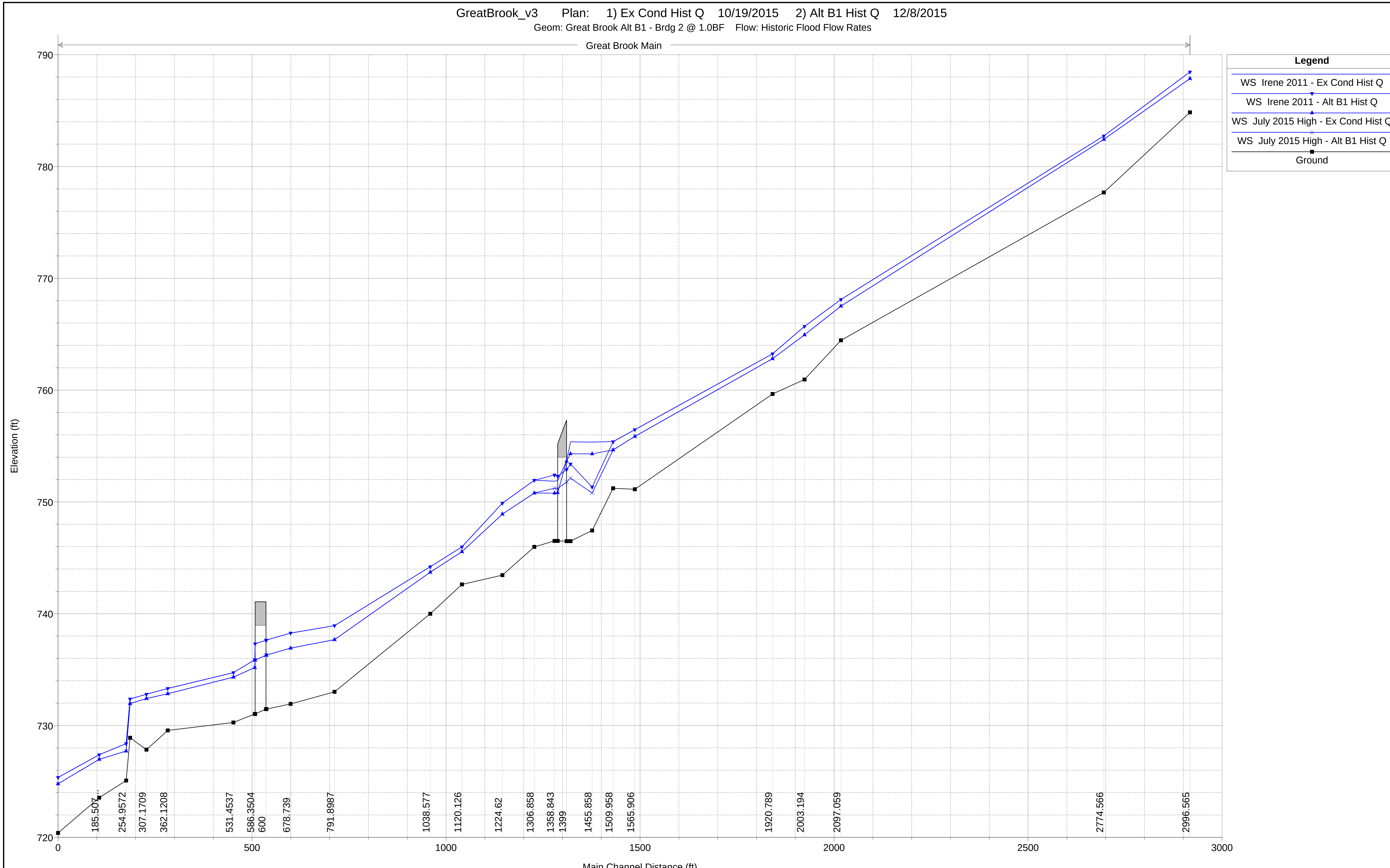
HEC-RAS River: Great Brook Reach: Main (Continued)

Reach	River Sta	Profile	Plan	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)	
Main	1358.843	Irene 2011	Ex Cond Hist Q	1500.00	746.51	751.85	751.85	754.24	0.020916	12.41	120.86	25.48	1.00
Main	1358.843	Irene 2011	Alt B1 Hist Q	1500.00	746.51	752.41		753.21	0.005941	7.19	208.61	48.22	0.60
Main	1358.843	July 2015 High	Ex Cond Hist Q	1055.00	746.51	750.79	750.69	752.70	0.020012	11.10	95.01	23.41	0.97
Main	1358.843	July 2015 High	Alt B1 Hist Q	1055.00	746.51	751.23		751.95	0.007787	6.84	154.32	46.04	0.66
Main	1306.858	Floyd 1999	Ex Cond Hist Q	1025.00	745.98	750.72		751.47	0.006801	6.97	147.15	38.21	0.63
Main	1306.858	Floyd 1999	Alt B1 Hist Q	1025.00	745.98	750.72		751.47	0.006801	6.97	147.15	38.21	0.63
Main	1306.858	May 2011	Ex Cond Hist Q	2520.00	745.98	750.78	752.05	755.18	0.038952	16.82	149.81	38.31	1.50
Main	1306.858	May 2011	Alt B1 Hist Q	2520.00	745.98	752.55	752.04	754.59	0.012541	11.47	219.66	40.96	0.87
Main	1306.858	Irene 2011	Ex Cond Hist Q	1500.00	745.98	751.93	750.48	752.85	0.006316	7.70	194.85	40.04	0.61
Main	1306.858	Irene 2011	Alt B1 Hist Q	1500.00	745.98	751.93		752.85	0.006316	7.70	194.85	40.04	0.61
Main	1306.858	July 2015 High	Ex Cond Hist Q	1055.00	745.98	750.80		751.56	0.006754	7.02	150.34	38.33	0.62
Main	1306.858	July 2015 High	Alt B1 Hist Q	1055.00	745.98	750.80		751.56	0.006754	7.02	150.34	38.33	0.62
Main	1224.62	Floyd 1999	Ex Cond Hist Q	1025.00	743.45	748.83	748.83	750.52	0.017846	10.42	98.37	29.21	1.00
Main	1224.62	Floyd 1999	Alt B1 Hist Q	1025.00	743.45	748.83	748.83	750.52	0.017846	10.42	98.37	29.21	1.00
Main	1224.62	May 2011	Ex Cond Hist Q	2520.00	743.45	752.34	752.34	753.60	0.007054	9.89	445.78	202.35	0.68
Main	1224.62	May 2011	Alt B1 Hist Q	2520.00	743.45	752.29	752.29	753.60	0.007334	10.04	436.50	202.02	0.70
Main	1224.62	Irene 2011	Ex Cond Hist Q	1500.00	743.45	749.89	749.89	751.94	0.017233	11.48	130.71	32.01	1.00
Main	1224.62	Irene 2011	Alt B1 Hist Q	1500.00	743.45	749.89	749.89	751.94	0.017233	11.48	130.71	32.01	1.00
Main	1224.62	July 2015 High	Ex Cond Hist Q	1055.00	743.45	748.91	748.91	750.62	0.017790	10.50	100.52	29.40	1.00
Main	1224.62	July 2015 High	Alt B1 Hist Q	1055.00	743.45	748.91	748.91	750.62	0.017790	10.50	100.52	29.40	1.00
Main	1120.126	Floyd 1999	Ex Cond Hist Q	1025.00	742.62	745.51	746.13	747.71	0.043204	11.88	86.28	44.33	1.50
Main	1120.126	Floyd 1999	Alt B1 Hist Q	1025.00	742.62	745.52	746.13	747.70	0.042966	11.86	86.44	44.34	1.50
Main	1120.126	May 2011	Ex Cond Hist Q	2520.00	742.62	746.69	748.23	751.66	0.058571	17.88	140.90	48.75	1.85
Main	1120.126	May 2011	Alt B1 Hist Q	2520.00	742.62	746.69	748.23	751.66	0.058571	17.88	140.90	48.75	1.85
Main	1120.126	Irene 2011	Ex Cond Hist Q	1500.00	742.62	745.98	746.90	749.02	0.047649	14.01	107.09	46.06	1.62
Main	1120.126	Irene 2011	Alt B1 Hist Q	1500.00	742.62	745.97	746.90	749.02	0.047699	14.01	107.06	46.06	1.62
Main	1120.126	July 2015 High	Ex Cond Hist Q	1055.00	742.62	745.55	746.18	747.80	0.043596	12.04	87.65	44.44	1.51
Main	1120.126	July 2015 High	Alt B1 Hist Q	1055.00	742.62	745.55	746.18	747.79	0.043376	12.02	87.80	44.46	1.51
Main	1038.577	Floyd 1999	Ex Cond Hist Q	1025.00	739.99	743.67	743.79	744.95	0.022574	9.09	112.75	52.56	1.09
Main	1038.577	Floyd 1999	Alt B1 Hist Q	1025.00	739.99	743.67	743.79	744.95	0.022637	9.10	112.65	52.56	1.10
Main	1038.577	May 2011	Ex Cond Hist Q	2520.00	739.99	745.06	745.70	747.83	0.027598	13.36	188.60	56.65	1.29
Main	1038.577	May 2011	Alt B1 Hist Q	2520.00	739.99	745.06	745.70	747.83	0.027598	13.36	188.60	56.65	1.29
Main	1038.577	Irene 2011	Ex Cond Hist Q	1500.00	739.99	744.20	744.49	745.96	0.024012	10.64	141.01	54.12	1.16
Main	1038.577	Irene 2011	Alt B1 Hist Q	1500.00	739.99	744.20	744.49	745.96	0.024005	10.64	141.02	54.12	1.16
Main	1038.577	July 2015 High	Ex Cond Hist Q	1055.00	739.99	743.71	743.83	745.02	0.022632	9.19	114.74	52.67	1.10
Main	1038.577	July 2015 High	Alt B1 Hist Q	1055.00	739.99	743.71	743.83	745.02	0.022690	9.20	114.65	52.67	1.10
Main	791.8987	Floyd 1999	Ex Cond Hist Q	1025.00	733.01	737.59	737.07	738.69	0.010967	8.43	121.63	34.99	0.80
Main	791.8987	Floyd 1999	Alt B1 Hist Q	1025.00	733.01	737.59	737.07	738.69	0.010967	8.43	121.63	34.99	0.80
Main	791.8987	May 2011	Ex Cond Hist Q	2520.00	733.01	742.38	739.77	743.10	0.002769	7.27	512.94	151.82	0.45
Main	791.8987	May 2011	Alt B1 Hist Q	2520.00	733.01	742.38	739.77	743.10	0.002769	7.27	512.94	151.82	0.45
Main	791.8987	Irene 2011	Ex Cond Hist Q	1500.00	733.01	738.93	737.97	740.14	0.008448	8.81	171.94	41.71	0.72
Main	791.8987	Irene 2011	Alt B1 Hist Q	1500.00	733.01	738.93	737.97	740.14	0.008448	8.81	171.94	41.71	0.72
Main	791.8987	July 2015 High	Ex Cond Hist Q	1055.00	733.01	737.68	737.13	738.79	0.010791	8.46	124.67	35.13	0.79
Main	791.8987	July 2015 High	Alt B1 Hist Q	1055.00	733.01	737.68	737.13	738.79	0.010791	8.46	124.67	35.13	0.79
Main	678.739	Floyd 1999	Ex Cond Hist Q	1025.00	731.93	736.83		737.64	0.006864	7.23	141.71	31.30	0.60
Main	678.739	Floyd 1999	Alt B1 Hist Q	1025.00	731.93	736.83		737.64	0.006864	7.23	141.71	31.30	0.60
Main	678.739	May 2011	Ex Cond Hist Q	2520.00	731.93	741.89		742.76	0.003089	7.74	405.22	88.15	0.44
Main	678.739	May 2011	Alt B1 Hist Q	2520.00	731.93	741.89		742.76	0.003089	7.74	405.22	88.15	0.44
Main	678.739	Irene 2011	Ex Cond Hist Q	1500.00	731.93	738.27		739.26	0.006186	8.00	191.36	37.97	0.58
Main	678.739	Irene 2011	Alt B1 Hist Q	1500.00	731.93	738.27		739.26	0.006186	8.00	191.36	37.97	0.58
Main	678.739	July 2015 High	Ex Cond Hist Q	1055.00	731.93	736.92		737.74	0.006845	7.30	144.57	31.30	0.60
Main	678.739	July 2015 High	Alt B1 Hist Q	1055.00	731.93	736.92		737.74	0.006845	7.30	144.57	31.30	0.60
Main	616.3432	Floyd 1999	Ex Cond Hist Q	1025.00	731.47	736.21	735.05	737.15	0.007859	7.74	132.38	29.42	0.64
Main	616.3432	Floyd 1999	Alt B1 Hist Q	1025.00	731.47	736.21	735.05	737.15	0.007859	7.74	132.38	29.42	0.64
Main	616.3432	May 2011	Ex Cond Hist Q	2520.00	731.47	741.08	737.82	742.37	0.005639	9.14	282.59	97.92	0.53
Main	616.3432	May 2011	Alt B1 Hist Q	2520.00	731.47	741.08	737.82	742.37	0.005639	9.14	282.59	97.92	0.53
Main	616.3432	Irene 2011	Ex Cond Hist Q	1500.00	731.47	737.64	736.03	738.79	0.007427	8.60	174.33	29.42	0.62
Main	616.3432	Irene 2011	Alt B1 Hist Q	1500.00	731.47	737.64	736.03	738.79	0.007427	8.60	174.33	29.42	0.62
Main	616.3432	July 2015 High	Ex Cond Hist Q	1055.00	731.47	736.30	735.13	737.25	0.007855	7.82	134.96	29.42	0.64
Main	616.3432	July 2015 High	Alt B1 Hist Q	1055.00	731.47	736.30	735.13	737.25	0.007855	7.82	134.96	29.42	0.64
Main	600			Bridge									
Main	586.3504	Floyd 1999	Ex Cond Hist Q	1025.00	731.03	735.14	734.91	736.62	0.015954	9.75	105.12	29.51	0.91
Main	586.3504	Floyd 1999	Alt B1 Hist Q	1025.00	731.03	735.14	734.91	736.62	0.015954	9.75	105.12	29.51	0.91
Main	586.3504	May 2011	Ex Cond Hist Q	2520.00	731.03	737.67	737.67	740.72	0.019270	14.01	179.85	29.51	1.00
Main	586.3504	May 2011	Alt B1 Hist Q	2520.00	731.03	737.67	737.67	740.72	0.019270	14.01	179.85	29.51	1.00
Main	586.3504	Irene 2011	Ex Cond Hist Q	1500.00	731.03	735.88	735.88	738.05	0.019274	11.82	126.89	29.51	1.00
Main	586.3504	Irene 2011	Alt B1 Hist Q	1500.00	731.03	735.88	735.88	738.05	0.019274	11.82	126.89	29.51	1.00
Main	586.3504	July 2015 High	Ex Cond Hist Q	1055.00	731.03	735.19	734.97	736.71	0.016185	9.90	106.62	29.51	0.92
Main	586.3504	July 2015 High	Alt B1 Hist Q	1055.00	731.03	735.19	734.97	736.71	0.016185	9.90	106.62	29.51	0.92
Main	531.4537	Floyd 1999	Ex Cond Hist Q	1025.00	730.27	734.27	734.27	735.64	0.017764	9.38	109.33	40.15	1.00
Main	531.4537	Floyd 1999	Alt B1 Hist Q	1025.00	730.27	734.27	734.27	735.64	0.017764	9.38	109.33	40.15	1.00
Main	531.4537	May 2011	Ex Cond Hist Q	2520.00	730.27	735.60	736.63	739.22	0.031503	15.26	165.18	43.71	1.38
Main	531.4537	May 2011	Alt B1 Hist Q	2520.00	730.27	735.60	736.63	739.22	0.031503	15.26	165.18	43.71	1.38
Main	531.4537	Irene 2011	Ex Cond Hist Q	1500.00	730.27	734.73	735.11	736.86	0.023729	11.72	127.99	41.37	1.17
Main	531.4537	Irene 2011	Alt B1 Hist Q	1500.00	730.27	734.73	735.11	736.86	0.023729	11.72	127.99	41.37	1.17
Main	531.4537	July 2015 High	Ex Cond Hist Q	1055.00	730.27	734.33	734.33	735.72	0.017690	9.45	111.60	40.30	1.00
Main	531.4537	July 2015 High	Alt B1 Hist Q	1055.00	730.27	734.33	734.33	735.72	0.017690	9.45	111.60	40.30	1.00

HEC-RAS River: Great Brook Reach: Main (Continued)

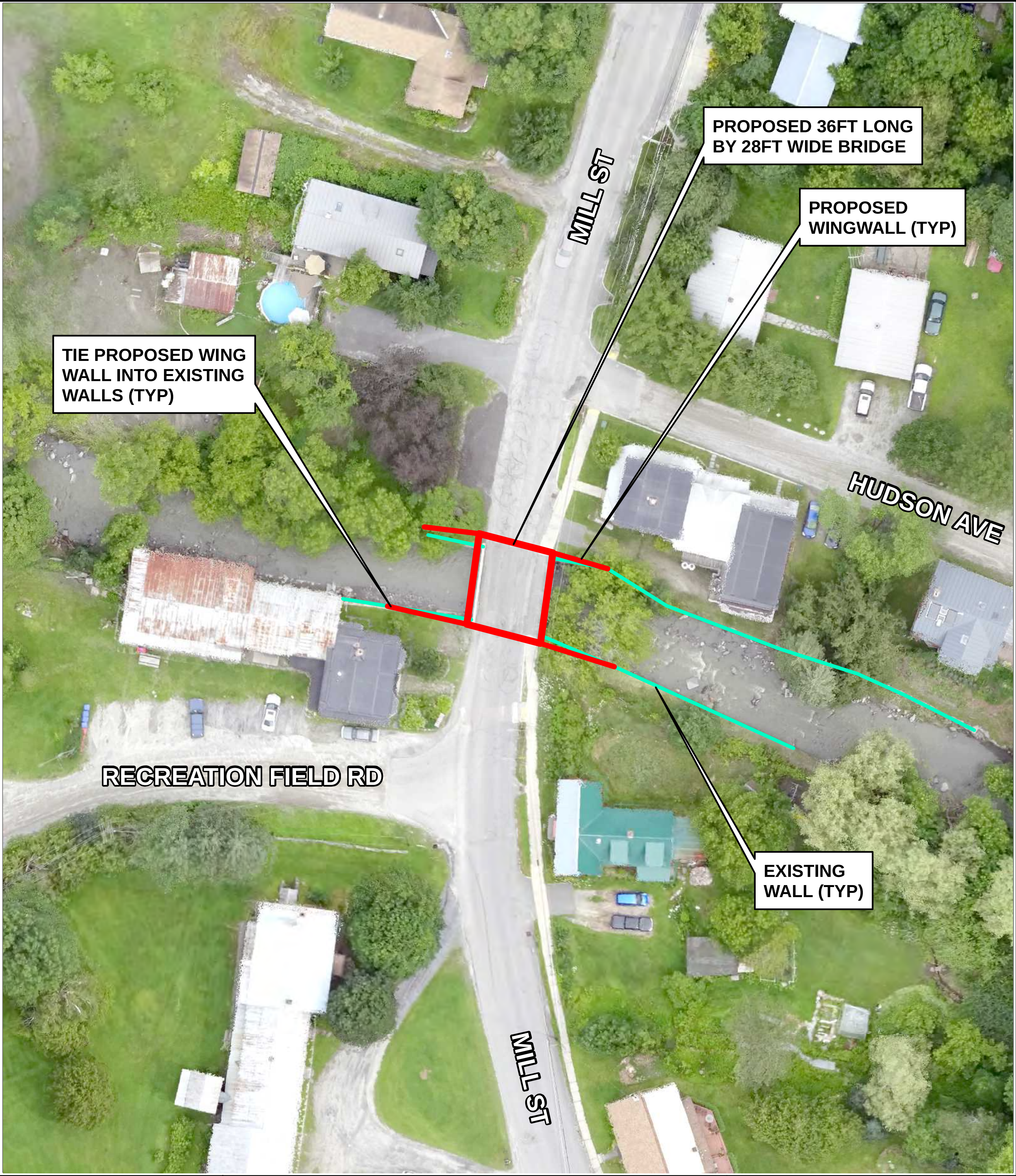
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	362.1208	Floyd 1999	Ex Cond Hist Q	1025.00	729.56	732.81	732.31	733.12	0.006655	4.67	265.86	206.81	0.59
Main	362.1208	Floyd 1999	Alt B1 Hist Q	1025.00	729.56	732.81	732.31	733.12	0.006655	4.67	265.86	206.81	0.59
Main	362.1208	May 2011	Ex Cond Hist Q	2520.00	729.56	734.13	733.50	734.59	0.005521	5.96	617.92	293.05	0.58
Main	362.1208	May 2011	Alt B1 Hist Q	2520.00	729.56	734.13	733.50	734.59	0.005521	5.96	617.92	293.05	0.58
Main	362.1208	Irene 2011	Ex Cond Hist Q	1500.00	729.56	733.31	732.72	733.69	0.006081	5.19	385.84	270.34	0.59
Main	362.1208	Irene 2011	Alt B1 Hist Q	1500.00	729.56	733.31	732.72	733.69	0.006081	5.19	385.84	270.34	0.59
Main	362.1208	July 2015 High	Ex Cond Hist Q	1055.00	729.56	732.84	732.34	733.16	0.006586	4.70	273.50	210.38	0.59
Main	362.1208	July 2015 High	Alt B1 Hist Q	1055.00	729.56	732.84	732.34	733.16	0.006586	4.70	273.50	210.38	0.59
Main	307.1709	Floyd 1999	Ex Cond Hist Q	1025.00	727.84	732.38	731.21	732.82	0.004412	5.59	291.03	268.66	0.52
Main	307.1709	Floyd 1999	Alt B1 Hist Q	1025.00	727.84	732.38	731.21	732.82	0.004412	5.59	291.03	268.66	0.52
Main	307.1709	May 2011	Ex Cond Hist Q	2520.00	727.84	733.47	733.25	734.24	0.006869	8.30	592.19	284.96	0.67
Main	307.1709	May 2011	Alt B1 Hist Q	2520.00	727.84	733.47	733.25	734.24	0.006869	8.30	592.19	284.96	0.67
Main	307.1709	Irene 2011	Ex Cond Hist Q	1500.00	727.84	732.80	732.49	733.37	0.005418	6.66	404.52	277.06	0.58
Main	307.1709	Irene 2011	Alt B1 Hist Q	1500.00	727.84	732.80	732.49	733.37	0.005418	6.66	404.52	277.06	0.58
Main	307.1709	July 2015 High	Ex Cond Hist Q	1055.00	727.84	732.41	731.25	732.86	0.004496	5.67	298.58	270.15	0.52
Main	307.1709	July 2015 High	Alt B1 Hist Q	1055.00	727.84	732.41	731.25	732.86	0.004496	5.67	298.58	270.15	0.52
Main	264.9572	Floyd 1999	Ex Cond Hist Q	1025.00	728.90	731.92	731.92	732.54	0.010535	7.01	253.82	221.32	0.77
Main	264.9572	Floyd 1999	Alt B1 Hist Q	1025.00	728.90	731.92	731.92	732.54	0.010535	7.01	253.82	221.32	0.77
Main	264.9572	May 2011	Ex Cond Hist Q	2520.00	728.90	732.97	732.97	733.87	0.012612	9.39	518.87	259.32	0.88
Main	264.9572	May 2011	Alt B1 Hist Q	2520.00	728.90	732.97	732.97	733.87	0.012612	9.39	518.87	259.32	0.88
Main	264.9572	Irene 2011	Ex Cond Hist Q	1500.00	728.90	732.38	732.38	733.06	0.010639	7.74	365.63	253.50	0.79
Main	264.9572	Irene 2011	Alt B1 Hist Q	1500.00	728.90	732.38	732.38	733.06	0.010639	7.74	365.63	253.50	0.79
Main	264.9572	July 2015 High	Ex Cond Hist Q	1055.00	728.90	731.96	731.96	732.58	0.010347	7.01	263.85	227.56	0.76
Main	264.9572	July 2015 High	Alt B1 Hist Q	1055.00	728.90	731.96	731.96	732.58	0.010347	7.01	263.85	227.56	0.76
Main	254.9572	Floyd 1999	Ex Cond Hist Q	1025.00	725.08	727.67	728.90	731.94	0.109178	16.58	61.82	38.94	2.32
Main	254.9572	Floyd 1999	Alt B1 Hist Q	1025.00	725.08	727.67	728.90	731.94	0.109178	16.58	61.82	38.94	2.32
Main	254.9572	May 2011	Ex Cond Hist Q	2520.00	725.08	729.86	731.10	733.40	0.036464	15.10	166.89	51.48	1.48
Main	254.9572	May 2011	Alt B1 Hist Q	2520.00	725.08	729.86	731.10	733.40	0.036464	15.10	166.89	51.48	1.48
Main	254.9572	Irene 2011	Ex Cond Hist Q	1500.00	725.08	728.38	729.57	732.49	0.078830	16.26	92.23	46.80	2.04
Main	254.9572	Irene 2011	Alt B1 Hist Q	1500.00	725.08	728.38	729.57	732.49	0.078830	16.26	92.23	46.80	2.04
Main	254.9572	July 2015 High	Ex Cond Hist Q	1055.00	725.08	727.72	728.95	731.97	0.106453	16.55	63.73	39.48	2.30
Main	254.9572	July 2015 High	Alt B1 Hist Q	1055.00	725.08	727.72	728.95	731.97	0.106453	16.55	63.73	39.48	2.30
Main	185.5077	Floyd 1999	Ex Cond Hist Q	1025.00	723.54	726.94	727.02	728.02	0.022601	8.33	123.09	64.92	1.07
Main	185.5077	Floyd 1999	Alt B1 Hist Q	1025.00	723.54	726.94	727.02	728.02	0.022601	8.33	123.09	64.92	1.07
Main	185.5077	May 2011	Ex Cond Hist Q	2520.00	723.54	727.95	728.64	730.71	0.034377	13.34	188.95	66.46	1.39
Main	185.5077	May 2011	Alt B1 Hist Q	2520.00	723.54	727.95	728.64	730.71	0.034377	13.34	188.95	66.46	1.39
Main	185.5077	Irene 2011	Ex Cond Hist Q	1500.00	723.54	727.38	727.60	728.90	0.024551	9.88	151.88	65.60	1.14
Main	185.5077	Irene 2011	Alt B1 Hist Q	1500.00	723.54	727.38	727.60	728.90	0.024551	9.88	151.88	65.60	1.14
Main	185.5077	July 2015 High	Ex Cond Hist Q	1055.00	723.54	726.97	727.06	728.08	0.022733	8.43	125.08	64.97	1.07
Main	185.5077	July 2015 High	Alt B1 Hist Q	1055.00	723.54	726.97	727.06	728.08	0.022733	8.43	125.08	64.97	1.07
Main	79.35866	Floyd 1999	Ex Cond Hist Q	1025.00	720.39	724.74	724.37	725.42	0.012011	6.62	155.90	75.72	0.80
Main	79.35866	Floyd 1999	Alt B1 Hist Q	1025.00	720.39	724.74	724.37	725.42	0.012011	6.62	155.90	75.72	0.80
Main	79.35866	May 2011	Ex Cond Hist Q	2520.00	720.39	726.25	725.99	727.51	0.012014	9.06	296.56	111.08	0.86
Main	79.35866	May 2011	Alt B1 Hist Q	2520.00	720.39	726.25	725.99	727.51	0.012014	9.06	296.56	111.08	0.86
Main	79.35866	Irene 2011	Ex Cond Hist Q	1500.00	720.39	725.35	725.01	726.20	0.012004	7.39	206.52	89.62	0.82
Main	79.35866	Irene 2011	Alt B1 Hist Q	1500.00	720.39	725.35	725.01	726.20	0.012004	7.39	206.52	89.62	0.82
Main	79.35866	July 2015 High	Ex Cond Hist Q	1055.00	720.39	724.79	724.42	725.48	0.012018	6.67	159.41	76.74	0.80
Main	79.35866	July 2015 High	Alt B1 Hist Q	1055.00	720.39	724.79	724.42	725.48	0.012018	6.67	159.41	76.74	0.80


GreatBrook_v3 Plan: 1) Ex Cond Hist Q 10/19/2015 2) Alt B1 Hist Q 12/8/2015
Geom: Great Brook Alt B1 - Brdg 2 @ 1.0BF Flow: Historic Flood Flow Rates
Great Brook Main
Legend
WS May 2011 - Ex Cond Hist Q
WS May 2011 - Alt B1 Hist Q
WS Floyd 1999 - Alt B1 Hist Q
WS Floyd 1999 - Ex Cond Hist Q
Ground
Elevation (ft)
Main Channel Distance (ft)
720
730
740
750
760
770
780
790
0
500
1000
1500
2000
2500
3000
185.507
254.9572
307.1709
362.1208
531.4537
586.3504
600
678.739
791.8987
1038.577
1120.126
1224.62
1306.858
1358.843
1399
1455.858
1509.958
1565.906
1920.789
2003.194
2097.059
2774.566
2996.565


GreatBrook_v3 Plan: 1) Ex Cond Hist Q 10/19/2015 2) Alt B1 Hist Q 12/8/2015
Geom: Great Brook Alt B1 - Brdg 2 @ 1.0BF Flow: Historic Flood Flow Rates
Great Brook Main
Legend
WS Irene 2011 - Ex Cond Hist Q
WS Irene 2011 - Alt B1 Hist Q
WS July 2015 High - Ex Cond Hist Q
WS July 2015 High - Alt B1 Hist Q
Ground
Elevation (ft)
Main Channel Distance (ft)
790
780
770
760
750
740
730
720
0
500
1000
1500
2000
2500
3000
185.507...
254.9572
307.1709
362.1208
531.4537
586.3504
600
678.739
791.8987
1038.577
1120.126
1224.62
1306.858
1358.843
1399
1455.858
1509.958
1565.906
1920.789
2003.194
2097.059
2774.566
2996.565

APPENDIX D

MILL STREET BRIDGE CONCEPT DESIGN, FLOOD PROFILES AND OUTPUT DATA



SOURCE(S):
UVM SAL - July 25 Data

APPENDIX D: CONCEPT SKETCH
PROPOSED 1.0 x BF BRIDGE AT MILL STREET

LOCATION:
Plainfield, VT

N

GREAT BROOK BRIDGES
ALTERNATIVES ANALYSIS

MXD: Y:\5315-03\Maps\GreatBrk_MilSt_Concept1.mxd

Map By: bmc
MMI#: 5315-03-3
Original: 10/29/2015
Revision: 01/04/2016
Scale: 1 inch = 50 feet

MILONE & MACBROOM
1 South Main Street
Waterbury, VT 05676
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www.miloneandmacbroom.com

HEC-RAS River: Great Brook Reach: Main

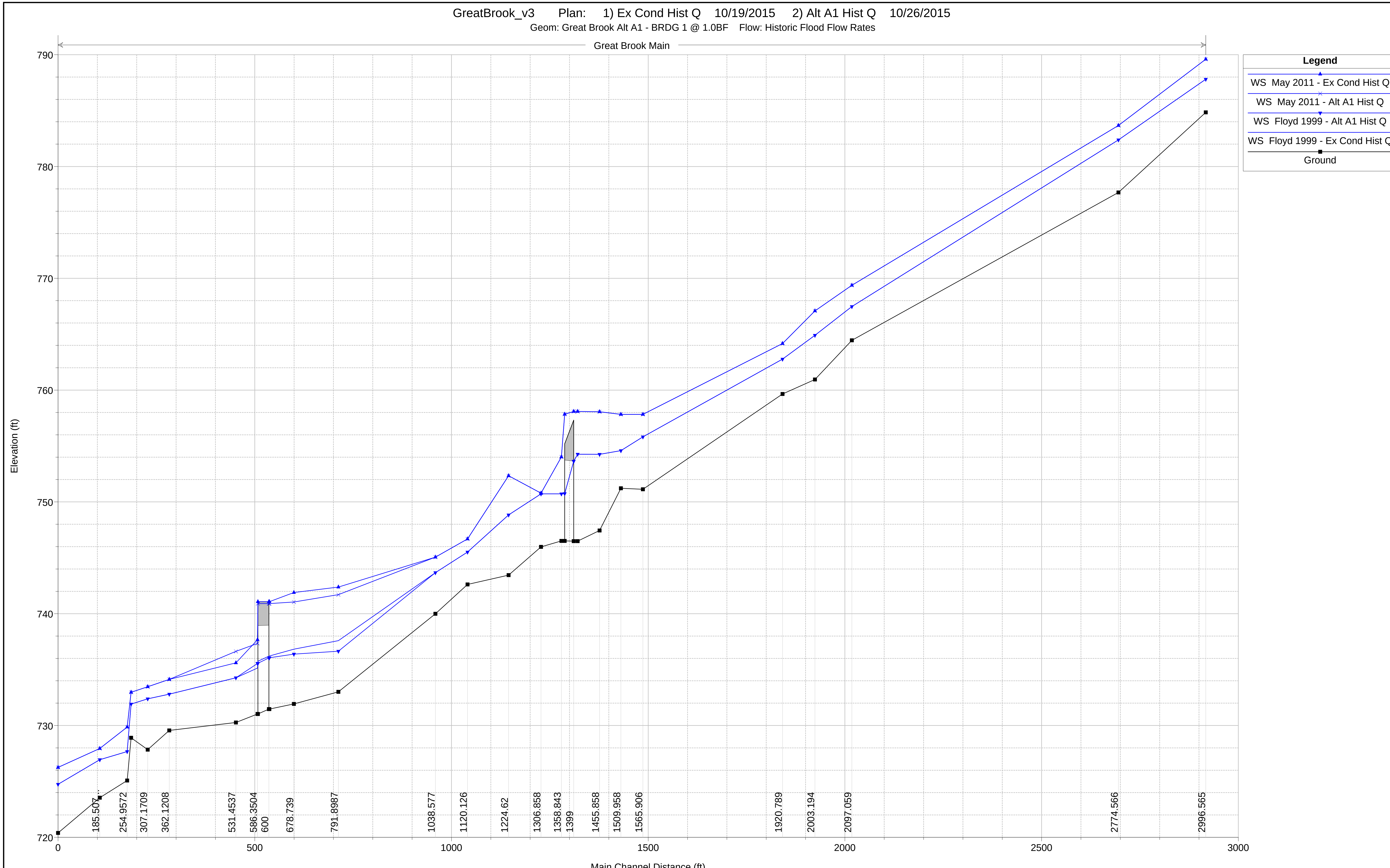
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	2996.565	Floyd 1999	Ex Cond Hist Q	1025.00	784.84	787.81	787.81	788.90	0.024343	8.39	122.19	57.01	1.01
Main	2996.565	Floyd 1999	Alt A1 Hist Q	1025.00	784.84	787.81	787.81	788.90	0.024343	8.39	122.19	57.01	1.01
Main	2996.565	May 2011	Ex Cond Hist Q	2520.00	784.84	789.60	789.60	791.51	0.020863	11.11	226.87	60.16	1.01
Main	2996.565	May 2011	Alt A1 Hist Q	2520.00	784.84	789.60	789.60	791.51	0.020863	11.11	226.87	60.16	1.01
Main	2996.565	Irene 2011	Ex Cond Hist Q	1500.00	784.84	788.46	788.46	789.83	0.022269	9.40	159.65	58.16	1.00
Main	2996.565	Irene 2011	Alt A1 Hist Q	1500.00	784.84	788.46	788.46	789.83	0.022269	9.40	159.65	58.16	1.00
Main	2996.565	July 2015 High	Ex Cond Hist Q	1055.00	784.84	787.87	787.87	788.96	0.023649	8.40	125.54	57.12	1.00
Main	2996.565	July 2015 High	Alt A1 Hist Q	1055.00	784.84	787.87	787.87	788.96	0.023649	8.40	125.54	57.12	1.00
Main	2774.566	Floyd 1999	Ex Cond Hist Q	1025.00	777.68	782.38	782.22	783.35	0.019710	7.87	130.27	56.35	0.91
Main	2774.566	Floyd 1999	Alt A1 Hist Q	1025.00	777.68	782.38	782.22	783.35	0.019710	7.87	130.27	56.35	0.91
Main	2774.566	May 2011	Ex Cond Hist Q	2520.00	777.68	783.67	784.05	785.92	0.030685	12.04	209.92	66.71	1.19
Main	2774.566	May 2011	Alt A1 Hist Q	2520.00	777.68	783.67	784.05	785.92	0.030685	12.04	209.92	66.71	1.19
Main	2774.566	Irene 2011	Ex Cond Hist Q	1500.00	777.68	782.73	782.92	784.28	0.028137	9.99	150.32	59.37	1.10
Main	2774.566	Irene 2011	Alt A1 Hist Q	1500.00	777.68	782.73	782.92	784.28	0.028137	9.99	150.32	59.37	1.10
Main	2774.566	July 2015 High	Ex Cond Hist Q	1055.00	777.68	782.42	782.27	783.41	0.019846	7.96	132.62	56.71	0.92
Main	2774.566	July 2015 High	Alt A1 Hist Q	1055.00	777.68	782.42	782.27	783.41	0.019846	7.96	132.62	56.71	0.92
Main	2097.059	Floyd 1999	Ex Cond Hist Q	1025.00	764.45	767.47	767.47	768.46	0.024616	7.97	128.65	65.44	1.00
Main	2097.059	Floyd 1999	Alt A1 Hist Q	1025.00	764.45	767.47	767.47	768.46	0.024616	7.97	128.65	65.44	1.00
Main	2097.059	May 2011	Ex Cond Hist Q	2520.00	764.45	769.38	769.11	770.87	0.016502	9.80	257.02	69.65	0.90
Main	2097.059	May 2011	Alt A1 Hist Q	2520.00	764.45	769.38	769.11	770.87	0.016502	9.80	257.02	69.65	0.90
Main	2097.059	Irene 2011	Ex Cond Hist Q	1500.00	764.45	768.11	768.06	769.31	0.021404	8.80	170.47	66.84	0.97
Main	2097.059	Irene 2011	Alt A1 Hist Q	1500.00	764.45	768.11	768.06	769.31	0.021404	8.80	170.47	66.84	0.97
Main	2097.059	July 2015 High	Ex Cond Hist Q	1055.00	764.45	767.51	767.51	768.52	0.024468	8.04	131.23	65.53	1.00
Main	2097.059	July 2015 High	Alt A1 Hist Q	1055.00	764.45	767.51	767.51	768.52	0.024468	8.04	131.23	65.53	1.00
Main	2003.194	Floyd 1999	Ex Cond Hist Q	1025.00	760.95	764.90	764.90	766.19	0.023115	9.11	112.45	44.32	1.01
Main	2003.194	Floyd 1999	Alt A1 Hist Q	1025.00	760.95	764.90	764.90	766.19	0.023115	9.11	112.45	44.32	1.01
Main	2003.194	May 2011	Ex Cond Hist Q	2520.00	760.95	767.09	767.09	769.12	0.019782	11.45	220.09	54.14	1.00
Main	2003.194	May 2011	Alt A1 Hist Q	2520.00	760.95	767.09	767.09	769.12	0.019782	11.45	220.09	54.14	1.00
Main	2003.194	Irene 2011	Ex Cond Hist Q	1500.00	760.95	765.70	765.70	767.27	0.021386	10.03	149.57	47.93	1.00
Main	2003.194	Irene 2011	Alt A1 Hist Q	1500.00	760.95	765.70	765.70	767.27	0.021386	10.03	149.57	47.93	1.00
Main	2003.194	July 2015 High	Ex Cond Hist Q	1055.00	760.95	764.94	764.95	766.26	0.023293	9.22	114.37	44.51	1.01
Main	2003.194	July 2015 High	Alt A1 Hist Q	1055.00	760.95	764.94	764.95	766.26	0.023293	9.22	114.37	44.51	1.01
Main	1920.789	Floyd 1999	Ex Cond Hist Q	1025.00	759.65	762.77	762.92	764.06	0.028965	9.12	112.38	53.16	1.11
Main	1920.789	Floyd 1999	Alt A1 Hist Q	1025.00	759.65	762.77	762.92	764.06	0.028965	9.12	112.38	53.16	1.11
Main	1920.789	May 2011	Ex Cond Hist Q	2520.00	759.65	764.17	764.81	766.92	0.034496	13.31	189.28	57.08	1.29
Main	1920.789	May 2011	Alt A1 Hist Q	2520.00	759.65	764.17	764.81	766.92	0.034496	13.31	189.28	57.08	1.29
Main	1920.789	Irene 2011	Ex Cond Hist Q	1500.00	759.65	763.25	763.59	765.08	0.032453	10.86	138.14	54.50	1.20
Main	1920.789	Irene 2011	Alt A1 Hist Q	1500.00	759.65	763.25	763.59	765.08	0.032453	10.86	138.14	54.50	1.20
Main	1920.789	July 2015 High	Ex Cond Hist Q	1055.00	759.65	762.81	762.97	764.13	0.028955	9.22	114.47	53.27	1.11
Main	1920.789	July 2015 High	Alt A1 Hist Q	1055.00	759.65	762.81	762.97	764.13	0.028955	9.22	114.47	53.27	1.11
Main	1565.906	Floyd 1999	Ex Cond Hist Q	1025.00	751.13	755.82	755.34	756.90	0.014233	8.34	122.83	37.62	0.81
Main	1565.906	Floyd 1999	Alt A1 Hist Q	1025.00	751.13	755.82	755.34	756.90	0.014236	8.35	122.82	37.62	0.81
Main	1565.906	May 2011	Ex Cond Hist Q	2520.00	751.13	757.83	757.83	760.19	0.019692	12.34	204.23	43.42	1.00
Main	1565.906	May 2011	Alt A1 Hist Q	2520.00	751.13	757.83	757.83	760.19	0.019692	12.34	204.23	43.42	1.00
Main	1565.906	Irene 2011	Ex Cond Hist Q	1500.00	751.13	756.46	756.23	758.06	0.017867	10.18	147.42	39.46	0.93
Main	1565.906	Irene 2011	Alt A1 Hist Q	1500.00	751.13	756.46	756.23	758.06	0.017867	10.18	147.42	39.46	0.93
Main	1565.906	July 2015 High	Ex Cond Hist Q	1055.00	751.13	755.85	755.40	756.97	0.014591	8.49	124.21	37.72	0.82
Main	1565.906	July 2015 High	Alt A1 Hist Q	1055.00	751.13	755.85	755.40	756.97	0.014591	8.49	124.21	37.72	0.82
Main	1509.958	Floyd 1999	Ex Cond Hist Q	1025.00	751.22	754.58	754.58	755.88	0.022700	9.15	111.99	43.69	1.01
Main	1509.958	Floyd 1999	Alt A1 Hist Q	1025.00	751.22	754.58	754.58	755.88	0.022692	9.15	112.00	43.69	1.01
Main	1509.958	May 2011	Ex Cond Hist Q	2520.00	751.22	757.83	756.77	759.10	0.009688	9.06	281.19	69.61	0.72
Main	1509.958	May 2011	Alt A1 Hist Q	2520.00	751.22	757.83	756.77	759.10	0.009688	9.06	281.19	69.61	0.72
Main	1509.958	Irene 2011	Ex Cond Hist Q	1500.00	751.22	755.40	755.40	756.97	0.021045	10.06	149.07	47.44	1.00
Main	1509.958	Irene 2011	Alt A1 Hist Q	1500.00	751.22	755.40	755.40	756.97	0.021045	10.06	149.07	47.44	1.00
Main	1509.958	July 2015 High	Ex Cond Hist Q	1055.00	751.22	754.65	754.65	755.96	0.022242	9.17	114.99	44.01	1.00
Main	1509.958	July 2015 High	Alt A1 Hist Q	1055.00	751.22	754.65	754.65	755.96	0.022242	9.17	114.99	44.01	1.00
Main	1455.858	Floyd 1999	Ex Cond Hist Q	1025.00	747.44	754.25	751.82	754.66	0.004218	5.09	201.31	44.01	0.42
Main	1455.858	Floyd 1999	Alt A1 Hist Q	1025.00	747.44	754.25	751.82	754.66	0.004218	5.09	201.31	44.01	0.42
Main	1455.858	May 2011	Ex Cond Hist Q	2520.00	747.44	758.07		758.60	0.003233	6.06	481.82	120.35	0.39
Main	1455.858	May 2011	Alt A1 Hist Q	2520.00	747.44	758.07		758.60	0.003233	6.06	481.82	120.35	0.39
Main	1455.858	Irene 2011	Ex Cond Hist Q	1500.00	747.44	755.35	752.76	755.90	0.004840	5.96	251.54	47.79	0.46
Main	1455.858	Irene 2011	Alt A1 Hist Q	1500.00	747.44	755.35	752.76	755.90	0.004840	5.96	251.54	47.79	0.46
Main	1455.858	July 2015 High	Ex Cond Hist Q	1055.00	747.44	754.29	751.89	754.71	0.004363	5.20	203.01	44.14	0.43
Main	1455.858	July 2015 High	Alt A1 Hist Q	1055.00	747.44	754.29	751.89	754.71	0.004363	5.20	203.01	44.14	0.43
Main	1400.035	Floyd 1999	Ex Cond Hist Q	1025.00	746.49	754.27	749.88	754.44	0.001033	3.28	312.43	52.69	0.24
Main	1400.035	Floyd 1999	Alt A1 Hist Q	1025.00	746.49	754.27	749.87	754.44	0.001033	3.28	312.43	52.69	0.24
Main	1400.035	May 2011	Ex Cond Hist Q	2520.00	746.49	758.09	752.20	758.40	0.001087	4.55	695.66	206.65	0.26
Main	1400.035	May 2011	Alt A1 Hist Q	2520.00	746.49	758.09	752.20	758.40	0.001087	4.55	695.66	206.65	0.26
Main	1400.035	Irene 2011	Ex Cond Hist Q	1500.00	746.49	755.37	750.72	755.63	0.001289	4.03	378.62	68.97	0.27
Main	1400.035	Irene 2011	Alt A1 Hist Q	1500.00	746.49	755.37	750.72	755.63	0.001289	4.03	378.62	68.97	0.27
Main	1400.035	July 2015 High	Ex Cond Hist Q	1055.00	746.49	754.31	749.94	754.48	0.001074	3.35	314.51	52.81	0.24
Main	1400.035	July 2015 High	Alt A1 Hist Q	1055.00	746.49	754.31	749.94	754.48	0.001074	3.35	314.51	52.81	0.24
Main	1399			Bridge									
Main	1358.843	Floyd 1999	Ex Cond Hist Q	1025.00	746.51	750.72	750.62	752.59	0.019815	10.96	93.50	23.40	0.97
Main	1358.843	Floyd 1999	Alt A1 Hist Q	1025.00	746.51	750.72	750.62	752.59	0.019817	10.96	93.50	23.40	0.97
Main	1358.843	May 2011	Ex Cond Hist Q	2520.00	746.51	754.02	754.02	757.01	0.019870	13.88	181.60	30.54	1.00
Main	1358.843	May 2011	Alt A1 Hist Q	2520.00	746.51	754.02	754.02	757.01	0.019870	13.88	181.60	30.54	1.00

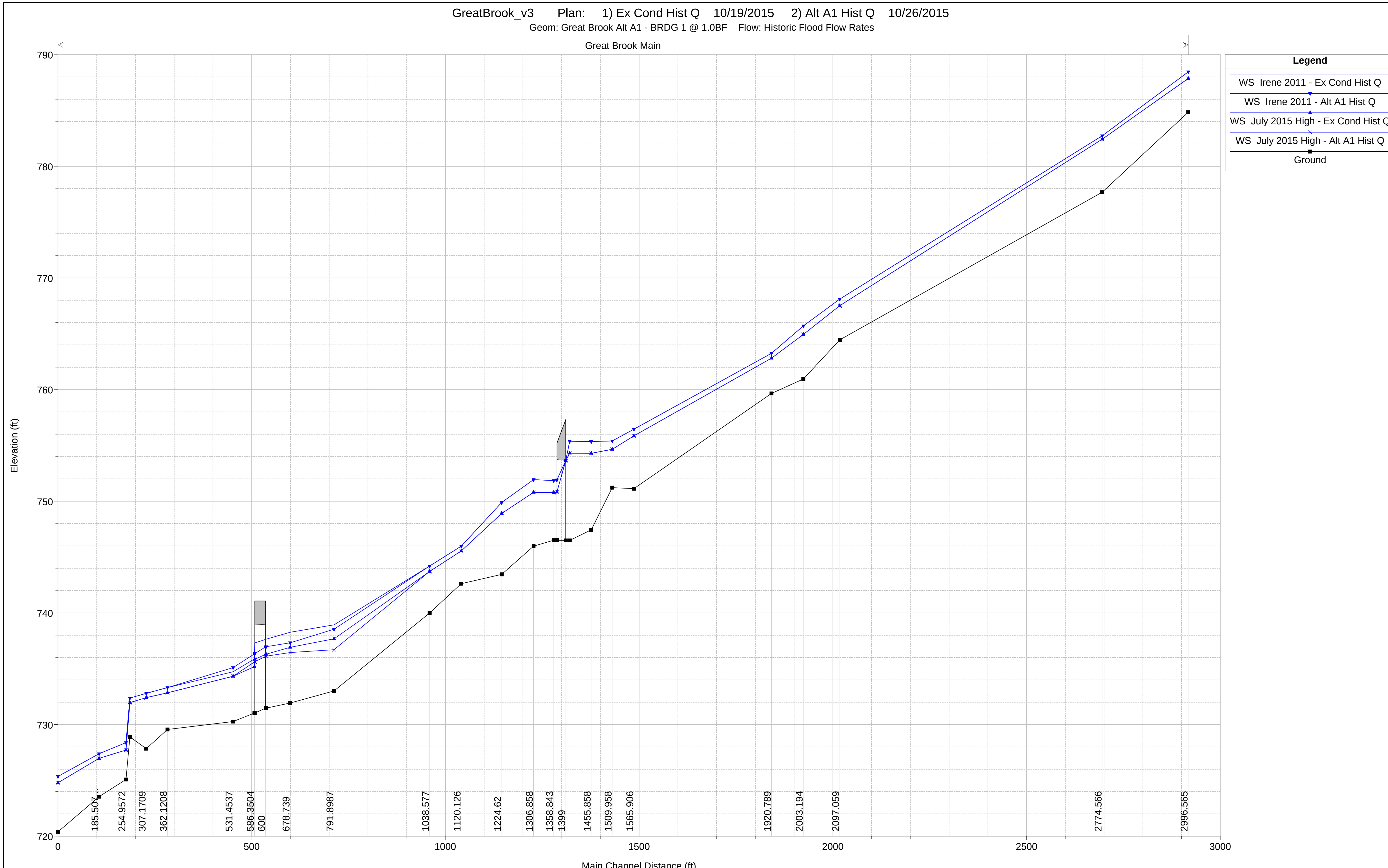
HEC-RAS River: Great Brook Reach: Main (Continued)

Reach	River Sta	Profile	Plan	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)	
Main	1358.843	Irene 2011	Ex Cond Hist Q	1500.00	746.51	751.85	751.85	754.24	0.020916	12.41	120.86	25.48	1.00
Main	1358.843	Irene 2011	Alt A1 Hist Q	1500.00	746.51	751.85	751.85	754.24	0.020916	12.41	120.86	25.48	1.00
Main	1358.843	July 2015 High	Ex Cond Hist Q	1055.00	746.51	750.79	750.69	752.70	0.020012	11.10	95.01	23.41	0.97
Main	1358.843	July 2015 High	Alt A1 Hist Q	1055.00	746.51	750.79	750.69	752.70	0.020012	11.10	95.01	23.41	0.97
Main	1306.858	Floyd 1999	Ex Cond Hist Q	1025.00	745.98	750.72		751.47	0.006801	6.97	147.15	38.21	0.63
Main	1306.858	Floyd 1999	Alt A1 Hist Q	1025.00	745.98	750.72		751.47	0.006801	6.97	147.14	38.21	0.63
Main	1306.858	May 2011	Ex Cond Hist Q	2520.00	745.98	750.78	752.05	755.18	0.038952	16.82	149.81	38.31	1.50
Main	1306.858	May 2011	Alt A1 Hist Q	2520.00	745.98	750.78	752.05	755.18	0.038952	16.82	149.81	38.31	1.50
Main	1306.858	Irene 2011	Ex Cond Hist Q	1500.00	745.98	751.93	750.48	752.85	0.006316	7.70	194.85	40.04	0.61
Main	1306.858	Irene 2011	Alt A1 Hist Q	1500.00	745.98	751.93	750.48	752.85	0.006316	7.70	194.85	40.04	0.61
Main	1306.858	July 2015 High	Ex Cond Hist Q	1055.00	745.98	750.80		751.56	0.006754	7.02	150.34	38.33	0.62
Main	1306.858	July 2015 High	Alt A1 Hist Q	1055.00	745.98	750.80		751.56	0.006754	7.02	150.34	38.33	0.62
Main	1224.62	Floyd 1999	Ex Cond Hist Q	1025.00	743.45	748.83	748.83	750.52	0.017846	10.42	98.37	29.21	1.00
Main	1224.62	Floyd 1999	Alt A1 Hist Q	1025.00	743.45	748.83	748.83	750.52	0.017840	10.42	98.38	29.21	1.00
Main	1224.62	May 2011	Ex Cond Hist Q	2520.00	743.45	752.34	752.34	753.60	0.007054	9.89	445.78	202.35	0.68
Main	1224.62	May 2011	Alt A1 Hist Q	2520.00	743.45	752.34	752.34	753.60	0.007054	9.89	445.78	202.35	0.68
Main	1224.62	Irene 2011	Ex Cond Hist Q	1500.00	743.45	749.89	749.89	751.94	0.017233	11.48	130.71	32.01	1.00
Main	1224.62	Irene 2011	Alt A1 Hist Q	1500.00	743.45	749.89	749.89	751.94	0.017233	11.48	130.71	32.01	1.00
Main	1224.62	July 2015 High	Ex Cond Hist Q	1055.00	743.45	748.91	748.91	750.62	0.017790	10.50	100.52	29.40	1.00
Main	1224.62	July 2015 High	Alt A1 Hist Q	1055.00	743.45	748.91	748.91	750.62	0.017790	10.50	100.52	29.40	1.00
Main	1120.126	Floyd 1999	Ex Cond Hist Q	1025.00	742.62	745.51	746.13	747.71	0.043204	11.88	86.28	44.33	1.50
Main	1120.126	Floyd 1999	Alt A1 Hist Q	1025.00	742.62	745.51	746.13	747.71	0.043204	11.88	86.28	44.33	1.50
Main	1120.126	May 2011	Ex Cond Hist Q	2520.00	742.62	746.69	748.23	751.66	0.058571	17.88	140.90	48.75	1.85
Main	1120.126	May 2011	Alt A1 Hist Q	2520.00	742.62	746.69	748.23	751.66	0.058571	17.88	140.90	48.75	1.85
Main	1120.126	Irene 2011	Ex Cond Hist Q	1500.00	742.62	745.98	746.90	749.02	0.047649	14.01	107.09	46.06	1.62
Main	1120.126	Irene 2011	Alt A1 Hist Q	1500.00	742.62	745.98	746.90	749.02	0.047649	14.01	107.09	46.06	1.62
Main	1120.126	July 2015 High	Ex Cond Hist Q	1055.00	742.62	745.55	746.18	747.80	0.043596	12.04	87.65	44.44	1.51
Main	1120.126	July 2015 High	Alt A1 Hist Q	1055.00	742.62	745.55	746.18	747.80	0.043596	12.04	87.65	44.44	1.51
Main	1038.577	Floyd 1999	Ex Cond Hist Q	1025.00	739.99	743.67	743.79	744.95	0.022574	9.09	112.75	52.56	1.09
Main	1038.577	Floyd 1999	Alt A1 Hist Q	1025.00	739.99	743.67	743.79	744.95	0.022574	9.09	112.75	52.56	1.09
Main	1038.577	May 2011	Ex Cond Hist Q	2520.00	739.99	745.06	745.70	747.83	0.027598	13.36	188.60	56.65	1.29
Main	1038.577	May 2011	Alt A1 Hist Q	2520.00	739.99	745.06	745.70	747.83	0.027598	13.36	188.60	56.65	1.29
Main	1038.577	Irene 2011	Ex Cond Hist Q	1500.00	739.99	744.20	744.49	745.96	0.024012	10.64	141.01	54.12	1.16
Main	1038.577	Irene 2011	Alt A1 Hist Q	1500.00	739.99	744.20	744.49	745.96	0.024012	10.64	141.01	54.12	1.16
Main	1038.577	July 2015 High	Ex Cond Hist Q	1055.00	739.99	743.71	743.83	745.02	0.022632	9.19	114.74	52.67	1.10
Main	1038.577	July 2015 High	Alt A1 Hist Q	1055.00	739.99	743.71	743.83	745.02	0.022632	9.19	114.74	52.67	1.10
Main	791.8987	Floyd 1999	Ex Cond Hist Q	1025.00	733.01	737.59	737.07	738.69	0.010967	8.43	121.63	34.99	0.80
Main	791.8987	Floyd 1999	Alt A1 Hist Q	1025.00	733.01	736.64	737.07	738.69	0.027991	11.49	89.23	33.37	1.24
Main	791.8987	May 2011	Ex Cond Hist Q	2520.00	733.01	742.38	739.77	743.10	0.002769	7.27	512.94	151.82	0.45
Main	791.8987	May 2011	Alt A1 Hist Q	2520.00	733.01	741.70	739.77	742.70	0.004125	8.36	412.94	138.58	0.55
Main	791.8987	Irene 2011	Ex Cond Hist Q	1500.00	733.01	738.93	737.97	740.14	0.008448	8.81	171.94	41.71	0.72
Main	791.8987	Irene 2011	Alt A1 Hist Q	1500.00	733.01	738.54	737.97	739.98	0.011150	9.64	156.02	38.88	0.82
Main	791.8987	July 2015 High	Ex Cond Hist Q	1055.00	733.01	737.68	737.13	738.79	0.010791	8.46	124.67	35.13	0.79
Main	791.8987	July 2015 High	Alt A1 Hist Q	1055.00	733.01	736.70	737.13	738.78	0.027768	11.57	91.17	33.47	1.24
Main	678.739	Floyd 1999	Ex Cond Hist Q	1025.00	731.93	736.83		737.64	0.006864	7.23	141.71	31.30	0.60
Main	678.739	Floyd 1999	Alt A1 Hist Q	1025.00	731.93	736.38	735.51	737.38	0.009374	8.01	127.90	31.30	0.70
Main	678.739	May 2011	Ex Cond Hist Q	2520.00	731.93	741.89		742.76	0.003089	7.74	405.22	88.15	0.44
Main	678.739	May 2011	Alt A1 Hist Q	2520.00	731.93	741.05		742.20	0.004494	8.78	333.37	78.97	0.52
Main	678.739	Irene 2011	Ex Cond Hist Q	1500.00	731.93	738.27		739.26	0.006186	8.00	191.36	37.97	0.58
Main	678.739	Irene 2011	Alt A1 Hist Q	1500.00	731.93	737.32		738.74	0.010723	9.54	157.29	31.76	0.75
Main	678.739	July 2015 High	Ex Cond Hist Q	1055.00	731.93	736.92		737.74	0.006845	7.30	144.57	31.30	0.60
Main	678.739	July 2015 High	Alt A1 Hist Q	1055.00	731.93	736.45	735.57	737.47	0.009459	8.12	129.96	31.30	0.70
Main	616.3432	Floyd 1999	Ex Cond Hist Q	1025.00	731.47	736.21	735.05	737.15	0.007859	7.74	132.38	29.42	0.64
Main	616.3432	Floyd 1999	Alt A1 Hist Q	1025.00	731.47	736.06	734.79	736.77	0.006153	6.79	151.00	36.00	0.58
Main	616.3432	May 2011	Ex Cond Hist Q	2520.00	731.47	741.08	737.82	742.37	0.005639	9.14	282.59	97.92	0.53
Main	616.3432	May 2011	Alt A1 Hist Q	2520.00	731.47	740.90	737.20	741.83	0.003784	7.74	325.42	41.05	0.45
Main	616.3432	Irene 2011	Ex Cond Hist Q	1500.00	731.47	737.64	736.03	738.79	0.007427	8.60	174.33	29.42	0.62
Main	616.3432	Irene 2011	Alt A1 Hist Q	1500.00	731.47	736.97	735.63	738.00	0.007238	8.16	183.79	36.00	0.64
Main	616.3432	July 2015 High	Ex Cond Hist Q	1055.00	731.47	736.30	735.13	737.25	0.007855	7.82	134.96	29.42	0.64
Main	616.3432	July 2015 High	Alt A1 Hist Q	1055.00	731.47	736.12	734.85	736.86	0.006222	6.88	153.30	36.00	0.59
Main	600			Bridge									
Main	586.3504	Floyd 1999	Ex Cond Hist Q	1025.00	731.03	735.14	734.91	736.62	0.015954	9.75	105.12	29.51	0.91
Main	586.3504	Floyd 1999	Alt A1 Hist Q	1025.00	731.03	735.55		736.42	0.008089	7.48	137.10	36.00	0.68
Main	586.3504	May 2011	Ex Cond Hist Q	2520.00	731.03	737.67	737.67	740.72	0.019270	14.01	179.85	29.51	1.00
Main	586.3504	May 2011	Alt A1 Hist Q	2520.00	731.03	737.34	737.08	739.77	0.015130	12.50	201.57	36.00	0.93
Main	586.3504	Irene 2011	Ex Cond Hist Q	1500.00	731.03	735.88	735.88	738.05	0.019274	11.82	126.89	29.51	1.00
Main	586.3504	Irene 2011	Alt A1 Hist Q	1500.00	731.03	736.33		737.61	0.009786	9.08	165.17	36.00	0.75
Main	586.3504	July 2015 High	Ex Cond Hist Q	1055.00	731.03	735.19	734.97	736.71	0.016185	9.90	106.62	29.51	0.92
Main	586.3504	July 2015 High	Alt A1 Hist Q	1055.00	731.03	735.61		736.50	0.008182	7.58	139.17	36.00	0.68
Main	531.4537	Floyd 1999	Ex Cond Hist Q	1025.00	730.27	734.27	734.27	735.64	0.017764	9.38	109.33	40.15	1.00
Main	531.4537	Floyd 1999	Alt A1 Hist Q	1025.00	730.27	734.27	734.27	735.64	0.017764	9.38	109.33	40.15	1.00
Main	531.4537	May 2011	Ex Cond Hist Q	2520.00	730.27	735.60	736.63	739.22	0.031503	15.26	165.18	43.71	1.38
Main	531.4537	May 2011	Alt A1 Hist Q	2520.00	730.27	736.63	736.63	738.83	0.014830	11.90	216.27	66.50	0.97
Main	531.4537	Irene 2011	Ex Cond Hist Q	1500.00	730.27	734.73	735.11	736.86	0.023729	11.72	127.99	41.37	1.17
Main	531.4537	Irene 2011	Alt A1 Hist Q	1500.00	730.27	735.10	735.10	736.80	0.016883	10.45	143.53	42.37	1.00
Main	531.4537	July 2015 High	Ex Cond Hist Q	1055.00	730.27	734.33	734.33	735.72	0.017690	9.45	111.60	40.30	1.00
Main	531.4537	July 2015 High	Alt A1 Hist Q	1055.00	730.27	734.33	734.33	735.72	0.017690	9.45	111.60	40.30	1.00

HEC-RAS River: Great Brook Reach: Main (Continued)

Reach	River Sta	Profile	Plan	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)	
Main	362.1208	Floyd 1999	Ex Cond Hist Q	1025.00	729.56	732.81	732.31	733.12	0.006655	4.67	265.86	206.81	0.59
Main	362.1208	Floyd 1999	Alt A1 Hist Q	1025.00	729.56	732.81	732.31	733.12	0.006655	4.67	265.86	206.81	0.59
Main	362.1208	May 2011	Ex Cond Hist Q	2520.00	729.56	734.13	733.50	734.59	0.005521	5.96	617.92	293.05	0.58
Main	362.1208	May 2011	Alt A1 Hist Q	2520.00	729.56	734.13	733.50	734.59	0.005521	5.96	617.92	293.05	0.58
Main	362.1208	Irene 2011	Ex Cond Hist Q	1500.00	729.56	733.31	732.72	733.69	0.006081	5.19	385.84	270.34	0.59
Main	362.1208	Irene 2011	Alt A1 Hist Q	1500.00	729.56	733.31	732.72	733.69	0.006081	5.19	385.84	270.34	0.59
Main	362.1208	July 2015 High	Ex Cond Hist Q	1055.00	729.56	732.84	732.34	733.16	0.006586	4.70	273.50	210.38	0.59
Main	362.1208	July 2015 High	Alt A1 Hist Q	1055.00	729.56	732.84	732.34	733.16	0.006586	4.70	273.50	210.38	0.59
Main	307.1709	Floyd 1999	Ex Cond Hist Q	1025.00	727.84	732.38	731.21	732.82	0.004412	5.59	291.03	268.66	0.52
Main	307.1709	Floyd 1999	Alt A1 Hist Q	1025.00	727.84	732.38	731.21	732.82	0.004412	5.59	291.03	268.66	0.52
Main	307.1709	May 2011	Ex Cond Hist Q	2520.00	727.84	733.47	733.25	734.24	0.006869	8.30	592.19	284.96	0.67
Main	307.1709	May 2011	Alt A1 Hist Q	2520.00	727.84	733.47	733.25	734.24	0.006869	8.30	592.19	284.96	0.67
Main	307.1709	Irene 2011	Ex Cond Hist Q	1500.00	727.84	732.80	732.49	733.37	0.005418	6.66	404.52	277.06	0.58
Main	307.1709	Irene 2011	Alt A1 Hist Q	1500.00	727.84	732.80	732.49	733.37	0.005418	6.66	404.52	277.06	0.58
Main	307.1709	July 2015 High	Ex Cond Hist Q	1055.00	727.84	732.41	731.25	732.86	0.004496	5.67	298.58	270.15	0.52
Main	307.1709	July 2015 High	Alt A1 Hist Q	1055.00	727.84	732.41	731.25	732.86	0.004496	5.67	298.58	270.15	0.52
Main	264.9572	Floyd 1999	Ex Cond Hist Q	1025.00	728.90	731.92	731.92	732.54	0.010535	7.01	253.82	221.32	0.77
Main	264.9572	Floyd 1999	Alt A1 Hist Q	1025.00	728.90	731.92	731.92	732.54	0.010535	7.01	253.82	221.32	0.77
Main	264.9572	May 2011	Ex Cond Hist Q	2520.00	728.90	732.97	732.97	733.87	0.012612	9.39	518.87	259.32	0.88
Main	264.9572	May 2011	Alt A1 Hist Q	2520.00	728.90	732.97	732.97	733.87	0.012612	9.39	518.87	259.32	0.88
Main	264.9572	Irene 2011	Ex Cond Hist Q	1500.00	728.90	732.38	732.38	733.06	0.010639	7.74	365.63	253.50	0.79
Main	264.9572	Irene 2011	Alt A1 Hist Q	1500.00	728.90	732.38	732.38	733.06	0.010639	7.74	365.63	253.50	0.79
Main	264.9572	July 2015 High	Ex Cond Hist Q	1055.00	728.90	731.96	731.96	732.58	0.010347	7.01	263.85	227.56	0.76
Main	264.9572	July 2015 High	Alt A1 Hist Q	1055.00	728.90	731.96	731.96	732.58	0.010347	7.01	263.85	227.56	0.76
Main	254.9572	Floyd 1999	Ex Cond Hist Q	1025.00	725.08	727.67	728.90	731.94	0.109178	16.58	61.82	38.94	2.32
Main	254.9572	Floyd 1999	Alt A1 Hist Q	1025.00	725.08	727.67	728.90	731.94	0.109178	16.58	61.82	38.94	2.32
Main	254.9572	May 2011	Ex Cond Hist Q	2520.00	725.08	729.86	731.10	733.40	0.036464	15.10	166.89	51.48	1.48
Main	254.9572	May 2011	Alt A1 Hist Q	2520.00	725.08	729.86	731.10	733.40	0.036464	15.10	166.89	51.48	1.48
Main	254.9572	Irene 2011	Ex Cond Hist Q	1500.00	725.08	728.38	729.57	732.49	0.078830	16.26	92.23	46.80	2.04
Main	254.9572	Irene 2011	Alt A1 Hist Q	1500.00	725.08	728.38	729.57	732.49	0.078830	16.26	92.23	46.80	2.04
Main	254.9572	July 2015 High	Ex Cond Hist Q	1055.00	725.08	727.72	728.95	731.97	0.106453	16.55	63.73	39.48	2.30
Main	254.9572	July 2015 High	Alt A1 Hist Q	1055.00	725.08	727.72	728.95	731.97	0.106453	16.55	63.73	39.48	2.30
Main	185.5077	Floyd 1999	Ex Cond Hist Q	1025.00	723.54	726.94	727.02	728.02	0.022601	8.33	123.09	64.92	1.07
Main	185.5077	Floyd 1999	Alt A1 Hist Q	1025.00	723.54	726.94	727.02	728.02	0.022601	8.33	123.09	64.92	1.07
Main	185.5077	May 2011	Ex Cond Hist Q	2520.00	723.54	727.95	728.64	730.71	0.034377	13.34	188.95	66.46	1.39
Main	185.5077	May 2011	Alt A1 Hist Q	2520.00	723.54	727.95	728.64	730.71	0.034377	13.34	188.95	66.46	1.39
Main	185.5077	Irene 2011	Ex Cond Hist Q	1500.00	723.54	727.38	727.60	728.90	0.024551	9.88	151.88	65.60	1.14
Main	185.5077	Irene 2011	Alt A1 Hist Q	1500.00	723.54	727.38	727.60	728.90	0.024551	9.88	151.88	65.60	1.14
Main	185.5077	July 2015 High	Ex Cond Hist Q	1055.00	723.54	726.97	727.06	728.08	0.022733	8.43	125.08	64.97	1.07
Main	185.5077	July 2015 High	Alt A1 Hist Q	1055.00	723.54	726.97	727.06	728.08	0.022733	8.43	125.08	64.97	1.07
Main	79.35866	Floyd 1999	Ex Cond Hist Q	1025.00	720.39	724.74	724.37	725.42	0.012011	6.62	155.90	75.72	0.80
Main	79.35866	Floyd 1999	Alt A1 Hist Q	1025.00	720.39	724.74	724.37	725.42	0.012011	6.62	155.90	75.72	0.80
Main	79.35866	May 2011	Ex Cond Hist Q	2520.00	720.39	726.25	725.99	727.51	0.012014	9.06	296.56	111.08	0.86
Main	79.35866	May 2011	Alt A1 Hist Q	2520.00	720.39	726.25	725.99	727.51	0.012014	9.06	296.56	111.08	0.86
Main	79.35866	Irene 2011	Ex Cond Hist Q	1500.00	720.39	725.35	725.01	726.20	0.012004	7.39	206.52	89.62	0.82
Main	79.35866	Irene 2011	Alt A1 Hist Q	1500.00	720.39	725.35	725.01	726.20	0.012004	7.39	206.52	89.62	0.82
Main	79.35866	July 2015 High	Ex Cond Hist Q	1055.00	720.39	724.79	724.42	725.48	0.012018	6.67	159.41	76.74	0.80
Main	79.35866	July 2015 High	Alt A1 Hist Q	1055.00	720.39	724.79	724.42	725.48	0.012018	6.67	159.41	76.74	0.80


GreatBrook_v3 Plan: 1) Ex Cond Hist Q 10/19/2015 2) Alt A1 Hist Q 10/26/2015
Geom: Great Brook Alt A1 - BRDG 1 @ 1.0BF Flow: Historic Flood Flow Rates
Great Brook Main
Legend
WS May 2011 - Ex Cond Hist Q
WS May 2011 - Alt A1 Hist Q
WS Floyd 1999 - Alt A1 Hist Q
WS Floyd 1999 - Ex Cond Hist Q
Ground
Elevation (ft)
Main Channel Distance (ft)
790
780
770
760
750
740
730
720
0
500
1000
1500
2000
2500
3000
185.507...
254.9572
307.1709
362.1208
531.4537
586.3504
600
678.739
791.8987
1038.577
1120.126
1224.62
1306.858
1358.843
1399
1455.858
1509.958
1565.906
1920.789
2003.194
2097.059
2774.566
2996.565


GreatBrook_v3 Plan: 1) Ex Cond Hist Q 10/19/2015 2) Alt A1 Hist Q 10/26/2015
Geom: Great Brook Alt A1 - BRDG 1 @ 1.0BF Flow: Historic Flood Flow Rates
Great Brook Main
Legend
WS Irene 2011 - Ex Cond Hist Q
WS Irene 2011 - Alt A1 Hist Q
WS July 2015 High - Ex Cond Hist Q
WS July 2015 High - Alt A1 Hist Q
Ground
Elevation (ft)
Main Channel Distance (ft)
185.507...
254.9572
307.1709
362.1208
531.4537
586.3504
600
678.739
791.8987
1038.577
1120.126
1224.62
1306.858
1358.843
1399
1455.858
1509.958
1565.906
1920.789
2003.194
2097.059
2774.566
2996.565
790
780
770
760
750
740
730
720
0
500
1000
1500
2000
2500
3000