APPENDIX F:

East Branch North River Project Development Summaries
Halifax and Whitingham, Vermont

River Corridor Plan for the East Branch of the North River - Project Development

The project steering committee reviewed and commented on the list of preliminary projects during a watershed tour in August 2017, and via email. A total of 30 projects are described in the River Corridor Plan. A subset of 12 high-priority projects were discussed by the steering committee for further development in Appendix E. Five (5) project areas from the list of high-priority projects were chosen for further development. One of the projects selected for further development is located in Halifax. The remaining four projects were included in an alternatives analysis for improving flood resiliency within the Village of Jacksonville. Project summaries are included in this appendix for the five highest priority project bundles. Each summary includes:

- A description of the site location and river reach
- A brief technical summary of the stressors on channel stability and aquatic habitat
- A description of channel and floodplain restoration alternatives
- Preliminary cost opinions for restoration alternatives
- A list of current and potential project partners and funding
- A review of regulatory requirements

The five project bundles chosen for further investigation were:

1. Projects NR-7 & NR-8: Segments M04.A, and M04.B on the East Branch of the North River - Approximately 5 acres of forested floodplain on both sides of the channel received huge volumes of sediment and debris during T.S. Irene. A tributary along the northern edge of the property also accesses the floodplain. Some past channel dredging activities were noted, including piled spoils and dredged material within the floodplain, however there still appears to be full access. Beaver ponds and other features provide wildlife habitat. Approximately 500ft of the north bank is lacking native woody vegetation. The bank is somewhat unstable and planform adjustments are likely to continue.
    - *Passive Restoration: Corridor Protection and Buffer Planting*
2. Project NR-13: Segment M06.B on the East Branch of the North River - The channel is narrow and deeply incised as it flows past the First Stop convenience store and several commercial buildings before crossing under Route 112. The existing bank armor appears undersized. The floodplain across the channel from the gas station was accessed during T.S. Irene and is slightly lower in elevation.
    - *Active Restoration: Floodplain Reconnection and Infrastructure Resiliency*
3. Project NR-16: The steel driveway bridge located at the confluence of the East Branch of the North River and the Gates Pond drainage is a bankfull constriction at 55% of bankfull width. Additionally, a berm on the left bank of the Gates Pond drainage at the confluence is restricting access to a flood chute and floodplain.
    - *Active Restoration: Bridge Replacement and Berm Removal*
4. Projects NR-17, NR-18 & 19: Segment M07.A on the East Branch of the North River - The concrete bridge at the northern entrance to the Whitingham municipal center is an extreme bankfull constriction (34%) and was the location of major overbank flooding during T.S. Irene. The 10ft wide, 6ft tall squash CMP culvert downstream under the southern entrance to the municipal center is a significant bankfull width

constriction at 64%. However, the upstream and downstream bridges have significantly lower capacity. The crossing downstream of the municipal offices at the intersection of Route 100 and Route 112 is an extreme bankfull constriction (38%).

- *Active Restoration: Bridge Replacement or Removal and Culvert Replacement*

5. NR-21: Segment M07.A on the East Branch of the North River – Downstream of the town offices and fire department, the East Branch of the North River passes underneath a house. The opening at the house is a bankfull constriction (45%).

    - *Active Restoration: Floodplain Reconnection and Infrastructure Resiliency*

Projects NR-7 & NR-8, Neubert Property River Corridor Protection

Existing Conditions

The Neubert property is located along the northern bank of the East Branch North River immediately upstream of the Abbotts Glen property. A series of beaver dams and a small cobble dam made to enhance a swimming area affect the water surface profile and sediment transport extending upstream approximately to the southeastern extent of the Neubert property. The river valley opens in this area and large elevated floodplains are present along both banks. This section of river valley is one of the few areas not encroached by Route 112. The channel is incised, likely due to historic straightening, however we observed active widening and meander development through the project area. Large volumes of coarse sediment deposited within the channel indicate that the segment may be transitioning to widening and aggradation as the dominant geomorphic processes.

Problem Overview

Tropical Storm Irene sent large volumes of floodwater over both banks through the project area and caused moderate erosion and channel migration along the north bank into the Neubert property. The channel widened to 80-100 feet through most of the project area. The channel is carving a large meander through the downstream portion of the site before it becomes confined by steep forested banks with bedrock along Abbotts Glen. The low-lying floodplain along the north side of the sharp bend provided critical area for debris storage during T.S. Irene (Figure 1). Woody vegetation was scoured away and the site was recolonized by some native woody shrub species, but is primarily vegetated with Japanese Knotweed (Figure 2). The tributary to the north of the driveway spilled across the floodplain leaving large sand deposits. Some dredging occurred during 2011 flood recovery work, creating several large spoils piles, but no berms. The spoils piles do not significantly reduce floodplain access or available storage. An approximate 10-25 year flood in October 2017 accessed the lower floodplain areas and scoured away large areas of Japanese Knotweed; native woody vegetation remains limited. Significant volumes of sand and fine gravel spilled onto the grassed area between the tributary and the driveway (Figure 3).

Figure 1: Aerial photograph of T.S. Irene deposits and channel migration

Figure 2: Coarse sediment deposits on the lower floodplain area

Figure 3: Sand deposits from the October 2017 flood along the tributary channel.

Scope of Work and Cost Estimate

Corridor Protection

The low-lying floodplains along the sharp bend and the upper floodplain areas within the mowed field represent some of the largest floodplain areas along the East Branch North River within the Town of Halifax. It is important to ensure that these floodplain areas remain intact and to establish native woody vegetation within the buffer of the East Branch North River and along the tributary. The channel is actively widening and adjusting planform and floodplain access will likely improve as the channel continues to aggrade material and develop a meander sequence. Channel and floodplain modifications (i.e. berming and dredging) could interrupt this process and increase channel incision, disconnecting the floodplains. The driveway through the upper floodplain is the only access to the Neubert house and must be maintained; however, the driveway is not elevated and will not affect floodplain access during the largest storm events. The VTANR Ecosystem Restoration Program may support a permanent river corridor conservation easement for the Neubert parcel. Based on a VTANR review of the land characteristics for this floodplain and its development potential, the easement value for the corridor and floodplain area of 7 acres would range between $10,500 and $14,000.

Buffer Planting

The mowed field along the driveway will provide minimal resistance to bank erosion and may allow the channel to unnaturally overwiden. Although some channel widening is expected as the river moves back toward an equilibrium condition, accelerated erosion due to lack of natural woody bank vegetation could result in large volumes of fine sediment washing into the river.

Native woody trees and shrubs should be planted along the near-bank area of the North River and along the tributary to increase long-term stability and allow for slower and more natural rates of channel adjustment. **The buffer plantings along the East Branch North River should account for ongoing widening and planform adjustment. Plantings should be set back from the top of the bank and larger (and more expensive) plantings should be located further from the bank.**

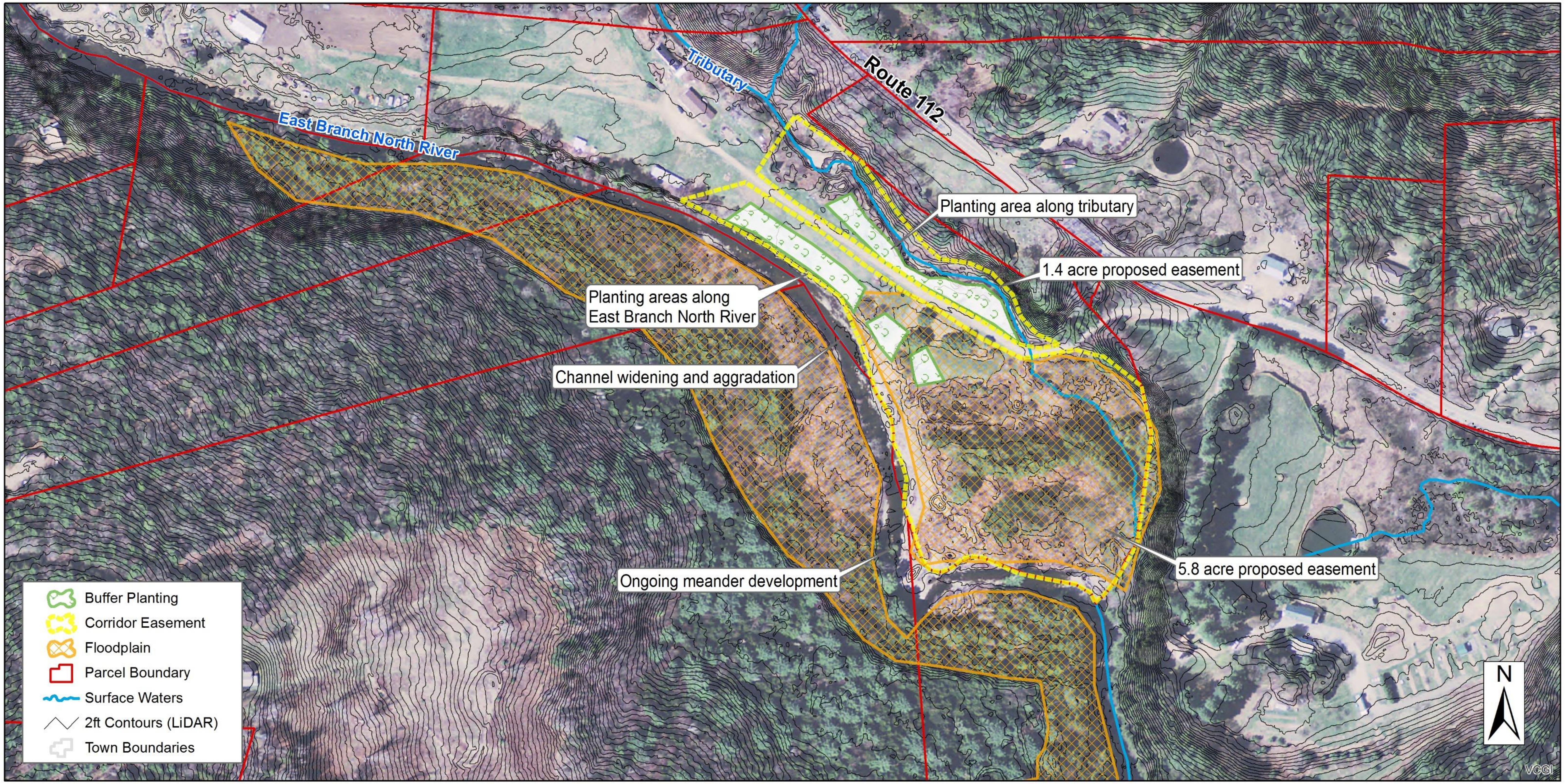
Established woody vegetation will also increase floodplain storage and retention of sediment and debris, and improve shading along both waterways. Based on the current lack of a buffer along the river and the reduced buffer along the tributary, and an objective to create a minimum buffer width of 50 feet, the total planting area would be approximately 0.8 acres (Figure 4). Assuming a target plant spacing of roughly 10ft on center, approximately 350 plants are needed for the site. If 1-gallon container stock trees and shrubs are used for the plantings, we estimate that the total project costs with labor will be $4,000 to $5,000. Planting costs could be reduced considerably with the use of bare root planting stock; however, the mortality would likely be much higher than container stock. Additional plantings could be distributed along the lower floodplain area, however the dense Japanese Knotweed growth with likely reduce the success of plantings in this area.

Funding and Project Partners

Potential funding opportunities for the easement include the VTANR Ecosystem Restoration Program, and possibly the NRCS CREP program depending on the status of the land use. The Windham County Natural Resource Conservation District (WCNRCD) Trees for Streams program is a potential funding opportunity for buffer plantings. FEA has discussed the project in depth with the property owner – Walter Neubert. Walter is excited about the project and recognizes the importance of protecting floodplain within his property and establishing riparian buffers.

Regulatory Requirements

No in-stream work or tree clearing is proposed as part of this project; therefore, no environmental clearances are needed from State or Federal regulatory agencies.



Fitzgerald Environmental Associates, LLC

WRC East Branch North River Corridor Plan

Neubert Property Buffer Planting and Corridor Protection

0 100 200 Feet

Date: Dec 11, 2017

Drawn: JHB

Notes:
- Background imagery is post-Irene from May 2014
- Draft corridor easement boundaries were drawn by FEA and reviewed by VTDEC, Dec 2017
- Floodplain extents based on historic imagery and LiDAR elevation data

Figure 4: Proposed plantings and easements on the Neubert property in Halifax, VT.

Projects NR-13, NR-16, NR-18, NR-19, and NR-21, East Branch of the North River Reaches M06.B, M07.A, and Gates Pond Drainage in the Village of Jacksonville

Existing Conditions

The Village of Jacksonville is located within the town of Whitingham, Vermont. Reach M07 of the East Branch of the North River flows parallel to Route 100 through the village, passing through an undersized bridge and an undersized culvert at the Whitingham municipal offices. The river then flows through a residential area, passes underneath a house and along the backside of outbuildings and homes, before entering an undersized culvert at the intersection of Route 100 and Route 112. Segment M07.B is severely incised, straightened, and armored in the village.

The Gates Pond outlet flows parallel to Gates Pond Road from a dam to the northeast and joins Reach M07 approximately 100 feet downstream of the Route 100 culvert outlet. At the confluence, access to a floodplain and flood chute are restricted by a berm. Downstream of the confluence, the river flows parallel to Route 112 and under three bridges in a deeply incised and armored channel. Downstream of the end of the stacked stone armoring near the Honora Winery, the river flows through a narrow channel constricted by an armored slope alongside the First Stop Convenience Store.

Five (5) high priority projects in Jacksonville were selected by the project steering committee for further analysis and review, and are described below from downstream to upstream. These projects are intended to address problems related to channel instability, undersized and geomorphically-incompatible crossings, limited floodplain access, and elevated risk to state, municipal, and private infrastructure during moderate and large floods. We chose a modeling approach to evaluate each of these projects as alternatives to better understand their individual and collective costs and benefits.

<u>Project NR-13</u>

The channel is narrow and deeply incised as it flows past the First Stop convenience store and several commercial buildings before crossing under Route 112. The existing bank armor appears undersized (Figure 5). The floodplain across the channel from the gas station was accessed during T.S. Irene and is slightly lower in elevation (Figure 6). Replacing the existing bank armor on the west bank, near the gas station, with a stacked stone wall could increase slope protection and increase bankfull width. Reshaping the east bank to lower the elevation of the floodplain to increase accessibility could lower flood risk to the gas station and increase attenuation of floodwaters and sediment on the floodplain.

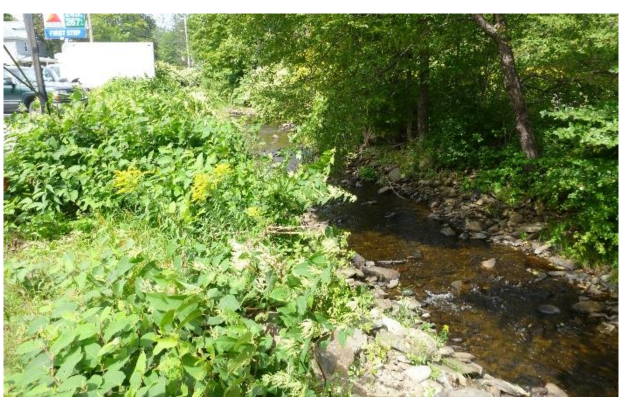


Figure 5: East Branch of the North River at the First Stop convenience store (right bank).

Figure 6: Floodplain on the left bank of the East Branch of the North River across from the First Stop convenience store.

Project NR-16

The steel driveway bridge located at the confluence of the East Branch of the North River and the Gates Pond drainage is a bankfull constriction at 55% of bankfull width. During the Irene flood, the constriction at this bridge caused increased flood elevations and overbank flow to the east, damaging the driveway to the Degray house. The bridge is also the first significant constriction downstream of the Gates Pond, increasing the potential for debris catchment. Additionally, a berm on the east bank of the Gates Pond drainage at the confluence is restricting access to a flood chute and floodplain (Figures 7 and 8). Removing the berm and replacing the bridge with a larger structure could lower flood depths in the confluence area.

Figure 7: A berm (right) restricts access to a floodplain (left) and flood chute along the Gates Pond drainage near the confluence with M07.A

Figure 8: Reconnecting the floodplain may make a downstream driveway vulnerable to erosion in larger flows.

Project NR-17, NR-18 & NR-19

The 90-foot long crossing under the intersection of Route 100 and Route 112 in downtown Jacksonville is severely undersized, causing severe overbank flooding in T.S. Irene. The bridge and downstream channel have an approximate width of only 6ft, or 38% of bankfull width (Figures 9 and 10). Electrical conduits on the downstream end of the bridge are exposed and could catch debris. When the bridge is up for replacement, it should be replaced with a large structure. The downstream channel should also be enlarged to match the capacity of the bridge.

Figure 9: Inlet to the undersized crossing at the intersection of Route 100 and Route 112.

Figure 10: Undersized channel downstream of the crossing, at the intersection with the Gates Pond Branch.

The 8.5ft wide squash CMP culvert under the southern entrance to the municipal center is in poor condition is a significant bankfull width constriction at 53% (Figures 11 and 12). The culvert capacity may back up floodwaters during high flow events, especially when sediment and debris accumulate or snag in the channel or at the structure inlet. However, the upstream and downstream bridges have significantly lower capacity. When the culvert comes up for replacement, replacing this culvert with a larger structure will mitigate flood risks. The entrances to the municipal center could be consolidated to a single crossing.

Figure 11: Undersized squashed culvert inlet at the Whitingham municipal complex.

Figure 12: Undersized squashed culvert outlet at the Whitingham municipal complex.

The concrete bridge at the northern entrance to the municipal center is an extreme bankfull constriction (34%) and was the location of major overbank flooding during T.S. Irene. The bridge hydraulic capacity is exceeded during large flood events, backing up floodwaters and increasing flood depths (Figures 13 and 14). The bridge could be replaced with a larger structure or removed to consolidate access to the municipal complex with the downstream culvert crossing. Alternatively, installation of a bypass channel behind the town hall was assessed as an alternative to relieve flooding on Route 100 in the Village.

Figure 13: Undersized bridge inlet at the Whitingham municipal complex.

Figure 14: Undersized bridge outlet at the Whitingham municipal complex.

Project NR-21

The house downstream of the Town offices and fire department is a bankfull constriction at its opening (45%). In large flood events, the opening of the house may increase local flood depths (Figures 15 and 16). The house is at risk of snagging debris that may cause structural damage and raise flood elevations, especially if upstream constrictions at the Town offices are removed. Alternatives considered included removing a portion of the house and creating a floodplain overflow area in the backyard.

Figure 15: Reach M07.A as it approaches a house is severely straightened and armored.

Figure 16: Inlet to the passage of reach M07.A under a house in Jacksonville.

Jacksonville Alternatives Analysis for River Corridor Improvements and Flood Resiliency

This analysis was prepared to better understand the effects of undersized stream crossings and a berm on flooding, floodplain access, and channel stability, as described in Projects NR-13, NR-16, NR-18, NR-19, and NR-21 of the River Corridor Plan. The floodplain maps and data generated through hydrologic and hydraulic analyses may be used to better understand how improvements to channel crossings, channel stability, floodplain access can improve the resiliency of infrastructure to flooding in the Village. The one-dimensional, steady flow river and floodplain hydraulics model and maps developed in this study cover Jacksonville from downstream of the Gates Pond Dam and Route 100 crossing north of the Village to upstream of the Route 112 crossing south of the Village (Figure 2). The flood elevations and flood extents generated by this modeling effort are intended for planning purposes only and do not supersede the effective FEMA Flood Hazard maps.

Hydrologic Analysis

We used the USGS StreamStats program to delineate the East Branch North River and Gates Pond outlet watersheds draining to the study area (Table 1). Using regional regression equations based on watershed area, storage, and annual precipitation the discharge was estimated for reach M07 upstream of the village of Jacksonville at Route 100, the Gates Pond Branch near the confluence of with reach M07, and the East Branch of the North River downstream of the confluence of M07 and the Gates Pond Branch (Olson 2014). The 500-year flows were used for flood depth mapping in Jacksonville.

Table 1: Flow estimates (cubic feet per second) for select recurrence interval floods on the East Branch North River.

Return Interval (years)	M07 North of Jacksonville at Route 100	Gates Pond Branch at Confluence	M06 Downstream of the confluence of M07 with the Gates Pond Branch
2	71.9	207	277
5	117	332	442
10	153	430	570
25	207	574	759
50	254	697	921
100	305	831	1100
200	363	981	1290
500	447	1200	1580

Hydraulic Analyses

HEC-GeoRAS and HEC-RAS 5.0.3 software (USACE, 2016) were used to create a one-dimensional, steady flow river and floodplain hydraulics model from Route 100 and Gates Pond upstream of Jacksonville to a junction connecting these two reaches, to the East Branch of the North River downstream of the First Stop Convenience store. We created a floodplain digital elevation model (DEM) for the study area using high-resolution (0.7 m) LiDAR elevation surfaces from a dataset covering Windham County in VT collected for USGS by Quantum Spatial in November 2015. We converted the DEM vertical elevation units from meters to feet and used it to create a Triangulated Irregular Network (TIN). The TIN format is an alternate method to represent the elevation surface that is faster to process for hydraulic modeling purposes.

To set up the HEC-GeoRAS model, we digitized the stream centerline and the top of each bank using 2015 imagery from the Vermont Center for Geographic Information (VCGI) and a LiDAR hillshade of the study area to emphasize topographic relief. We constructed the hydraulic model as a single reach for the 5,417-foot-long study area. Next, we drew cross-sections perpendicular to channel and floodplain flow stretching across the valley to contain all areas of overbank flow at the cross-section. An accurate 3D lateral profile of the floodplain and channel was generated in HEC-GeoRAS by sampling the DEM along the cross-sections and correcting the bankfull channel dimensions with field survey data.

Field Survey

Field verification of selected cross sections, especially in areas with steep side slopes, and the dimensions of bridge and culvert openings as well as one house opening was completed in September 2017. This verification effort is very important when constructing a hydraulic model from LiDAR derived DEMs which are typically less accurate at stream crossings and along steep road embankments where the DEM may be adjusted to reflect the "bare earth" condition. Culvert dimensions and accurate channel and bank geometry are critical components for HEC-RAS modeling.

Modeling Details

We imported the HEC-GeoRAS cross-section data into HEC-RAS 5.0.3 and assigned floodplain and channel roughness values (Manning's N values) based on land cover from aerial imagery, and field survey observations. Roughness values ranged from 0.02 (paved roads and parking lots) to 1 (houses) following Chow (1959) and Arcement et al. (1989). To correct for LiDAR scatter at the water surface, channel bottom elevations were adjusted based on comparison to the channel survey data collected in September 2017. Typical channel bottom adjustments ranged from 0.5 to 1 feet based on elevations surveyed in the field. We also plotted the channel longitudinal profile and checked for any unnatural slope changes. We included a total of 53 cross-sections in the model. We extended cross sections as needed to contain all areas of overbank flow in between cross-sections in HEC-GeoRAS. Levees were placed on the berm and roads to prevent the model from flooding the area outside until it was overtopped. Blocked obstructions were traced in GIS and imported into the model to simulate buildings. Building locations were raised in the terrain model, while bridge locations and the location of the house over the stream were lowered to the channel elevation for more accurate flood depths and extents. The steady flow model was run using a subcritical flow regime.

Alternatives Analysis and Flood Depth Mapping

The estimated benefits of implementing river corridor projects NR-13, NR-16, NR-18, NR-19, and NR-21 are described in Table 2 below. Project locations shown in Figure 17. The projects are described in more detail in the following pages.

Alternative Number & RCP Project	**Existing**	**Proposed**
1) NR-18: *Remove Bridge*	Floodwaters jump the stream channel at an undersized bridge at the town offices and an undersized culvert on Route 100.	Removing the bridge alone lowers floodwaters so they do not escape the channel at the town offices. Resizing this constriction reduces the risk of debris snagging.
2) NR-18 & NR-19: *Remove Bridge, Replace Culvert with Larger Structure*	Floodwaters jump the stream channel at an undersized bridge at the town offices and an undersized culvert on Route 100.	Removing the bridge lowers floodwaters so they do not escape the channel at the town offices. Resizing the culvert to a 16’ wide bridge and sloping back the right bank of the channel at a 2:1 from the old bridge to the downstream end of the fire station further reduces flood water extents and elevations.
3) NR-18 & NR-19: *Diversion Channel Around Town Offices*	Floodwaters jump the stream channel at an undersized bridge at the town offices and an undersized culvert on Route 100. The water escaping the channel at the town offices runs down Route 100 to the intersection with Route 112. The water escaping the channel at the Route 100 culvert flows across the road at the intersection.	A diversion channel designed to convey flows of approximately 70 cubic feet per second lowers water surface extents and elevations on the main channel, so the floodwaters do not escape the channel at the town offices with the existing bridge and culvert left in place. This project has significant risks associated with channel avulsion at the diversion and therefore is not recommended.
4) NR-21: *Remove Section of House Over Stream, Level Yard*	The channel constriction at the house raises flood depths and could snag debris in large storms.	Leveling the yard alone minimally lowers flood elevations (approximately 0.1 ft). Removing the portion of the house that is obstructing flows lowers flood depths upstream by approximately 1 ft. The overbank flooding is mostly contained to the lawn of the fire department and house on the right bank. Removing the constriction reduces the risk of debris snagging and raising flood depths.
5) NR-17: *Replace Route 100 Bridge with Larger Structure*	The water escaping the channel at the Route 100 bridge flows across the road at the intersection.	In the scenario where the Route 100 bridge is resized to a bankfull structure, there is no flooding on Route 100 or Route 112 at the intersection and reduced flooding behind the houses on Route 100. Resizing this constriction reduces the risk of debris snagging.
6) NR-16: *Berm Removal*	Water can escape from the channel over the low point of the berm in major events, but the flood chute behind it is filling with debris and could be more effective for flood attenuation.	Removing the berm allows 20% of the floodwater from the Gates Pond branch to spread across the floodplain and decreases velocities by approximately 25%.
7) NR-13: *Lower Left Bank Floodplain, Armor*	Floodwaters jump the stream channel at the first of the triple bridges and just downstream of the first stop convenience store. Water runs along Route 112 starting at the lower end of the parking area and downstream from the church.	Removing portions of the berm to allow access to the floodplain on the east bank decreases flood depths by approximately ½ foot and decreases velocities by approximately 20%.

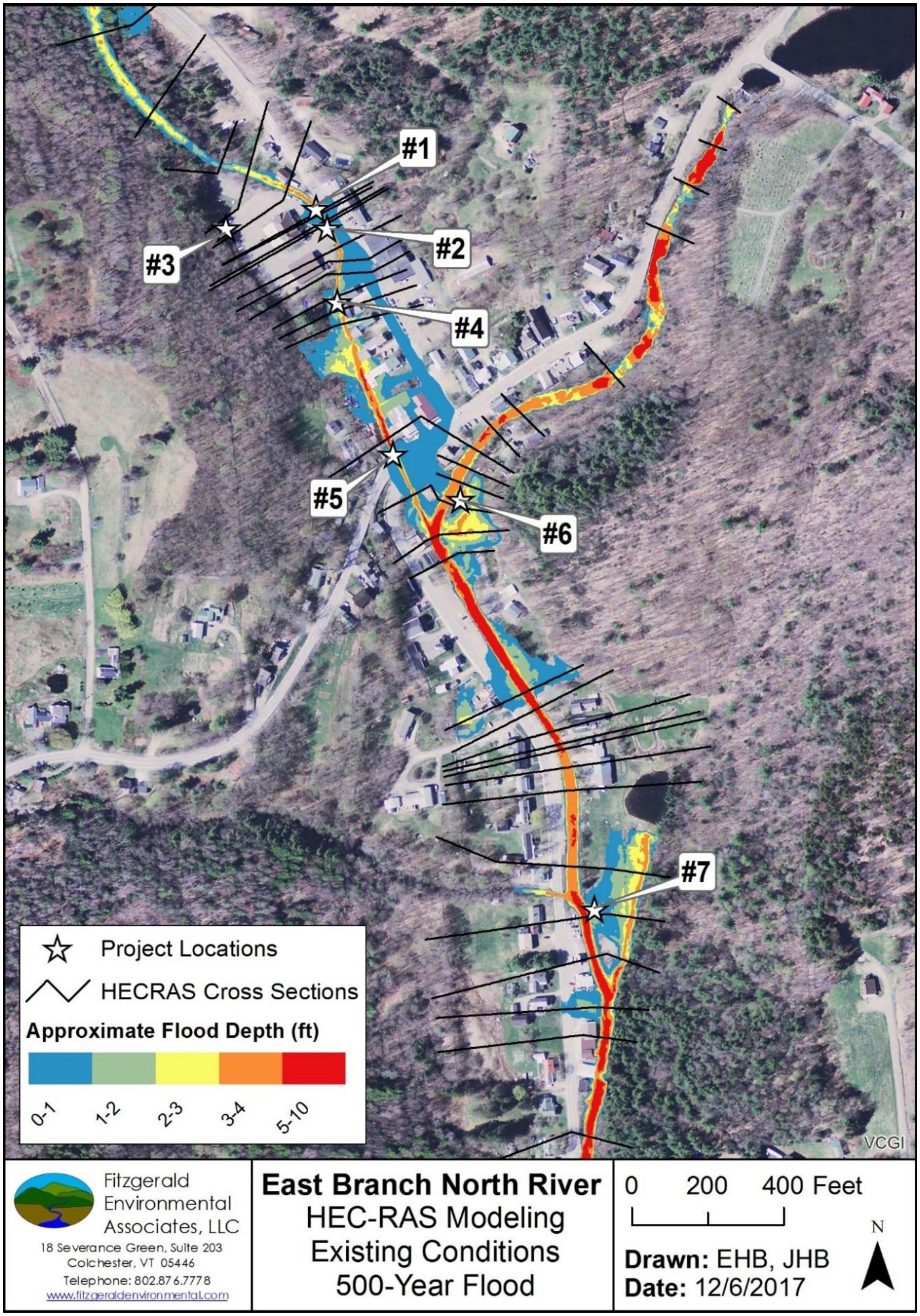


Figure 17: Alternatives modeled for the river corridor projects in Jacksonville. Approximate 500-year flood depths under existing conditions modeled with HEC-RAS.

Alternative 1: Project NR-18 (Bridge Removal)

Scope of Work and Cost Estimate

To increase the capacity of the East Branch North River to pass large flows and debris, we recommend removing this crossing. The crossing is redundant as an entrance to the municipal offices, with a crossing immediately downstream. The downstream culvert has a large capacity, so in the modeled alternative in which only the bridge was removed floodwaters dropped by 2-2.5 feet during the 500-year flow and remained in the channel at the municipal complex (Figure 18). In the Alternative 1 scenario, the culvert is at capacity, suggesting floodwaters are still at risk of jumping out of the channel and onto Route 100 (Figure 19).

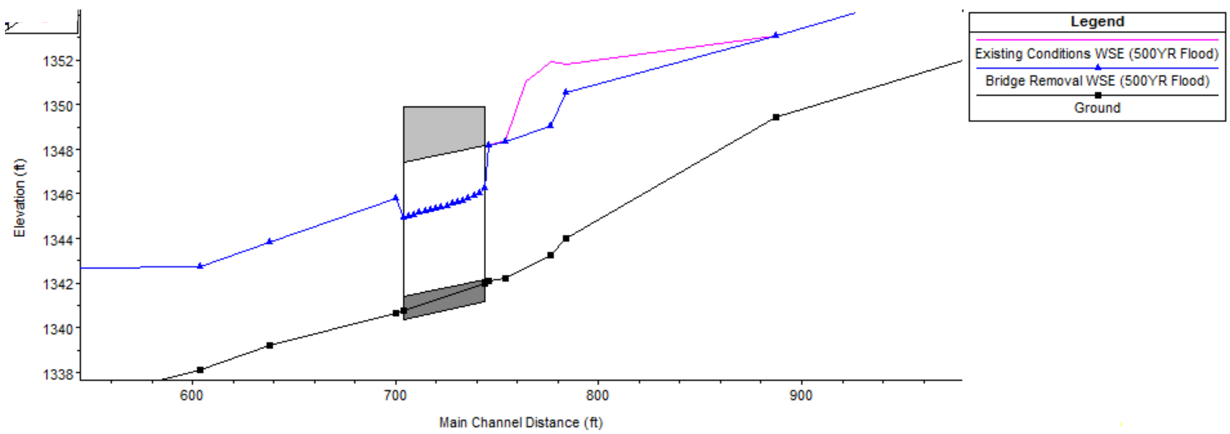


Figure 18: Profile of modeled water surface elevations at the Town Hall in Alternative 1 where the bridge is removed, and culvert is left as-is (blue) and under existing conditions (pink). The culvert is at capacity in the 500-year flood without the bridge in place.

The project will require demolition and removal of the existing structure and some bank excavation and reshaping. We anticipate approximately 40-50CY of material to be removed from the bridge and from the embankment along the parking lot. Approximately 30CY of heavy stone armor will be required to improve the stacked stone wall along the parking lot. Assuming rates of $120/hour for an excavator and operator, $30/CY for excavation and trucking, and $50/CY for construction of a stacked stone wall, we estimate that this project will cost $5,000 - $10,000 if completed by the Town Highway Department. If the project is put out to bid to private contractors, it will likely cost more.

Landowner Contacts

The bridge is owned by the Town of Whitingham. Evan has discussed this project with the Town Road Foreman Stanley Janovsky, who stated that the bridge removal and bank improvements could be completed by the Public Works department.

Regulatory Requirements

A VTANR stream alterations permit may be required for removal of the crossing. A U.S. Army Corps of Engineers permit likely will not be required as the project mainly involves removal of fill below OHW, however this should be confirmed during future project phases.

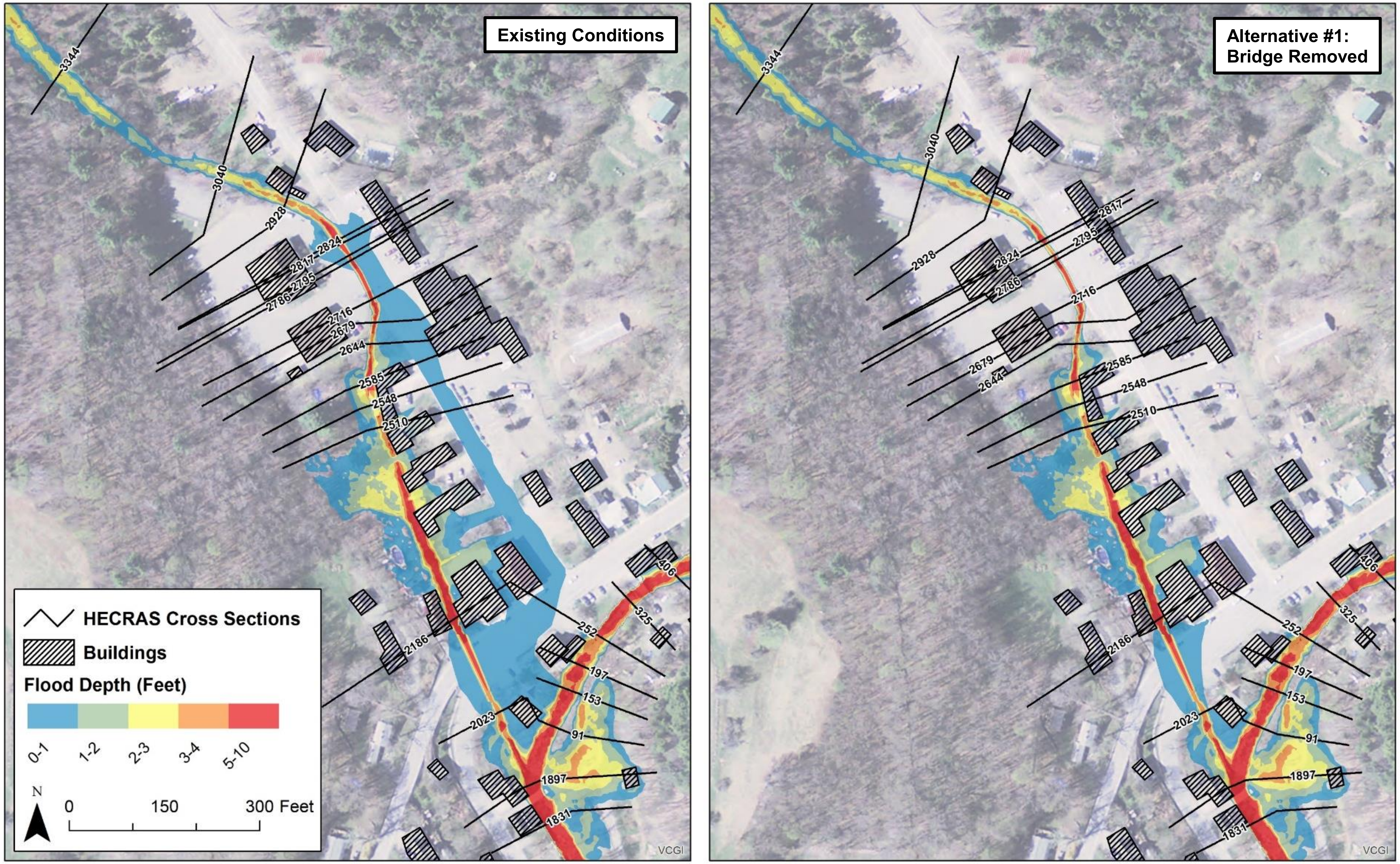


Figure 19: Approximate 500-year flood depths modeled with HEC-RAS for existing conditions (left) and the alternative in which the bridge at the municipal complex is removed (right).

Alternative 2: Projects NR-18 & NR-19 (Bridge Removal & Culvert Replacement)

Scope of Work and Cost Estimate

To increase hydraulic capacity of the East Branch North River channel to pass flows during larger floods, we recommend replacing the culvert at the town offices with a larger structure in addition to removing the upstream bridge. Additionally, the estimated bankfull width for this section of the East Branch North River is 15.6 feet, but the current channel width is approximately 10 feet (Figure 20). Therefore, we propose widening the channel bottom by approximately 5 feet upstream and downstream of the new structure along the west bank at the municipal complex and fire station (approximately 240 linear feet along the channel). The existing culvert is at capacity in the 500-year flood, raising flood depths upstream and is at risk for snagging debris. Increasing the size of the culvert to a bankfull structure and increasing the channel capacity is predicted to allow the crossing to pass all floods without backing up floodwaters. In the Alternative 2 scenario, modeled flood depths are 3-5 feet lower in the 500-year flood than existing conditions (Figure 21).

The channel enlargement will require approximately 450CY of excavation and approximately 180CY of heavy stone armor. Assuming rates of $30/CY for excavation and trucking and $50/CY for placed stone armor, this portion of the project will cost $20,000 - $30,000. Replacing the culvert with a bankfull width structure will require additional analysis and design, and will likely cost over $200,000 for a box culvert or over $400,000 for a bridge.

Figure 20: Schematic showing existing bank dimensions (white dash) and proposed channel bottom widening and bank shaping (red) on the right bank of the East Branch North River at the fire station.

Landowner Contacts

The culvert crossing and the streambank along the fire station are owned by the Town and the project has been discussed with the Selectboard and Public Works. They are supportive of the project but recognize the Town would need to pursue grant funding to cover the work.

Potential Funding

The most appropriate funding for structure replacement is a VTrans Structures Grant. However, the entrance roads to the municipal center are not on the Town Highway Maps, therefore they are technically private driveways. As such, this structure is not eligible for VTrans funding at this time. The Town would need to go through a process of officially adopting these roads as Town roads in order to be eligible for funding.

Regulatory Requirements

A VTANR stream alterations permit will be required for replacing the crossing with a larger structure and widening the channel. A U.S. Army Corps of Engineers permit may be required for structure replacement and channel widening.

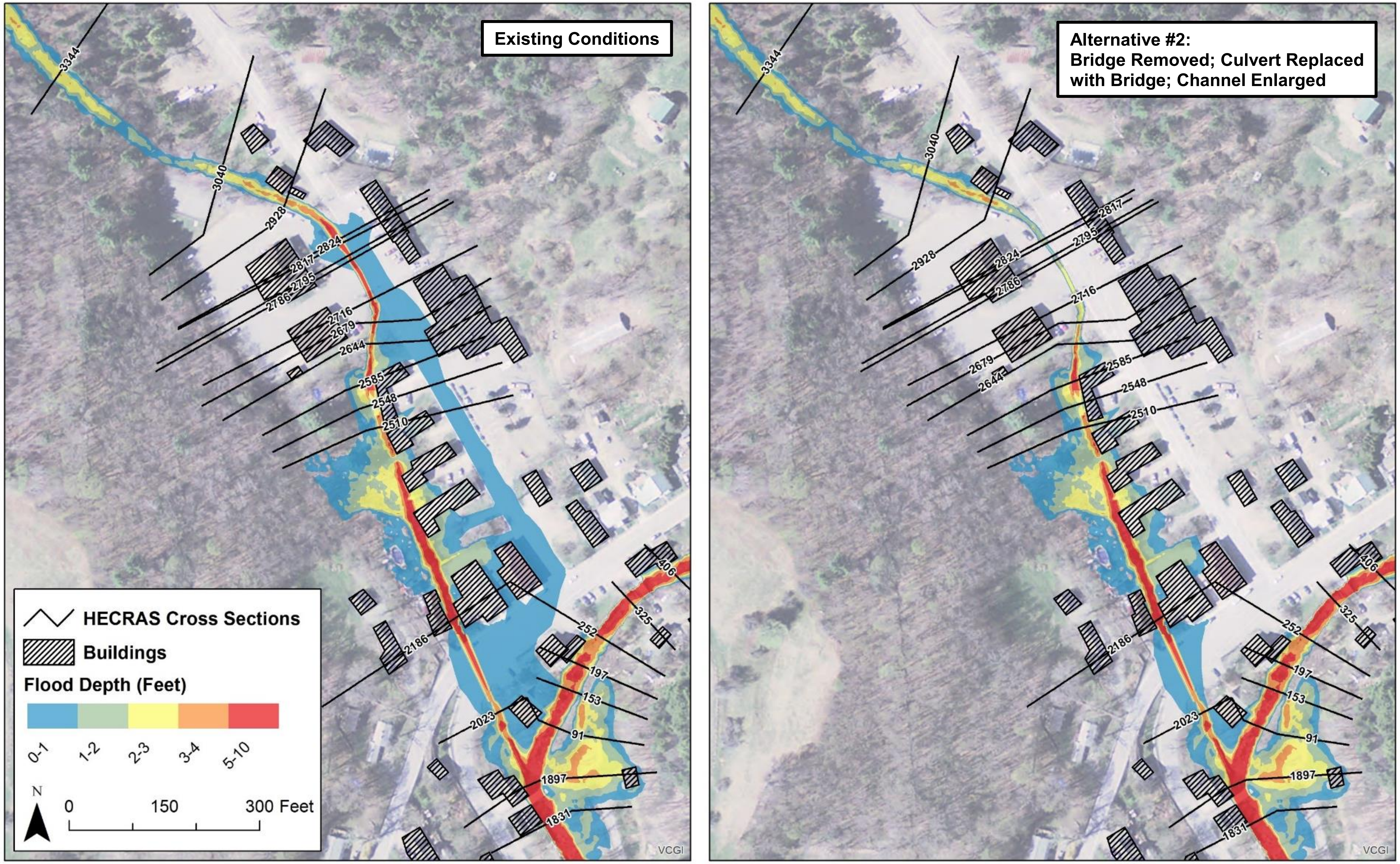


Figure 21: Approximate 500-year flood depths modeled with HEC-RAS for existing conditions (left) and the alternative in which the bridge at the municipal complex is removed, the culvert at the municipal complex is replaced with a bankfull structure, and the channel along the municipal complex and fire station is enlarged on the west bank (right).

Alternative 3: Projects NR-18 & NR-19 (Diversion Channel around Town Offices)

Scope of Work and Cost Estimate

As an alternative to increasing the hydraulic capacity of the East Branch North River at the municipal complex, as described in Alternatives 1 & 2, we evaluated the potential to divert excess flood flows around the back (west) side of the Municipal Center, thus avoiding overflows down Route 100 in the Village. This project had been discussed between Town officials and the VTANR River Engineer, who provided a concept sketch of the project. Out of courtesy to the Town and VTANR, we evaluated this project even though we had significant reservations about its effectiveness in meeting the river corridor and floodplain objectives of this study.

We modeled the diversion of 70 cfs of flow through a diversion channel during the 500-year flood. We chose 70 cfs as this was our estimate of overflow down Route 100 during the Irene flood. With flows in the main channel lowered by 70 cfs, the bridge at the municipal complex was not overtopped and flooding of Route 100 at the Town Offices was eliminated in the model. Because the flow is returned to the channel before the downstream bridge at the intersection of Route 100 and Route 112, floodwaters still escaped the channel at the bridge (Figure 23).

This diversion channel construction would require approximately 1,200CY of excavation and 600CY of stone armor (Figure 22). Assuming rates of $30/CY for excavation and trucking and $50/CY for placed stone armor, this portion of the project will cost approximately $60,000 to $80,000. The project will also require design and construction of a diversion structure at the upstream extent of the channel. This structure will be critical to reduce the risk of too much flow entering the bypass channel and may cost upwards of $50,000 to $100,000. Additional costs include land acquisition, potentially moving the basketball court, and repairs to the parking lot. We anticipate that total project costs will be $200,000 to $300,000.

This project is not recommended due to the high risk involved in diverting flood flows into a setting and channel not meant to handle flood flows. During large floods the East Branch North River carries a significant debris and sediment load, as evidenced by the woody debris snagging and sediment deposition throughout the Village in flood events. The diversion of floodflows in a bypass channel would increase the risk of sediment and debris snagging at that location, and potentially cause the main flow to avulse or jump into the diversion channel. This would likely result in significant property damage downstream.

Landowner Contacts

Most of the route for the proposed side channel is owned by the Town of Whitingham. The upper and lower extents of the side channel would pass through portions of 3-4 privately owned parcels. Evan Fitzgerald has discussed the project with representatives from the Town including the Selectboard and Public Works.

Regulatory Requirements

The floodplain wetland south of the fire station may be large enough to meet the Class II criteria. This project will likely require wetland permits from both VTANR and Army Corps of Engineers. Stream alteration permits will likely be required for the diversion structure. Tree clearing will likely need to be coordinated with USACE and other federal agencies (i.e., USFWS) to avoid or minimize impacts on potential habitat for threatened or endangered bat species.

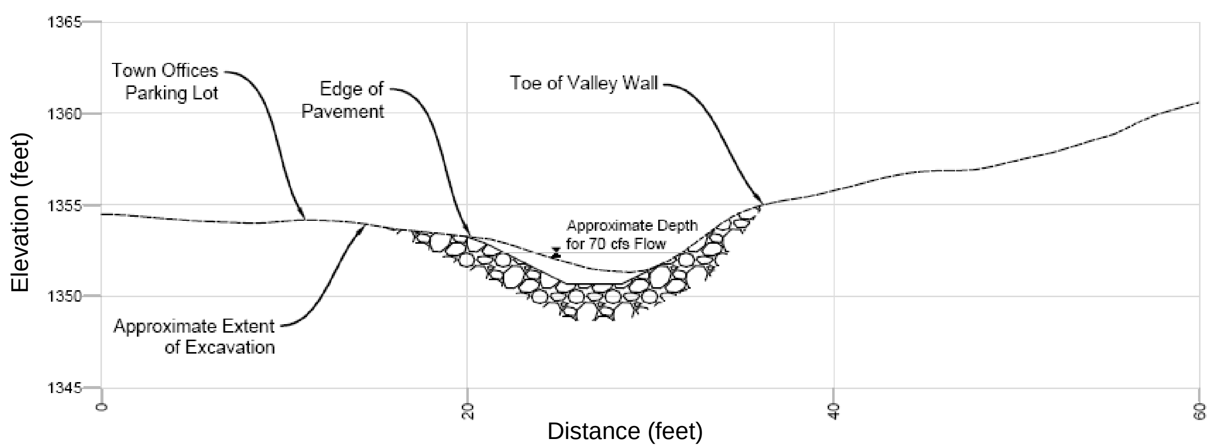


Figure 22: The existing channel conveying water behind the Town Offices, which is not currently connected to the East Branch North River at its upstream end (Top); and a conceptual design (Bottom) showing the existing ground surface (dashed line) and the proposed channel dimensions (solid line) with rock armor.

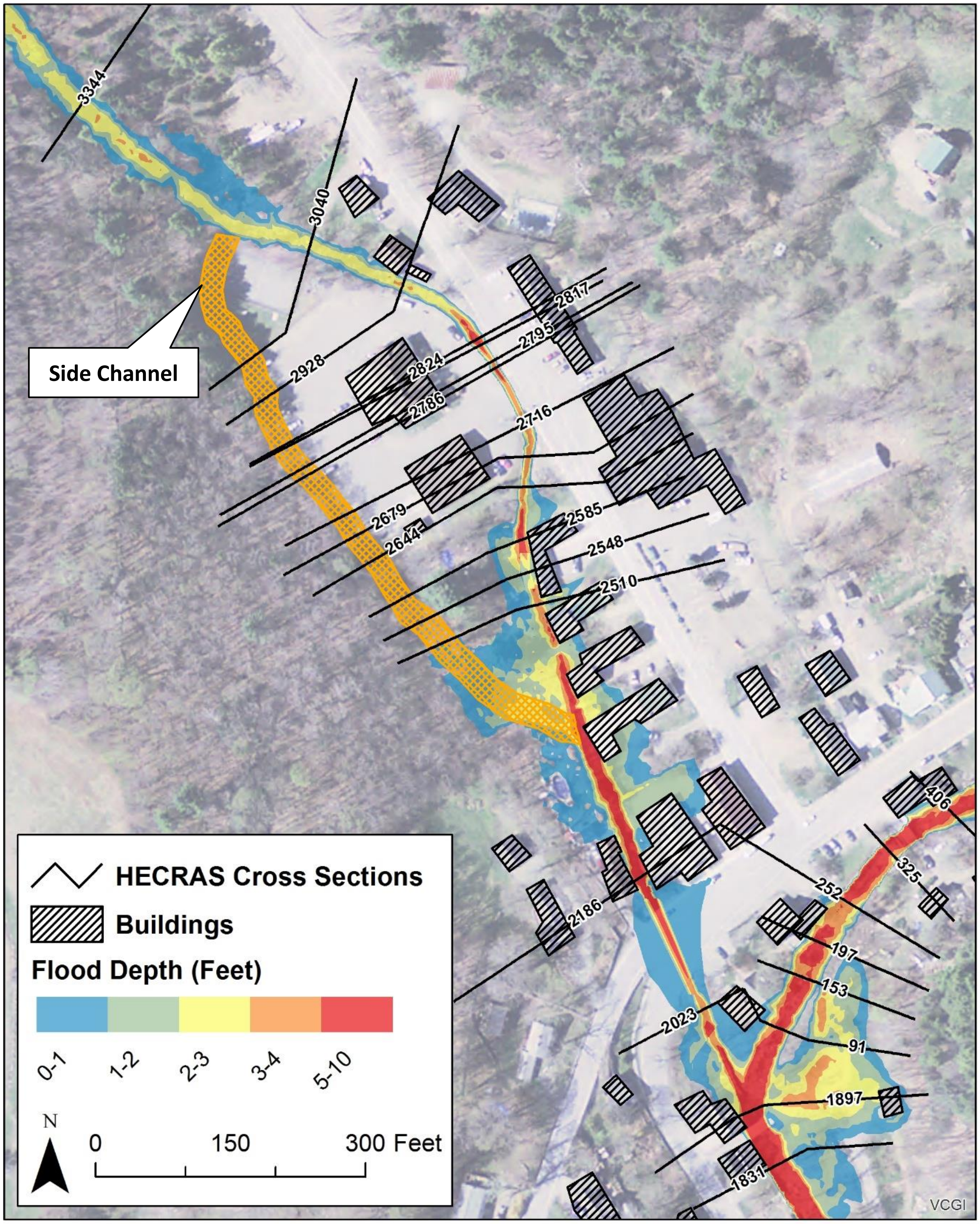


Figure 23: Approximate 500-year flood depths modeled with HEC-RAS for the alternative in which a side channel (70 cfs capacity) is excavated behind the municipal complex (right).

Alternative 4: Project NR-21 (Removing House Over Stream, Leveling Yard)

Scope of Work and Cost Estimate

To reduce the risk of snagging debris and exacerbating flooding, as well as to increase the capacity of the East Branch North River to pass large flows and debris, we modeled the effects of removing the section of the house over the stream. Additionally, we modeled the effects of leveling the back yard to increase floodplain access. Based on discussions with Town officials, we suspect this hump of material in the backyard may be fill from the reconstruction of the municipal complex after severe flooding in 1938. A floodplain is located on the west bank of the river and enhancing the size of the floodplain and ease of access for floodwaters could reduce flood damage to the houses built on the river's east bank.

Modeling alternatives considering the effects of removing the section of the house over the stream and removing material from the backyard of the house resulted in minor reductions (approximately 1 foot) in flood depths and extents at the house, with no benefit predicted upstream or downstream. Levelling the floodplain resulted in right (west) overbank flow velocity reductions of 23-45% and downstream channel velocity reductions of 7-39%. Removing the house would also reduce the risk of debris snagging and exacerbating flooding.

Additional design work is recommended for any floodplain restoration effort. Based on unit costs for excavation and off-site trucking of the material from the floodplain of $30/CY, we estimate that the excavation portion of this project will cost between $15,000 and $25,000.

Landowner Contacts

Evan has discussed the modeling results and proposed projects with the landowner, Robin Kingsley, who expressed interest in floodplain restoration and reconnection. Town officials, including the Road Commissioner Stanley Janovsky, are enthusiastic about this project.

Regulatory Requirements

Any floodplain restoration work would be within the buffer of a potential Class II wetland along the floodplain. This would require VTANR permits and may require permits from the Army Corps of Engineers. Tree clearing may need to be coordinated with USACE and other federal agencies (i.e., USFWS) to avoid or minimize impacts on potential habitat for threatened or endangered bat species. Proposed wetland disturbance is likely under the Army Corps of Engineers reporting threshold of 5,000 sqft.

Alternative 5: NR-17 (Resize Route 100 Bridge)

Scope of Work and Cost Estimate

In order to increase hydraulic capacity of the East Branch North River channel to pass flows during larger floods, we recommend replacing the bridge at the intersection of Route 100 and Route 112 with a larger structure. Based on our hydraulic model the bridge is overtopped in the 25-year flood and in large floods the bridge affects flooding for several houses along Route 100. Additionally, the structure is a severe channel constriction at risk for snagging debris. Increasing the size of the structure to a bankfull bridge is predicted to allow the crossing to pass all floods without causing them to jump the channel at the road. Flooding for the houses directly adjacent to the channel upstream of the crossing is still predicted (Figure 24). In the scenario that combines this alternative with Alternative 2 (removing the municipal complex bridge and replacing the municipal complex culvert with a bankfull structure), no flooding of Route 100 or Route 112 was predicted by the model (Figure 25). Replacement of this large structure would require extensive additional design and planning. We estimate that this project would likely cost upwards of $500,000.

Landowner Contacts

The crossing is at the intersection of two Vermont State Highways and thus is under the jurisdiction of the Vermont Agency of Transportation. Evan discussed the project VTrans, however the bridge is not a priority for replacement as it is not in poor structural condition, despite a low rating for hydraulic capacity.

Regulatory Requirements

A VTANR stream alterations permit will be required for replacing the crossing with a larger structure and any widening performed in the downstream channel. A U.S. Army Corps of Engineers permit will also likely be required for structure replacement and any downstream channel widening.

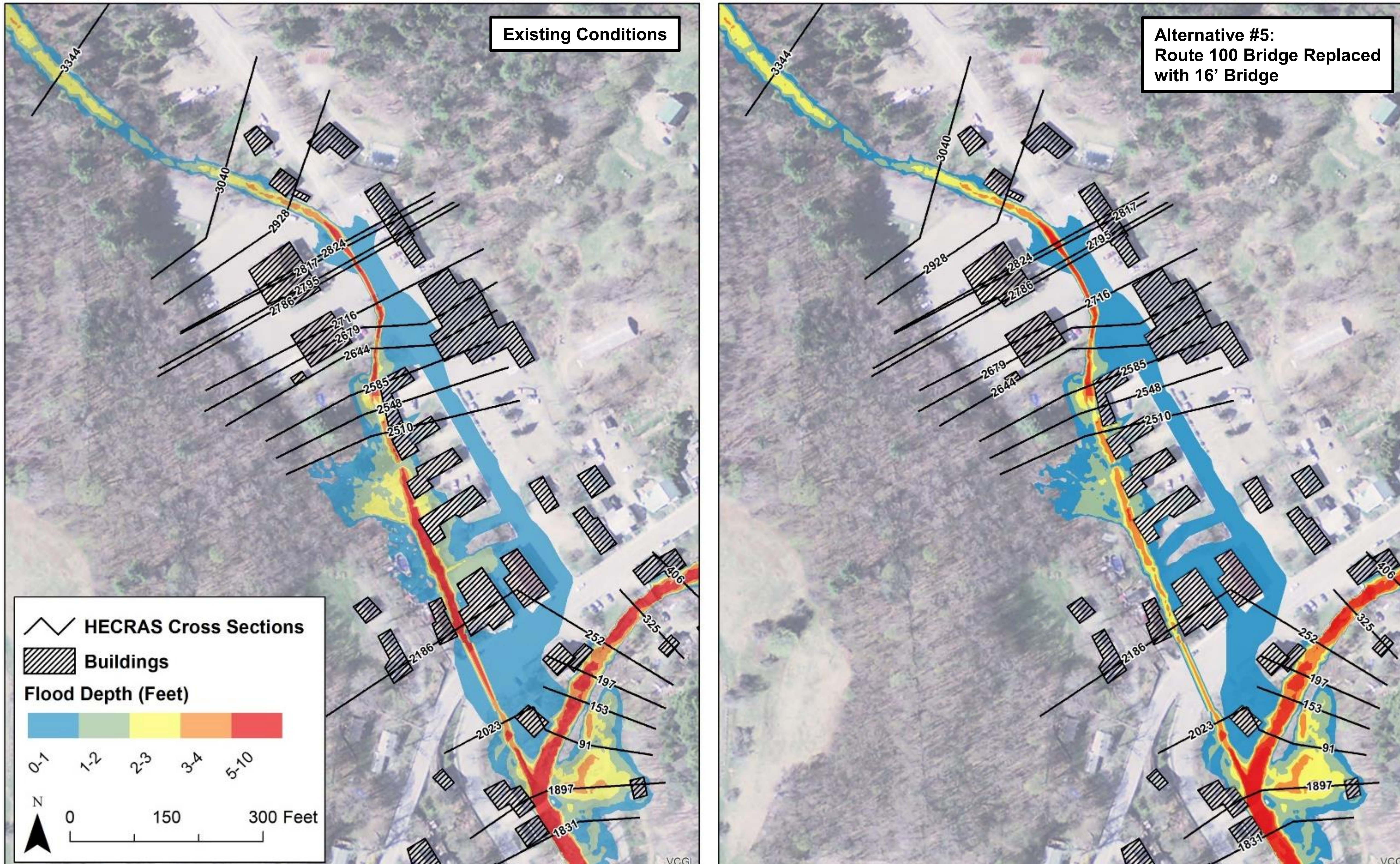


Figure 24: Approximate 500-year flood depths modeled with HEC-RAS for existing conditions (left) and the alternative in which the Route 100 bridge is replaced with a bankfull structure (right).

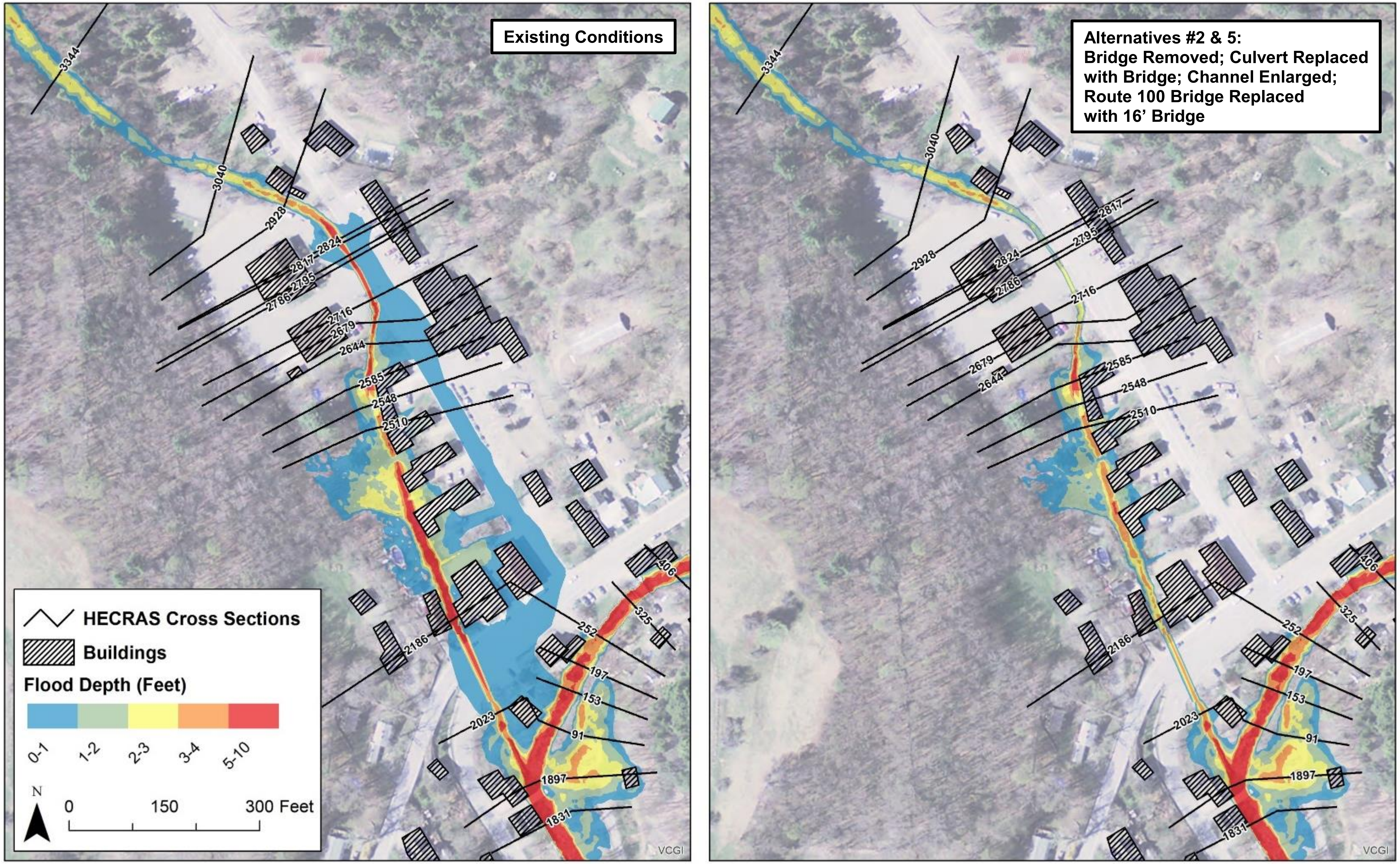


Figure 25: Approximate 500-year flood depths modeled with HEC-RAS for existing conditions (left) and the model which combines Alternatives 2 & 5 (right).

Alternative 6: Project NR-16 (Berm Removal)

Scope of Work and Cost Estimate

An approximately 200ft long historic berm is located along the east bank of the tributary to the East Branch of the North River draining Gates Pond. The berm blocks access to a flood chute and floodplain. Alternative 6 considered the effect of removing the berm on flood depths and velocities during the 500-year flood. Several large trees are growing on top of the berm and provide valuable stability to the bank and shading for the channel. We recommend removing portions of the berm to minimize disturbance to large trees while restoring sufficient access to the floodplain.

Based on the field surveys of the berm dimensions and assuming the removal of 150 linear feet of berm, we estimate that approximately 250-300CY of dredged channel material would be removed. We recommend shaping the north bank back to a stable 1V:3H slope to reduce the risk of bank erosion and to increase bankfull channel width by approximately 15-20%. In the modeled alternative, the increased floodplain storage along the east bank would decrease water elevations during large flood events by less than 0.5 feet. These reductions are relatively low; however, the model predicts that berm removal would allow 20% of the floodwater in the 500-year flood to access the floodplain and decrease channel velocities by approximately 25% (Figure 26). This project will require additional design to ensure that berm removal will not increase flood vulnerability to the downstream houses. The driveway will also require additional stabilization and drainage improvements. We estimate that this project will cost between $15,000 and $20,000.

Landowner Contacts

Evan has discussed the existing conditions with the owner of the property containing the berm (Brian Sullivan). Evan has not yet discussed the project with the Degray household, located on the floodplain downstream of the berm.

Regulatory Requirements

A VTANR stream alterations permit and an Army Corps of Engineers permit would be required for any channel work below ordinary high water (OHW), however this may not be needed. Tree clearing may need to be coordinated with USACE and other federal agencies (i.e., USFWS) to avoid or minimize impacts on potential habitat for threatened or endangered bat species.

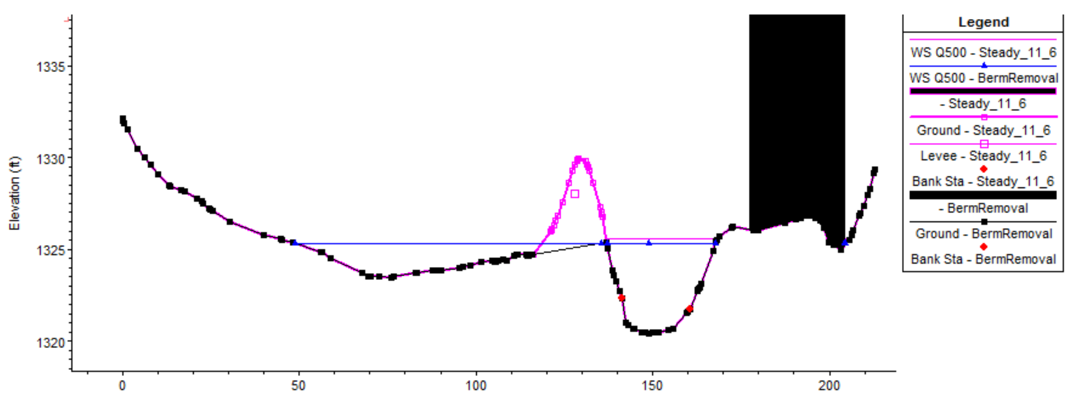


Figure 26: Model cross section showing increased floodplain area following berm (pink line) removal.

Alternative 7: Project NR-13 (Lower East Bank Floodplain)

Scope of Work and Cost Estimate

A floodplain on the East Branch of the North River across from the First Stop Convenience Store was accessed in T.S. Irene and was slightly lower in elevation than the gas station, reducing damage to the property. Flood deposits stockpiled on the floodplain have raised the elevation and lessened the potential benefits during future floods. Reshaping the east bank to form a floodplain bench and lowering the elevation of the upper floodplain area could reduce the risk of flooding and erosion at the First Stop Convenience Store (Figure 27). The stability of the embankment along the west bank should be assessed and replaced with large stone armor if needed. The embankment could be reconfigured with a stacked stone wall to increase channel capacity. In the modeled alternative where the floodplain was lowered by 1-2 feet, flood depths were lowered by over 1-foot in the 500-year event and velocities were reduced by 20%. We estimated approximately 800 to 1,000CY of excavation and off-site trucking. Replacing the west embankment with a stacked stone wall would require approximately 100CY of placed stone armor. Based on unit costs of $30/CY for excavation and trucking and $50/CY for placed stone armor, we estimate that the total project costs will be between $25,000 and $35,000.

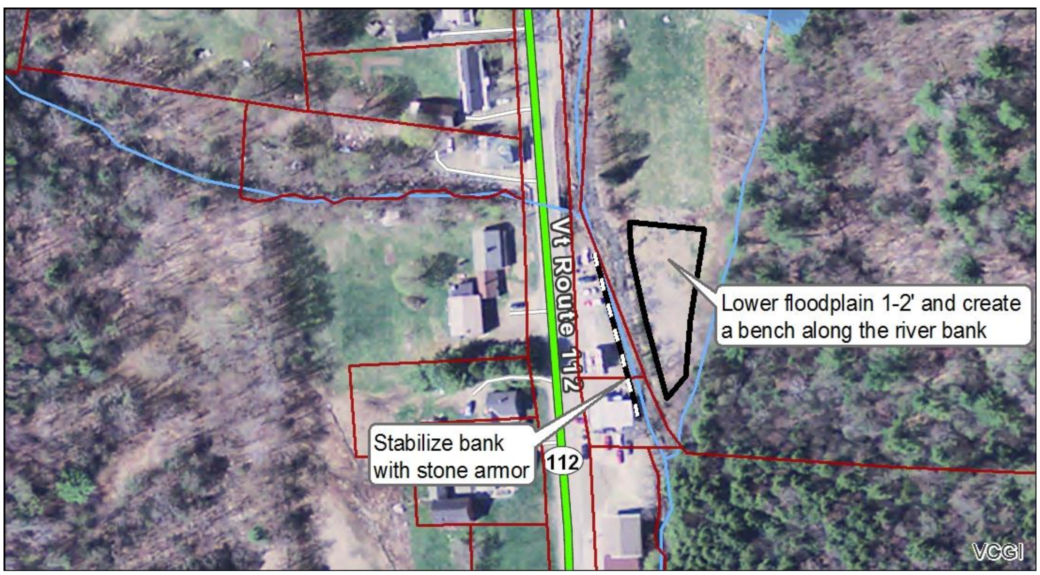


Figure 27: Extent of floodplain lowering for implementation of Alternative 7 and recommended stacked stone wall along the First Stop Convenience Store property.

Landowner Contacts

The project has not been discussed with the First Stop Convenience Store owners (west bank) or with the Honora Winery (east bank).

Regulatory Requirements

Work within the channel below OHW will likely require permits from VTANR and the Army Corps of Engineers. Tree clearing may need to be coordinated with USACE and other federal agencies (i.e., USFWS) to avoid or minimize impacts on potential habitat for threatened or endangered bat species.

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