TO: **Brattleboro Housing Authority**

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

DATE: **June 30, 2015**

RE: Hydrologic & Hydraulic Analysis of Melrose Terrace Results Report

Introduction

Melrose Terrace and other areas in Brattleboro, Vermont have experienced repetitive flooding, most recently during Tropical Storm Irene. As a result of the flooding, the Brattleboro Housing Authority (BHA) will be relocating the housing currently located at Melrose Terrace. BHA is exploring options at the site for the next users.

This study explored flood mitigation alternatives around Melrose Terrace to inform the best uses of the property in order to reduce future flood and erosion risks both at the subject property and at surrounding properties. The analysis considered risks to roads and bridges, the ability to maintain useable building areas that have acceptable risk levels, environmental benefits, and feasibility (i.e., permitting needs and cost).

Hydrology

Design flows used in hydraulic modeling were obtained from the FEMA effective flows (FEMA, 2007) or by scaling flows from surrogate USGS stream gauges to the project area for flood recurrence intervals not calculated by FEMA (Table 1). Multiple sources of hydrology were considered and compared including USGS Vermont StreamStats regression equations (Olson, 2002, 2014), steep streams regression equations (Jacobs, 2010), and the FEMA Effective flows (FEMA, 2007). Also included were USGS Bulletin 17B (USGS, 1982) analyses using HEC-SSP (USACE, 2010b) from the Dog River at Northfield Falls (USGS gauge 04287000) the Mad River at Moretown (USGS gauge 04288000) and Ayers Brook at Randolph (USGS gauge 01142500). Bulletin 17B analyses were also included for these three gauges using only post 1970 flow data, based on a NOAA recommendation that indicates an increase in peak flood flows in the northeast starting in 1970 (Collins, 2009; NMFS, 2011). The current FEMA effective flows were chosen as a conservative estimate of design flows at the project site, and scaled flows from the Dog River were chosen for recurrence intervals not included in the FEMA flows because they fit the magnitudes of the effective flows.

Multiple sources of flow data were considered for estimates of peak flows during Tropical Storm Irene. Flow estimates were calculated from the flow exceedance curve of effective flows (MMI, 2012), and by scaling Irene peak flows from the Dog River at Northfield Falls (USGS gauge 04287000), Mad River at Moretown (USGS gauge 04288000), Ayers Brook at Randolph (USGS gauge 01142500), and Saxtons River at Saxtons River (USGS gauge 01154000) to the project site by drainage area. Irene flows used in the hydraulic modeling were chosen by improving upon previous flow estimates (MMI, 2012) during the model calibration procedure using known high water marks and flow patterns.

TABLE 1
Design Flows

2-yr**	5-yr**	10-yr*	25-yr**	50-yr*	100-yr*	500-yr*	Irene
1,454	2,437	3,182	4,623	5,994	7,400	11,500	5,800

*FEMA effective flows.
**Scaled from USGS gauge, Dog River at Northfield Falls, VT.

Duplicate Model

Whetstone Brook has a detailed hydraulic study that defines the Special Flood Hazard Area (FEMA, 2007). Any proposed projects to be implemented in the floodway or 100-year floodplain would be required to submit hydraulic modeling to either show no increase in flood levels or to propose a change to the effective FEMA flood maps. One required element of this submission is to create a FEMA duplicate model and build upon that to link the proposed hydraulic changes back to the FEMA effective model. A FEMA duplicate model and revised duplicate model have been prepared as part of this project to assist with future projects that may be pursued at the project site.

A duplicate of the 1982 HEC-2 hydraulics model for the Town of Brattleboro was created by entering the original HEC-2 data into the HEC-RAS (USACE, 2010a). The original HEC-2 data were truncated to cover the 1.3-mile long project reach from the confluence of Whetstone Brook and Ames Hill Brook (FEMA cross section BB) to just downstream of the Brookside Drive Bridge (FEMA cross sections AL). HEC-RAS is used to compute water surface profiles for one-dimensional, steady-state, and gradually varied flow. HEC-RAS is capable of modeling water surface profiles under subcritical, supercritical, and mixed-flow conditions. The basic computational procedure is based on the solution of the one-dimensional energy equation. Energy losses are evaluated by friction (Manning's Equation) and contraction/expansion (coefficient multiplied by the change in velocity head).

A revised duplicate model was created by making minor alterations to the HEC-2 data at bridges so that the HEC-RAS model would run without errors. Results were compared to the effective profile (FEMA, 2007). The average difference between the revised duplicate HEC-RAS model and the FEMA effective 100-year profile is 0.2 feet, with a range of 3.0 feet to -3.2 feet. As expected, the modeled flood levels deviated further from the FEMA profile near bridges due to different modeling approaches used between RAS and HEC-2.

Existing Conditions Model

An existing conditions model was developed using new survey on the Whetstone Brook for 4,600 feet (0.9 miles) of channel from Ames Hill Brook near Hayes Court to the river bend downstream of VT Route 9. FEMA cross section locations were maintained where possible and resurveyed to reflect the existing channel and floodplain geometry. Additional cross sections were added to include the locations controlling hydraulics as determined during a site walk by Milone & MacBroom on May 11, 2015. Survey data were collected in the wet channel, across the floodplain, and on bridges by MSK Engineering and Design in May 2015. Topography was supplemented with previous survey of Melrose Terrace by Stevens & Associates in April 2012. All elevations refer to the 1988 North American Vertical Datum (NAVD88). Manning's hydraulic roughness values are based on field observations. Buildings are included as blocked obstructions.

Flood water jumped its banks (i.e., avulsed) from the Whetstone Brook channel just upstream of Melrose Terrace during Tropical Storm Irene and followed Melrose Street and a swale behind residential buildings to rejoin the main channel flow downstream of Melrose Terrace. The floodpath has been included in a second version of the existing conditions hydraulic model to represent the split that led to the unusual condition of dry buildings at the FEMA floodway yet flood damages to buildings along the back edge of the FEMA floodplain. The partitioning of flow at the split flow junction is optimized by HEC-RAS by matching the energy grade line at in the floodpath and the main channel. The split flow model results in lower water surface elevations in the main channel and higher water surface elevations in the floodpath as observed during Tropical Storm Irene. The split flow model was used as the existing conditions model and in alternatives where water is still expected to travel behind buildings along Melrose Street.

Subcritical flow (i.e., deep and slower moving water) is used in the existing conditions model, both because it was used in the FEMA effective model and because it allows for stabilization of the model during split flow optimization. Mixed and subcritical flow regime results were compared and showed equal water surface elevations at most locations in the model, with the mixed flow regime resulting in local dips in the water surface elevation downstream of the George F. Miller Bridge and at Glen Park. The subcritical flow regime is acceptable for analysis of alternatives even though some instances of supercritical (i.e., shallow and jetting water) are known to exist near the bridges.

Model Validation

The hydraulic model was compared to known measured water surface elevations from Tropical Storm Irene and found to have an accuracy of +/- 2 feet in most locations (Table 2). Known water surface elevations were collected from FEMA surveyed high water marks. Differences between observed and modeled elevations may be due to debris and obstructions that were in the channel during Tropical Storm Irene. The FEMA observed values are all adjacent to bridges that are areas that are known to have complex hydraulic patterns and are therefore not the most ideal spots for validation. The hydraulic model is adequate for a comparative evaluation of alternatives.

TABLE 2
Model Results Compared to Known Water Surface Elevations for Tropical Storm Irene

NON-SPLIT FLOW, subcritical			Average = 5,800 cfs		
River Station	**Location Description**	**Observed Water Surface Elevation (feet NAVD88)**	**Modeled Water Surface Elevation (feet NAVD88)**	**Difference (feet)**	**Data Source**
3035	US of George Miller Drive Bridge	436.6	439.0	2.4	Fair, FEMA High Water Mark by USGS
2954	DS of George Miller Drive Bridge	437.0	434.1	-2.9	Good, FEMA High Water Mark by USGS
1915	US of Route 9 Bridge	428.6	430.6	2.0	Fair, FEMA High Water Mark by USGS
1660	DS of Route 9 Bridge	424.8	425.1	0.3	Good, FEMA High Water Mark by USGS

SPLIT FLOW, subcritical optimized			Average = 5,800 cfs		
River Station	**Location Description**	**Observed Water Surface Elevation (feet NAVD88)**	**Modeled Water Surface Elevation (feet NAVD88)**	**Difference (feet)**	**Data Source**
3035	US of George Miller Drive Bridge	436.6	438.4	1.8	Fair, FEMA High Water Mark by USGS
2954	DS of George Miller Drive Bridge	437.0	432.9	-4.1	Good, FEMA High Water Mark by USGS
1915	US of Route 9 Bridge	428.6	430.6	2.0	Fair, FEMA High Water Mark by USGS
1660	DS of Route 9 Bridge	425.4	425.1	-0.3	Good, FEMA High Water Mark by USGS

Alternatives Analysis

Flood mitigation alternatives (Table 3, Appendix 1) were evaluated by altering the existing conditions model and comparing existing and proposed flood levels (Appendix 2) and velocities. Each alternative is summarized below and a description of hydraulic changes is provided. Change in water surface elevation for the modeled Tropical Storm Irene flow is discussed because it is a recent large flood that many people in the community can visualize. The concept-level alternatives evaluated here are based on finding the best flood mitigation solutions and do not explicitly consider willingness of landowners to participate where alternatives include lands surrounding the BHA property.

TABLE 3
Summary of Alternatives and Project Objectives

Group	ID	Alternative	OBJECTIVES: Reduce Flood & Erosion Risks @ BHA Property	Reduce Flood & Erosion Risks @ Surrounding Properties	Reduce Flood & Erosion Risks @ Roads and Bridges	Maintain Usable Building Area	Environmental Benefits	Permitting	Cost
	1	No Action	-	-	-	+	-	+	+
	2	Remove all buildings.	o	-	-	-	o	+	+
Full Floodplain Restoration (River Corridor plus Known Damage Areas) - Remove all buildings and lower land	3a	All natural site. George F. Miller bridge and road also removed.	+	+	+	-	+	+	o
	3b	George F. Miller bridge and road retained.	+	+	+	-	o	+	o
	3c	George F. Miller bridge and road retained. Build wall around upstream portion of site.	+	o	+	-	o	-	-
Partial Floodplain Restoration (FEH Zone) - Remove 11 buildings and lower land	4a	George F. Miller bridge and road also removed.	+	o	+	o	o	+	o
	4b	George F. Miller bridge and road retained.	o	o	-	o	o	+	o
	4c	George F. Miller bridge and road retained. Build wall around upstream portion of site.	o	o	-	o	-	-	-
	5	Floodplain restoration at bend downstream of Melrose Terrace by lowering land elevation.	-	o	o	+	+	+	+
Bridge Alternatives	6a	Enlarge bridge on George F. Miller Drive.	+	o	+	+	+	o	-
	6b	Remove bridge on George F. Miller Drive.	+	o	+	+	+	o	o
	6c	Overflow Culvert at George F. Miller Drive.	o	o	+	+	+	o	o
	7a	Enlarge bridge at Route 9. Create a 2-yr floodbench at bridge.	-	+	+	+	+	o	-
	7b	Enlarge bridge at Route 9. Create a 10-yr floodbench at bridge.	-	o	o	+	+	o	-
Partial Floodplain Restoration (FEMA Floodway) - Remove 6 buildings and lower land	8a	George F. Miller bridge and road also removed.	+	o	+	o	o	+	+
	8b	George F. Miller bridge and road retained.	-	-	-	o	-	-	+
	8c	George F. Miller bridge and road retained. Build wall around upstream portion of site.	-	-	-	o	-	-	o
	9	Floodwall around Melrose Terrace.	-	-	-	+	-	-	o
Combinations		5 + 7a	-	+	+	+	+	+	-
		3a + 7a	+	+	+	+	+	+	-
		3a + 7a + 5	+	+	+	+	+	+	-
		LEGEND: + good; o moderate; - poor							

Alternative 1: No Action

The first alternative is the no action alternative where existing conditions are left to remain. The split flow model is considered the existing conditions base model because it best represents the high flow floodpath observed during Irene. The split flow model passes 24% of the flow behind the homes lining Melrose Street during the modeled Irene storm.

The bridges located near the project site constrict flow and lead to backwatering – the condition where water is slowed down, blocked, and has increased flood levels. During the simulated Irene flood, the George F. Miller Bridge increases flood levels 5.5 feet and the Route 9 Bridge increased flood levels 5.3 feet.

Water surface elevations in the floodpath are between 1 and 6 feet higher in elevation than the flow in the main channel. The separation of flow is why many of the homes along the main channel and in the FEMA floodway were not damaged while homes at the back of the floodplain were damaged during Irene. With no action, it is expected that flooding and possible avulsion will take place during the 10-year flood and larger.

Alternative 2: Remove All Buildings

This alternative assumes that all of the buildings owned by the Brattleboro Housing Authority at Melrose Terrace will be removed from the site. All obstructions from the buildings were removed from the model. The flood wall and all above ground utilities are assumed to be removed. The ground surface is assumed to remain at its current elevation and continue to be covered with mowed grass, trees, and shrubs. Floodwater will be able to flow freely across the site and no buildings are present to trap the water away from the channel. This condition was modeled with the non-split flow model. Water surface elevations in the main channel increase up to 1.2 feet because the water previously in the floodpath is now redistributed across the floodplain and main channel. The water surface elevations in the floodpath at the back of the site are reduced between 1.0 and 5.4 feet.

Alternative 3: Full Floodplain Restoration (River Corridor plus Known Damage Areas)

A full floodplain restoration assumes that all buildings, walls, and utilities have been removed from the Melrose Terrace site southwest of Melrose Street. This area approximately coincides with the VTANR River Corridor boundary. One additional residential building near the back of the floodplain was also removed. Melrose Street is maintained to access the existing private homes. The land in the restored floodplain area is lowered to the 2-year flood level in order to provide additional flood conveyance, sediment and debris storage, and slow flood waters to reduce erosion potential. Stabilization would be needed along the back of the floodplain restoration scenarios to reduce erosion risk. A slope of 3 horizontal to 1 vertical was assumed. This alternative was modeled with non-split flow because water would be able to freely drain to the river and no longer be trapped behind buildings. This alternative has been modeled with three variations:

3a. George F. Miller Bridge and road are also removed. (site fully naturalized)
3b. George F. Miller Bridge and road remain.
3c. George F. Miller Bridge and road remain and a flood wall is built along the upstream edge of the floodplain.

Alternative 3a results in flood reductions of up to 5.0 feet at the middle of Melrose Terrace in Whetstone Brook, 6.9 feet in the floodpath, and 1.9 feet at the upstream end of Melrose Terrace at the lower end of Glen Park. This alternative leads to large flood reductions, yet also reduces access to the site and other properties on Melrose Street given the bridge removal.

Alternative 3b reduces the likelihood of avulsion and provides many of the benefits of alternative 3a, but leaving the George F. Miller Bridge reduces the flood benefits at the middle of the Melrose Terrace property from 5.0 feet to 3.8 feet. Benefits remain at the upstream and downstream ends of the property similar to alternative 3a. This alternative provides good flood reduction benefits and should be considered if removal of the George F. Miller Bridge is not preferred.

Alternative 3c has similar water surface elevation reductions on the Melrose Terrace site as alternative 3b, with the exception that there is a 0.2 feet lower flood reduction at the upstream end of the site near Glen Park. The inclusion of a flood wall at the upstream end of the property would require participation from the landowner at the end of Melrose Street to block water from the floodpath. The effects of a taller floodwall may push water onto other properties across the river, especially if debris jamming takes place. Modeling shows that the wall increases risk and raises the water surface elevation, increases the velocity, or increases both for the Irene, 100-year, and 500-year floods beyond alternative 3b.

Alternative 4: Partial Floodplain Restoration (FEH, Fluvial Erosion Hazard Zone)

A partial floodplain restoration assumes that eleven buildings, and the associated flood wall and utilities, closest to the river are removed from the Melrose Terrace site. This area approximately coincides with the previously mapped fluvial erosion hazard (FEH) zone. Some of the existing buildings are assumed to remain near the back of the floodplain and Melrose Street is maintained to access the existing private homes. The land in the proposed floodplain restoration area would be lowered to the 2-year water surface elevation in order to provide additional flood conveyance, sediment and debris storage, and slow flood waters to reduce erosion. This alternative was modeled with non-split flow because water would be able to freely drain to the river and is no longer be trapped behind buildings. This alternative has also been modeled with three variations:

- 4a. George F. Miller Bridge and road are also removed. (site fully naturalized)
- 4b. George F. Miller Bridge and road remain.
- 4c. George F. Miller Bridge and road remain and a flood wall is built along the upstream edge of the floodplain.

Alternative 4a reduces flood levels 4.5 feet at the middle of Melrose Terrace main channel, 7.3 feet in the floodpath, and 1.9 feet at the upstream end of Melrose Terrace at the lower end of Glen Park. The reduced floodplain size compared to alternative 3a does lower flood reduction benefits by 0.5 to 1.0 feet at the middle of Melrose Terrace, but has similar benefits at the upstream and downstream ends of the site. This alternative leads to large flood reductions, yet also reduces access to the site and other properties on Melrose Street given the bridge removal.

Alternative 4b has almost zero flood reduction benefit in the middle of Melrose Terrace due to leaving the George F. Miller Bridge in place that backs up water. The bridge approach (i.e., the fill under the road as it approaches the bridge) blocks almost the entire proposed floodplain area and reduces the flood benefits at the middle of the Melrose Terrace property from 4.5 feet to 0.1 feet compared to alternative 4a. Flood reduction benefits remain at the upstream and downstream ends of the property similar to alternative 4a.

Alternative 4c has similar water surface elevation reductions on the Melrose Terrace site as alternative 4b, with the exception that there is a 0.2 feet lower flood reduction at the upstream end of the site near Glen Park. This alternative would require a 4- to 5-foot tall floodwall to contain the 500-year flood in the channel. The inclusion of a flood wall at the upstream end of the property would require participation from the landowner at the end of Melrose Street. The effects of a floodwall would likely increase risk and push some water across the river towards other properties, especially if a sediment and debris jam takes place. Modeling shows that the wall raises the water surface elevation, increases the velocity, or increases both for the Irene, 100-year, and 500-year floods beyond alternative 4b.

Alternative 5: Floodplain Restoration at the Bend Downstream of Melrose Terrace

The channel is narrow and incised without floodplain as it takes a hard right turn (facing downstream) downstream of the Melrose Terrace site approaching the VT Route 9 Bridge. An incised channel is not able to access its floodplain to dissipate energy and deposit sediment and debris. This condition can increase the erosion potential and the chances of sediment and debris clogging the VT Route 9 Bridge. This alternative creates a new floodplain area along the channel on the right bank from the downstream end of Melrose Terrace to the VT Route 9 Bridge that is connected to the channel. The new floodplain would include excavation of the land to lower it to the 2-year water flood level. The current floodplain is located at approximately the 10-year flood level.

The new floodplain area is backwatered by the Route 9 Bridge, meaning water backs up against the structure and ponds on the upstream side. Flood reduction benefits thus require an increase in the size of the VT Route 9 Bridge in addition to the floodplain restoration. Qualitative benefits include allowing water to slow, spread, and deposit sediment and debris before reaching the bridge. This alternative was thus tested in combination with increasing the size of the VT Route 9 Bridge. This alternative reduces velocity in the channel and thus lowers the erosion risk at the Melrose Street road embankment.

Alternative 6: George F. Miller Bridge

The George F. Miller Bridge is a 55-foot wide single span structure. The bankfull width of the channel is 60 feet as determined during a 2007 stream channel assessment. The bridge backs up flood waters, and the model shows a rise of 5.5 feet from downstream to upstream of the bridge for the Irene flood. All storms greater than the 25-year flood overtop the bridge. When overtopped, floodwater spills over the river banks and flows towards Melrose Terrace. Three scenarios were tested at the bridge including:

- 6a. Enlarge bridge on George F. Miller Drive.
- 6b. Remove bridge on George F. Miller Drive.
- 6c. Overflow culvert at George F. Miller Drive.

Alternative 6a includes replacement of the bridge with a 95-foot long single span bridge. This alternative also includes widening the channel upstream and downstream of the structure to create small floodbenches at the 2-year water surface elevation to create a smooth transition through the structure and provide additional flood conveyance area. The replacement bridge is able to pass all modeled storms without overtopping, although water is still flowing in the floodpath. Flood reduction benefits are 3.9 feet directly upstream of the bridge. This benefit extends approximately 500 feet upstream of the bridge. The reduced backwatering does not extend up to the avulsion site so the hydraulics at the floodpath are unchanged from existing conditions.

Alternative 6b includes removal of the bridge and installation of the small floodbenches at the former bridge location. The bridge removal lowers the Irene flood level an additional 1.0 foot beyond the benefits of enlarging the bridge. The removal of the bridge has been explored in combination with floodplain restoration (alternatives 3a and 4a).

Alternative 6c includes installation of an overflow culvert under the northwest approach to the existing George F. Miller Bridge. The proposed concrete box culvert is 15 feet wide and 5 feet that would require creation of a small floodbench upstream and downstream to transition flow between the channel and structure. Flood reduction benefits are 2.9 feet directly upstream of the bridge, which is 1 foot less than replacing the bridge (alternative 6a). The 100-year and 500-year floods still overtop the bridge deck.

Alternative 7: VT Route 9 Bridge

The VT Route 9 Bridge is an undersized structure with an effective opening width of 47 feet (78% of the channel bankfull width). The bridge backs up flood waters, and the model shows a rise of 5.3 feet from downstream to upstream of the bridge for the Irene flood. The bridge is skewed at 39 degrees from the direction of river flow, further reducing the effective size of the opening by 20% (actual width is 61 feet and the effective width is 47 feet). The arch shape of the opening is narrow at the top where flood levels reach that blocks debris and readily clogs the opening. A 16-inch water main hangs below the top of the arch that blocks high flows and catches debris. This pipe is vulnerable to damage as it hangs below the lowest bridge beam. The low point in the road is to the west of the bridge where water flowed over during Irene. The model shows that storms greater than the 10-year flood level overtop the bridge.

A new bridge was modeled that has a single span bridge with a width of 120 feet. The new bridge assumes that the low chord is level with the bottom of the existing water main. The new bridge would be designed to protect the water main behind the bridge beams. The road surface would remain near its existing elevation. A railing structure would remain and therefore continues to block high flows. The bridge skew of 39% was maintained as realignment was not deemed practical. A small floodbench was included through the bridge to widen the conveyance area and provide a smooth transition in and out of the bridge. Two flood bench scenarios were tested:

7a. 2-year floodbench
7b. 10-year floodbench

In alternative 7a, the new bridge will pass the Irene flow without overtopping. Flood reductions are 2.5 feet upstream of the bridge and extend upstream to the Melrose Terrace property. Overtopping would still occur for the 50-, 100-, and 500-year floods, but at a greatly reduced depth. For example, the 100-year flood depth over Route 9 would be reduced to 0.8 feet, a reduction of 2.2 feet from existing conditions. Bridge replacement is recommended to reduce flood risks both at Melrose Terrace and along VT Route 9.

Alternative 7b proposes to create a higher floodbench at the 10-year flood level was included because the upstream and downstream tops of banks are currently located at approximately the 10-year elevation. This bench level would provide a smoother transition between the bridge and channel. The flood reduction upstream of the bridge is reduced by 1.0 foot upstream compared to alternative 7a.

A combination alternative was evaluated that increases the size of the bridge opening and create a new floodplain at the bridge (combination 5 + 7a). The floodplain provides flood reductions between 0.5 and 0.7 feet at the downstream end of Melrose Terrace and the area upstream of VT Route 9, beyond the reductions provided by the bridge replacement alone.

Alternative 8: Partial Floodplain Restoration (FEMA Floodway)

Residential buildings, walls, and utilities are located in the FEMA floodway of Whetstone Brook. This alternative will remove the six (6) residential buildings and associated infrastructure in the floodway. The land in this area will be excavated to create a floodplain at the 2-year water surface elevation. This smaller version of a floodplain restoration alternative is recommended to be implemented first if phased removal of housing takes place at Melrose Terrace. This alternative has been modeled with three variations:

- 8a. George F. Miller Bridge and road are also removed. (site fully naturalized)
- 8b. George F. Miller Bridge and road remain.
- 8c. George F. Miller Bridge and road remain and a flood wall is built along the upstream edge of the floodplain.

Alternative 8a provides flood reduction benefits of between 4.3 and 1.3 feet upstream of the George F. Miller Bridge and up to 2.7 feet in the floodpath. The 10-year flood will no longer avulse and travel through the Melrose Terrace property, and flood discharge in the floodpath is reduced for larger storms. Flood benefits are up to 1.7 feet less than full floodplain restoration (alternative 3a).

Alternative 8b maintains the George F. Miller Bridge. Less floodwater avulses out of the Whetstone Brook main channel traveling behind the homes on Melrose Terrace with 2.5 feet lower water surface elevations at the back of the site. Water surface elevations in the main channel increase up to 0.7 feet due to the redistribution of water at the site. The 10-year flood no longer will avulse and travel through the Melrose Terrace property. Flood reduction benefits provided by the floodplain restoration are not seen in water surface elevation reductions because the George F. Miller Bridge still backwaters the channel.

Alternative 8c is not recommended for implementation. The floodwall around the remaining homes, in combination with the George F. Miller Bridge, raises flood water 1.2 feet above existing conditions around the site. The Melrose Terrace remaining buildings would be dry, but the increase in flooding would affect adjacent properties. A 7 foot tall wall would be required to exclude the 500-year flood from the remaining portion of Melrose Terrace. The George F. Miller Bridge would still overtop for the 25-year recurrence interval and higher storms, allowing floodwater into the site at that location.

Alternative 9: Floodwall around Melrose Terrace

To keep floodwater out of the Melrose Terrace site and maintain all other existing conditions would require a tall floodwall around the entire site that is over 12 feet tall at the upstream end. The wall was assumed to remain in the existing location, but connected completely around the property and made tall enough to contain the 500-year flood in the channel. The negative aesthetics of a 12-foot tall wall

would ruin the feel of Melrose Terrace and surrounding properties. The completion of a wall while maintaining the George F. Miller Bridge would be difficult to design because the water surface is so high above the bridge deck during large storms that the water would run down the road and into Melrose Terrace. The flood wall alternative increases flood and erosion risks at surrounding properties and is thus not recommended and likely not permittable.
A floodwall would have many negative effects and is not recommended for implementation. Although the Melrose Terrace site may remain dry, this alternative increases water surface elevation and risk on many adjacent properties. Glen Park could experience almost 4 feet higher flooding in an Irene size flood. Properties across the river from Melrose Terrace could experience 3.2 feet higher flooding. Velocities would also increase, increasing risk of erosion damage to the George F. Miller Bridge and adjacent properties. These negative impacts to other properties are expected to outweigh the benefits to Melrose Terrace.

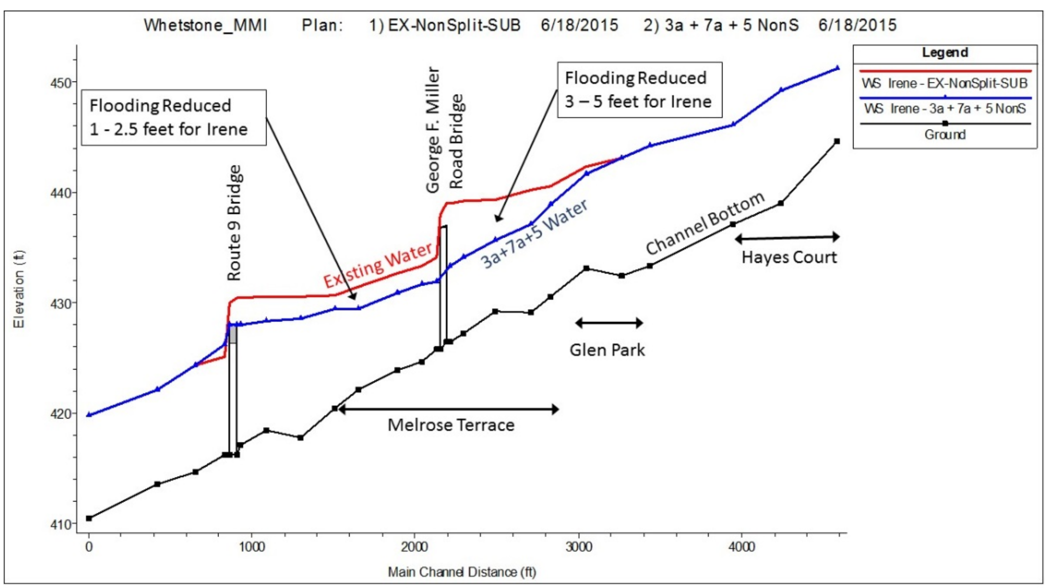
Combination with Largest Flood Reduction Benefit

A combination of alternatives is able to address multiple issues that are all contributing to flooding in the vicinity of Melrose Terrace. This alternative provides the largest flood reduction benefit at the Melrose Terrace site and surrounding properties. The following alternatives are recommended:

3a. Full floodplain restoration with George F. Miller Bridge and road are also removed;
7a. Route 9 Bridge replacement; and
5. Floodplain restoration at bend downstream of Melrose Terrace.

The combined benefits of these alternatives reduce flooding from the VT Route 9 Bridge, extending upstream through the Melrose Terrace site. Flood reductions range between 1.0 and 5.1 feet (Figure 1). Larger flood reduction up to 7.6 feet occurs in the floodpath along the back of Melrose Terrace. The combination of alternatives provides additional benefits beyond the individual alternatives because as backwatering is reduced each subsequent alternative can function more effectively.

Figure 1
Existing and Proposed Flood Profile for Modeled Tropical Storm Irene Flood



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