Navigating Benefit-Cost Analysis in Inland New York & New England

Ashokan Watershed Stream Management Program
Cornell Cooperative Extension of Ulster County

Phoenicia, New York

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AGENDA

- Hazard Mitigation Background
- Benefit-Cost Analysis (BCA) Background
- General Guidelines for all BCA
- General Guideline for Inland New York/New England
- Case Studies – Individual Mitigation Projects for Critical Infrastructure
  - Lessons Learned
- Important Changes in 2013-2014
- Case Studies – Local Flood Analysis (LFA)
  - Lessons Learned

Benefit-Cost Analysis = BCA

Benefit-Cost Ratio = BCR

HAZARD MITIGATION BACKGROUND

- Communities must have a FEMA-approved Hazard Mitigation Plan in place to receive Federal grants for hazard mitigation projects
  - PDM (Pre-Disaster Mitigation)
  - HMGP (Hazard Mitigation Grant Program)
  - FMA (Flood Mitigation Assistance)
- With many declared disasters in recent years, HMGP tends to be the most available mitigation program

HAZARD MITIGATION BACKGROUND

Eligible Activities	HMGP	PDM	FMA
Property Acquisition and Structure Demolition or Relocation	X	X	X
Structure Elevation	X	X	X
Mitigation Reconstruction			X
Dry Floodproofing of Historic Residential Structures	X	X	X
Dry Floodproofing of Non-residential Structures	X	X	X
Minor Localized Flood Reduction Projects	X	X	X
Structural Retrofitting of Existing Buildings	X	X	
Non-structural Retrofitting of Existing Buildings and Facilities	X	X	X
Safe Room Construction	X	X	
Wind Retrofit for One- and Two-Family Residences	X	X	
Infrastructure Retrofit	X	X	X
Soil Stabilization	X	X	X
Wildfire Mitigation	X	X	
Post-Disaster Code Enforcement	X		
Generators	X	X	
5% Initiative Projects	X		

MITIGATION & BENEFIT-COST ANALYSIS

- So… What is BCA?

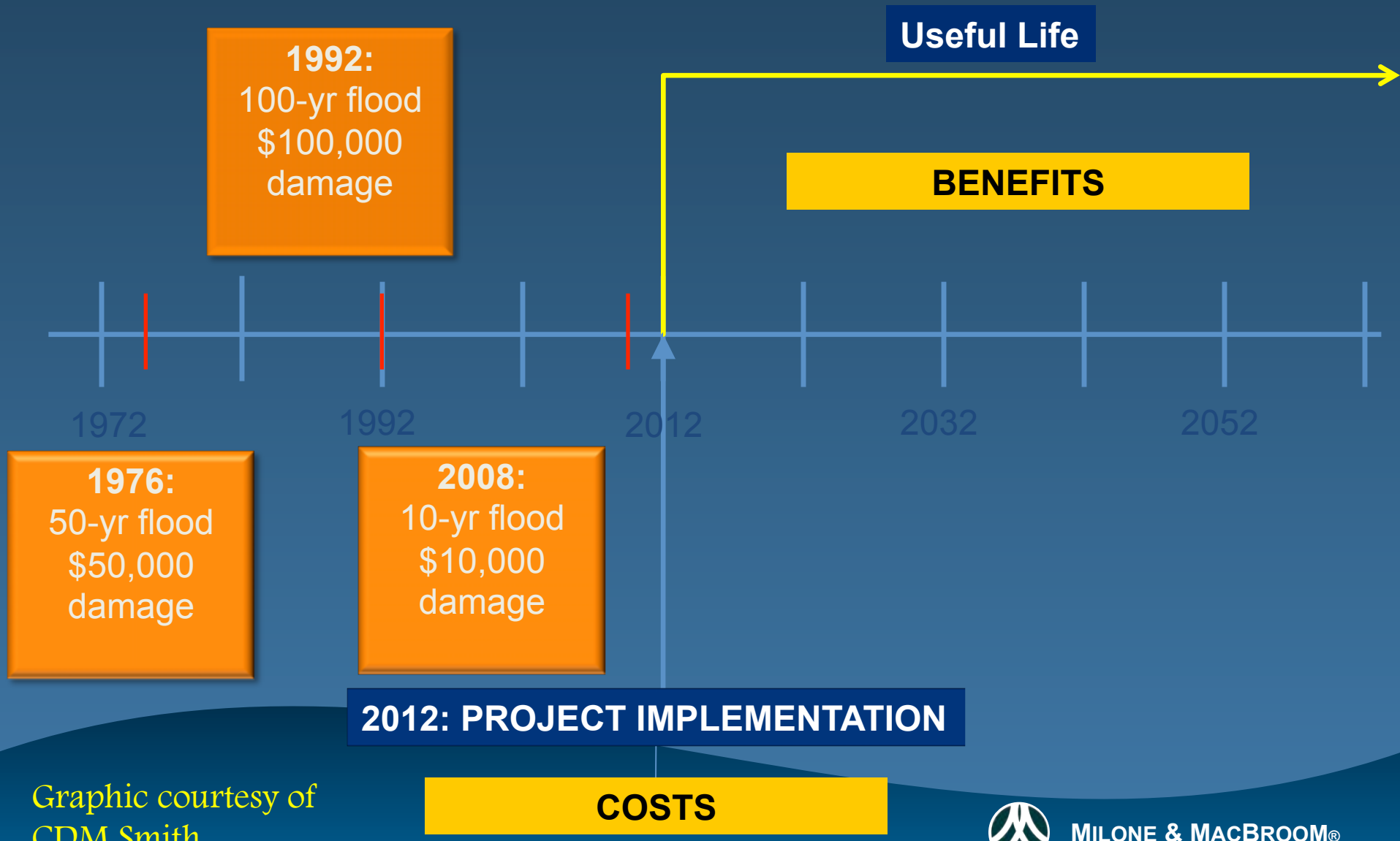
  - ✓ Process of determining the BCR
  - ✓ A mitigation project cannot be funded by FEMA unless it has a BCR greater than 1.0
    - Benefits = Damages Avoided, units of $
    - Benefits over the life span of project must exceed project cost
  - ✓ FEMA's BCA tool must be used for this determination

MITIGATION & BENEFIT-COST ANALYSIS

Benefits = Damages Avoided, units of $

Graphic courtesy of CDM Smith

MITIGATION & BENEFIT-COST ANALYSIS



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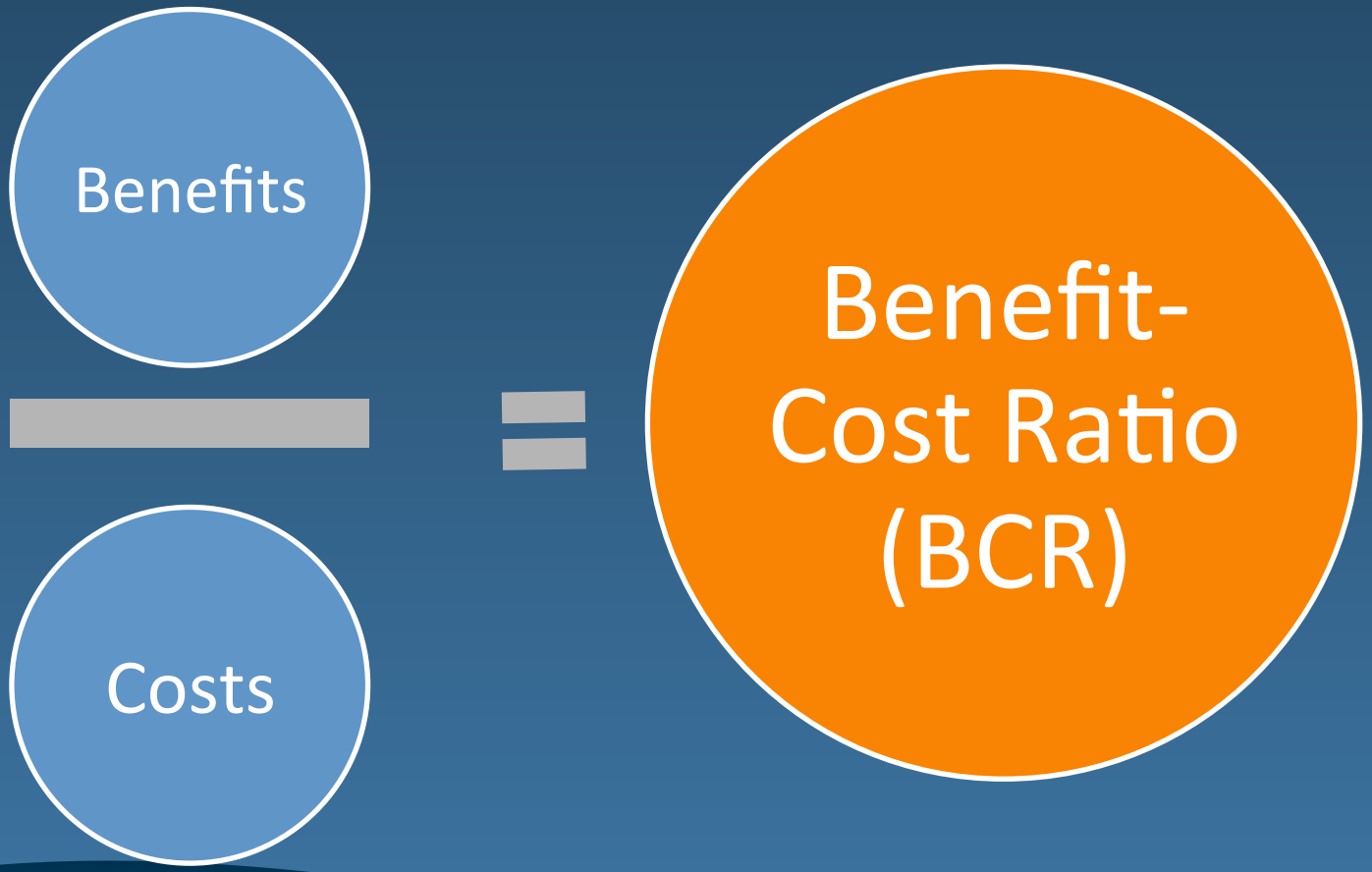
MITIGATION & BENEFIT-COST ANALYSIS



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MITIGATION & BENEFIT-COST ANALYSIS

- ✓ Many good projects that reduce flood damage and protect water quality do not have BCR >1.0
  - These projects can be funded by someone or something that is not FEMA
- ✓ However, we can also use BCA to evaluate projects that may not be appropriate for FEMA funding due to timing, logistics, project cost, or other factors
  - The new "Local Flood Analysis" (LFA) process is a good example

FEMA BCA Course Objectives

- Estimate hazard mitigation project costs
- Compute hazard mitigation project benefits
- Identify, gather, and analyze BCA documentation required by FEMA

Today's presentation is less about how to estimate costs and run the program, and more about strategies to generate benefits

FEMA

MITIGATION & BENEFIT-COST ANALYSIS

- The BCA tool includes six modules
- Two modules can evaluate flooding:

✓ Flood
✓ Hurricane Winds
✓ Wildfire
✓ Tornado
✓ Earthquake
✓ Damage Frequency

MITIGATION & BENEFIT-COST ANALYSIS

- The Flood Module determines long-term benefits (reduced damages) from the frequency analysis that is embodied in the Flood Insurance Study, on its profiles, and on the FIRMs

- The Damage Frequency Module determines long-term benefits (reduced damages) by analyzing the damages from more than one event with different recurrence intervals (frequencies)

MITIGATION & BENEFIT-COST ANALYSIS

- *The BCA is tough on the northeast*
- The Damage Frequency (DF) Module is often essential for our types of mitigation projects. Why?
  - ✓ Not every project site is in a FEMA SFHA
  - ✓ We don't necessarily need to acquire 100 homes from a floodplain, build a tornado safe room, or brace assets to prevent earthquake damage
  - ✓ We *are* trying to mitigate for road washouts, bank failures, landslides, erosional hazards, etc. – along with flooding of homes and businesses

GENERAL GUIDELINES FOR ALL BCA

- For Flood module: we need the FIS, FIRM, and elevations
- For Damage Frequency module: we need knowledge of hydrology, recurrence intervals, and calculating precipitation event frequencies and flood event frequencies
- Benefits ($) = Avoided damages and loss of function ($)
- For the Damage Frequency module:
  - ✓ Reducing damage to utilities, roads, and critical facilities will help cost effectiveness
  - ✓ Damage must be frequent to generate BCRs >1.0
  - ✓ **Damage from <u>one</u> extreme event will not typically help a BCR > 1.0**

Think about it this way: would we design a project for the 500-year flood? If not, should a mitigation project be funded for an event this rare?

GENERAL GUIDELINES FOR NY & NEW ENGLAND

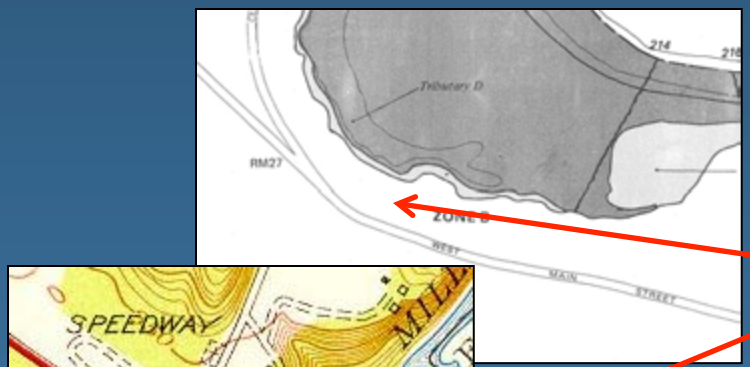
- When using the Damage Frequency Module:
  - ✓ Search for local and small-scale intense rain and flood events to help build a record of damage
  - ✓ Traffic counts and long detour times may help and should always be considered
  - ✓ Losses of functions may be substantial in small communities (public works, highway, or the limited utilities that may be available)
  - ✓ Protection of infrastructure will generally help BCRs exceed 1.0
  - ✓ Tally the labor hours and expenses to recover from the previous damaging events
  - ✓ Include staff and volunteers

CASE STUDIES

Individual Mitigation Projects for Critical Infrastructure
(6 passing BCRs and 2 failing BCRs)

#1 – Millers Falls Road Landslide

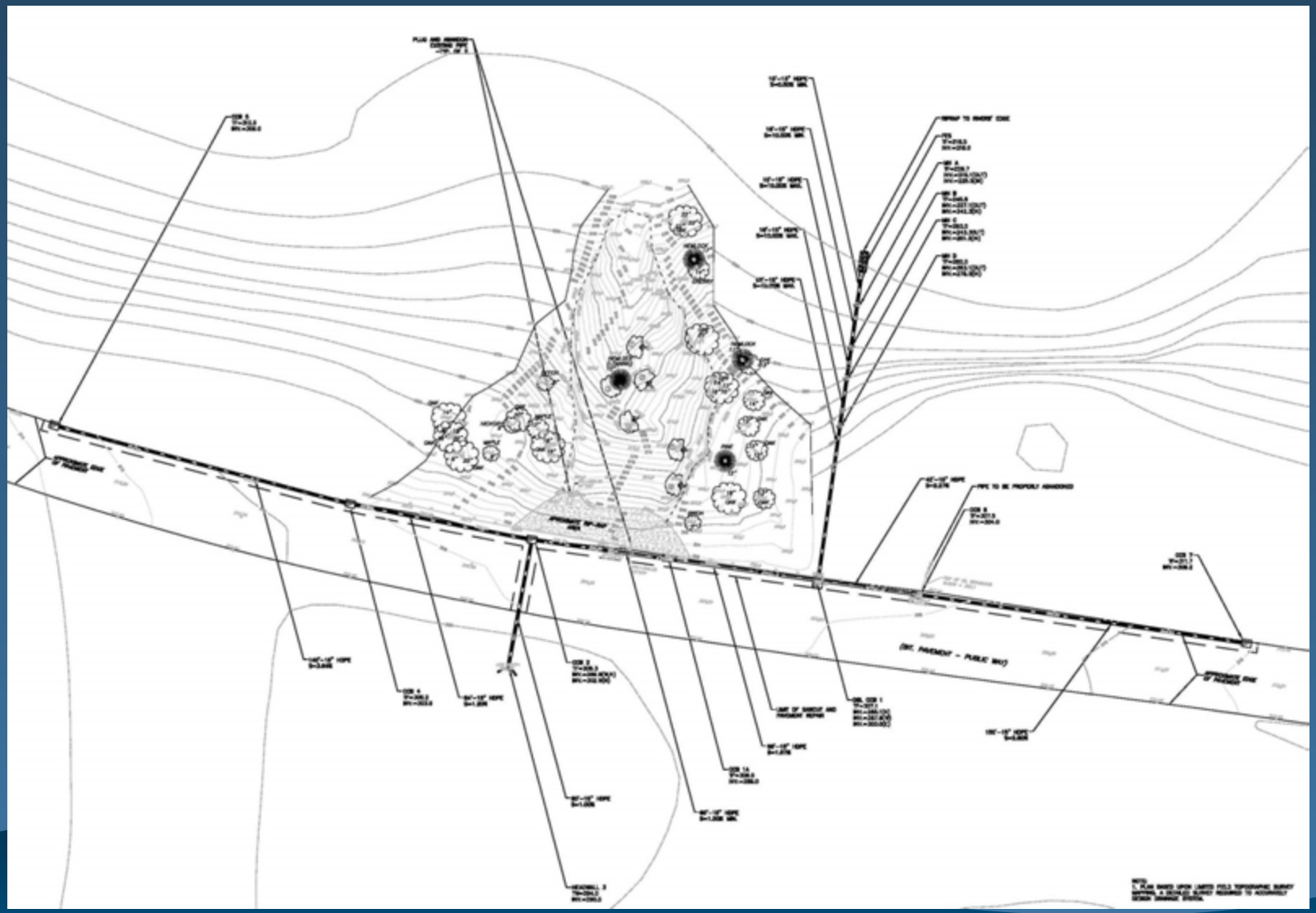
- Landslide threatens Millers Falls Road
- Project would be to stabilize the slope and prevent future erosion and failure of the roadway
- Road is arterial and provides emergency access between two villages
- Neither the road nor the slope are in a SFHA – we MUST use the DFA module



#1 – Millers Falls Road Landslide

- Survey and preliminary design were needed for cost estimates
- Objectives: replace the undersized stormwater drainage system, eliminate sources of groundwater, and convey water to the base of the slope

#1 – Millers Falls Road Landslide



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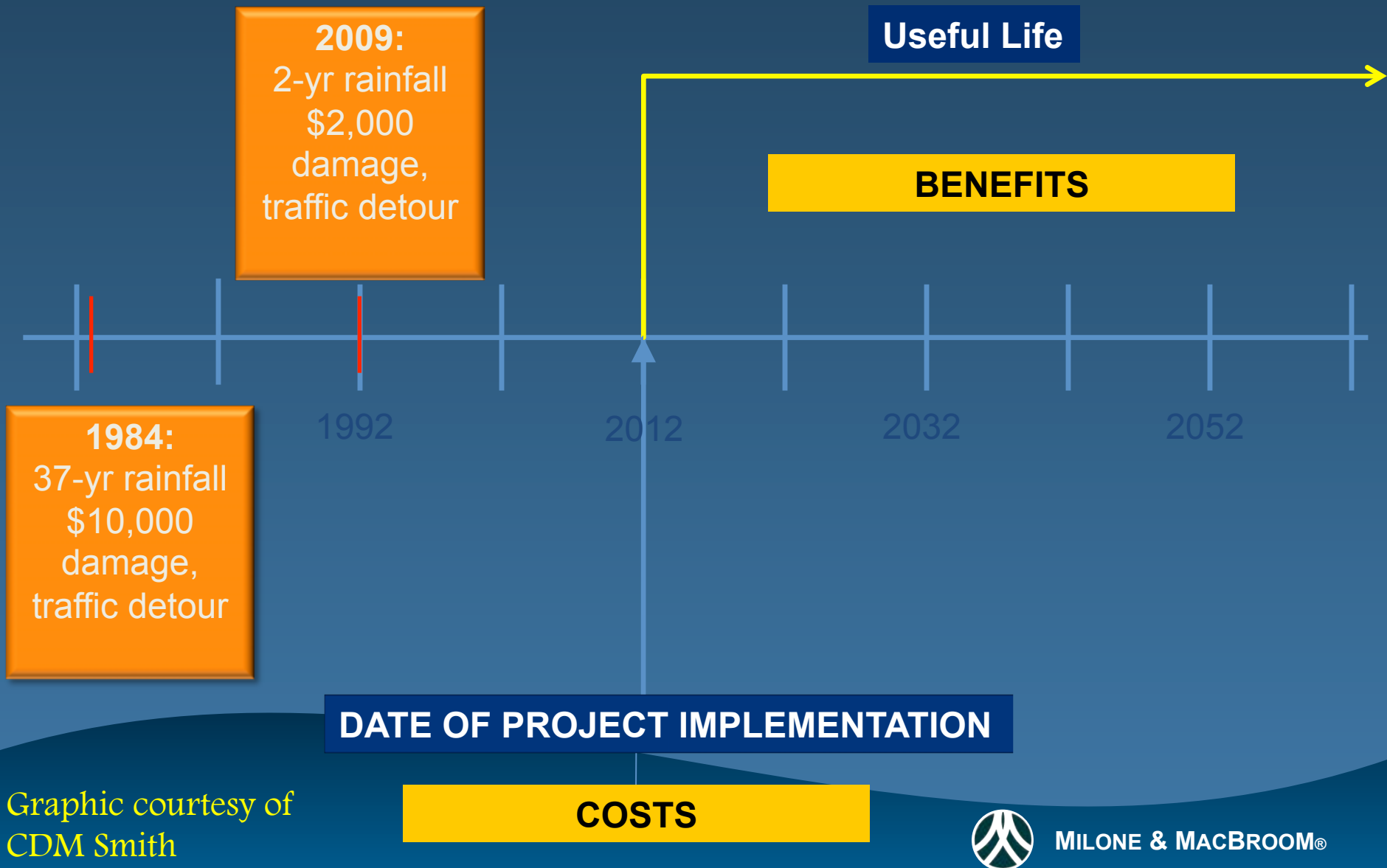
#1 – Millers Falls Road Landslide

- Landslide event frequencies were determined
- Historical damages known from 1984 (37-year rain event) and 2009 (2-year rain event)
- Damage Frequency module utilized
- Loss of road causes a seven-minute detour for 4,300 vehicles
- Project design for 100-year storm
- Assume that 200-year storm will cause minor damage and sliding
- Project cost = $327,000
- BCR = 2.01
- Lesson: a short detour may seem trivial but is important when coupled with high traffic counts

Note visible repairs from 2009

#1 – Millers Falls Road Landslide



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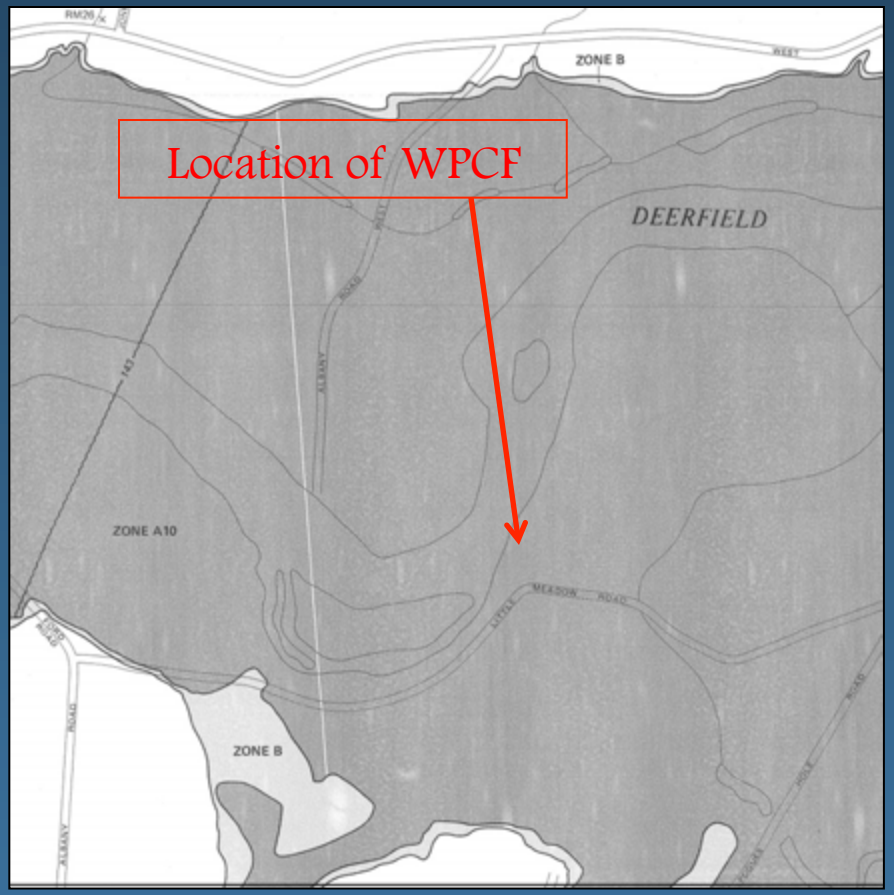
#2 – Deerfield River Bank Stabilization

- Bank erosion along Deerfield River is threatening Little Meadow Road
- Project would be to stabilize the bank and prevent future erosion
- The road is within the SFHA associated with the Deerfield River
- The road is access to the WPCF and a sewer trunk is located in the road



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#2 – Deerfield River Bank Stabilization

- Determined that only conceptual design was needed due to nearby bank stabilization projects completed by NRCS
- The nearby projects could inform our design and our cost estimates
- Selected design was to use fabric soil wraps, riprap, and plantings

Subject Site

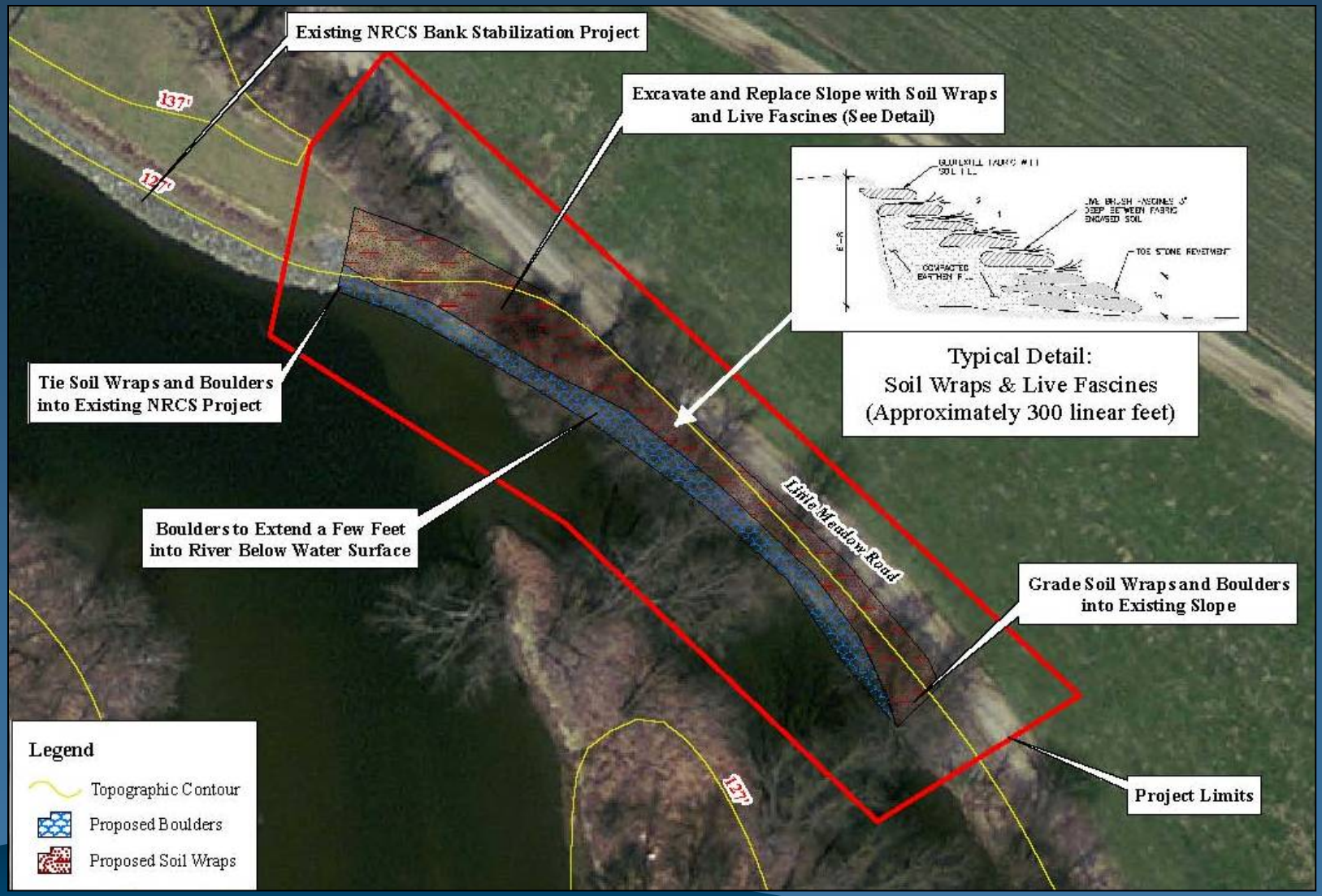
Adjacent NRCS project

#2 – Deerfield River Bank Stabilization

- Historical erosion and event frequencies needed to be well understood
- October 2005 flood (17-year recurrence interval) eroded five feet laterally
- Historical aerial photographs were used to determine other erosion losses
- Damage Frequency module utilized
- Loss of bank may cause loss of 12-inch sewer trunk to WPCF that serves 1,657 people including Deerfield Academy and Historic Deerfield
- Complete inundation after sewer failure can cause an outage of many days

Inundation of road after Irene

#2 – Deerfield River Bank Stabilization



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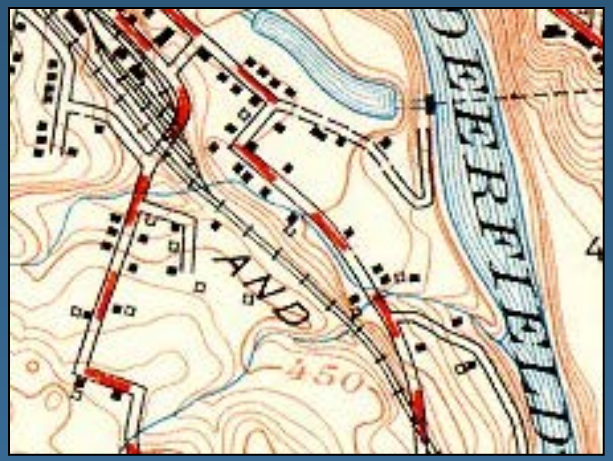
#2 – Deerfield River Bank Stabilization

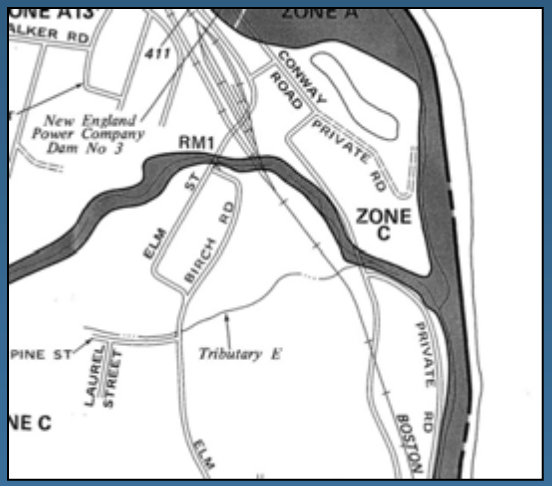
- Bank stabilization cost estimate of $394,000
- Comparable to nearby NRCS project cost of $400,000
- Designed to protect through the 100-year flood
- Assumed that the 500-year flood would cause damage
- Mitigation benefits of $448,000
- BCR = 1.13
- Lesson: conceptual design may be sufficient, thus reducing up-front costs

Adjacent NRCS project

#3 – South Street Culvert Replacements

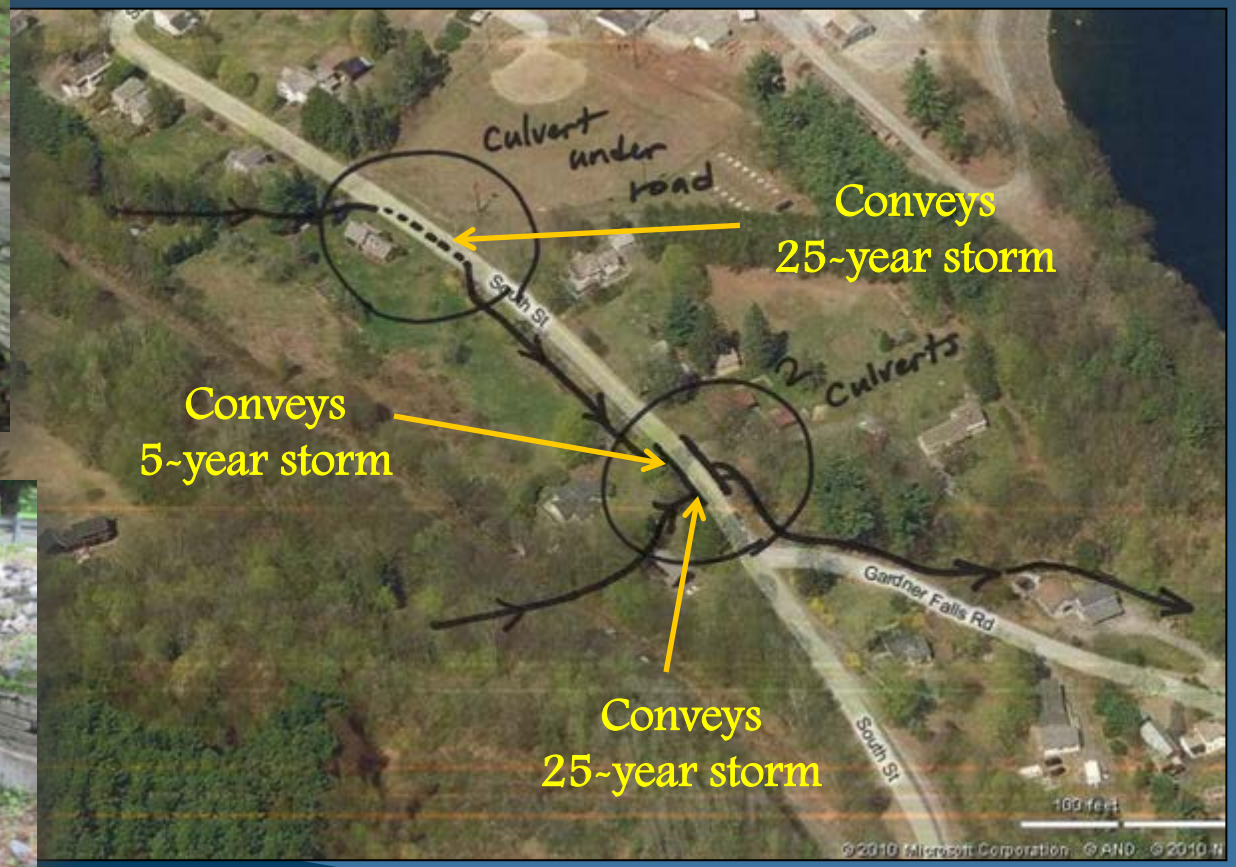
- Conveyance and drainage improvement that may alleviate nuisance and/or overbank flooding from a group of culverts
- Secondary benefit would be to prevent failure of culverts
- One stream is located in a SFHA crossing South Street
- Critical facility (Shelburne Falls WPCF) is accessed from this road





#3 – South Street Culvert Replacements

- ✓ Possibility of upgrading one, two, or three culverts
- ✓ Conducted survey, calculated existing capacities, selected new capacities



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#3 – South Street Culvert Replacements

- Historical damages needed to be well understood
- Flood event frequencies were determined

Gloria
1985

Floyd
1999

October
2005

Irene
2011

#3 – South Street Culvert Replacements

- Floods of 1985 (Gloria), 1999 (Floyd), and 2000 had recurrence intervals of 10, 12, and 6 years for the streams and records of damage
- Floods of 1987, 2005, and 2007 had poor damage records
- Damage Frequency module utilized
- Road closure causes 24-minute detour of 10 miles for 970 cars/day
- Loss of culverts may cause loss of 12-inch sewer trunk to WPCF that serves 1,740 people in Buckland and Shelburne
- Cost to repair road and sewer line would be $618,000
- But we were faced with some tough questions:
  - Should the new culverts convey the 500-year storm? 100-year?
  - Should all three culverts be replaced?
  - Or only two?

#3 – South Street Culvert Replacements

- Replacement of two short segments would cost $683,000
- BCR = 0.54
- No need to try BCA for all three culverts

Re-focus

- The middle culvert is least able to convey storm flows
- Design for 100-year storm
- Replacement of that one segment would cost $361,000
- Benefits = 366,000
- BCR = 1.01
- Lesson: let the BCA expose the best project

#4 – Hawley Highway Garage Riverbank Stabilization

- Severe erosion along the Chickley River occurred behind the highway garage during Irene
- The highway garage is a critical facility in this very small town
- The town does not participate in NFIP; flood hazard areas are not mapped
- Emergency streambank repair work had been conducted
- Was it appropriate?

#4 – Hawley Highway Garage Riverbank Stabilization

- Found that the riverbank had been put back together hastily
- An engineered solution was desired to reduce the effects of future floods
- The material in place now is unconsolidated and the channel was constricted more than it was prior to Irene
- HEC-RAS modeling showed a 50-year flood will wash away the current riverbank

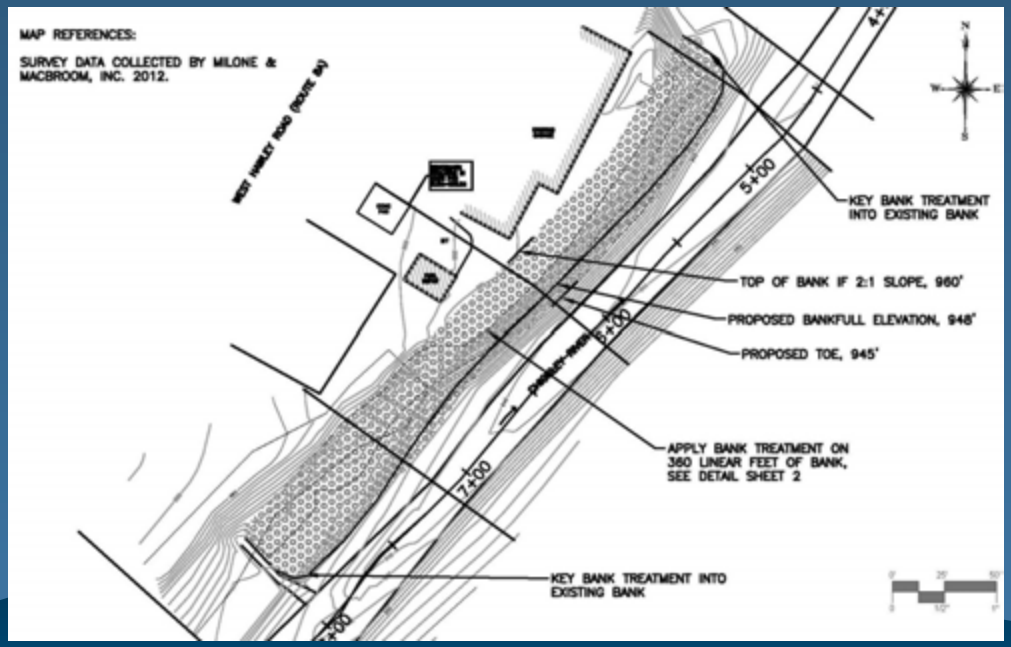
Is this material going to wash away during the next flood?

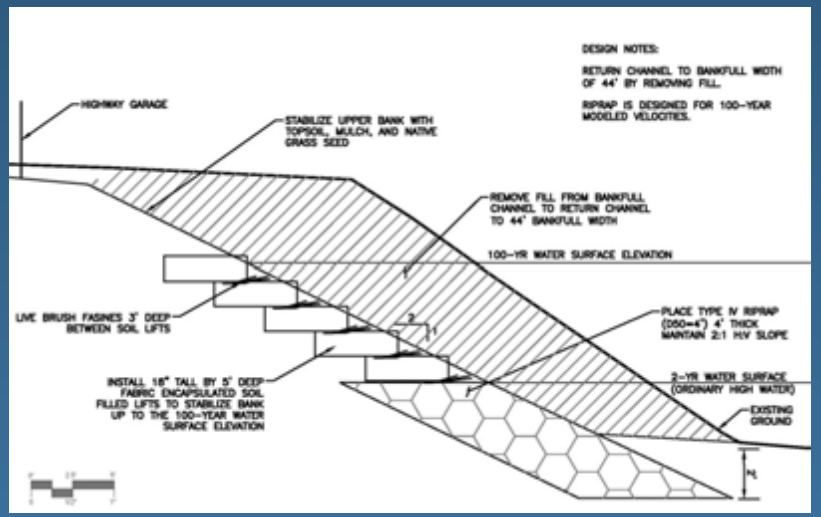
#4 – Hawley Highway Garage Riverbank Stabilization

- Damage Frequency Module necessary to determine BCR
- The direct damage from Irene was $248,000, plus:
  - ✓ The Town housed a fire truck in the garage; National Guard had to winch it out as it was tilting toward the collapsed part
  - ✓ The 2-way radio station was lost so radio communication was down for a while
  - ✓ Half of the building was unusable for nine months
- Damages from flood events were compiled (1998, 2005, and Irene)
  - ✓ Irene RI = 343 years
  - ✓ 1998 RI = 185 years
  - ✓ 2005 RI = 42 years
  - ✓ $64,000 estimate for repairs in 1998
  - ✓ Negligible repairs in 2005
  - ✓ *Two events with known recurrence intervals and damages were sufficient*
- Designed fabric-encapsulated soil lifts above riprap
  - ✓ Riprap below annual high water
  - ✓ Soil lifts up to the 100-year flood level

#4 – Hawley Highway Garage Riverbank Stabilization

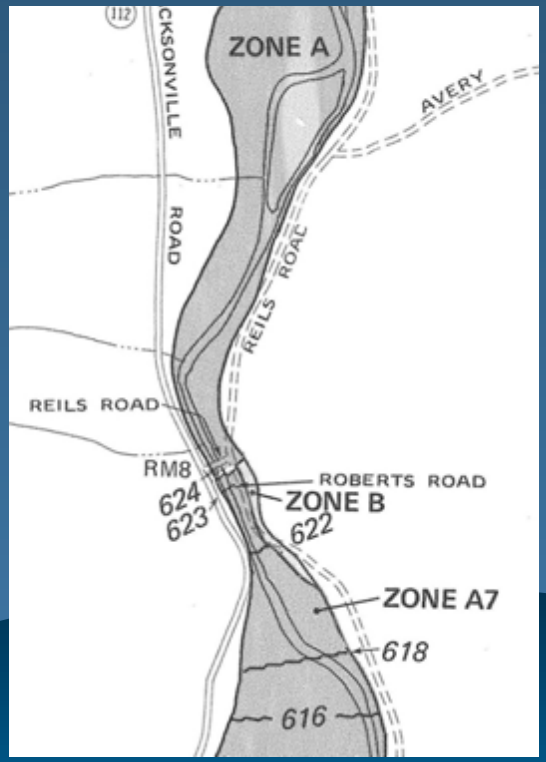
- Project cost estimate was $351,000
- Designed for 100-year flood and minor damage from 500-year flood
- Benefits were $369,000 vs. total costs of $354,000
- BCR = 1.04
- Project advanced to HMGP application
- Lesson: protection of critical facilities can lead to higher BCRs

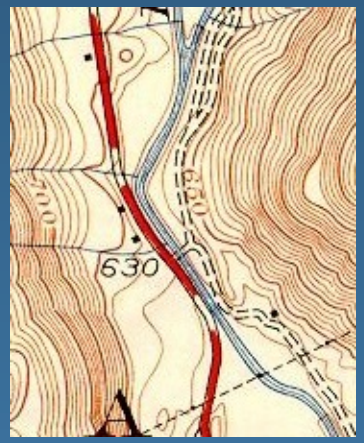




#5 – Route 112/North River Bank Stabilization

- The North River flows along the side of Route 112
- The flood from Irene caused additional erosion
- Loss of the road would be unacceptable because it is a designated evacuation route from the VT Yankee nuclear power plant
- The road carries significant traffic between Massachusetts and Vermont
- Riverbank stabilization was desired





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#5 – Route 112/North River Bank Stabilization

- Two sections of erosion: 300’ at riverbend, 75’ section at bridge
- An engineered solution was desired to reduce the effects of future floods

Upstream section at riverbend

Downstream section at bridge

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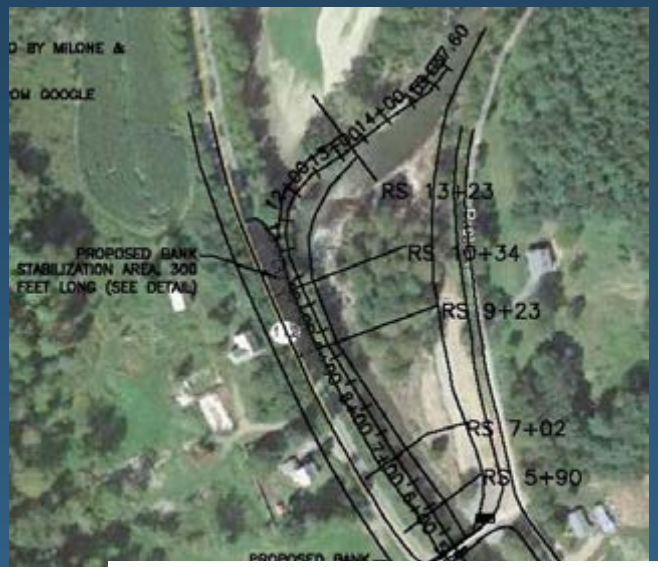
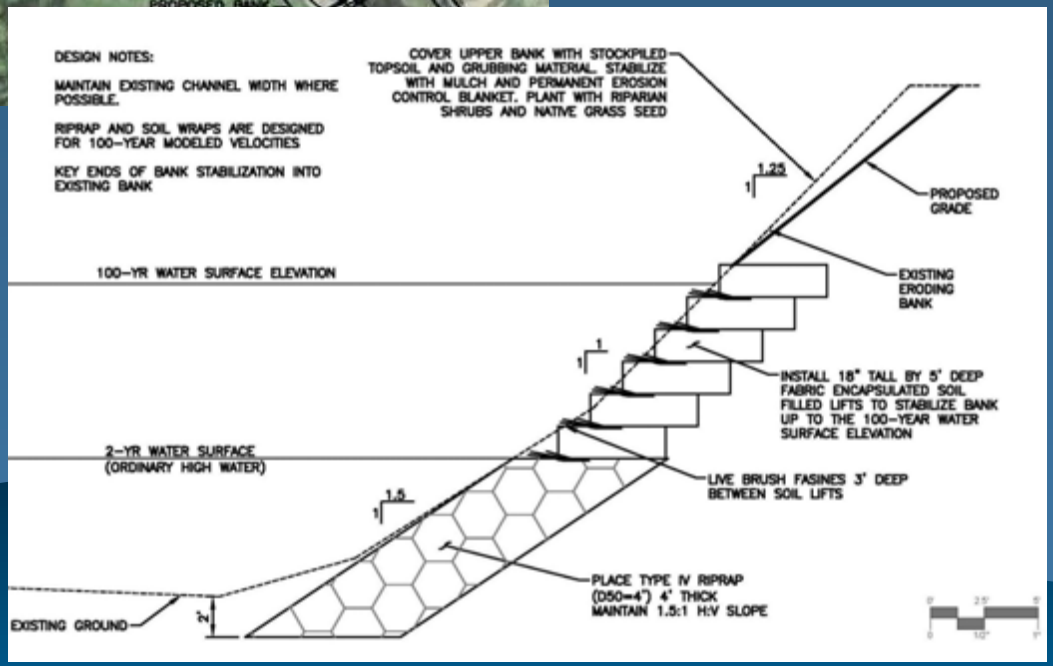
#5 – Route 112/North River Bank Stabilization

- Damage Frequency Module necessary to determine BCR
- The following erosion rates were determined:
  - ✓ Annual spring storms cause minimal but measurable lateral erosion
  - ✓ A 10-year flood erodes three feet laterally based on storms that occurred from 1997 to 2009
  - ✓ Irene (RI = 343 years) eroded six feet laterally
- Traffic counts for Route 112
  - ✓ $72,000 per day benefit!
  - ✓ Status as evacuation route for VT Yankee nuclear power plant was not needed
- Designed fabric-encapsulated soil lifts above riprap
  - ✓ Riprap below annual high water
  - ✓ Soil lifts up to the 100-year flood level
- Designed for 100-year flood and minor damage from 343-year flood

#5 – Route 112/North River Bank Stabilization



- Project cost estimate was $407,000
- Benefits were $547,000 vs. total costs of $410,000
- BCR = 1.33
- Project advanced to HMGP application
- Lesson: traffic counts did it again!



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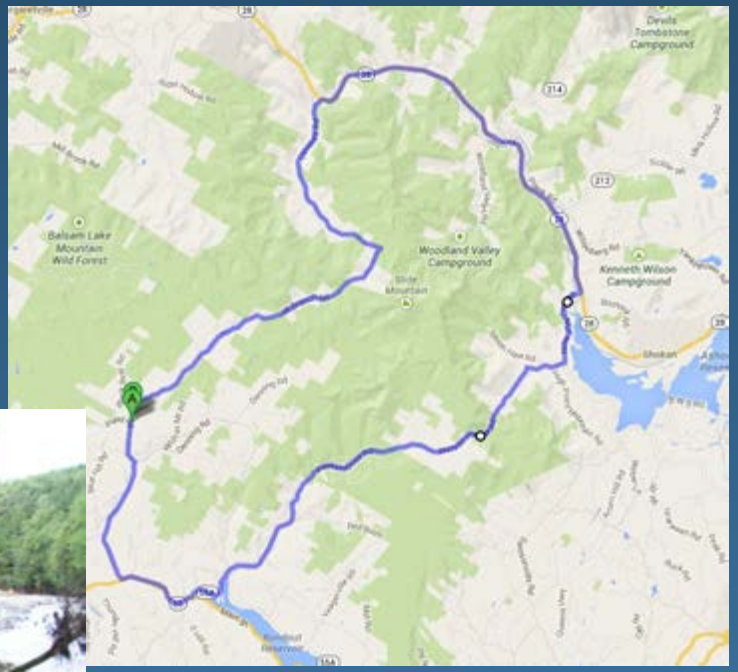
#6 – "S-Turn" Bank Stabilization

- The West Branch Neversink River flows along the side of Route 47
- The flood from Irene destroyed the road at this location
- The road carries moderate traffic but the detour adds 60 miles
- Riverbank stabilization was desired



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#6 – "S-Turn" Bank Stabilization

- Damage occurred in floods of 2005, 2006, 2011 (Irene), and 2012

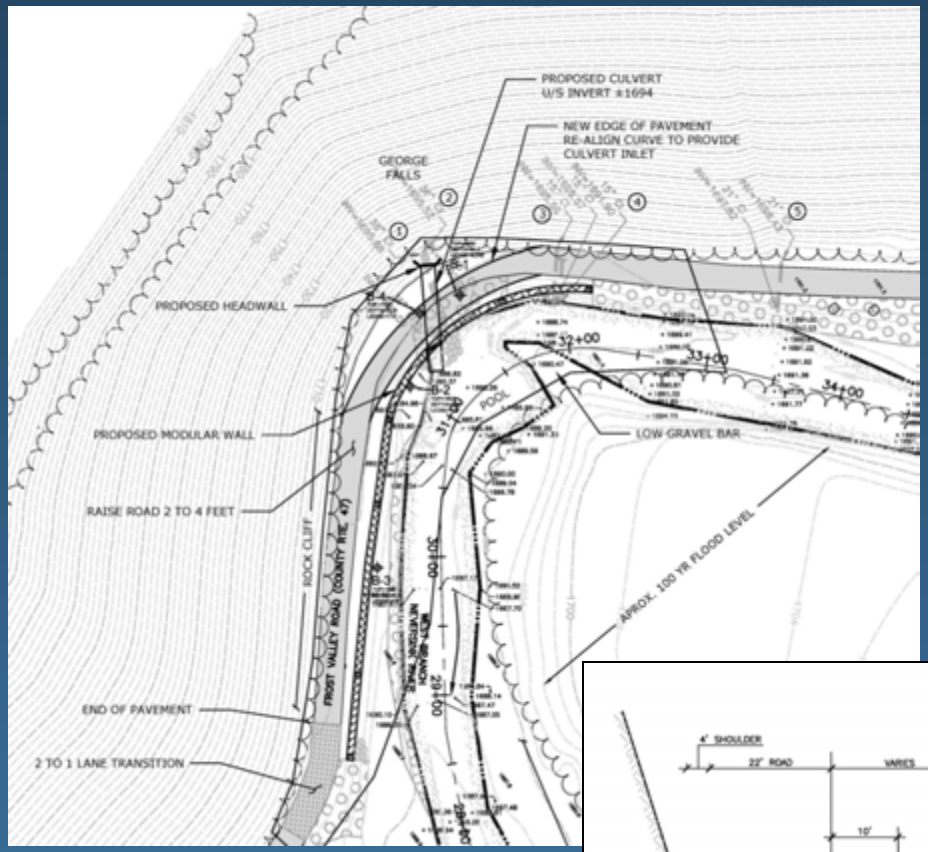
#6 – "S-Turn" Bank Stabilization

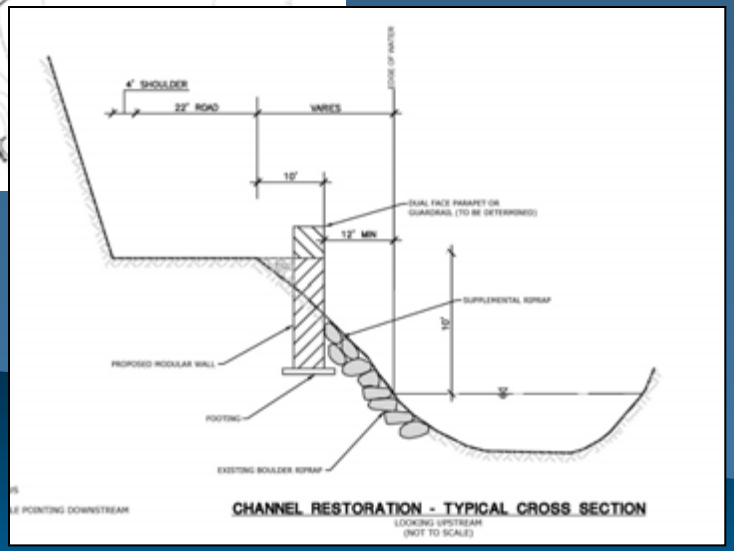
- An engineered solution was desired to reduce the effects of future floods
- Designed sheet pile protection and new cross culverts from opposite side of the road
- Designed for 100-year flood and minor damage from 500-year flood
- Damage Frequency Module necessary to determine BCR
- Traffic counts for Route 47 were moderate at 466
  - ✓ $41,000 per day benefit when combined with the detour!
  - ✓ Status as a key access route for the YMCA camp was not needed

Date	Event	Damages	Indirect Costs
6/28/06	8-yr flood	$8,000	1 lane open
8/28/11	20-yr flood*	$595,000	Closed 6 days
9/18/12	11-yr flood	$104,000	Closed 3 days

*When is it good for a big flood to plot as a frequent event? When calculating BCRs!

#6 – "S-Turn" Bank Stabilization





- Project cost estimate was $645,426
- Benefits were $825,106 vs. total costs of $659,227
- BCR = 1.25
- Project advanced to HMGP
- Lesson: don't oversell Irene; if it was a 20-year flood at the nearest gauge, go with it
- Lesson: long detours will offset low traffic counts

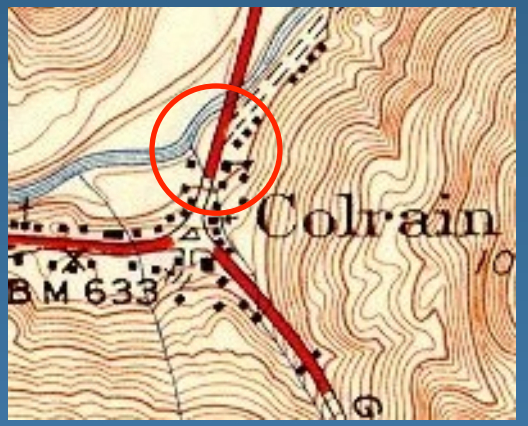
A Postscript to #6 – "S-Turn" Bank Stabilization

- The 60% design cost estimate is $804,000
- Recall that benefits were $825,106
- Revised BCR = 1.01
- HMGP application will need to be amended
- Lesson: always make sure your BCR doesn't start at 1.0. A small buffer is good to have when the application is submitted.*

*Advice from FEMA Region 1

#7 – Colrain Highway Garage Relocation

- The North River flooded the highway garage during Irene
- Basement and garage were inundated but the office was spared by an inch
- This is a critical facility in this small town
- Town's objective was to rebuild the highway garage elsewhere

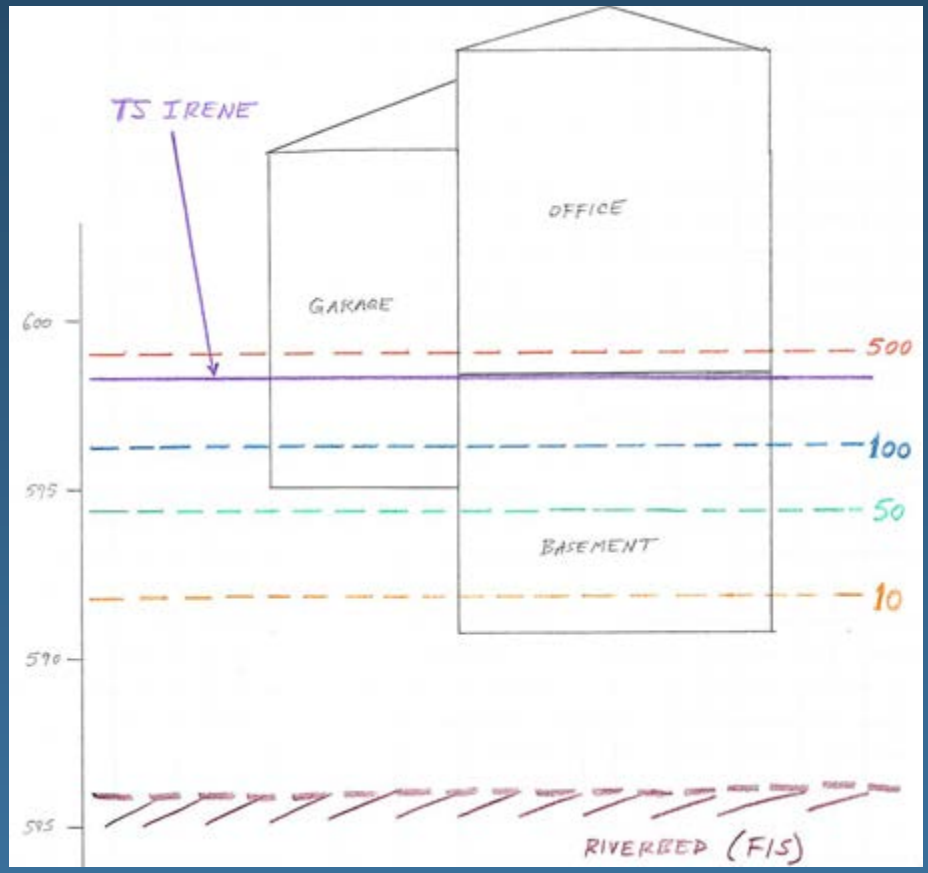


#7 – Colrain Highway Garage Relocation

- Objective: relocate the highway garage from the SFHA
- Either Flood Module or Damage Frequency could be used to determine BCR
- Damage Frequency Module:
  - ✓ The highway garage was flooded twice in its history (1938 & Irene)
  - ✓ The damage from Irene was $76,000
  - ✓ The degree of damage in 1938 was reportedly the same
- Flood Module:
  - ✓ FIS elevations published
  - ✓ Building elevations were available from the town
- The Town already owns the land and therefore would not need to acquire it
- Complication was that the building may not survive a relocation
- Constructing a new highway garage elsewhere was more feasible but less eligible under HMGP

#7 – Colrain Highway Garage Relocation

- Project cost assumed = $500,000 for a new highway garage or a relocation
- Benefits = $30,000 from DF Module
- Benefits = $36,000 from Flood Module
- BCR = 0.07
- The building doesn't flood frequently enough!
- Should it be in the SFHA? No
- Is it a good project? Yes
- BCR > 1.0? No
- Lesson: frequent damage is needed for BCR > 1.0; but critical facilities should be outside the 500-year flood zone



#8 – Shelburne Falls Wellfield Protection/Mitigation

- The water supply wells for Shelburne Falls are along the North River
- The site was flooded and scoured during Irene
- This caused a temporary loss of supply for the Village of Shelburne Falls
- Objectives would be to elevate wellheads and/or protect the control house

#8 – Shelburne Falls Wellfield Protection/Mitigation

- Additional scoping was necessary – what was really needed?
- The water department determined that the wellheads were not the issue
- The well control building was flooded by Irene and this caused the outage
- The water elevation was higher than the 500-year flood elevation
- Objective was to utilize the Flood Module or the Damage Frequency Module to determine BCR
- Mitigation could include elevation of the building and/or dry floodproofing

#8 – Shelburne Falls Wellfield Protection/Mitigation

- DFA module suffered from lack of information
- Flood module utilized the FIS and building elevations
- Project cost assumed = $20,000
- Base of the building is *already* above the 100-year flood elevation
- Low frequency contributes to generated benefits of $1,500
- BCR = 0.08
- Should it be in the 500-yr? No
- Is it a good project? Yes
- BCR > 1.0? No
- Lesson: frequent damage is needed for BCR > 1.0; but critical facilities should be outside the 500-year flood zone

WHAT HAVE WE LEARNED?

- Many mitigation projects may alleviate flooding, erosion, etc.
- These may be good projects, but only some are cost-effective to FEMA
- Linkage to critical facilities, utilities, busy roads, and/or long detours will increase BCRs
- Frequent events will drive up the BCR
- Infrequent events will not drive up the BCR
- Don't be tempted to apply for mitigation funds for a project designed to address damage caused only by "the Irenes"
- A thoughtful and methodical selection process will successfully result in BCRs >1.0 and capture mitigation funding from FEMA

WHAT HAVE WE LEARNED?

But what else did we learn? – Lessons learned in 2012/2013:

- After a disaster, there may be a strong desire to put rivers back together
- Without a way to link "restoration" to benefits, BCA isn't possible
- Towns may not be able to "see" the best projects while recovering
- Perhaps we need to search for good projects when we aren't busy recovering – but will this discourage us from mitigating after disasters?

Pre or Post-Irene	BCR	Type of Project	Outcome
Pre	2.01	Landslide Stabilization	Funded under HMGP
Post	**1.33**	**Route 112 Riverbank Stabilization**	**Under Consideration**
Post	**1.25**	**S-Turn Riverbank Stabilization**	**Under Consideration**
Pre	1.13	Deerfield River Bank Stabilization	Funded under HMGP
Post	**1.04**	**Highway Garage Bank Stabilization**	**Under Consideration**
Pre	1.01	Culvert Replacement	Funded under HMGP
Post	**0.08**	**Well Control House Floodproofing**	**Not submitted**
Post	**0.07**	**Highway Garage Relocation**	**Not submitted**

IMPORTANT CHANGES IN 2013-2014

1. Standby power supplies are eligible for FEMA mitigation funds
2. Acquisitions are automatically cost-effective if <$275,000 and located in the SFHA
3. Elevations are automatically cost-effective if <$176,000 and in located the SFHA
4. Open space and riparian area benefits can be included in the BCR once it reaches 0.75 or greater
5. Non-stationary hazards (i.e., progressive bank erosion) can be evaluated more effectively rather than waiting for the "failure/ no failure" scenario
6. Volunteer time can be counted for tallying avoided response
7. Social benefits (avoided mental health issues) can be counted
8. Sea level rise can be considered

IMPORTANT CHANGES IN 2013-2014

- How can the non-stationary hazard guidance help?
- Consider our landslide and riverbank examples:
  - ✓ The head of the landslide has already reached the road
  - ✓ The Deerfield River is within striking distance of the sewer trunk
  - ✓ The North River bank is within striking distance of Route 112
  - ✓ The Hawley Highway Garage can't wait any longer
- Wouldn't it be better to evaluate projects *before* failure is imminent?

CASE STUDIES

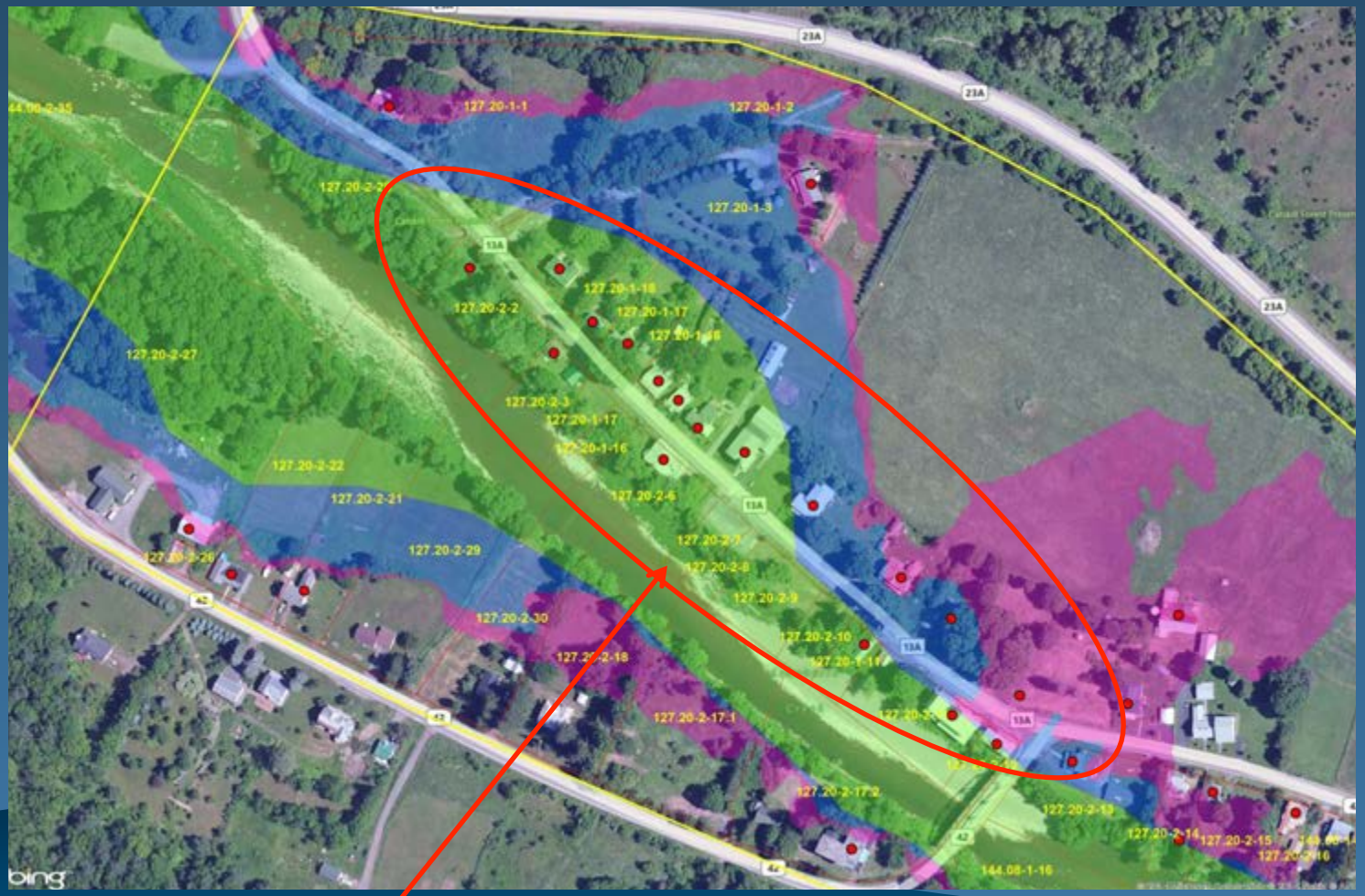
Local Flood Analysis (LFA) in Prattsville and Lexington

PRATTSVILLE LFA

- Evaluation of building acquisitions
  - ✓ 18 commercial and residential buildings in the SFHA were run through a preliminary BCA using assessed values, approximate elevations, and the FIS hydraulic profile
  - ✓ BCRs ranged from 0.03 to 10.63, with only nine BCRs >1.0
- How can the automatic cost-effectiveness help?
  - ✓ 17 of 18 commercial and residential acquisitions may be cost-effective under the new policy

LEXINGTON LFA

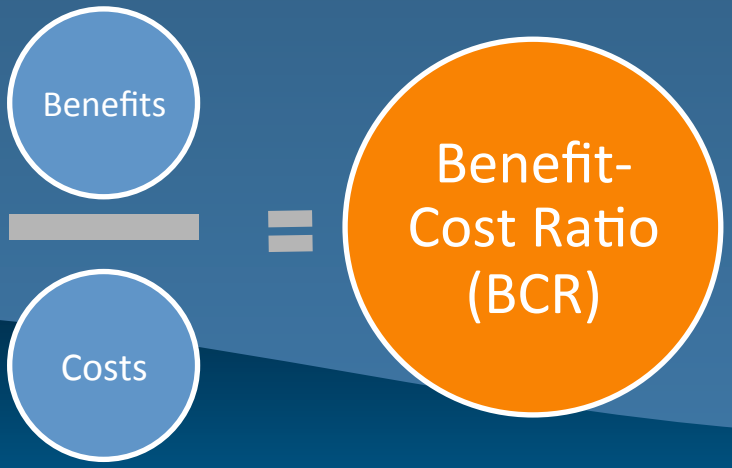
- Evaluation of bridge replacement and floodplain bench creation



MILONE & MACBROOM®

LEXINGTON LFA

- Evaluation of bridge replacement and floodplain bench creation
  - ✓ 20 residential buildings and the old hotel in the SFHA were run through the Flood Module to generate benefits (not to generate BCRs)
  - ✓ Benefits ranged from $1,700 to $47,000 per house
  - ✓ Benefit approximately $229,000 for hotel
  - ✓ These benefits will then be summed outside of the BCA program, and the sum will become the numerator in the BCR



LEXINGTON LFA

- It is possible that the BCR will not be greater than 1.0
- Next steps:
  - ✓ Evaluate other funding sources
  - ✓ Evaluate building acquisitions and elevations – some of them may qualify for automatic cost effectiveness under the "275/176" policy released in 2013

QUESTIONS

Links to BCA Resources

Benefit Cost Toolkit Version 5.0 Download

- http://www.fema.gov/media-library/assets/documents/92923

Benefit Cost Analysis Training Manuals

- http://www.fema.gov/media-library/assets/documents/28998
  - Dave Murphy recommends these manuals even though they are for an older version of the toolkit.