Transportation Resilience Planning Tool (TRPT)

MUNICIPAL DAY, 2023

OCTOBER 20, 2023

SLR

Fitzgerald Environmental Associates, LLC.

Applied Watershed Science & Ecology

DuBois & King inc.

STONE ENVIRONMENTAL

smart mobility

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Project Partners

Vermont State Agencies

- Agency of Transportation
- Agency of Digital Services
- Agency of Natural Resources
- Emergency Management
- Agency of Commerce and Community Development

Project Consultants

- SLR Consulting
- Fitzgerald Environmental
- Stone Environmental
- University of Vermont
- Smart Mobility
- DuBois & King

Regional Planning Commissions

- Addison County Regional Planning Commission (ACRPC)
- Bennington County Regional Commission (BCRC)
- Central Vermont Regional Planning Commission (CVRPC)
- Chittenden County Regional Planning Commission (CCRPC)
- Lamoille County Planning Commission (LCPC)
- Mount Ascutney Regional Commission (MARC)
- Northeastern Vermont Development Association (NVDA)
- Northwest Regional Planning Commission (NRPC)
- Rutland Regional Planning Commission (RRPC)
- Two Rivers-Ottauquechee Regional Commission (TRORC)
- Windham Regional Commission (WRC)

Agenda

1. Introduction
2. Vulnerability Analysis and Scoring
3. Criticality Analysis and Scoring
4. Demo and Q&A
5. Additional Resilience Efforts and Resources

Irene and July 2023

- State Highway Costs (Emergency and Permanent Repairs)
  - Irene: ~ $138M
  - VT23-1: ~ $142M

- In the time between the two storms 2011-2023 Vermont Agency of Transpiration:
  - Programmed $229.4 million of Federal emergency relief assistance
  - **Nearly 130 projects**, ranging from minor damage repair to major reconstruction of bridges and highways, were accomplished.
  - These project locations either had **none or very minimal** damage from the July 2023 event

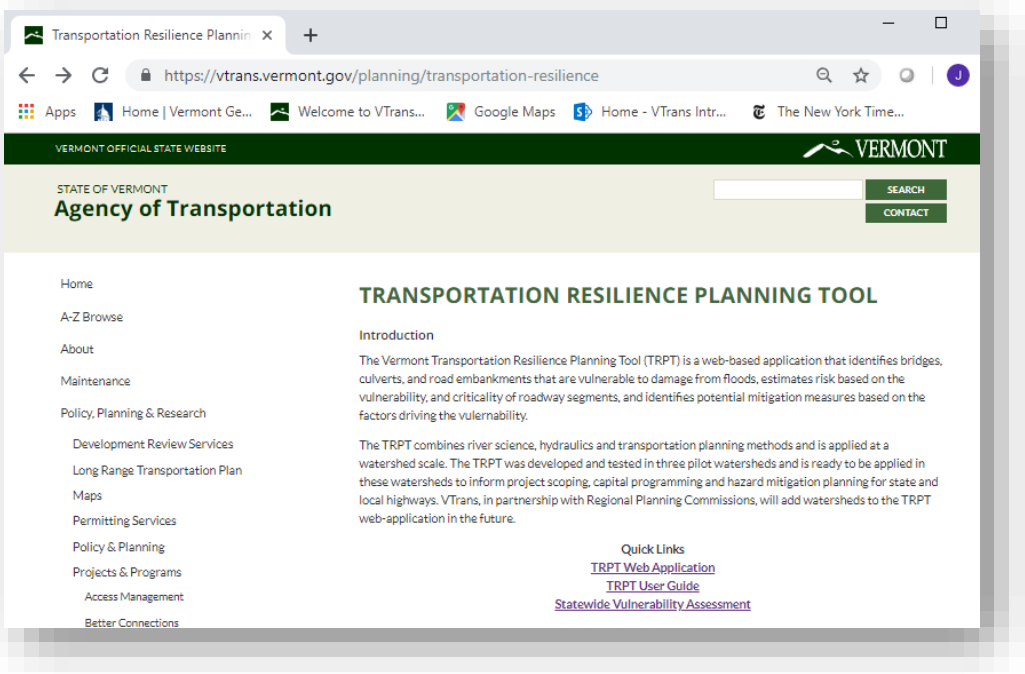
TRPT Website

- Direct link to TRPT

https://roadfloodresilience.vermont.gov

- Link to VTrans TRPT Website

https://vtrans.vermont.gov/planning/transportation-resilience



https://resources.vtrans.vermont.gov/vtransResilienceAppTEST/#/map

Flood Levels

Recurrence Interval (years)	Annual Exceedance Probability (AEP; %)	Typical Scenario
10	10%	High-intensity, short-duration summer thunder burst
50	2%	Local floods from repetitive thunderstorms in one or more watersheds in short periods of times (i.e., training storms) resulting in localized loss of structures and road segments
100	1%	Regional floods such as nor'easters and tropical storms that impact large areas of the state with major road and infrastructure loss

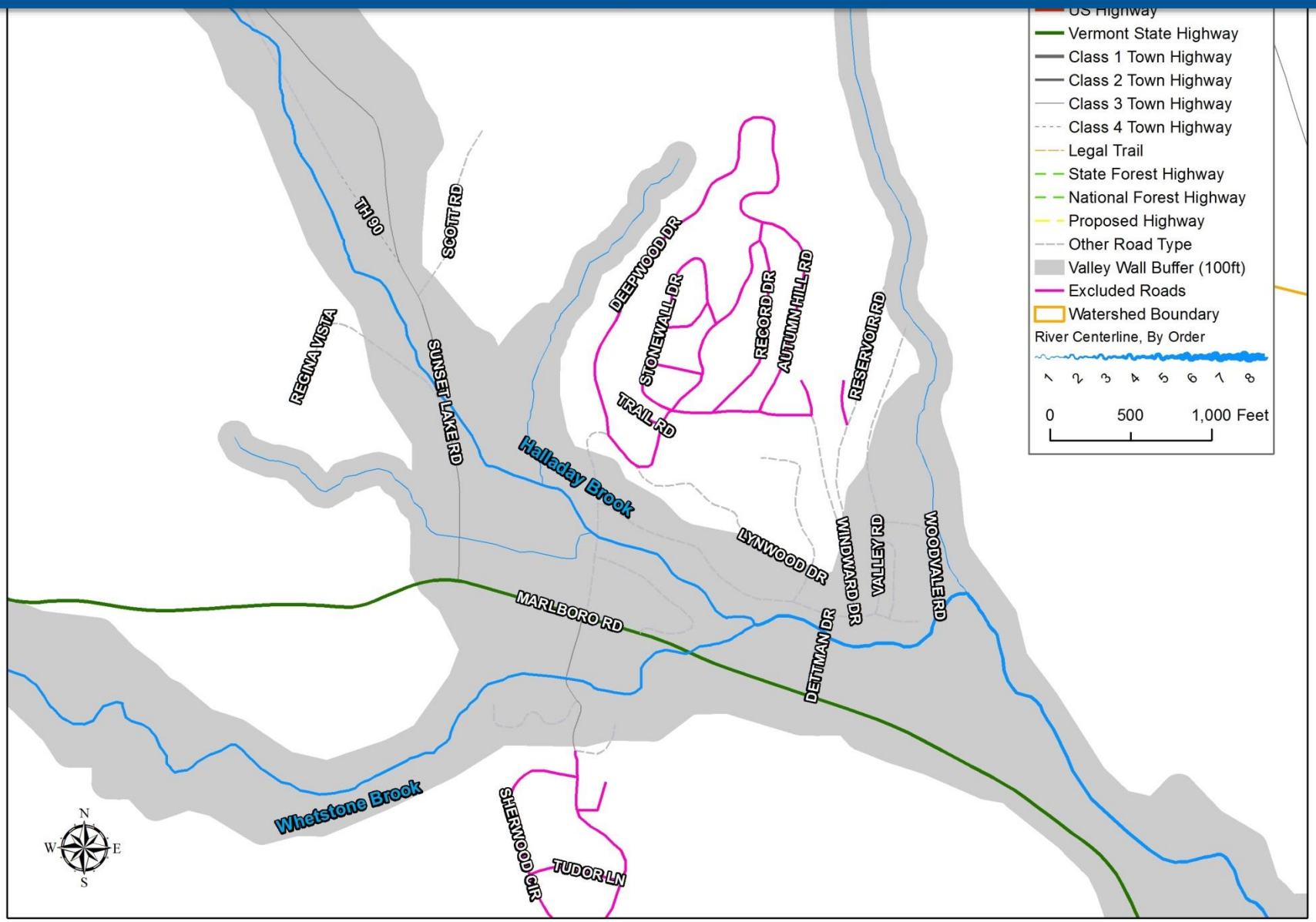
Definitions

Vulnerability: The extent that a transportation asset is exposed to a threat from inundation, erosion, or deposition.

Criticality: How important is the transportation asset that dictates the consequence of the disruption to mobility due to damage.

Risk: The combination of the probability of vulnerability and criticality.

Where is Vulnerability Unlikely?



Any road segment <u>not</u> within 100-feet of a valley floor were assigned a vulnerability of 0.

Inundation, Erosion, Deposition

Great Brook
Brook Road Damage, 10-Year Flood
Plainfield, VT
7/19/2015
Photo taken by B. Towbin

Great Brook
Brook Road Damage, 10-Year Flood
Plainfield, VT
7/20/2015
Photo taken by B. Towbin

Inundation

Winooski River
Cochran Road in Richmond, VT
8/29/2011
Photo taken by Shem Roose Photography

Erosion

Mendon Brook
US 4 in Mendon, VT
9/1/2011
Photo taken by J. Louisos

Deposition


Money Brook,
Route 100 in Plymouth, VT
1973
Photo taken by M. Tucker

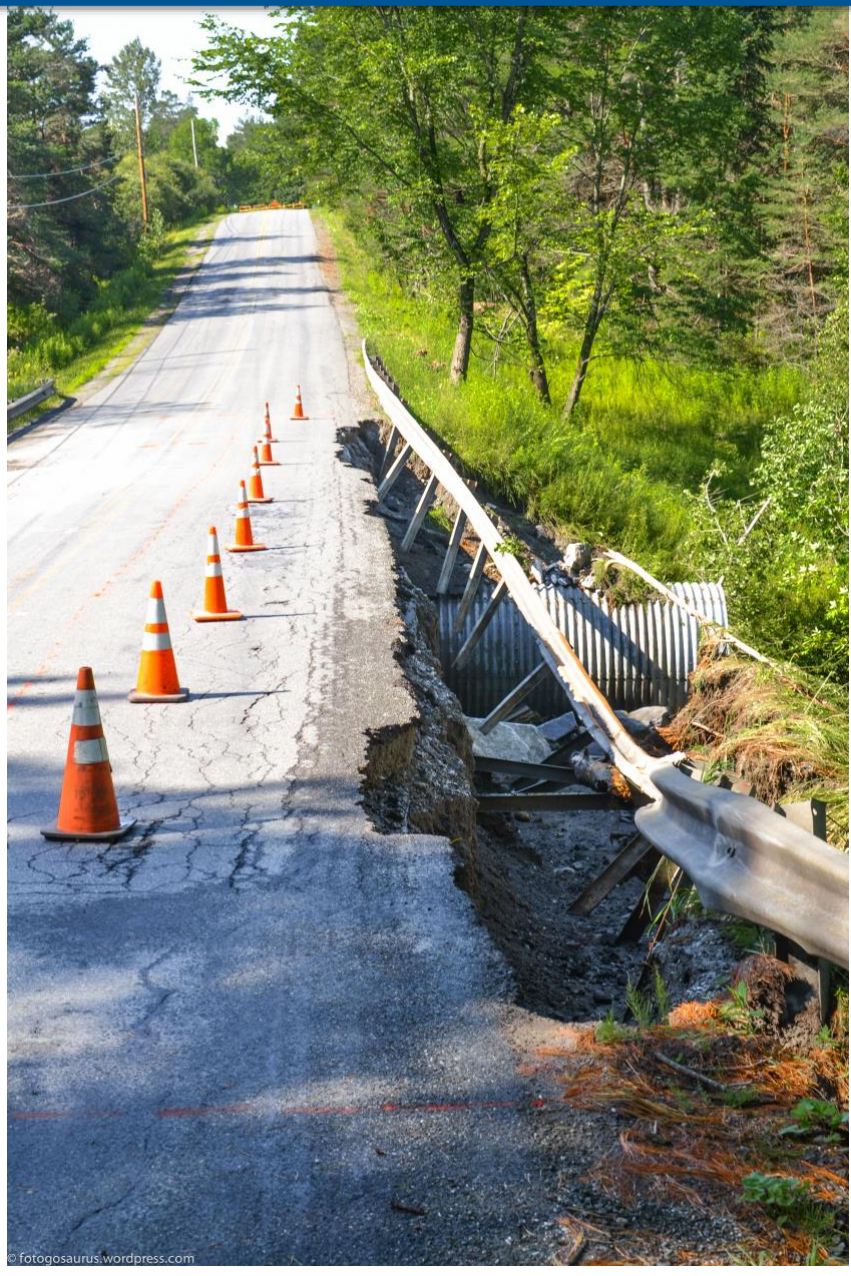
Failure Modes

Failure Mode	Influence	Damage Distance	Vulnerability Type
Partial Closure	<24 hours Single lane closure Shoulder repair Reduced capacity with some travel	100 feet or less	Temporary inundation Minor erosion Minor deposition
Full Closure	24 hours to several days Multi-lane closure Detour required	100s of feet	Large-scale Inundation Localized erosion Localized deposition
Temporary Failure	Partial destruction of facility Days to a week for recovery Maintain one lane if possible Detour required	100s to 1,000s of feet	Erosion Deposition Large-scale Inundation
Complete Failure	Complete destruction of facility A week to months for recovery Long-term travel disruptions	Varies	Erosion Deposition

(Adapted from FHWA and WSDOT, 2019)

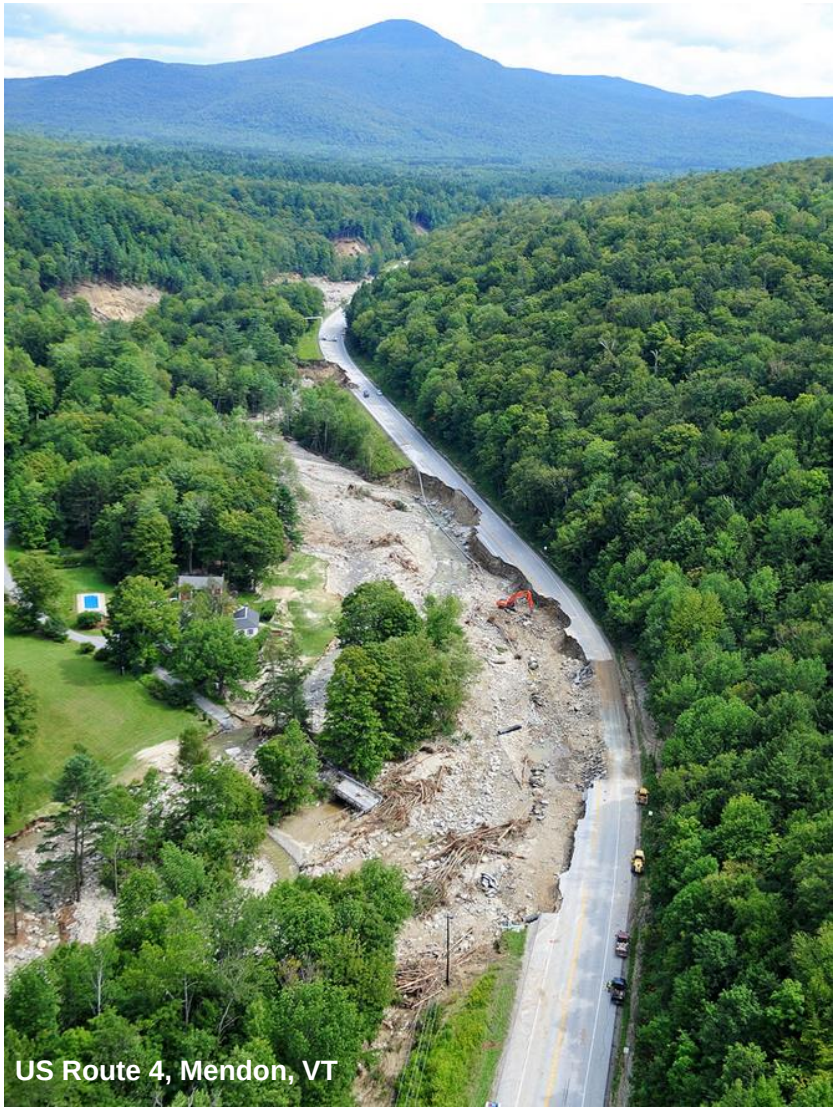
Failure Mode - Partial Closure

Great Brook
Creamery Street in Plainfield, VT
5/27/2011
Photo taken by G. Springston



Great Brook
Brook Road in Plainfield, VT
7/20/2015
Photo taken by B. Towbin

Failure Mode – Complete Failure



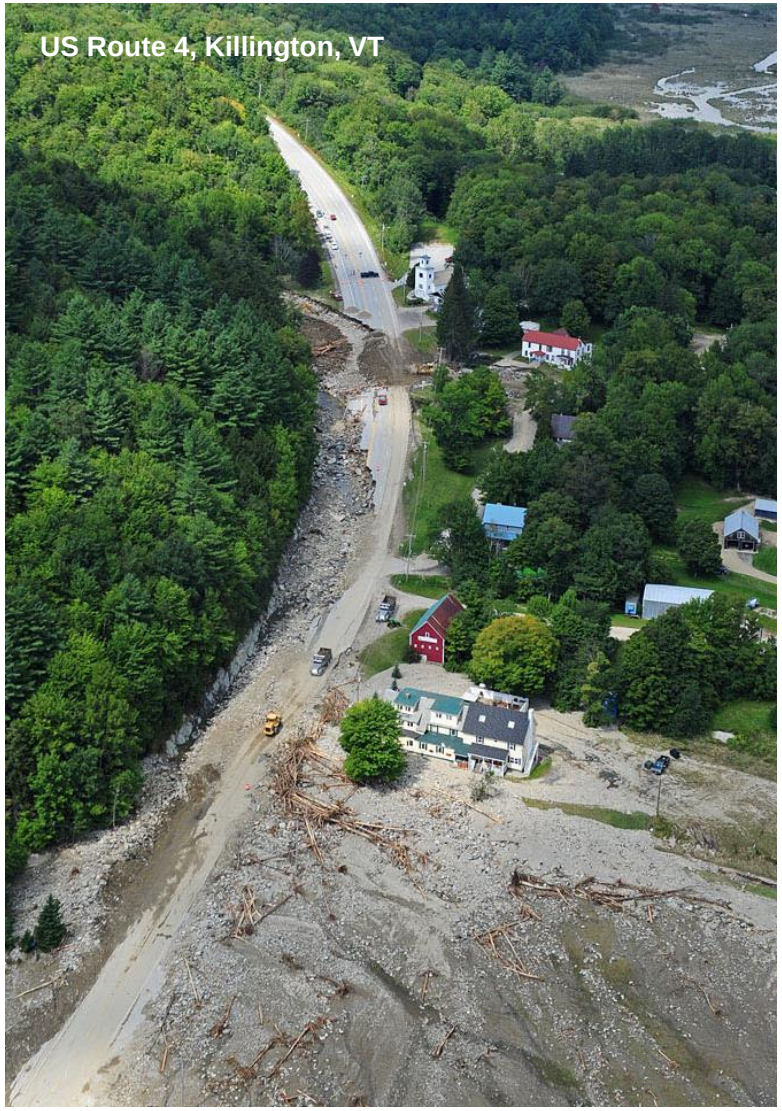


Photo credits: Lars Grange, Mansfield Heliflight

Vulnerability Variables

	VARIABLES				SCALE		
More detailed variables	Inundation	Erosion	Deposition		Road Segments	Structures	River Segments
* Documented Past Damages	√	√	√		√	√	
* River-Roadway Relief (feet)	√				√		
Incision Ratio and Entrenchment Ratio	√	√					√
* FEMA 100-Year Flood Depth Above Road (feet)	√				√		
Length of Road in 100-Year Floodplain (feet)	√				√		
* Bridge/Culvert Invert-Roadway Relief (feet)	√					√	
Structure Width vs. Bankfull Channel Width (%) (HGR-based)	√	√	√			√	
Specific Stream Power (W/m^2)		√	√				√
Dominant Substrate Size		√					√
Valley Confinement		√					√
Remaining River Corridor Width where the ROW or Development Confine River (%)		√			√		
Length of ROW in River Corridor (feet)		√	√		√		
Erosion (SGA Data, GC Screen)		√				√	
Armoring (SGA Data, GC Screen)		√				√	
Culvert Slope (SGA Data, GC Screen)		√				√	
5% or Larger Slope Decrease Areas (count)			√				√
3rd Order or Larger Confluences (count)			√				√
* Change in Confinement Ratio from Upstream Reach			√				√
Road Crossings (count)			√		√		
* Mass Failures in Upstream Reach (feet)			√				√
Bank Erosion in Upstream Reach (% of Channel Length)			√				√
Channel Slope (SGA Data)			√				√
Sediment Discontinuity (SGA Data, GC Screen)			√			√	
Approach Angle (SGA Data, GC Screen)			√			√	
Less detailed variables (to replace more detailed variables when they do not exist)							
Valley Slope	√						√
Surficial Landform in Corridor Area		√					√
Steep slopes in Upstream or First Order Reach (feet)			√				√

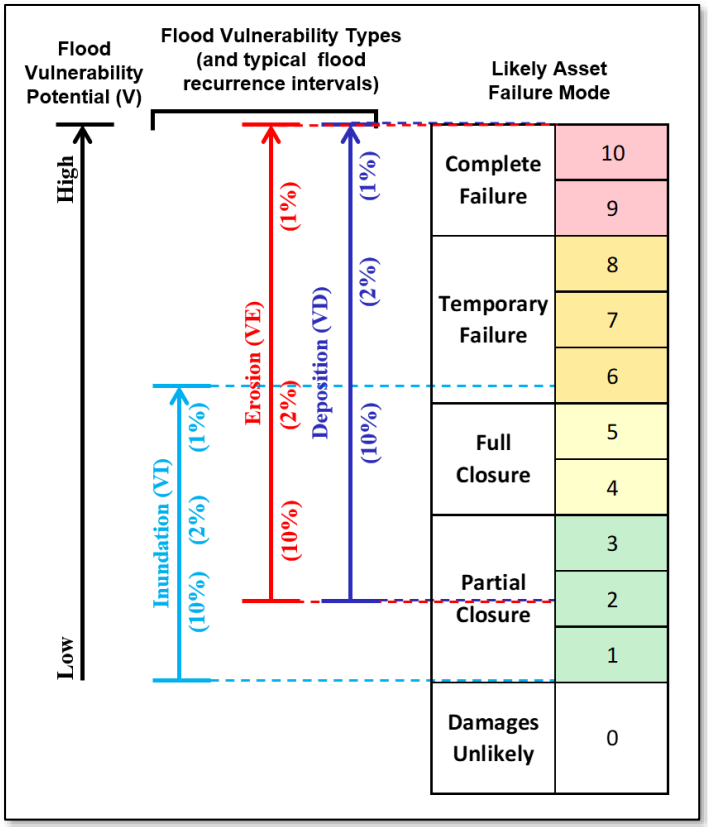
Vulnerability

$V_{\text{ROAD EMBANKMENT}} = MAX(V_{I,ROAD}; V_{E,ROAD}; V_{D,ROAD})$

$V_{\text{BRIDGES}} = MAX(V_{I,\ BRIDGES}; V_{E,BRIDGES}; V_{D,BRIDGES})$

$V_{\text{CULVERTS}} = MAX(V_{I,CULVERTS}; V_{E,CULVERTS}; V_{D,CULVERTS})$

where: I = inundation, E = erosion, D = deposition



Criticality

1. **Network Criticality**
   - Impact on travel due to failed trips and delays associated with simulated flood damage

2. **Critical Closeness Accessibility**
   - Importance of a road link access to critical facilities such as hospitals

3. **Locally Identified Importance**
   - Importance of a road for local use as reported by residents

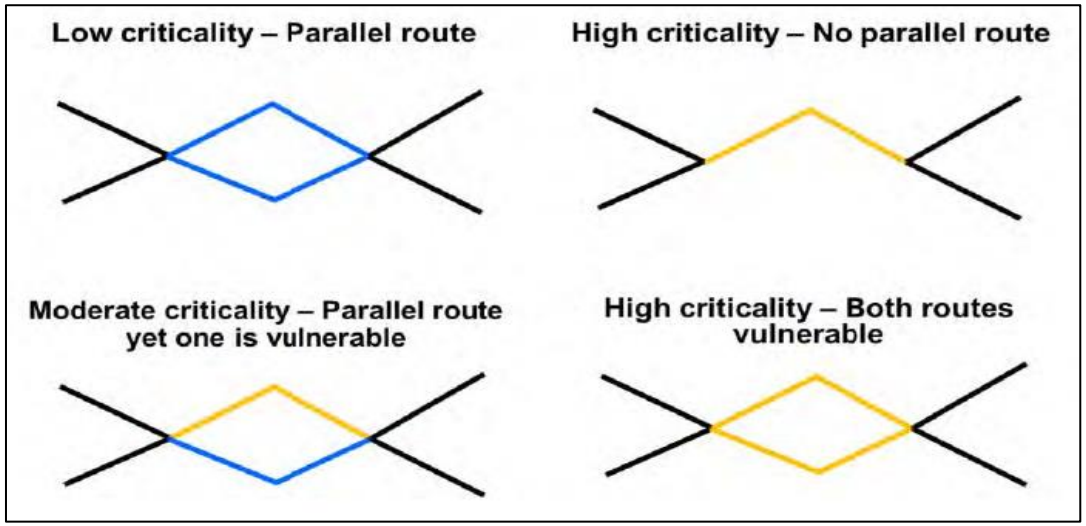
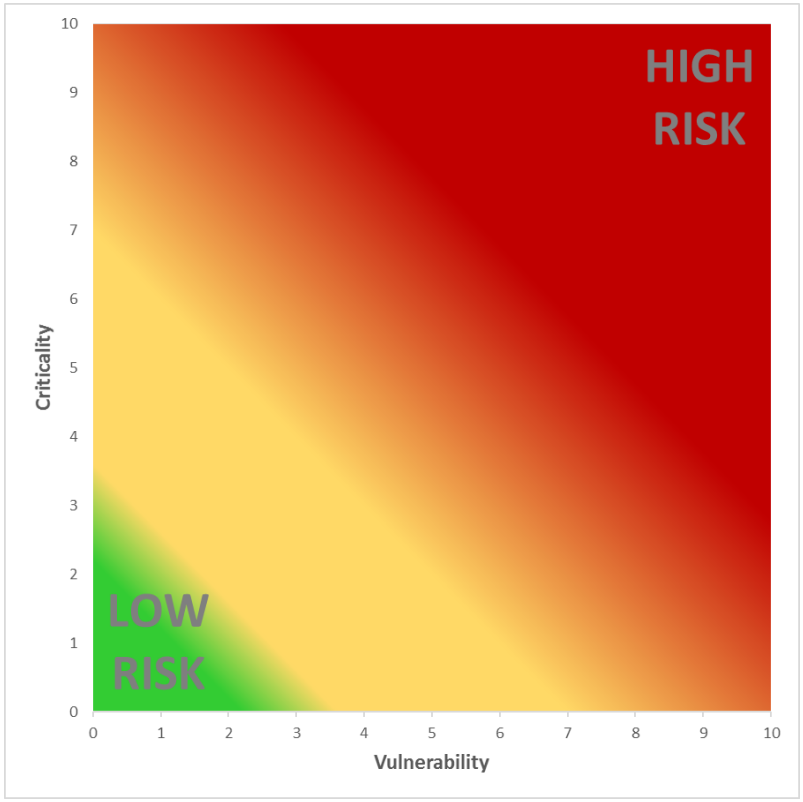
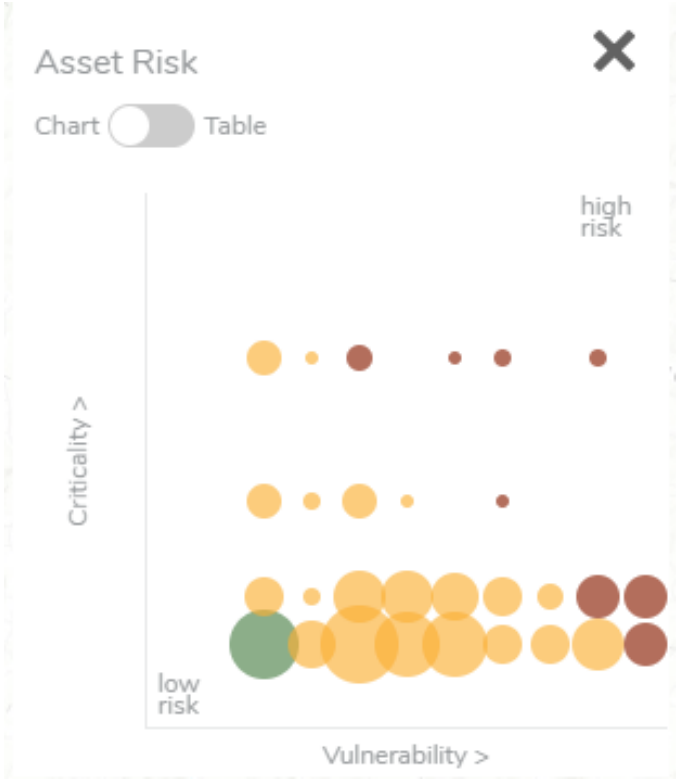


Illustration of vulnerability-based criticality showing low (blue) and high (orange) criticality scenarios

Risk

Risk is equal to the average of Vulnerability and Criticality.





Value	Risk
> 5	High
2-5	Medium
0-2	Low

Statewide Field QA

TRPT properly identified risk at 9 of 10 sites visited.

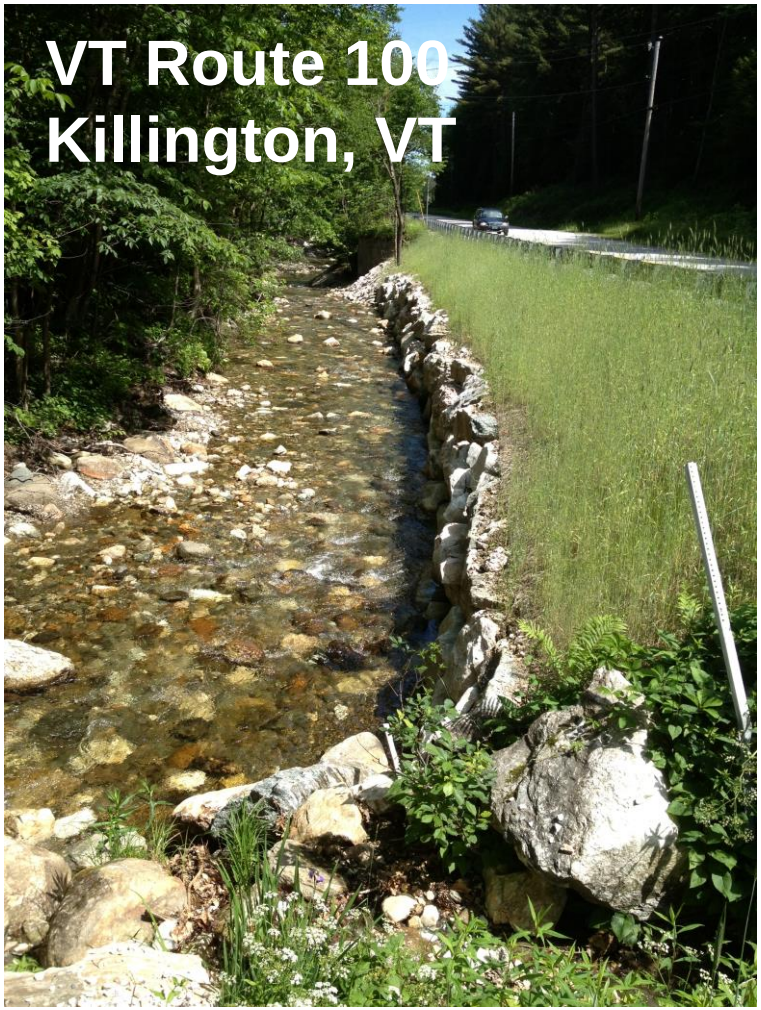
TRPT Limitations

- The TRPT is static data viewer. Conditions may have changed if damages have occurred or a mitigation project was implemented.

- Errors are possible with a watershed-based analysis where GIS data do not resolve key site features such as bedrock or disconnected floodplains.

Mitigation

Placed riprap wall

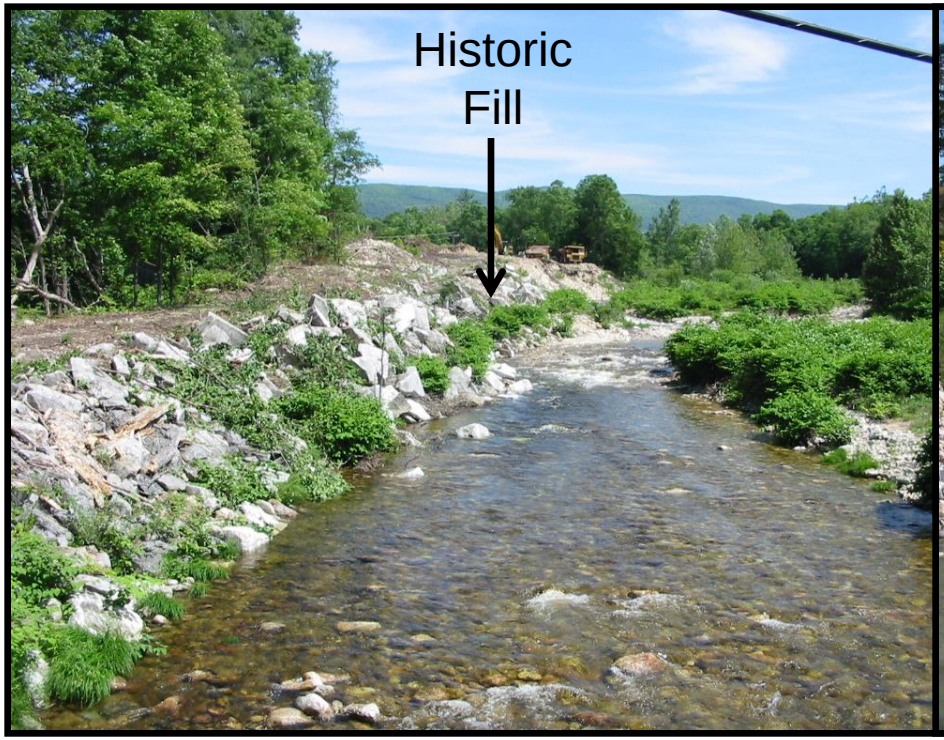


VT Route 155, Mt. Holly, VT

(E. Fitzgerald, 2013)

Mitigation

Floodplain Restoration Example



Roaring Branch
Bennington, VT
2008

Roaring Branch
Bennington, VT
2010

Demo

https://vtrans.vermont.gov/planning/transportation-resilience

Additional Resources

- Part 667 Reducing Repeat Damage Tool
- VTrans Resilience Improvement Plan (RIP), RIP analysis, and PROTECT
- FHWA Emergency Relief (ER) Program

Thank You!

- Link to VTrans TRPT Website

https://vtrans.vermont.gov/planning/transportation-resilience

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