GREEN INTERNATIONAL AFFILIATES, INC.
CIVIL AND STRUCTURAL ENGINEERS

MILONE & MACBROOM

Mount Holly ER STP 0133(8)

Vegetated Slope Stabilization along VT Route 155

ACEC VT 5th Annual Technical Transfer Presentation

March 11, 2020

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American Council of Engineering Companies of Vermont

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Introduction

Project Owner

VTrans

- **Bruce Martin, P.E. – Project Manager**

Engineers of Record

Green International Affiliates, Inc.

- **Thomas Bigelow, P.E.**

Milone & MacBroom

- **Roy Schiff, P.E, Phd**

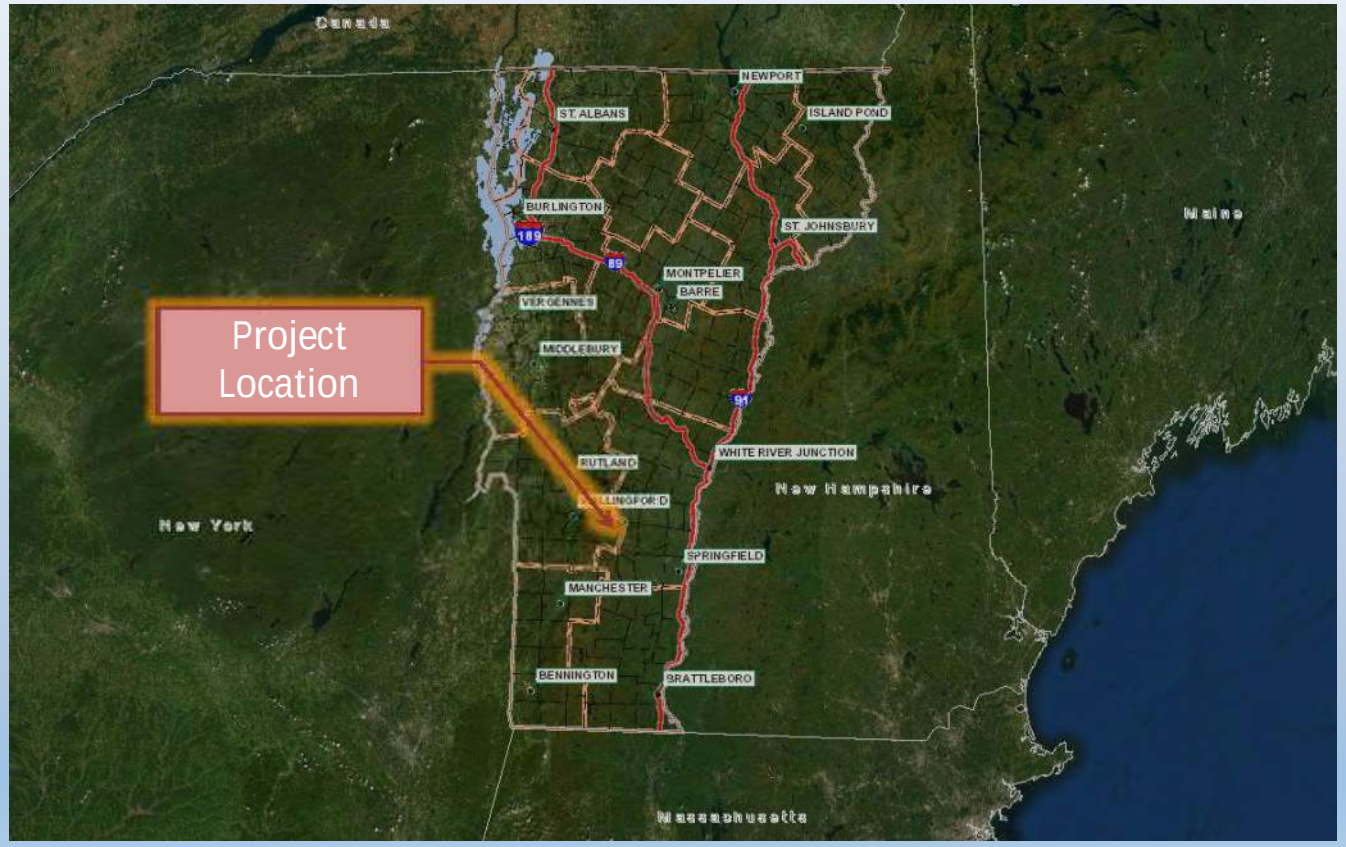
Agenda

- Project Purpose
- Pre-Construction Conditions and Issues
- Proposed Design
  - Stream geomorphology
  - Stone toe design
  - Vegetated slope design
  - Culvert and slope swale design
- Constructability Considerations
- Final Condition
- Lessons Learned

Project Purpose

- **Rebuild and stabilize the failing roadway embankment**
- **Create a resilient roadway and slope**
- **Reconstruct the failing roadway (VT Route 155)**
- **Replace undersized culverts**

Project Location



(vtransmaps.vermont.gov)

ECAP5 Add callouts to the project site, Manchester, VT 100, VT 11 and VT 30 and US ROute 7

Erik C. Atkins, P.E., 2/14/2019

Project Location

(Google Earth)

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Erik C. Atkins, P.E., 2/14/2019

Project Location

(Google Earth)

Fun Fact

- **Horatio Earle was born in 1855 Mount Holly**
- **Known as the "Father of Good Roads"**
- **Created the world's first mile of concrete road in Detroit, MI**

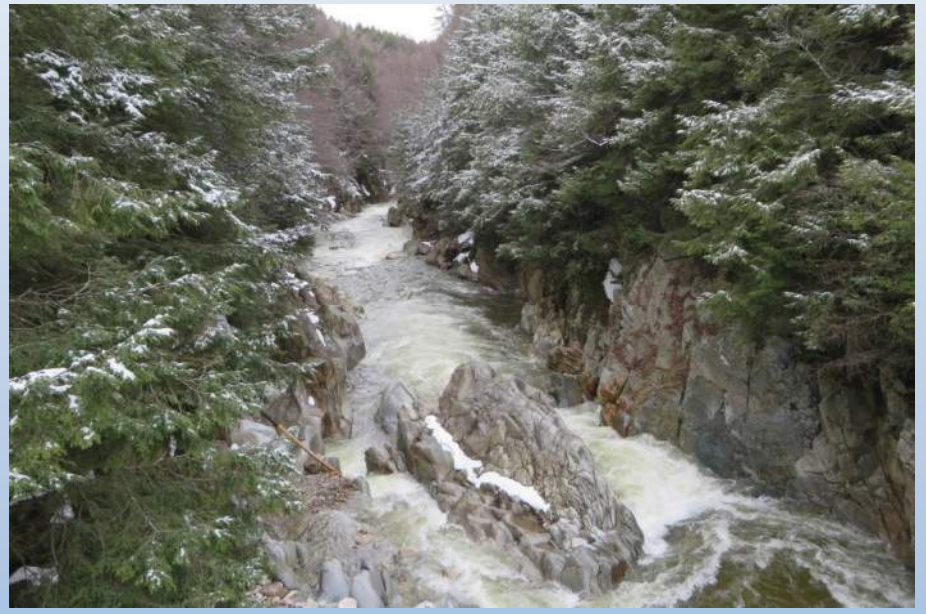
(Michigan.gov)

(explorer.acpa.org)

Brief History

Mill River

- The Mill River was once a major avenue of transportation for the Algonquin and Iroquois people.
- In the late 1700's colonist settlements were established near gristmills and sawmills at suitable sites along the river.
- There were at least a dozen mills working along the river during the 18th and 19th centuries.
- While the mills were at work utilizing the water in the river, transportation routes were being established in the valley carved by the Mill River and its tributaries.

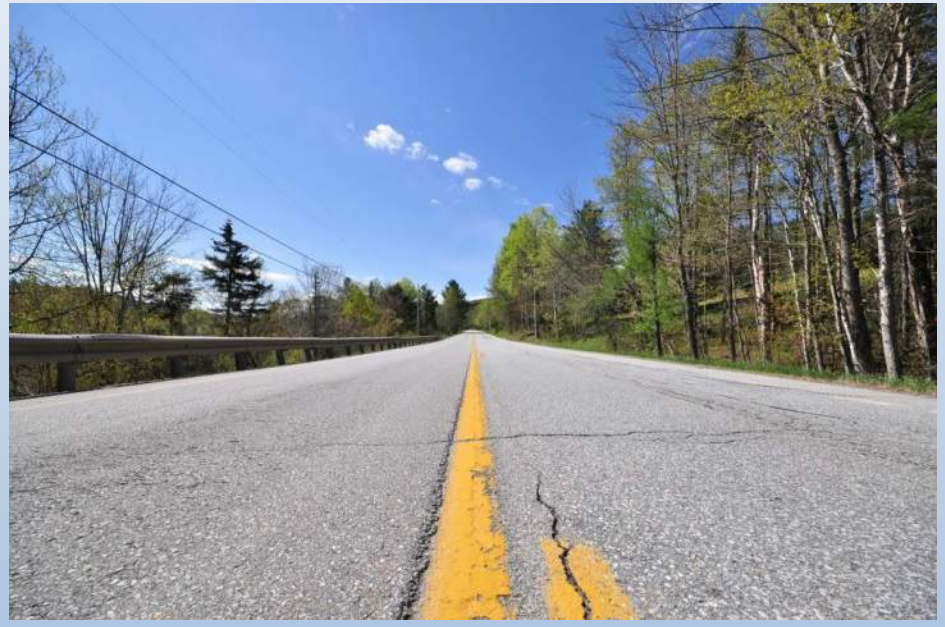


(Wikipedia.org)

Brief History

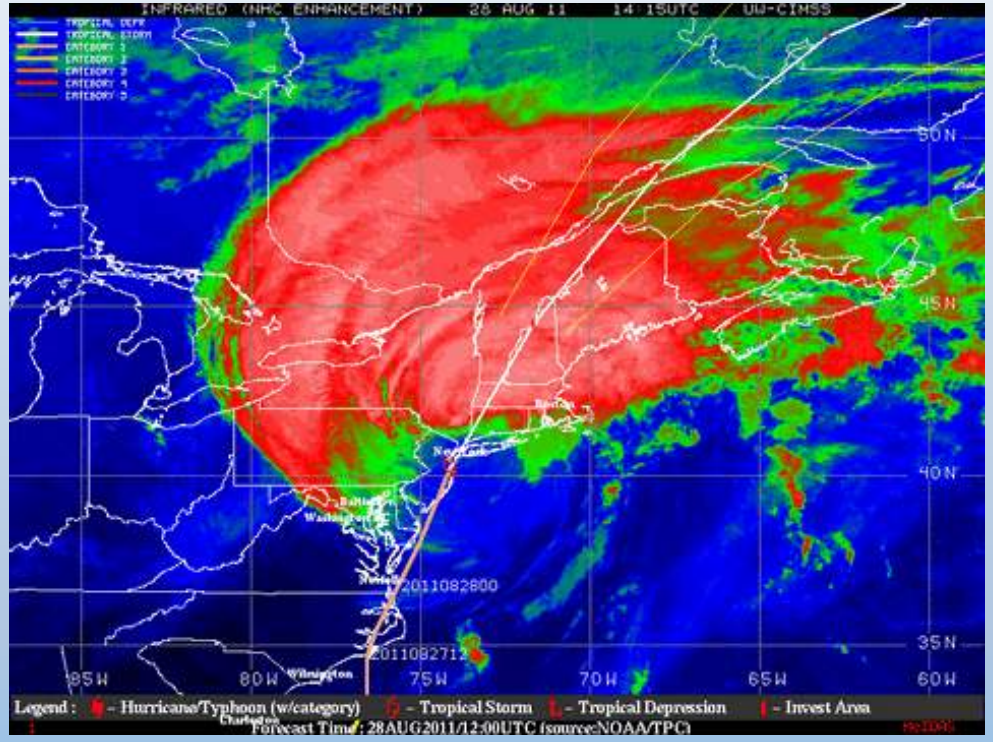
VT Route 155

- 10 miles of two-lane highway constructed in May 1961
- The roadway was previously designated VT Route 8 until the section between Weston and Wallingford was re-designated as VT Route 155.
- Much of it borders the Green Mountain National Forest
- Important regional north/south Route east of US Route 7



Tropical Storm Irene

- **Tropical Storm Irene struck Vermont on August 29**
- **Irene dumped as much as 11 inches of rain on parts of Vermont**
- **Resulted in $733 million in damage.**



(NOAA/TPC)

Project Site in 2009, Before Irene

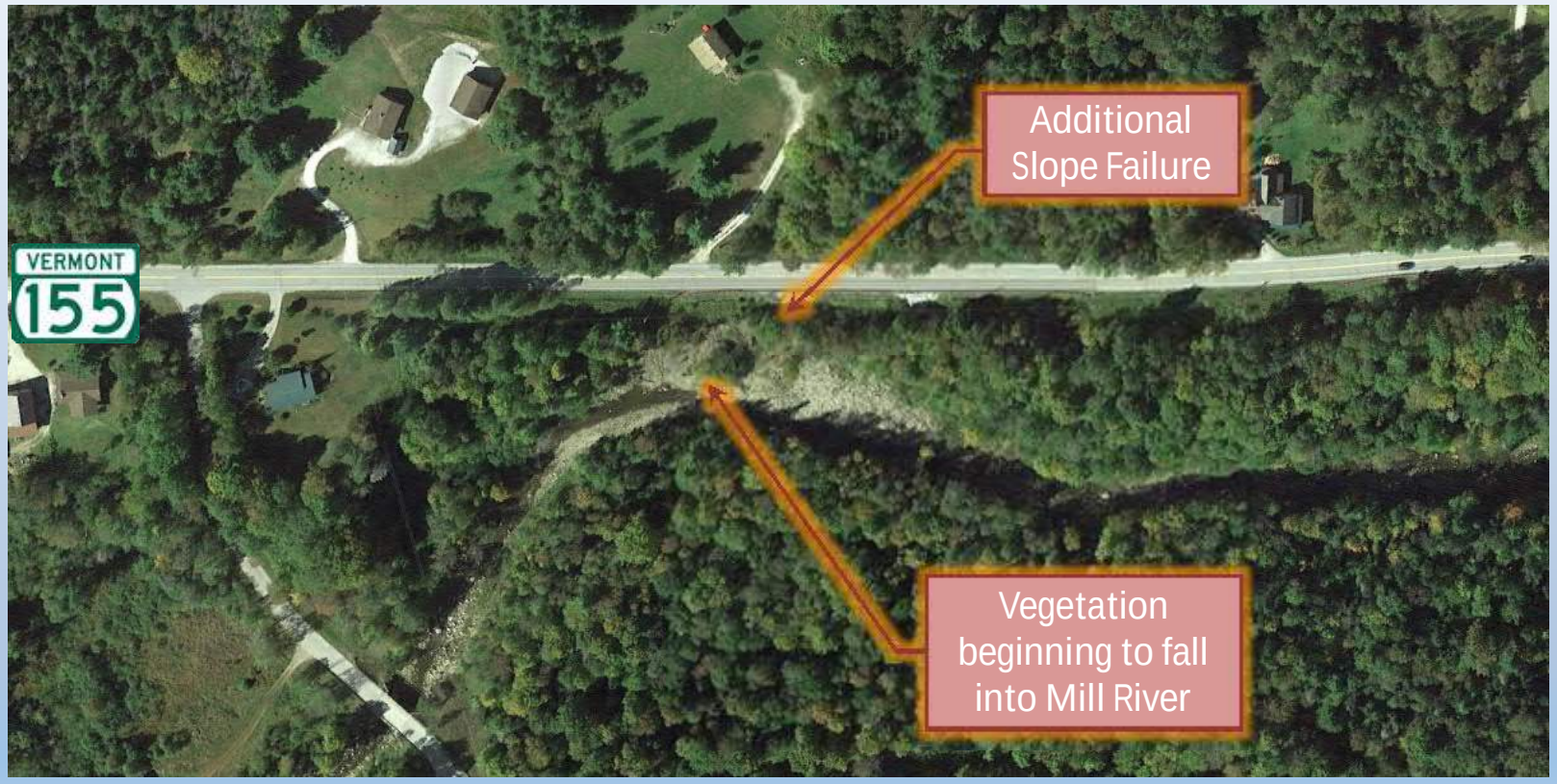
(Google Earth)

Project Site in 2011, After Irene

(Google Earth)

Project Site in 2012

Project Site in 2013



(Google Earth)

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Project Site in 2013

Additional Slope Failure

Vegetation beginning to fall into Mill River

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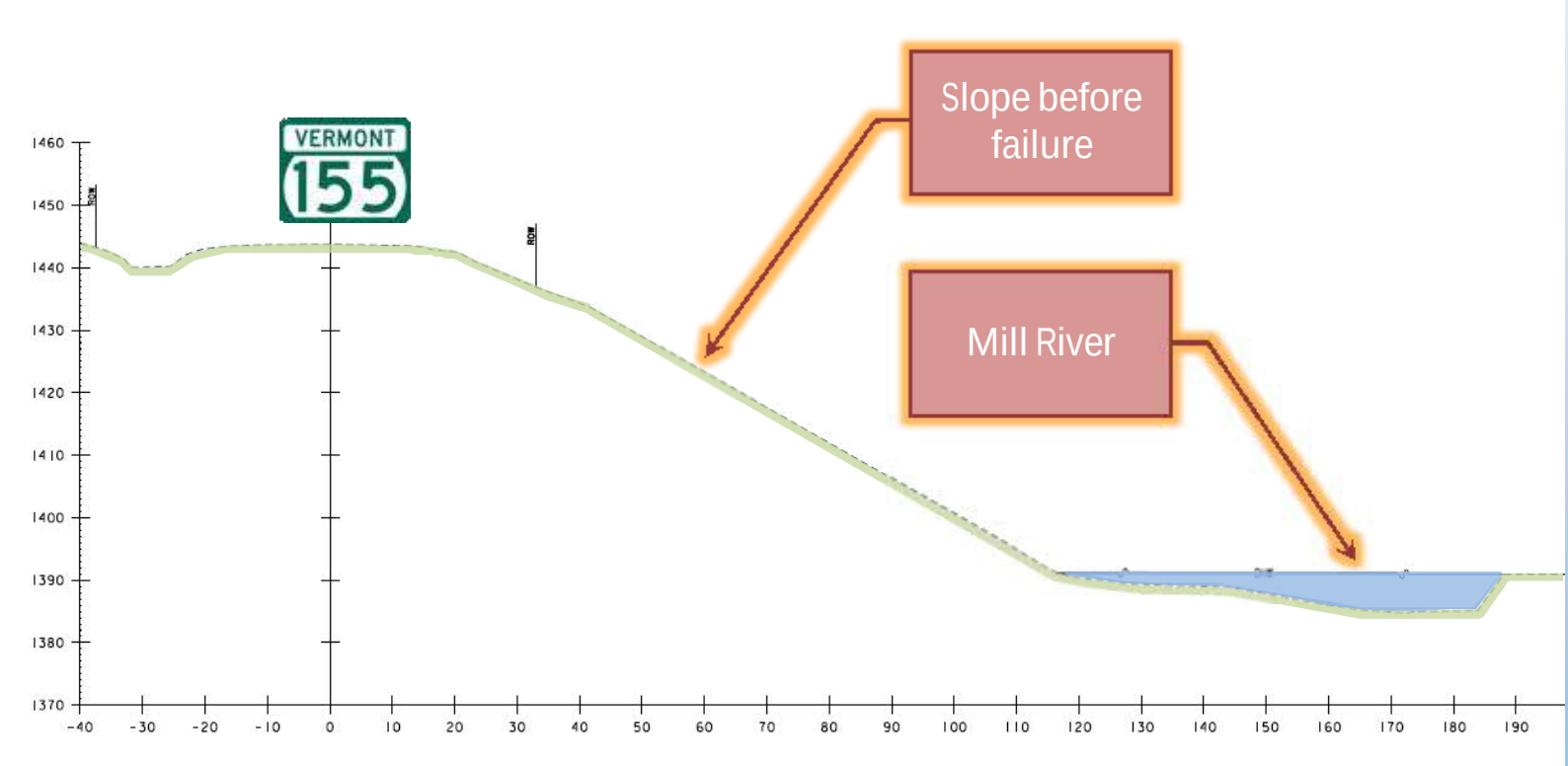
Project Site in 2014

(Google Earth)

Project Site in 2018 prior to Construction

Cross Section of Slope Failure



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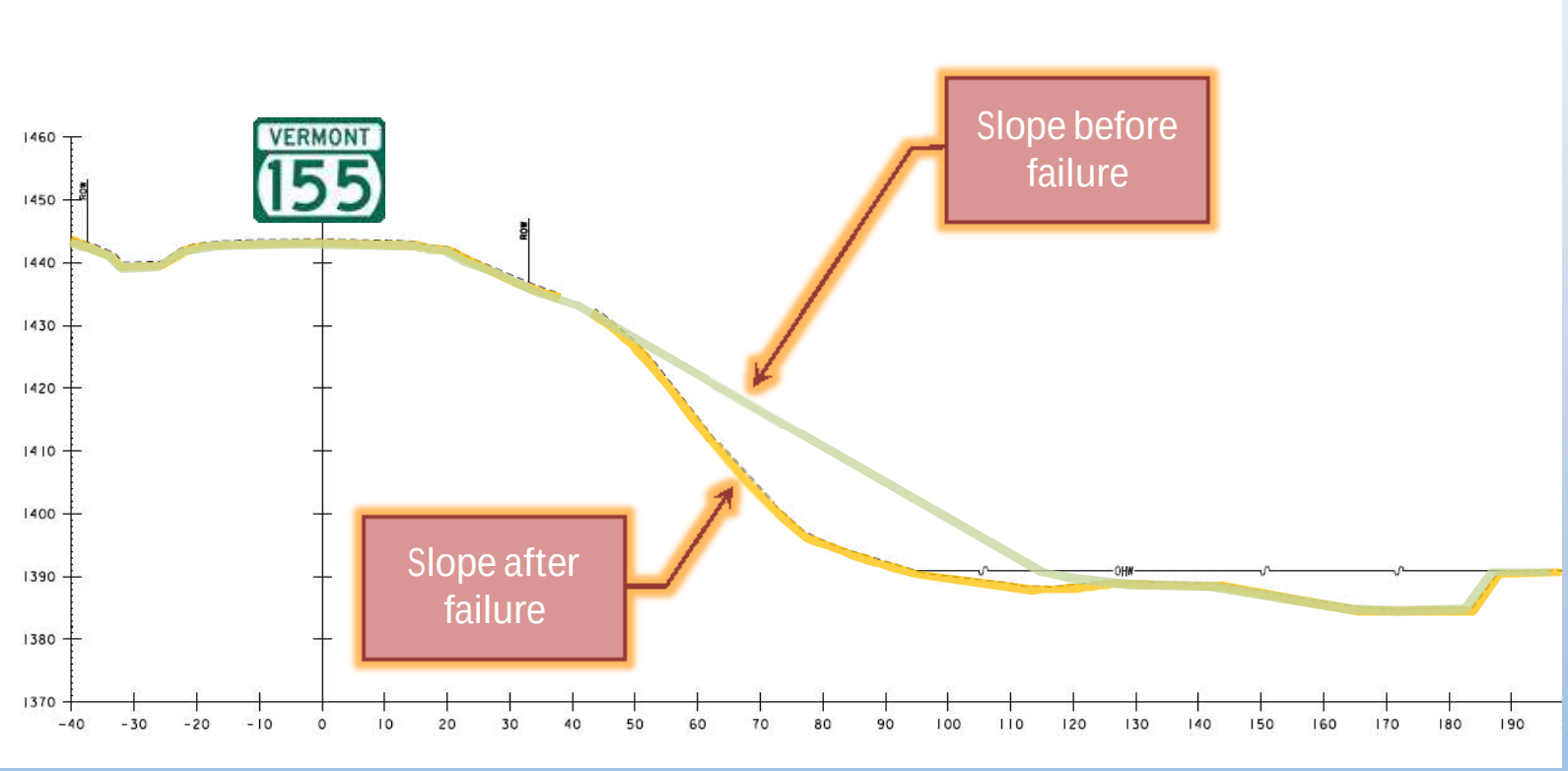

Project Team Involvement

- **Project originally scoped as typical slope stabilization with bulk stone toe and stone fill slope.**
- **Green and MMI approached VTrans with the Vegetated Slope Concept**
- **Prepared analysis that weighed Pros, Cons and potential for cost savings**
- **Worked with VTrans to determine effects of vegetated slope design on overall slope stability**

Preliminary Design

- **Stream geomorphology**
- **Stone toe design**
- **Vegetated slope design**
- **Culvert and slope swale design**

Stream Geomorphology

- Riffle-pool channel
- Barlow Road Bridge opening width = 36 feet
- Bankfull channel width = 65-70 feet
- River erosion of bottom of slope led to mass failure
- Large floodplain on the eastern bank, across from failure 3-4 feet above channel bottom
- Replicate steep forested banks with downed trees that are stable

Stream Geomorphology

(FEA, 4/29/2014)

Stream Geomorphology

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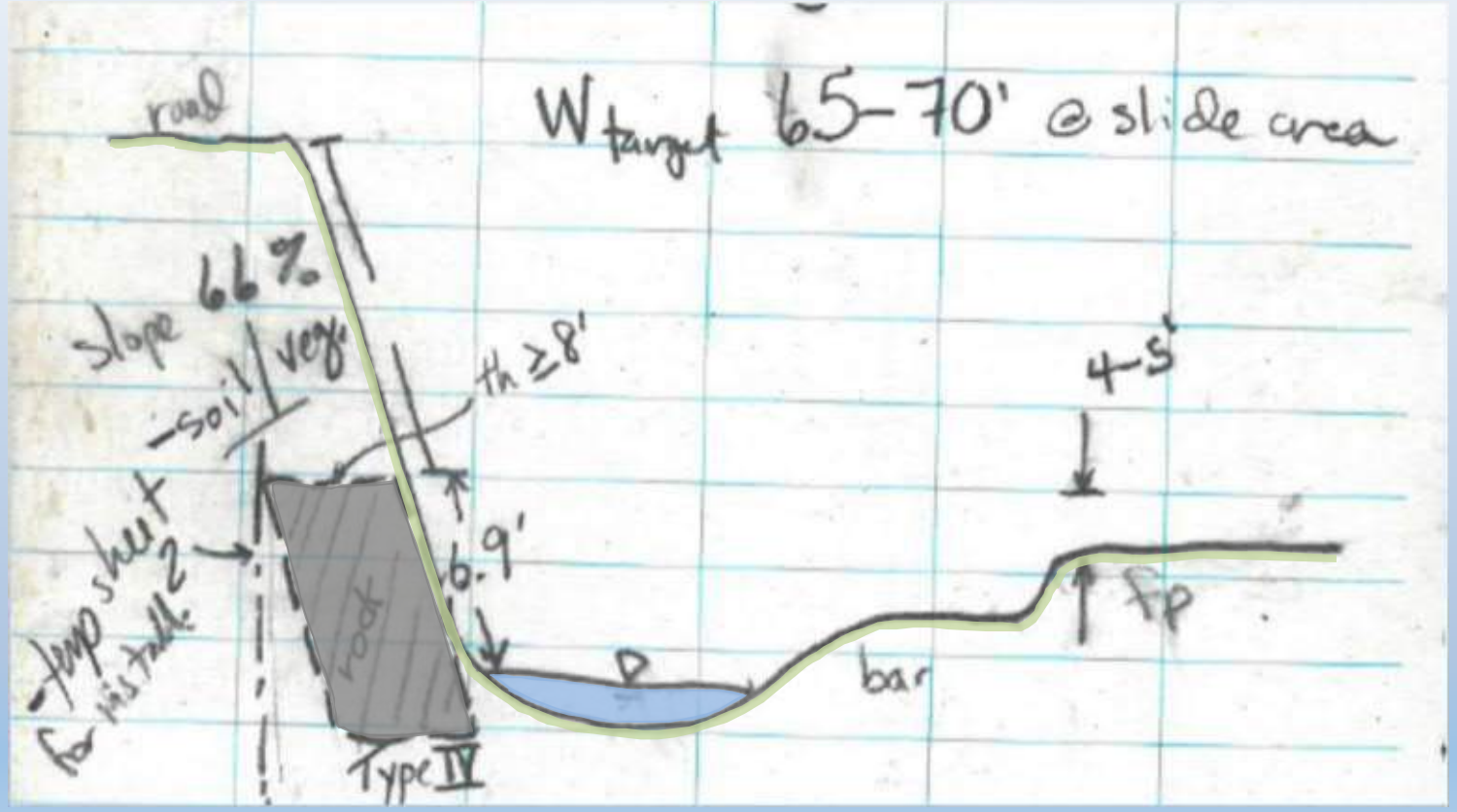
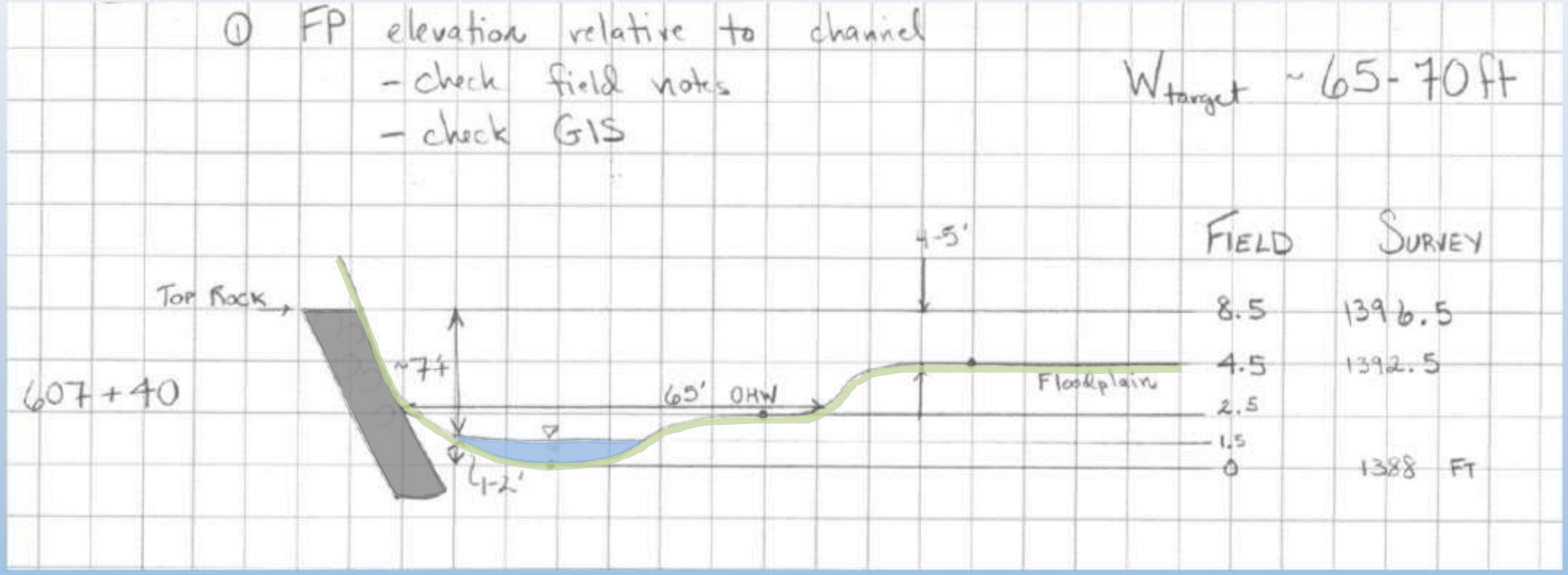
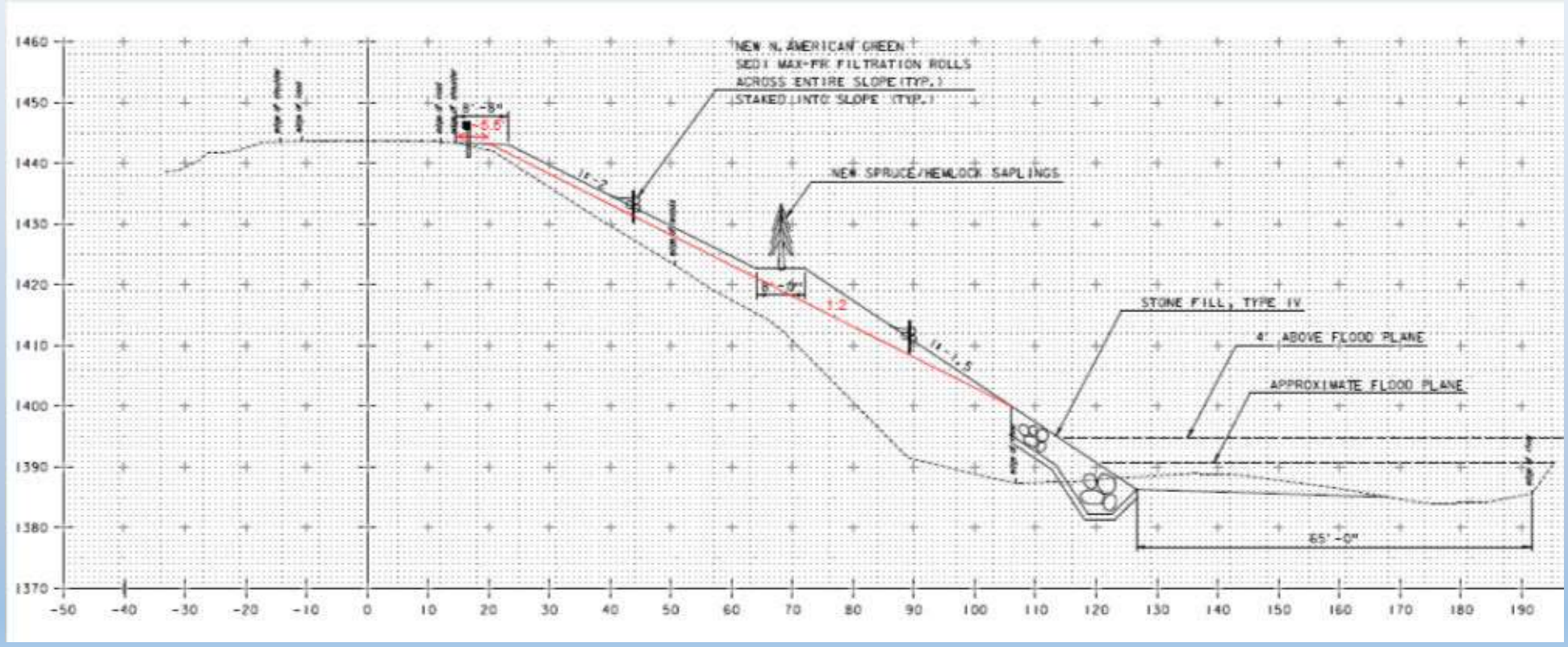


Stream Geomorphology

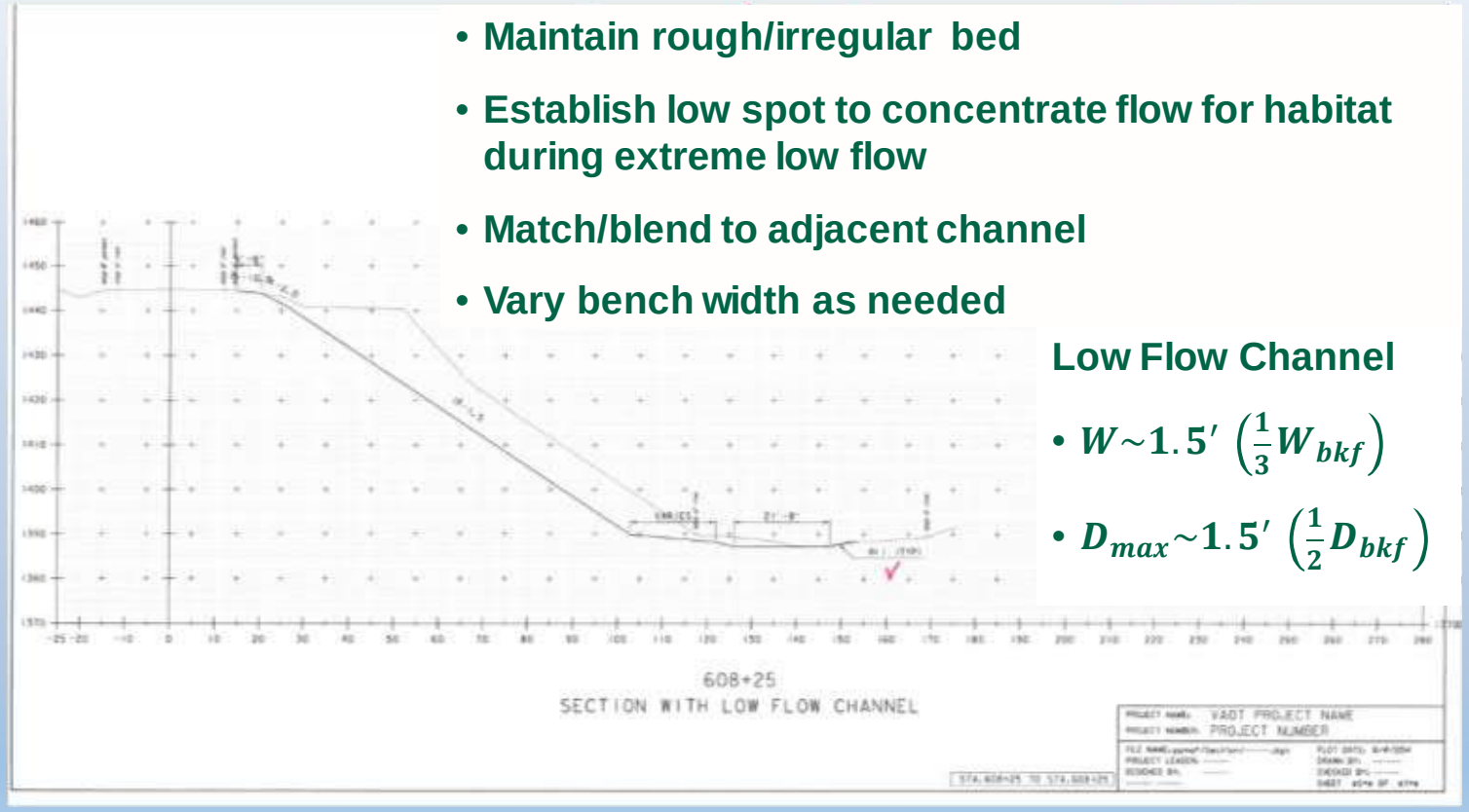


Stream Geomorphology



Stream Geomorphology

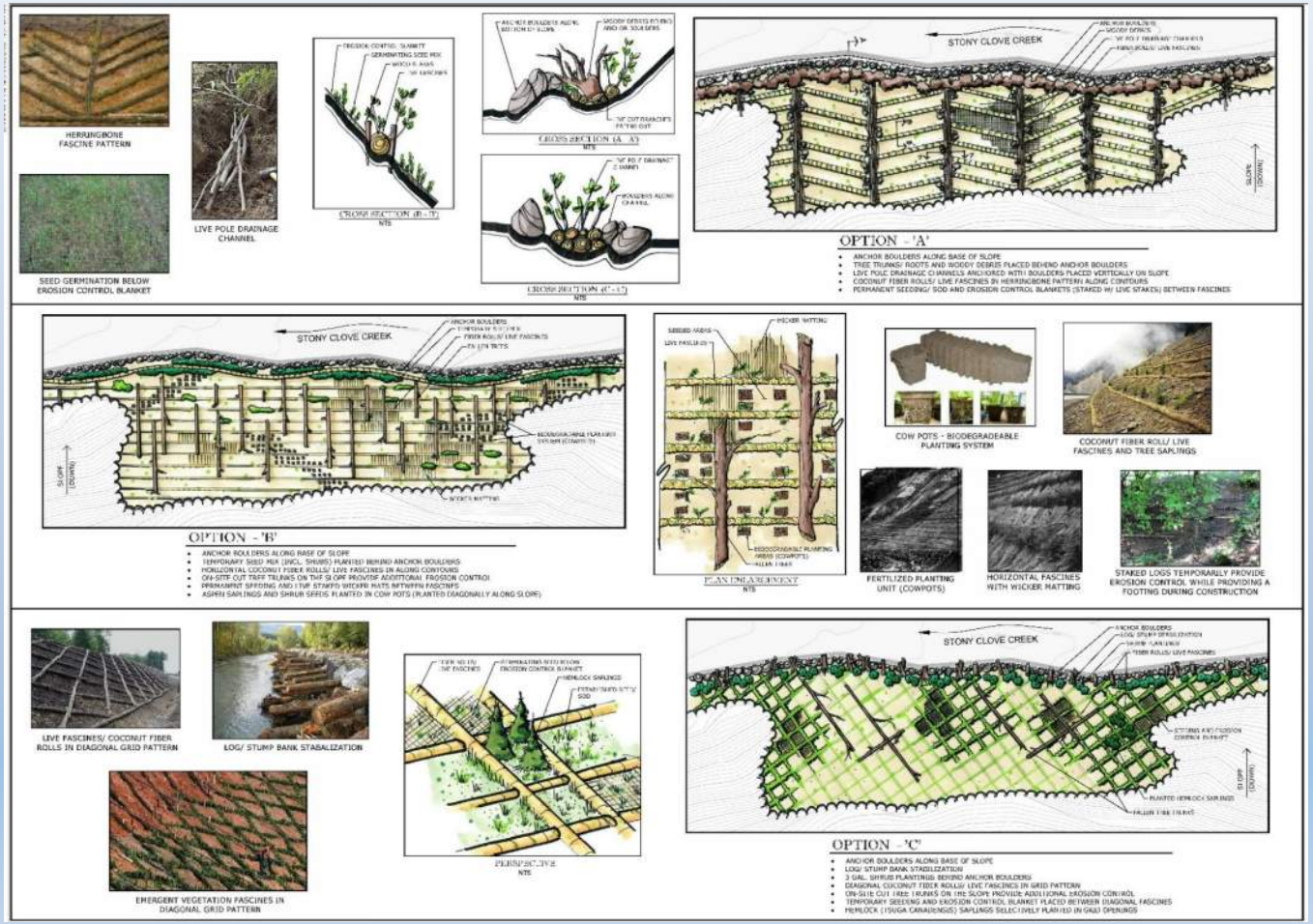
- Maintain rough/irregular bed
- Establish low spot to concentrate flow for habitat during extreme low flow
- Match/blend to adjacent channel
- Vary bench width as needed



Low Flow Channel

- $W \sim 1.5' \left(\frac{1}{3} W_{bkf}\right)$
- $D_{max} \sim 1.5' \left(\frac{1}{2} D_{bkf}\right)$

Preliminary Slope Concepts



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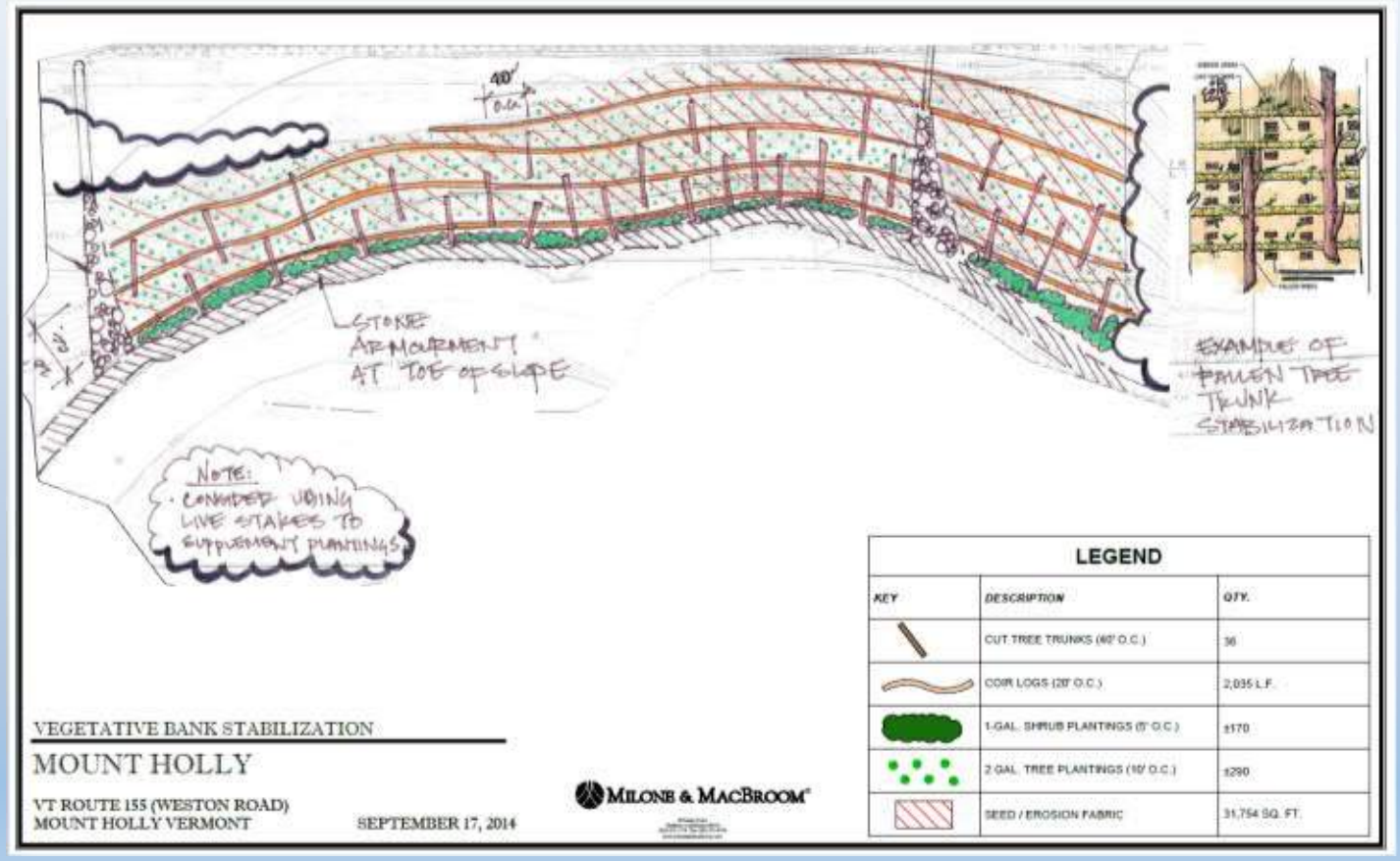

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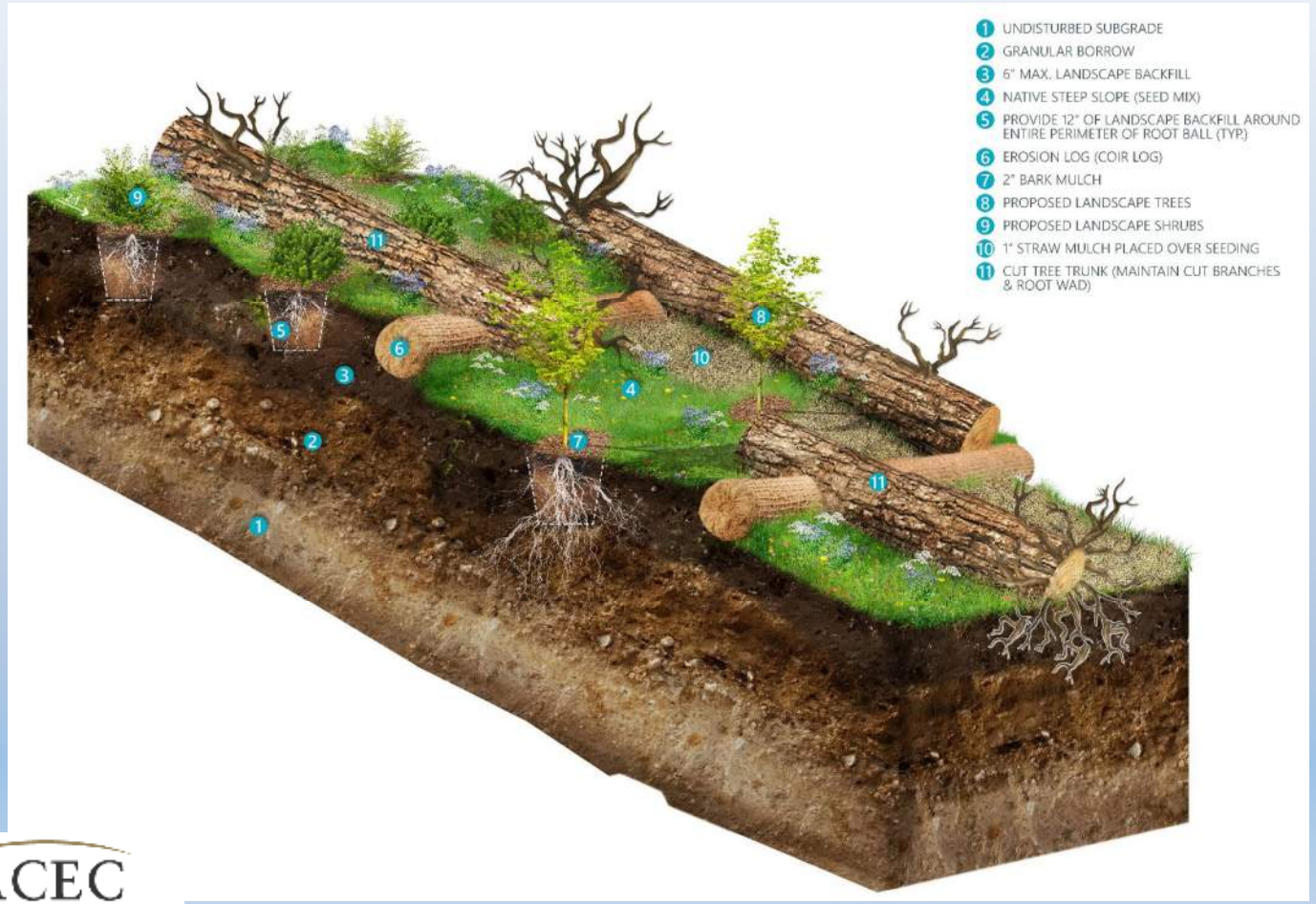

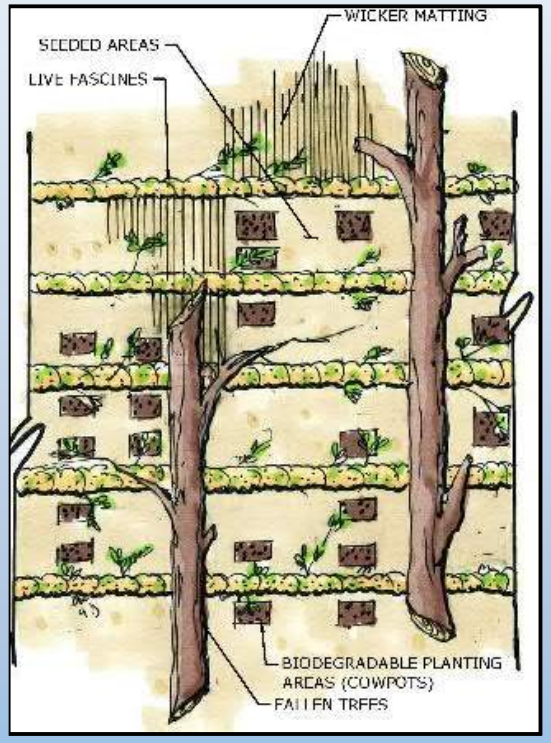

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Planting Palette

Balsam Fir

White Pine

Red Maple

Red Oak

Paper/Gray Birch

Redtwig/ Gray Dogwood

Nannyberry Viburnum

Winter Rye (annual)

Indian Grass

Big Bluestem

Tridens

Rudbeckia

Monarda

Liatris

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Geotechnical Design

- **Global stability of the design was reviewed by VTrans**
- **Initial design proposed 1.5H:1V slopes with a bench**
- **Recommended 2H:1V slope**

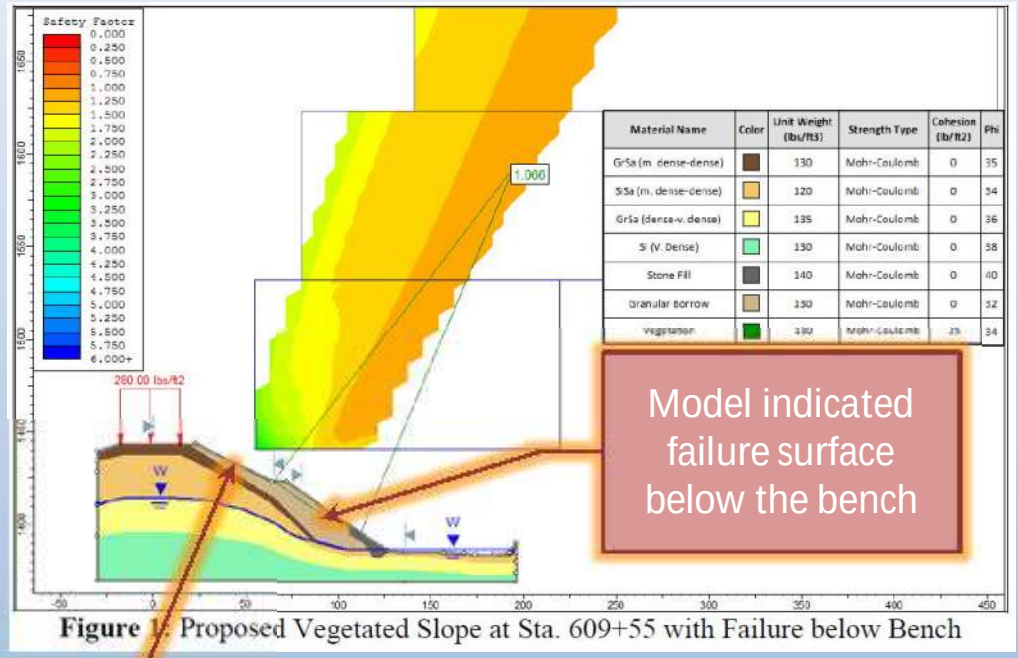

Figure 1: Proposed Vegetated Slope at Sta. 609+55 with Failure below Bench

(VTrans)

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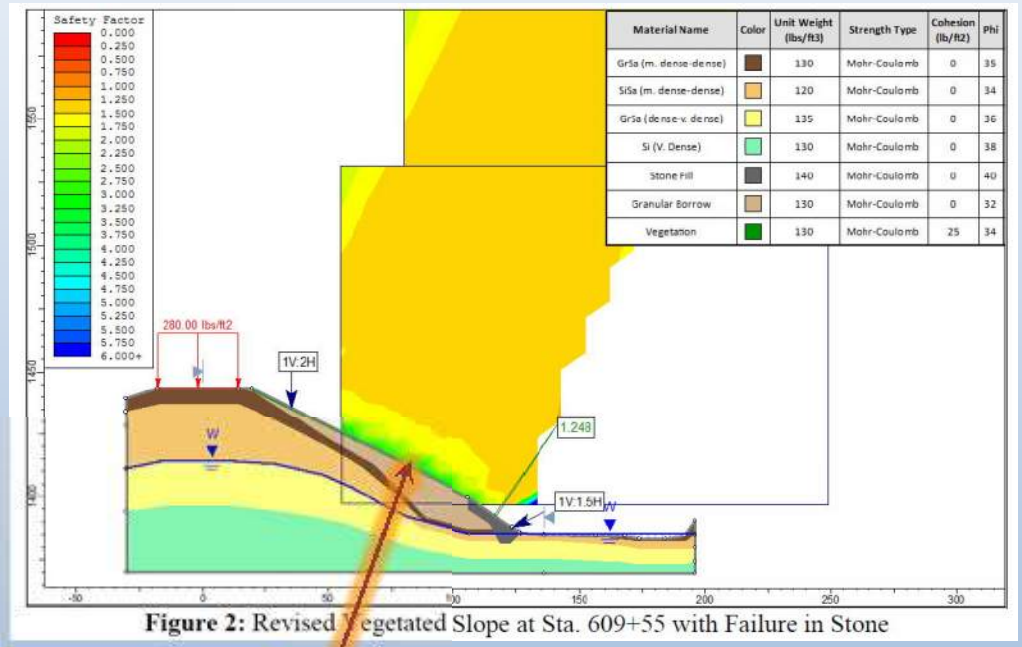


Figure 2: Revised Vegetated Slope at Sta. 609+55 with Failure in Stone

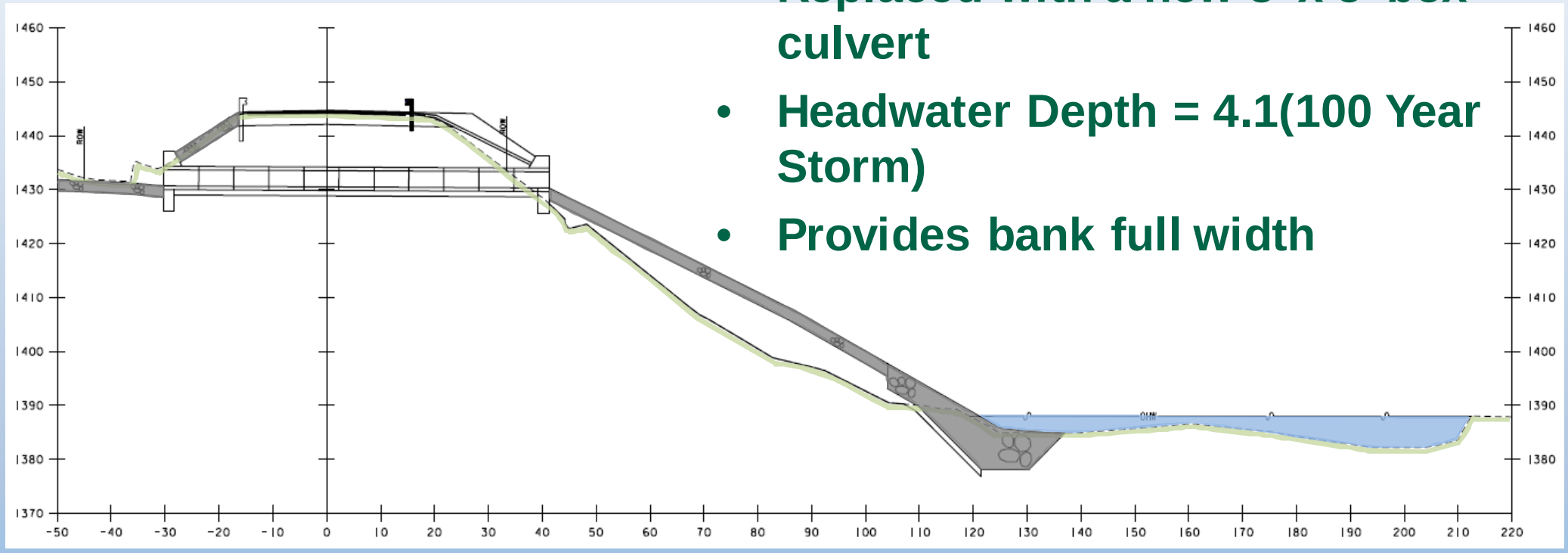
(VTrans)

2H:1V Slope

Culvert Design

- **Existing culverts determined to be undersized**
- **36” CMP Culvert**
  - **Slope failure deformed existing culvert**
  - **Ending service life**
  - **15’ from finished grade to bottom of culvert**
  - **Exceeded Hw/D Ratio**
  - **Did not provide bank full width**

- Replaced with a new 3’ x 5’ box culvert
- Headwater Depth = 4.1(100 Year Storm)
- Provides bank full width



Culvert Design

(VTrans)

Slope Swale Design

- **Steep 2H:1V Slope**
- **100 CFS from 3' x 5' box culvert**
- **Sized stone using HEC-15**
- **D50 stone of 2.75-feet**
- **Reduce Velocities**
- **Prevent scour and erosion of the slope**
- **Designed for 100-Year Storm**

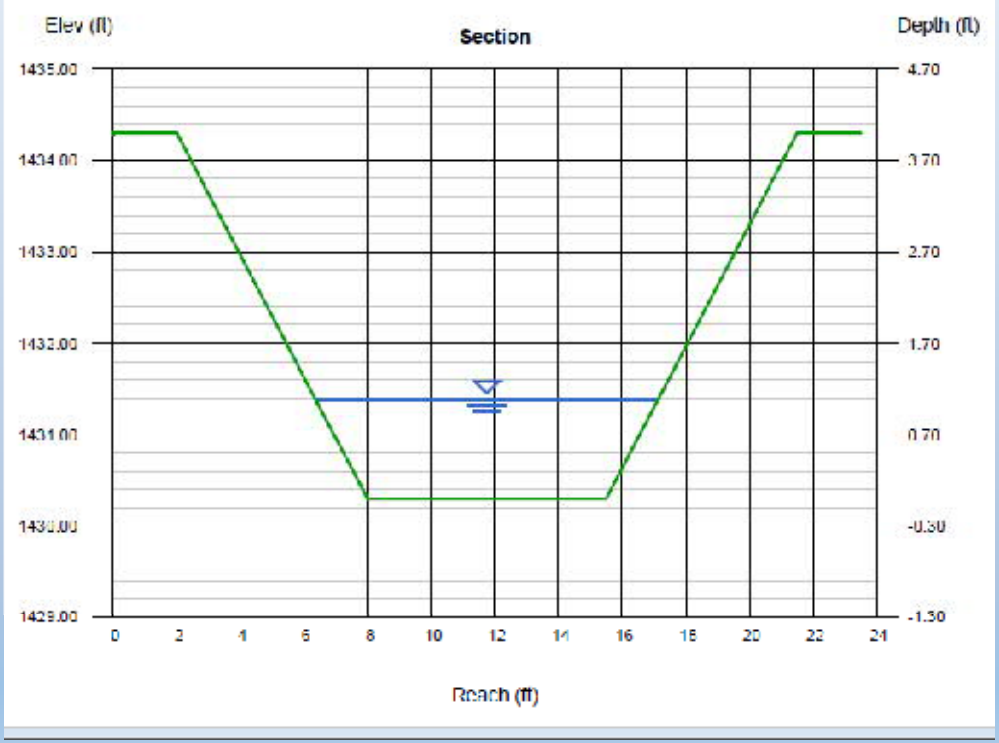
Slope Swale Design

100 year @ MM5.61 7.5-foot bottom width channel

Trapezoidal	
Bottom Width (ft)	= 7.50
Side Slopes (z:1)	= 1.50, 1.50
Total Depth (ft)	= 4.00
Invert Elev (ft)	= 1430.30
Slope (%)	= 56.00
N-Value	= 0.100

Calculations	
Compute by:	Known Q
Known Q (cfs)	= 100.00

Highlighted	
Depth (ft)	= 1.09
Q (cfs)	= 100.00
Area (sqft)	= 9.96
Velocity (ft/s)	= 10.04
Wetted Perim (ft)	= 11.43
Crit Depth, Yc (ft)	= 1.59
Top Width (ft)	= 10.77
EGL (ft)	= 2.66



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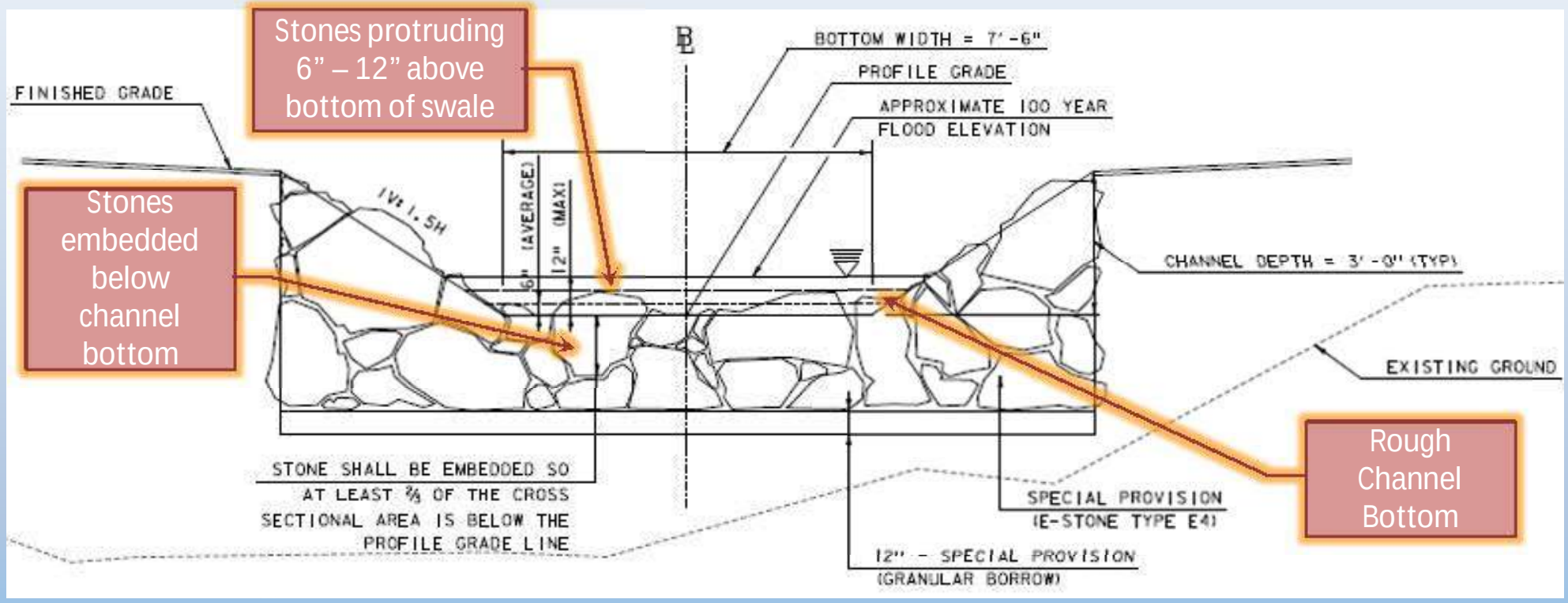
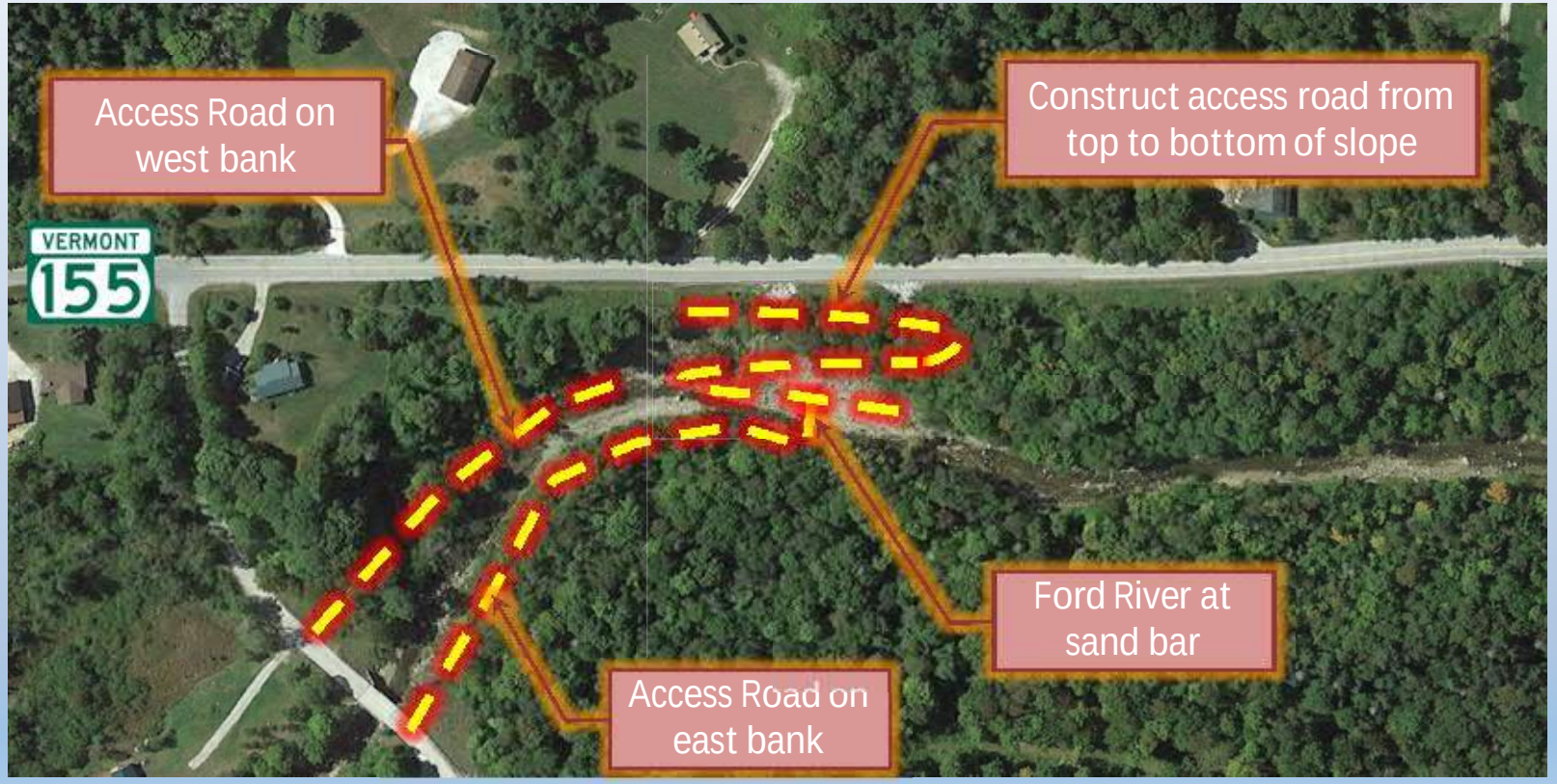
Slope Swale Design



Access Road



(Google Earth)

Access Road

Access Road

Permitting

- Northern Long-Eared bat
- Time of Year Restrictions
  - Bats
  - River work
- Army Corp
- Title 19
- ANR stream

Construction

- **Construction Considerations**
  - **Time of Year Restrictions**
  - **Placing large tree trunks on the slope**
  - **Groundwater and slope stability**
  - **Washing in E-Stone**
  - **Gaining access to entire slope**

(EVI Technical Services/ C. Calabrese)

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Lessons Learned

- **Understanding river and floodplain morphology is key to developing holistic solutions to river/road conflicts**
- **Designing with nature can jump start a self-sustaining slope**
- **Vegetated slopes can be as resilient as stone slopes in the long term.**
- **Mitigate groundwater during construction**
- **Consider tighter seasonal restrictions (if feasible)**

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Questions

Thank you!

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