Building Climate Resiliency in the Clesson Brook Watershed

Community Open House – Summary of Project Findings

June 7th, 2023

Project Partners:

Town of Buckland

Franklin Regional Council of Governments

GZA GeoEnvironmental

Field Geology Services
Fluvial Geomorphology

Funding provided by:

MVP
Municipal Vulnerability Preparedness

MassDEP
Massachusetts Department of Environmental Protection

Overview

- Climate Change Context
- Project Background
- Project Goals & Outcomes
- Project Findings
- Next steps

Upstream view of the Brook along Clesson Brook Road.

Climate Change Context


2008 - Ice Storm


2011 – Tropical Storm Irene

GREENFIELD RECORDER

Downed trees, power outages result from fast-moving storm 10/8/2020

Microburst wreaks havoc in Deerfield, Montague 7/31/2019

Quabbin Reservoir has lost 10 billion gallons of water due to drought 8/31/2016

Wet and wild: Heavy rains cause localized flooding headaches 2/26/2016

Utilities warn that power could be out for days in Northeast 10/30/2017

Heavy weekend rainfall leads to flooding, road closures throughout Franklin County

7/18/2021

Climate Change Context

Human

Increase in Vector Borne Diseases Incidence and Bacterial Infections, including West Nile Virus and Lyme disease due to more favorable conditions for ticks and mosquitoes.

Reduction in Food Safety and Security due to production and supply chain issues, as well as spoilage during power outages.

Infrastructure

Damage to Inland Buildings from heavy rainfall and overwhelmed drainage systems.

Reduction in Clean Water Supply, particularly for communities reliant on well water.

Damage to Electric Transmission and Utility Distribution Infrastructure associated with heat stress and extreme events.

Natural Environment

Freshwater Ecosystem Degradation due to warming waters, drought, and increased runoff.

Forest Health Degradation from warming temperatures, changing precipitation, extreme storms, and increasing pest occurrence.

Governance

Increase in Costs of Responding to Climate Migration, including planning for abrupt changes in local populations.

Increase in Demand for State and Municipal Government Services, including emergency response, food assistance, and state-sponsored health care.

Economy

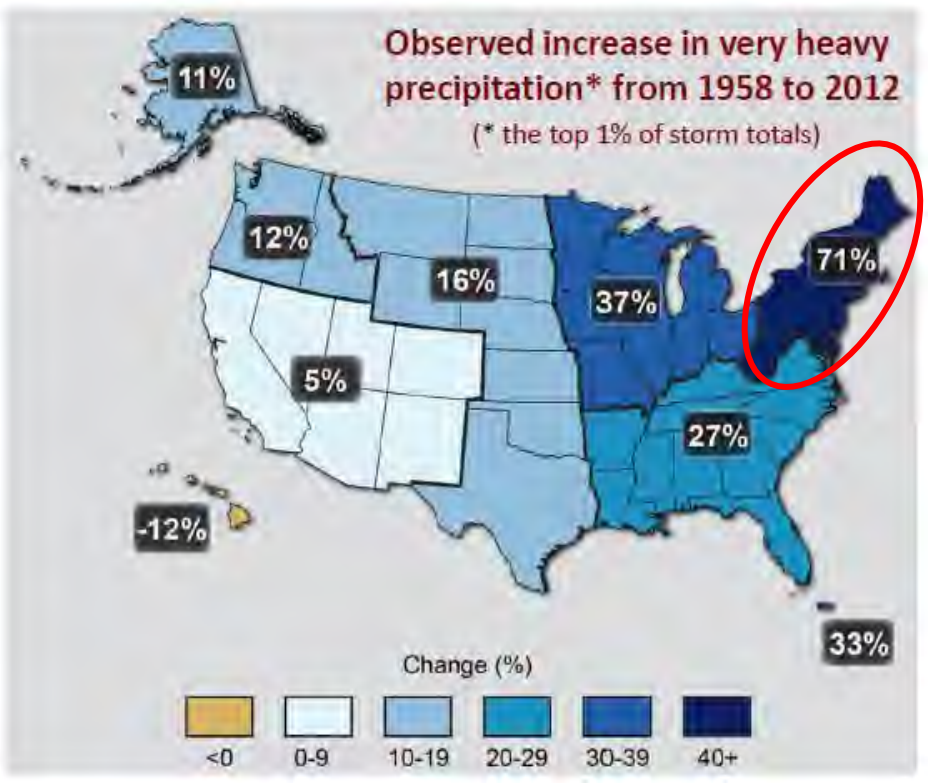
Reduction in the Availability of Affordably Priced Housing from direct damage (e.g., flooding) and the scarcity caused by increased demand.

Damage to Tourist Attractions and Recreation Amenities, particularly those associated with distinct New England seasons.

Climate change **increases** existing risks already present in the Clesson Brook Watershed

Project Background

Why are we concerned about climate change in the Clesson Brook Watershed?



Observed increase in heavy precipitation **is highest in the Northeast**

During Tropical Storm Irene, Clesson Brook overflowed its banks, adjacent roads, and farm fields, wiping out crops and washing away agricultural soils

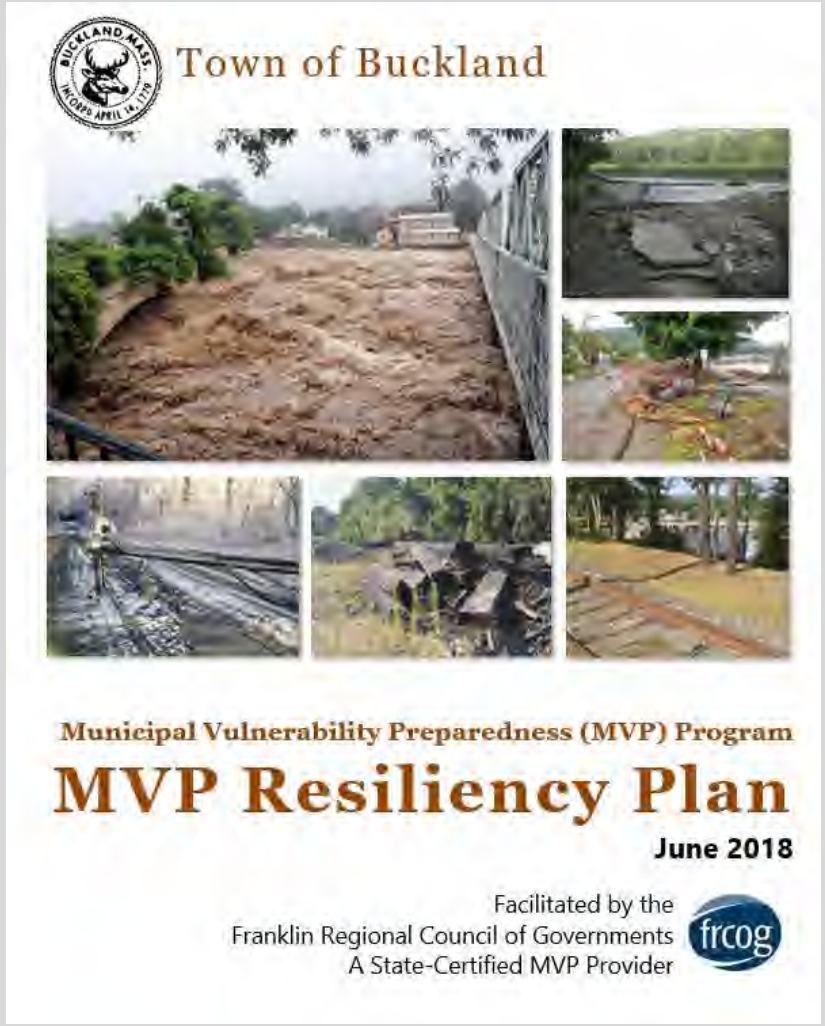
Photo courtesy of the Greenfield Recorder/Paul Franz

"Relentless rainfall" during the summer of 2021 highlights how local communities continue to be impacted by heavy flood events due to climate change

Project Background

Concerns Raised in Buckland's 2018 Municipal Vulnerability Preparedness Plan

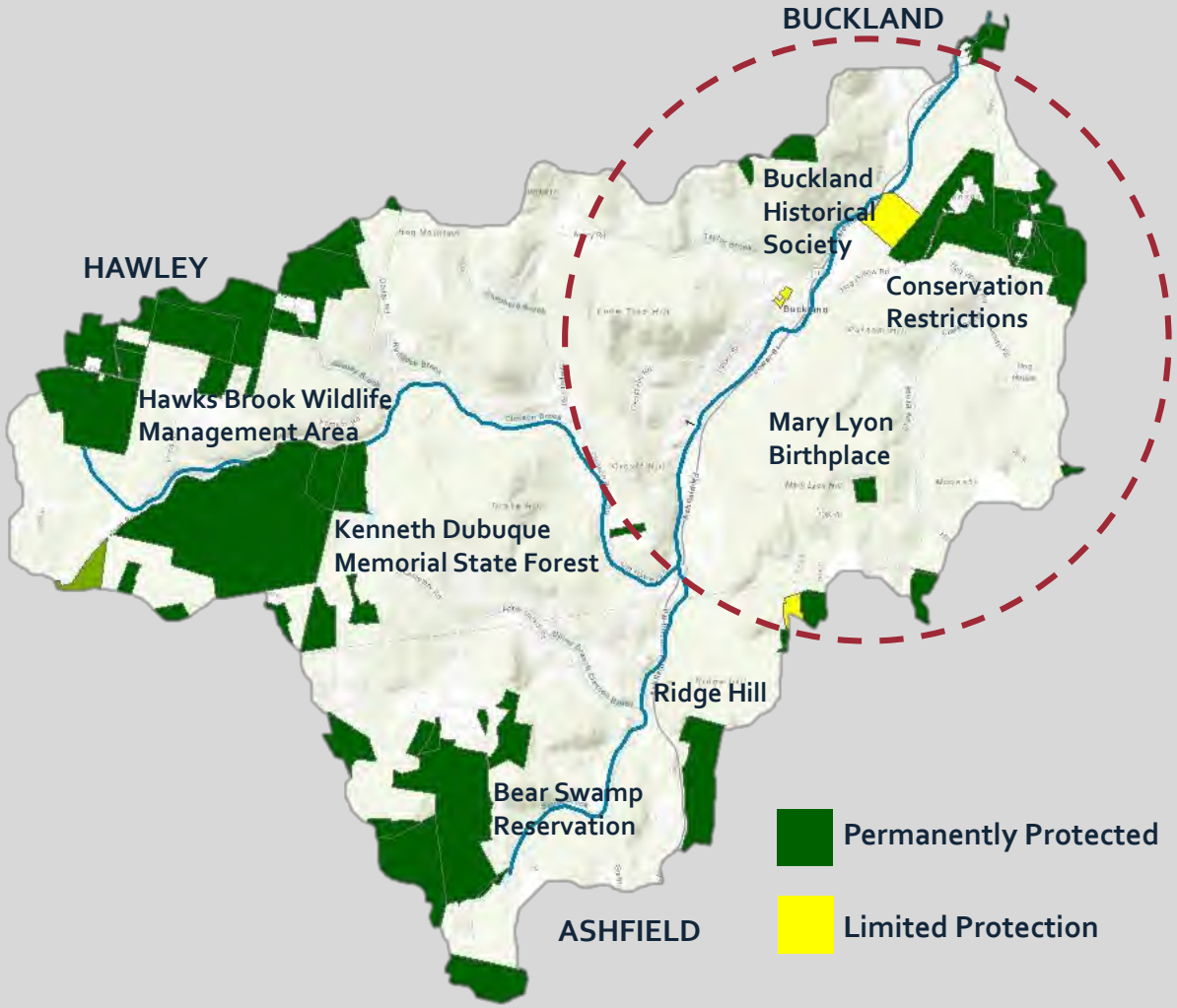
- **Undersized and failing culverts** in the Clesson Brook Watershed
  - These pose a current and future risk to transportation and emergency response
- **Flooding and fluvial erosion** along Clesson Brook
  - Areas damaged by TS Irene are still experiencing severe erosion that threatens roads and bridges
- The Buckland Recreation Area is plagued by **chronic flooding and erosion**



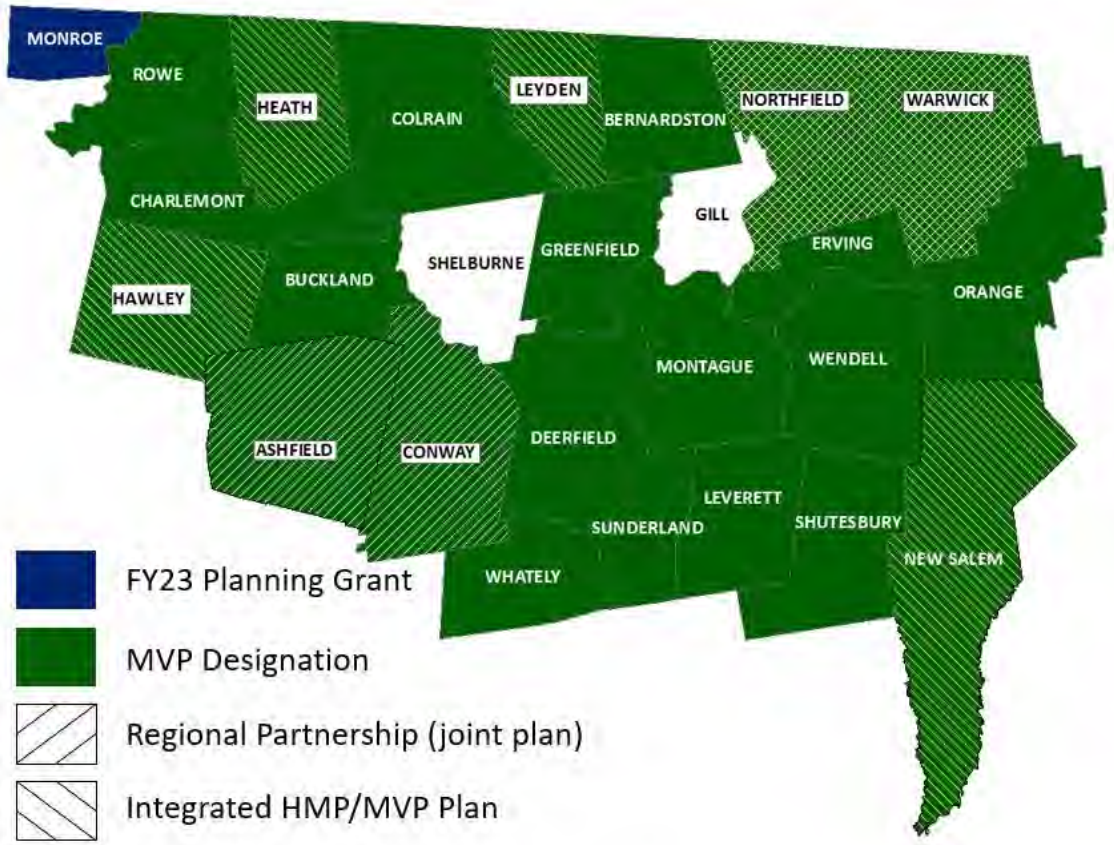
Project Background

Concerns Raised in the 2017 Watershed-Based Plan to Maintain the Health and Improve the Resiliency of the Deerfield River Watershed

- **Very little protected land in the upland tributary areas and the watershed as a whole**
- Agricultural uses **along the stream corridors**
- **Stormwater runoff from Route 112 and other roads** that are adjacent to Clesson Brook and its tributaries



Project Background



Buckland received a $100,117 grant from **the state's Municipal Vulnerability Preparedness (MVP) program** for a project to develop a *Watershed-Based Assessment and Climate Resiliency Plan for the Clesson Brook Watershed*.

An additional $38,500 grant awarded to the Franklin Regional Council of Governments by the **MassDEP's 604b Water Quality Management Grant Program** will be used to develop this comprehensive plan.

Project Goals & Outcomes

1. **Fluvial geomorphic assessment** of the Clesson Brook watershed to provide information on the causes of erosion, channel instability, and habitat degradation

2. **Prepare a Hydrologic and Hydraulic Model** of the Clesson Brook to estimate peak flow rates and evaluate flood water surface elevations and flow paths under current conditions and projected future conditions considering climate change

3. **Develop a database of road-stream crossings** along the Clesson Brook to be used for prioritizing replacements

Figure 11. Comparison of bank composition (inner line), height (middle line), and stability (outer line) along a portion of South River.

Example of a fluvial geomorphic assessment completed for the South River Watershed in Ashfield and Conway

Project Goals & Outcomes (cont.)

4. **Prioritize parcels** within the Clesson Brook watershed for conservation

5. **Identify restoration projects** and prepare proposed conceptual designs

6. Complete **Watershed-Based Plan for Clesson Brook**

7. **Community engagement**

Example of a completed restoration project: boulder deflectors positioned in stream to help slow the flow

Project Findings – Road Stream Crossing

Stream crossing assessment

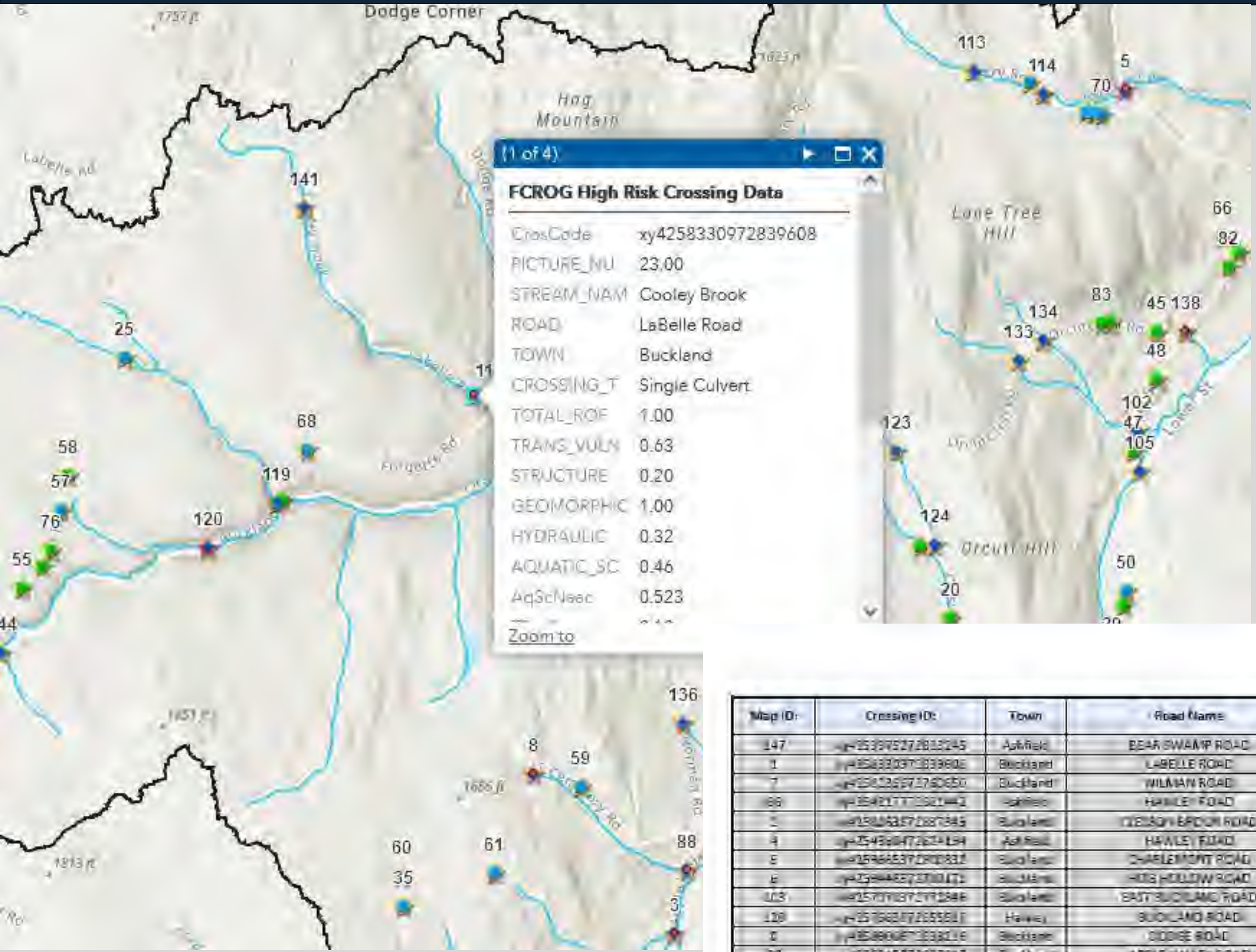
- Prioritized 152 culverts and bridges in watershed

- FRCOG High Risk Crossings, 0 or 3 points;
- NAACC Barrier, up to 4 points;
- Detour Length, 0 or 2 points;
- Open Space, 0 or 1 point;
- ORW, 0 or 1 point;
- NHESP, 0 or 1 point;
- Coldwater Fisheries, 0 or 1 point; and
- BioMap 2, 0 or 1 point.

Results published to Clesson Brook Watershed Crossing App, which is available to town staff

- Final app includes priority projects, vulnerable river segments, and prioritized parcels for conservation

Project Findings – Road Stream Crossing



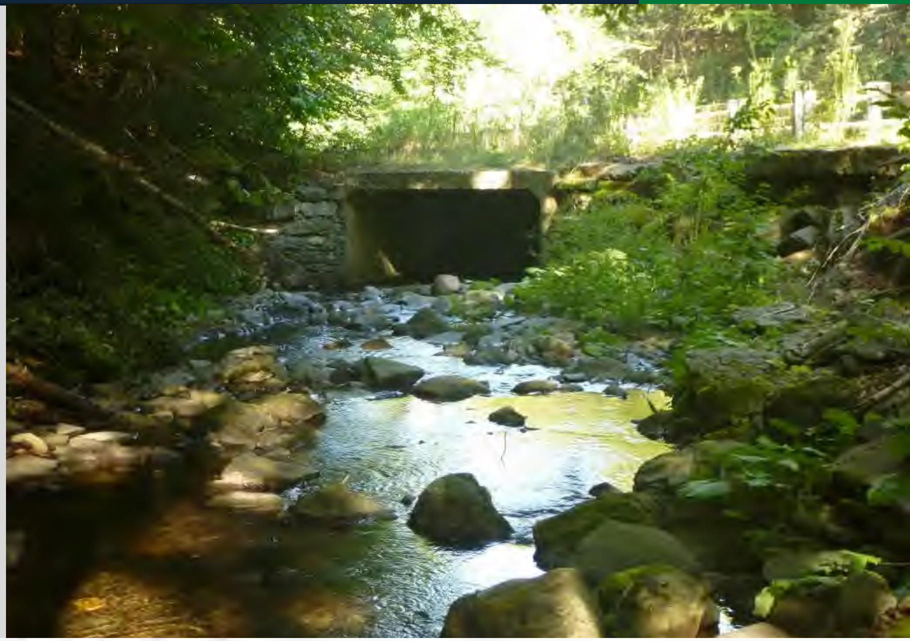


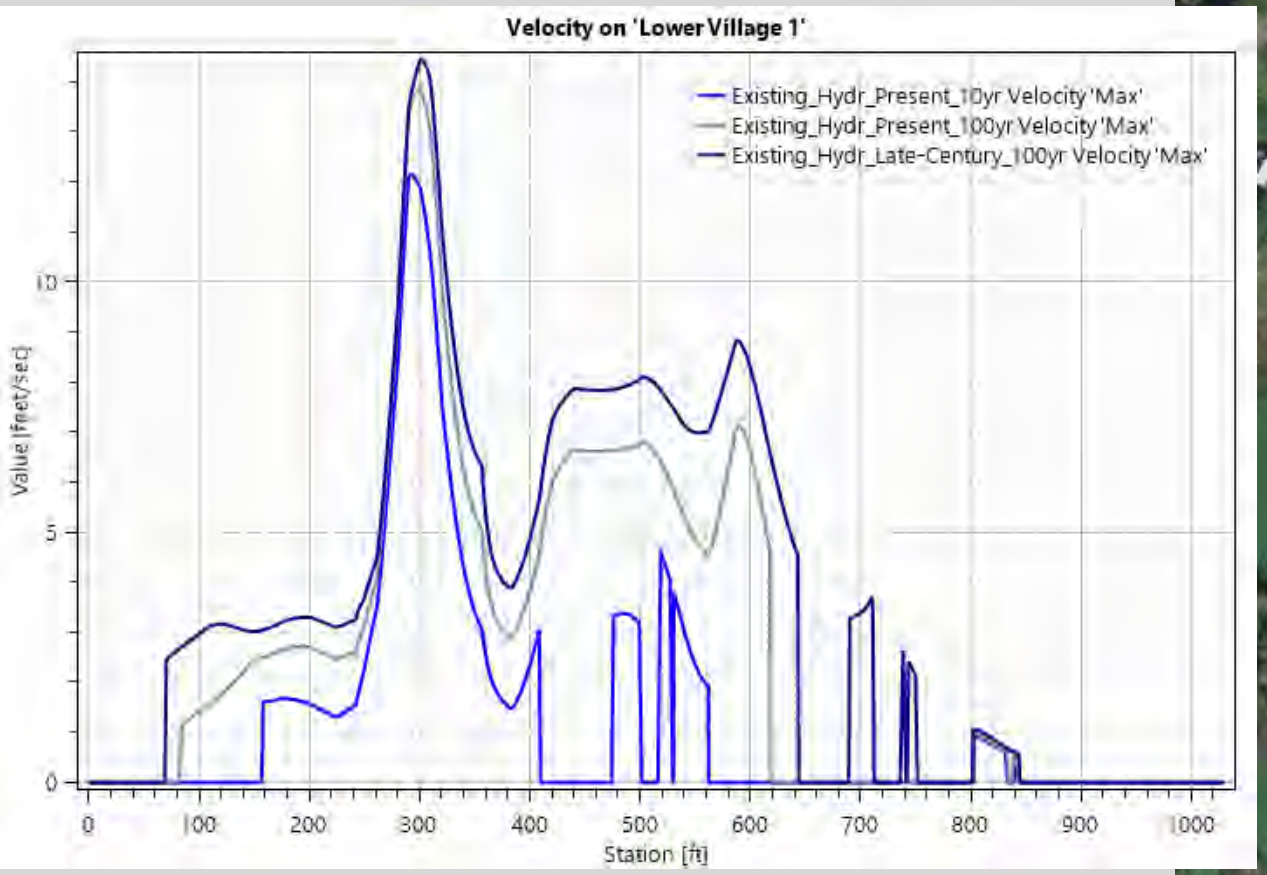
Table of Prioritized Road-Stream Crossings for Replacement
June 6, 2022

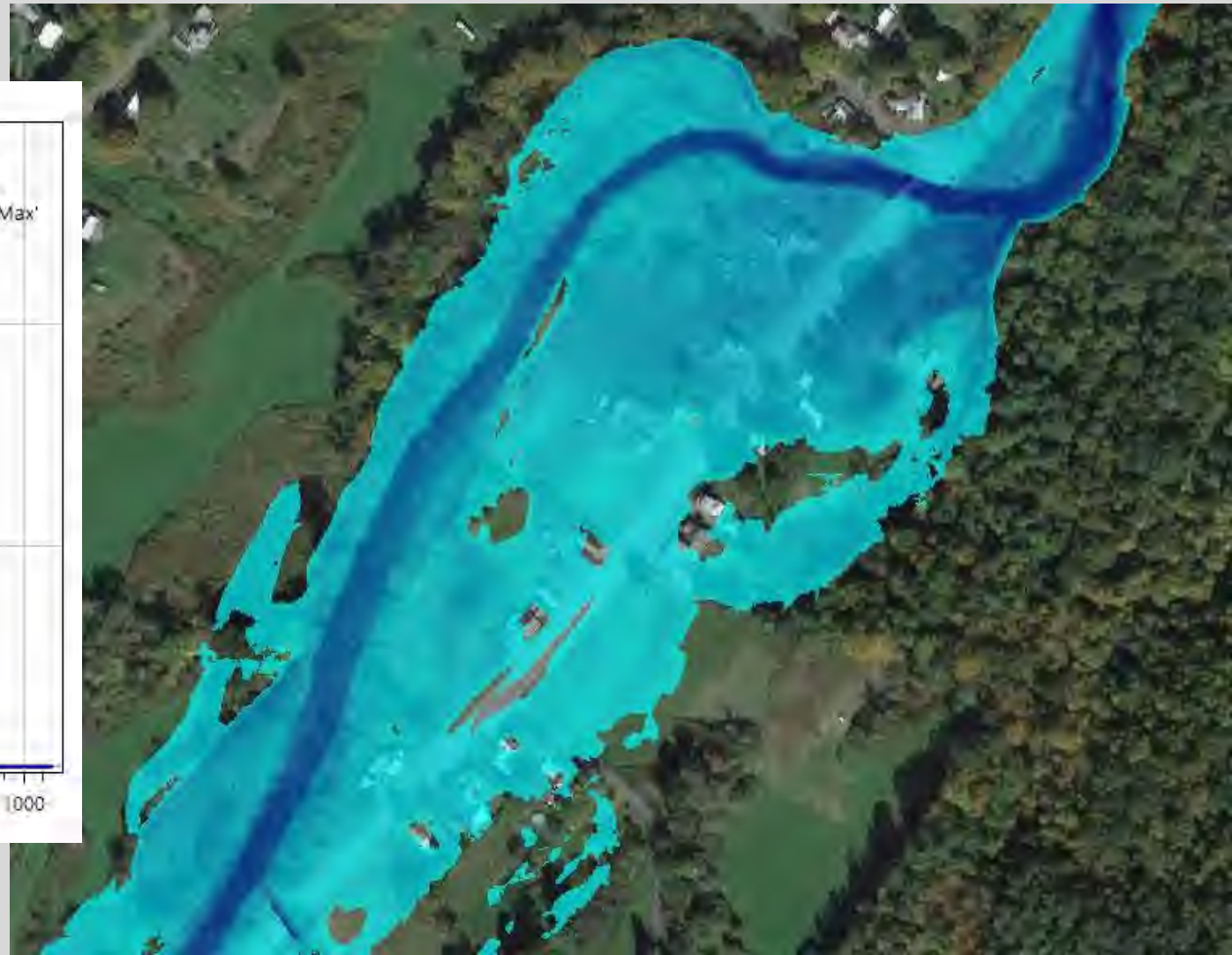
Map ID:	Crossing ID:	Town	Road Name	Stream Name	FRCOG High Risk Crossings	NAACC Barrier	Detour Length	Open Space	ORW	NHESP	Coldwater Fisheries	BioMap 2	Total Points	Priority Rank
147	[illegible]	Ashfield	BEAR SWAMP ROAD	Smith Brook	3	3	2	1	1	1	0	1	12	1
1	[illegible]	Buckland	LABELLE ROAD	Cooley Brook	3	4	2	0	0	0	1	1	11	2
7	[illegible]	Buckland	WILMAN ROAD	Trib Clark Brook	3	4	2	0	0	0	1	1	11	2
86	[illegible]	Ashfield	HAWLEY ROAD	Smith Brook	3	3	2	0	0	1	1	0	10	3
2	[illegible]	Buckland	CLESSON BROOK ROAD	Cooley Brook	3	2	2	0	0	0	1	1	9	4
4	[illegible]	Ashfield	HAWLEY ROAD	Smith Brook	3	2	2	0	0	1	0	1	9	4
5	[illegible]	Buckland	CHARLEMONT ROAD	Taylor Brook	3	4	2	0	0	0	0	0	9	4
6	[illegible]	Buckland	HOG HOLLOW ROAD	Trib Clesson Brook	3	4	2	0	0	0	0	0	9	4
103	[illegible]	Buckland	EAST BUCKLAND ROAD	Clark Brook	3	4	0	0	0	0	1	1	9	4
128	[illegible]	Hawley	BUCKLAND ROAD	Clesson Brook	0	3	2	0	1	1	1	1	9	4
8	[illegible]	Buckland	DODGE ROAD	Ruddock Brook	3	1	2	0	0	0	1	1	8	5
38	[illegible]	Buckland	APPLE VALLEY ROAD	Upper Branch Clesson Brook	3	3	0	0	0	0	1	1	8	5
113	[illegible]	Hawley	BUCKLAND ROAD	Trib Clesson Brook	0	3	2	0	1	1	0	1	8	5
137	[illegible]	Hawley	EAST ROAD	Trib Clesson Brook	0	3	2	0	1	1	0	1	8	5
22	[illegible]	Ashfield	BEAR SWAMP ROAD	Smith Brook	0	0	2	1	1	1	1	1	7	6
31	[illegible]	Buckland	EAST BUCKLAND ROAD	Clark Brook	0	2	2	0	1	0	1	1	7	6
119	[illegible]	Buckland	AVERY ROAD	Taylor Brook	0	4	2	0	0	0	0	1	7	6
115	[illegible]	Buckland	SHEPARD ROAD	Shepherd Brook	0	3	2	0	0	0	1	1	7	6
116	[illegible]	Buckland	CLESSON BROOK ROAD	Ruddock Brook	0	3	2	0	0	1	1	0	7	6
118	[illegible]	Buckland	LABELLE ROAD	Cooley Brook	0	3	2	0	0	0	1	1	7	6
121	[illegible]	Buckland	[illegible] ROAD	Shepherd Brook	0	3	2	0	0	0	1	1	7	6
130	[illegible]	Ashfield	BEAR SWAMP ROAD	Smith Brook	0	2	2	1	0	1	0	1	7	6
141	[illegible]	Hawley	LABELLE ROAD	Trib Cooley Brook	0	2	2	0	1	0	1	1	7	6
145	[illegible]	Ashfield	[illegible] ROAD	Trib Upper Branch Clesson Brook	3	3	0	0	1	0	0	0	7	6

Project Findings – Hydraulic modeling

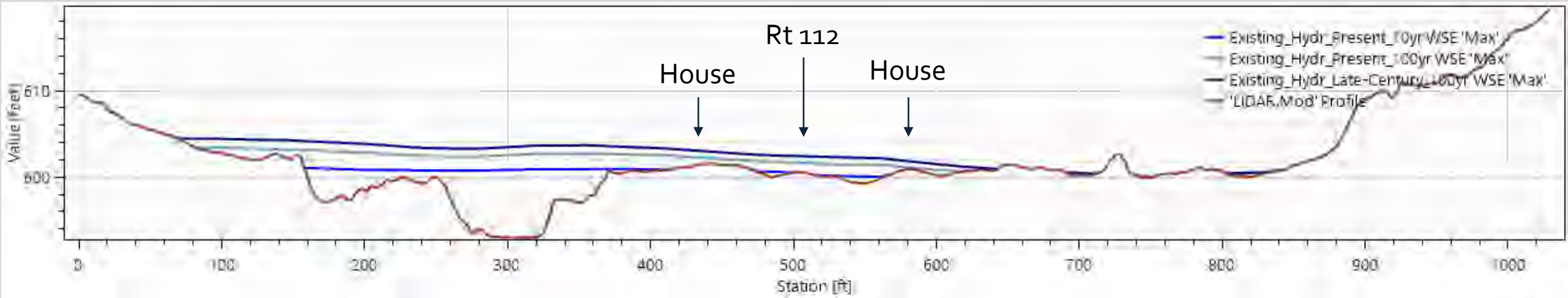
Hydraulic modeling of Clesson Brook

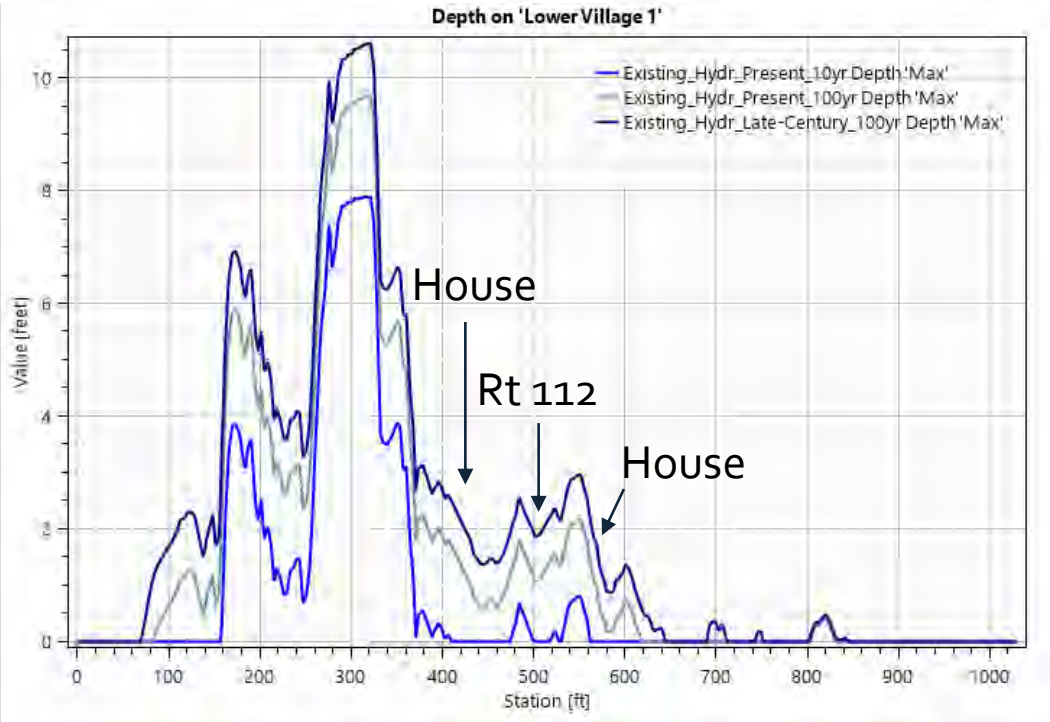
- 2D HEC-RAS model





Project Findings – Hydraulic modeling





Project Findings – Fluvial Geomorphic Assessment

Headcuts (knickpoints)

- 87 headcuts mapped along Clesson Brook
- Headcuts migrate upstream leaving a deeper channel (ie. more flow contained within channel and impaired floodplain connection)
- Vertical instability leads to lateral instability and potential undermining of infrastructure

Project Findings – Fluvial Geomorphic Assessment

Bank stability

- Eroding banks – 20%
- Armored banks – 15%

Looking at a deposit of glacial till on the right bank of the brook, which is a source of sedimentation

Project Findings – Fluvial Geomorphic Assessment

Mass failures (landslides)

- Major sediment source – sediment loading and water quality impairments
- 28 mapped – largest ~180 feet long and 40 feet high

Project Findings – Fluvial Geomorphic Assessment

Channel straightening

- Long segments of stream are artificially straightened
- Increased slope = increased velocities and capacity to transport sediment
- Wood is unevenly distributed

Project Findings – Fluvial Geomorphic Assessment

Individual pieces of wood and log jams mapped

- 1062 pieces
- 97 pcs/mile
- Natural conditions = 175 to 225 pcs/mile (McKinley et al., undated)

Wood provides geomorphic and habitat benefits

- Increased flow complexity
- Sediment sorting and storage
- Pool creation and maintenance
- Provide cover habitat

What is a Restoration Project?

- Address local site-specific concerns such as stabilizing an eroding bank or reducing threats to infrastructure
- While addressing sediment transport and storage, water quality, habitat, climate change and other concerns
- Address causes of channel instability in order to reduce stresses on adjacent stream segments
- Move stream towards an equilibrium condition

Restoration Projects – Examples

- Store sediment and water in the headwaters (chop and drop wood additions, wetland restoration)
- Floodplain reconnection (floodplain lowering, berm breaching/removal, side channel activation)
- Riparian buffer establishment/enhancement
- Removing constraints (upsizing bridges and culverts, dam removal)
- Flow deflection techniques as alternative to hard armoring

Restoration Projects – Examples

Uplands / headwaters –

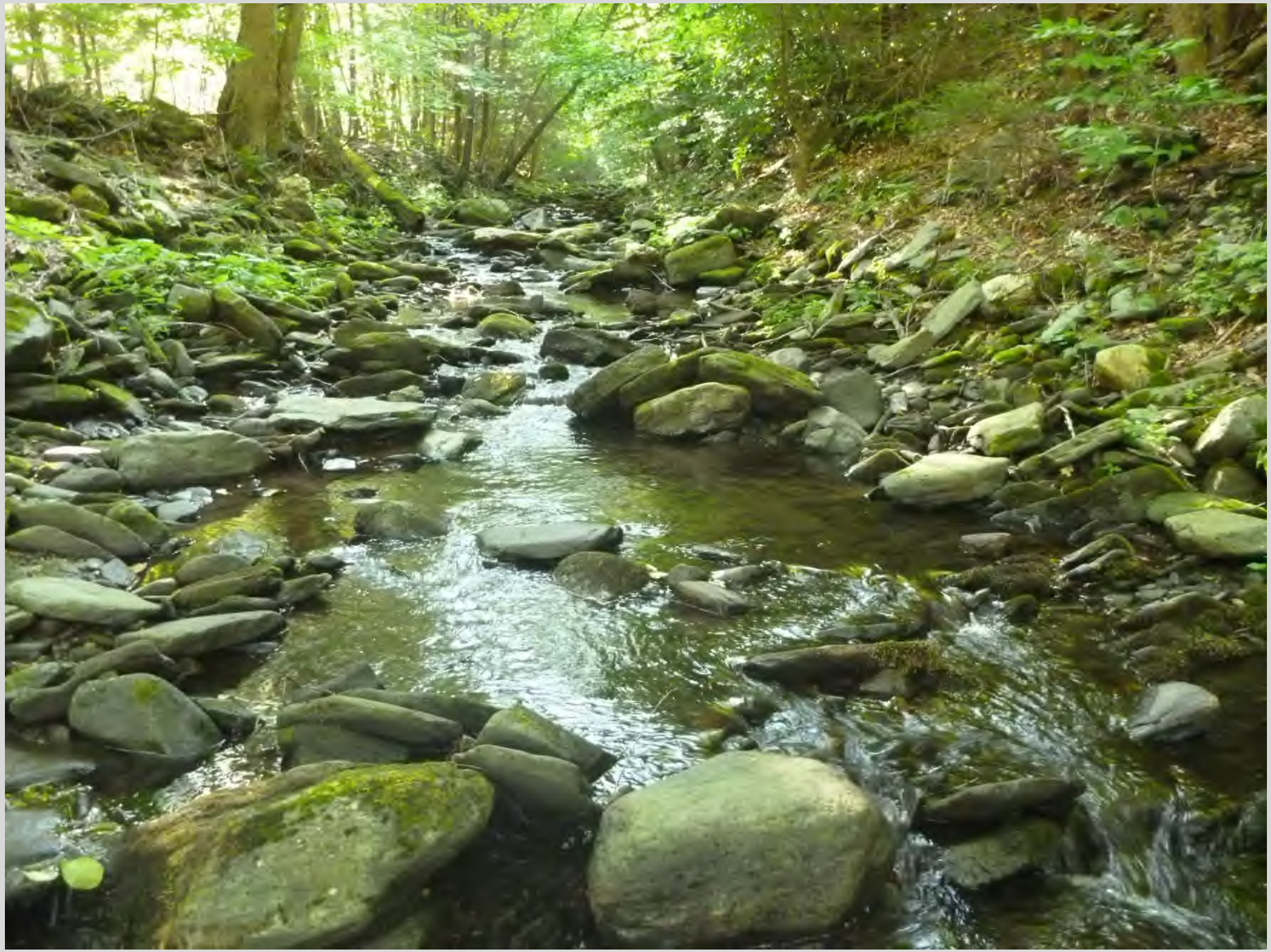
- Wood additions, wetland restoration, culvert upgrades/crossing removal
- Limit sediment mobilization/maximize storage (ie. stabilize mass failures)
- Land conservation

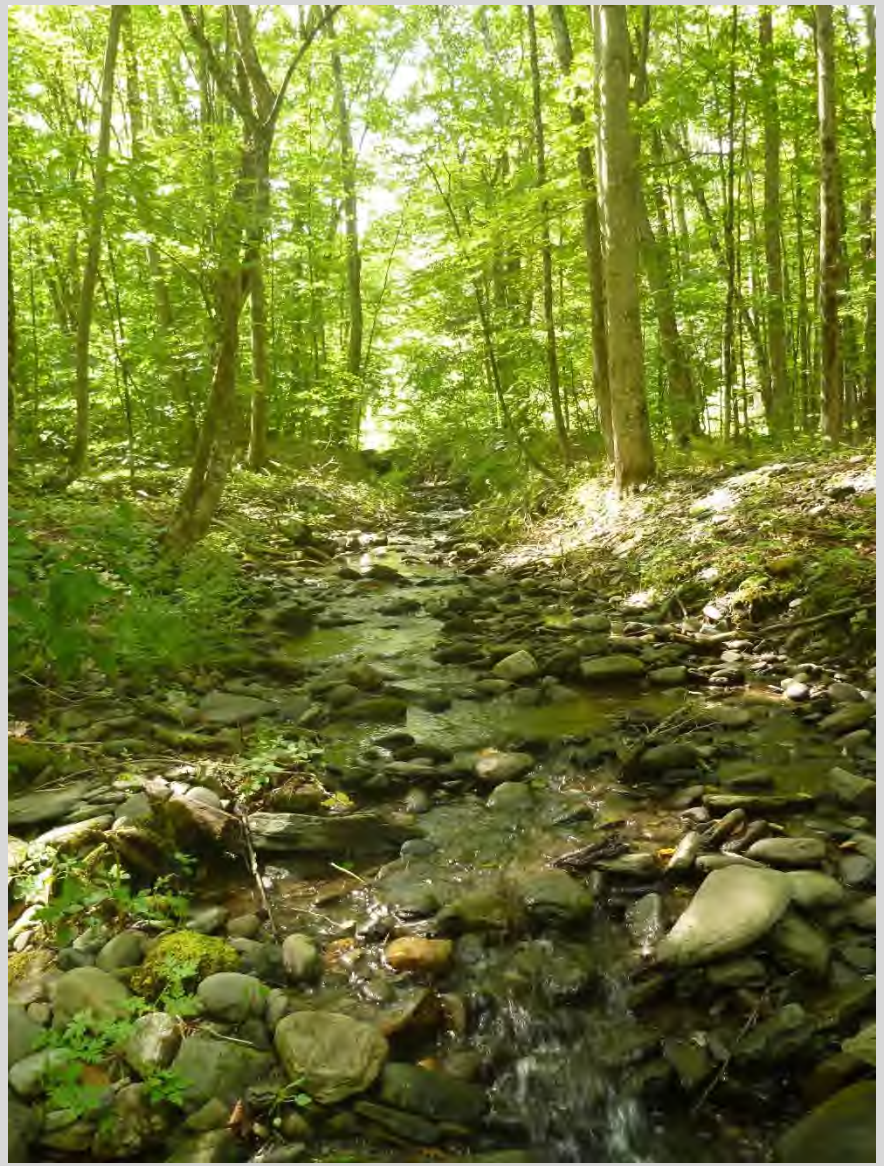
Valley bottom (agricultural, residential, commercial land uses) –

- Floodplain reconnection (floodplain lowering, berm breaching/removal)
- Removing constraints (bridge and culvert upgrades, dam removal)
- Riparian buffer establishment/enhancement (invasive species mitigation)
- Encourage meanders and complexity with instream structures
- Flow deflection as alternative to hard armoring
- Land conservation (and soon…River Corridor Easements)

Wood additions - Chop and drop

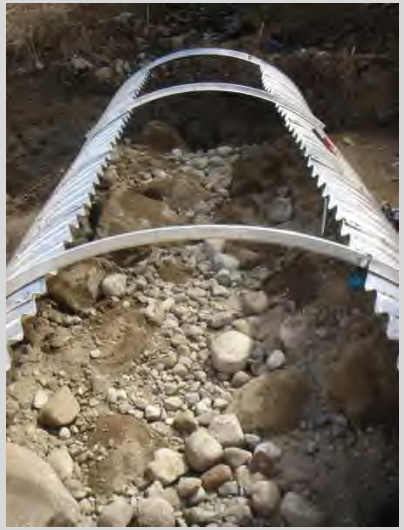
Wood additions - Chop and drop





Horseshoe Brook culvert replacement

May 6—10, 2013



Courtesy of Jim MacCartney

Horseshoe Brook culvert replacement

Before – October 2012 (looking upstream)
4’ diameter CMP; 0.6’ drop

After – July 2013 (looking upstream)
10.75’ embedded aluminum arch

Courtesy of Jim MacCartney

Middle Columbia Rd. culvert remediation

September 5—11, 2014

Before – Nov. 2013 (looking upstream)
6.25’ diameter steel culvert; 40° skew

Photo by John Magee

After – Oct. 2014 (looking upstream)
46’ clear span; steel beam bridge

Before (looking downstream)

Photo by John Magee

After (looking downstream)

Courtesy of Jim MacCartney

Middle Farrer Brook culvert removal

November 6—7, 2007

Before (looking upstream)
5’ diameter CMP; 2.8’ drop

After (looking upstream)
Road retired; valley fill removed

Before (looking downstream)

After (looking downstream)

Courtesy of Jim MacCartney

Prioritized List of Restoration Projects – Culvert upgrade

Project type: Road crossing upgrade/replacement
Town: Buckland Location: Dodge Rd Lat/Long: 42.589006, -72.838216
Stream segment: Ruddock Brook

Culvert on Dodge Rd has failed multiple times washing out large portions of Dodge Rd (according to local residents) and continues to represent an extreme fluvial erosion hazard with a high likelihood of failure. Located at valley slope break with an extensive beaver pond complex upstream. Landowner has installed beaver deceiver devices to reduce likelihood of beavers clogging culvert inlet. Upgrade culvert to meet State stream crossing standards with bottomless arch, may include floodplain relief culverts.

Prioritized List of Restoration Projects – Culvert upgrade

Project type: Road crossing upgrade/replacement
Town: Hawley Location: Buckland Rd Lat/Long: 42.576646, -72.855391
Stream segment: Clesson Brook, CLE19B

Box culvert installed post-Irene is extreme fluvial erosion hazard with high likelihood of failure. Located at valley slope break downstream of artificially straightened channel. 6ft high by 12ft wide, perched 4 ft. Modeling shows overtopping at 10-year recurrence interval (R.I.) event. No aquatic organism passage (AOP). Replace culvert with bridge or bottomless arch, may include habitat structures upstream and downstream.

Prioritized List of Restoration Projects – Remove constraints

Project type: Remove bridge ruins/channel constriction
Town: Buckland Location: Intersection of Route 112 and Old Hawley Rd
Lat/Long: 42.570146, -72.802286 Stream segment: Clesson Brook, CLE11A

The bridge at the east end of Old Hawley Rd became clogged with sediment, wood, and debris during Tropical Storm Irene and an avulsion channel was carved around the bridge. The now ruined structure, which served one house, will likely not be repaired or replaced. The bridge ruins and roadway approaches constrict the channel and block portions of its floodplain representing a fluvial erosion hazard during high flow events. Remove the ruined structure and restore sediment transport and flood conveyance through the reach. Instream habitat structures may be installed to further restore geomorphic function. Invasive species mitigation targeting Japanese knotweed should be considered as part of the restoration of the site.

Mass failure stabilization

Prioritized List of Restoration Projects – Mass failure stabilization

Project type: Mass failure stabilization, flow deflectors, bank cutting/flow diversion
Town: Buckland Location: Near Buckland Recreation Area Lat/Long: 42.615840, -72.766073
Stream segment: Clesson Brook, CLE01

This dynamic reach, just upstream of the confluence with the Deerfield River, flows along the Buckland Recreation Area. Erosion of glacial banks threatens the recreation paths and high school running trails. The largest mass failure is approximately 20 feet high and 225 feet long and contributes a significant volume of sediment to lower Clesson Brook and the Deerfield River. Stabilize the toe of high bank using nature-based solutions and slope upper bank, before stabilizing with vegetation. Engineered log jams or log sills may be used to deflect flow away from the eroding bank. Side channel flow could be increased through bank cutting/flow diversion, which would divert flow into a low left bank channel and away from the mass failures. If permitting allows the mainstem channel could be diverted through more aggressive treatments.

Floodplain reconnection

Prioritized List of Restoration Projects – Floodplain reconnection

Project type: Headcut stabilization, floodplain connection, and instream habitat structures
Town: Buckland Location: Clesson Brook Rd ~0.5mi west of Shepard Rd Lat/Long: 42.580717, -72.825029
Stream segment: Clesson Brook, CLE15B

Vertical instability along Clesson Brook following excessive sediment mobilization and deposition during Tropical Storm Irene has resulted in a deeper channel with impaired floodplain connection and increased erosion hazards. Segment CLE15B includes six mapped headcuts and a windrow (berm) blocking a portion of the right bank floodplain. Install log sills to help arrest headcut migration and stabilize the bed. Boulder-supported log jams and other instream habitat structures encourage sediment sorting and deposition while enhancing habitat. These treatments are designed to slow flow velocities, encourage aggradation, and divert flows onto the right bank floodplain. Breaching the berm would further improve floodplain connection along this artificially straightened stream segment.

Riparian buffer enhancement

Riparian buffer enhancement

FOREST4_ST1_1_2019

FOREST4_ST1_1_2020

FOREST4_ST1_1_2021

Prioritized List of Restoration Projects – Buffer enhancement

Project type: Riparian buffer enhancement
Town: Buckland Location: Rt 112 across from Wilder Homestead Lat/Long: 42.580717, -72.825029
Stream segment: Clesson Brook, CLE05B and CLE05A

Impaired riparian buffer along Route 112 across from the Wilder Homestead Museum leads to lack of channel shading and elevated water temperatures. Mature riparian buffers reduce sediment and nutrient loading and increase bank stability. While impaired buffers are widespread along Clesson Brook, this site has space to accommodate the planting of native trees and shrubs, whereas many other sites do not. Buffer planting may be paired with invasive species mitigation.

Log jams – Flow deflection

Wood buttress – Flow deflection

Wood buttress – Flow deflection

Before…

…and after

Prioritized List of Restoration Projects – Flow deflection

Project type: Bank stabilization and riparian buffer enhancement
Town: Buckland Location: ~700 ft south of intersection of Route 112 and Purinton Rd
Lat/Long: 42.607644, -72.774317 Stream segment: Clesson Brook, CLE03C

Bank erosion along the previously straightened stream channel threatens an agricultural field and residential parcel. Continued erosion of the farm field represents a significant source of sediment and nutrients. Engineered log jams are recommended to deflect flow away from the eroding bank and promote instream deposition. Stabilizing the bank will allow the establishment of a 35-foot wide buffer of native trees and shrubs, which will help limit nutrient inputs from the agricultural field. As an agricultural producer, this project would be eligible for EQIP funding through NRCS.

River Corridor Easement – Bristol, VT

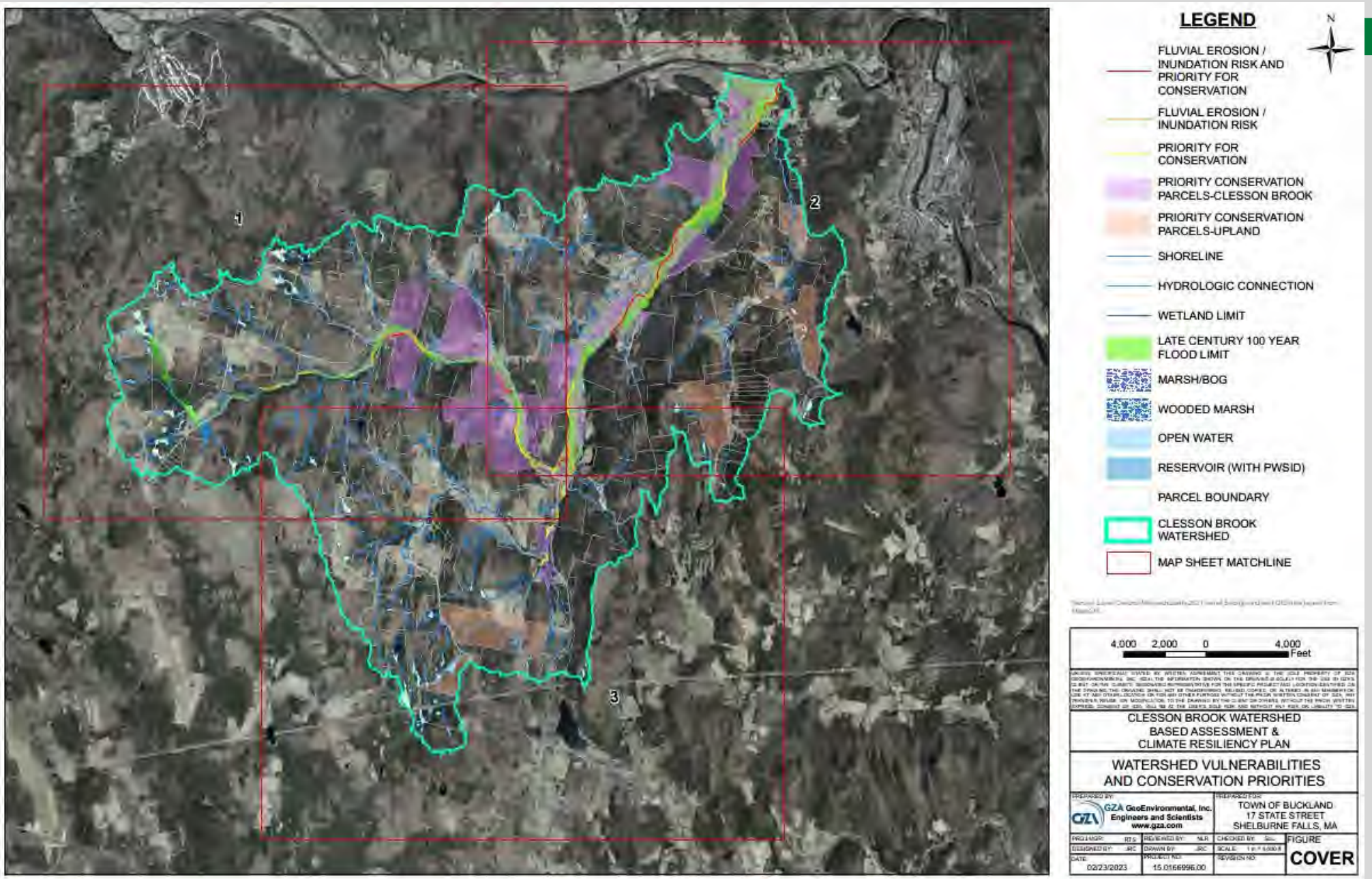
- 40.1 acres on New Haven River
- 3,900 ft river frontage
- Managed hayfield, floodplain forest and actively meandering, avulsing stream channel
- Landowner, who had farmed land for generations, pursued easement after damages from Tropical Storm Irene
- Town has protected land with goals of building flood resiliency and providing public river recreation

Prioritized List of Restoration Projects – River Corridor Easement

Project type: River Corridor Easement
Town: Buckland Location: Downstream of Upper St bridge
Lat/Long: 42.582525, -72.798309 Stream segment: Clesson Brook, CLE09

Low elevation floodplain divided into several parcels and currently in agricultural use. Site of a channel avulsion during Tropical Storm Irene, when sediment, wood, and debris were deposited (photo on left). Since, the stream has been "put back" into the straightened channel along Route 112. Hydraulic modeling data shows inundation at 10-year R.I. event (pink polygon in photo on right). Site is good candidate for a River Corridor Easement, a channel management and planning tool under development in Massachusetts, where landowners are compensated for allowing natural river processes (ie. flooding, sediment deposition, avulsions) to occur. This site could act as an asset for the village downstream by attenuating flood flows and allowing sediment to be deposited on the floodplain.

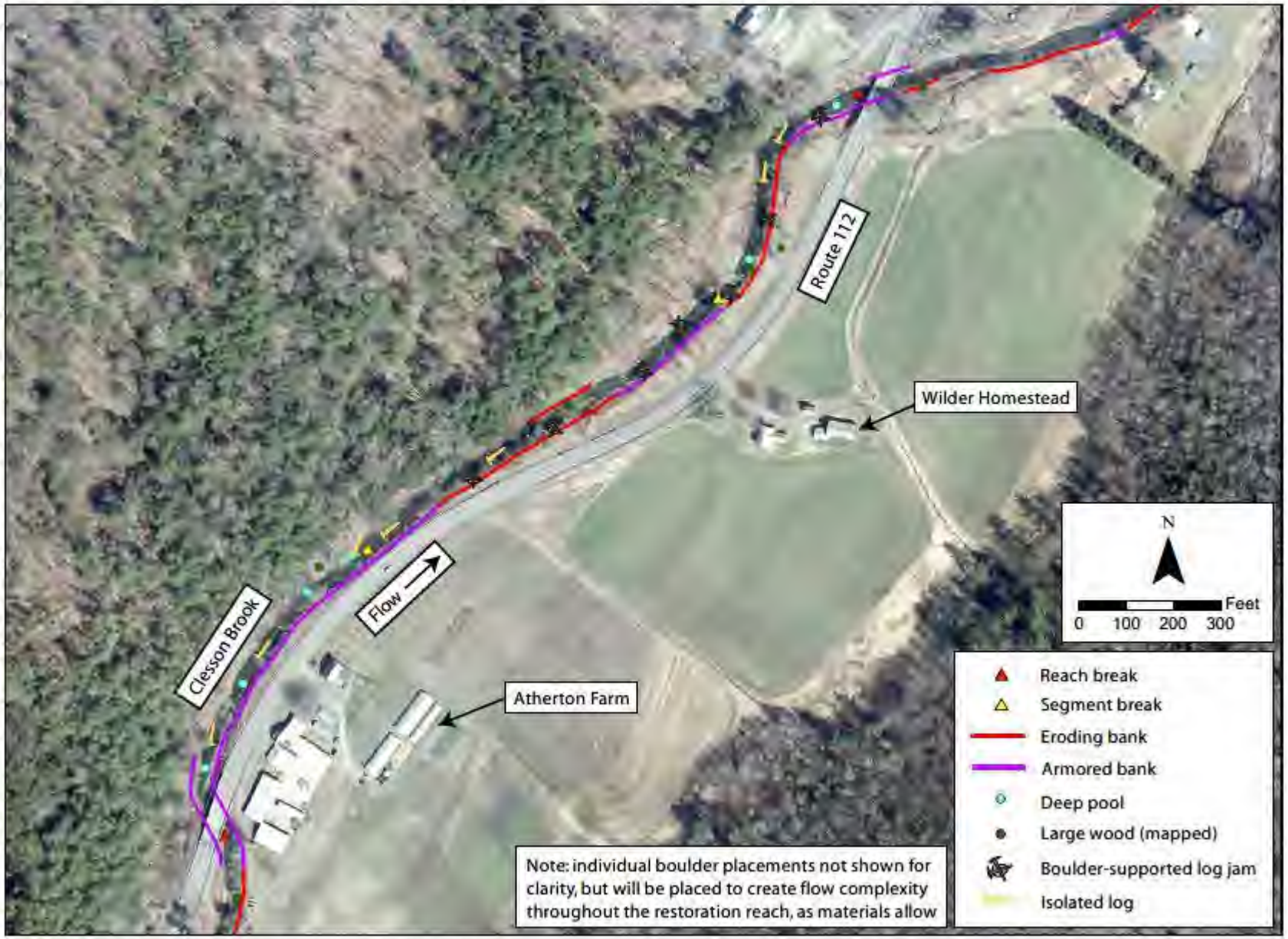
Project Findings – Parcel Prioritization



Project Findings – Conceptual Designs

Clesson Brook - Clessons River Farm Site. Conceptual Design Plan View.

Project Findings – Conceptual Designs



Clesson Brook - Reach CLE05 Site. Conceptual Design Plan View.

Project Findings – Conceptual Designs

Project type: Road crossing upgrade/replacement and mass failure stabilization
Town: Buckland Location: Route 112, Ashfield Rd Lat/Long: 42.613240, -72.768920
Stream segment: Clesson Brook, CLE03A

Undersized MassDOT bridge (#B28004) is extreme fluvial erosion hazard with risk of clogging with sediment from adjacent and upstream mass failures. Located downstream of artificially straightened channel and at angle to stream channel. Sediment deposition inside structure and along left abutment limits hydraulic capacity. Significant scour at right bank abutment. Significant rust on steel span. Low clearance at upstream opening. Modeling shows overtopping at 10-year R.I. event. Replace bridge with increased span and increased clearance, add floodplain culverts, and stabilize mass failure.

Project Findings – Conceptual Designs

Clesson Brook - Route 112 Bridge Site (MassDOT B28004). Conceptual Design Plan View (Modeled Late Century 100-year flow event).

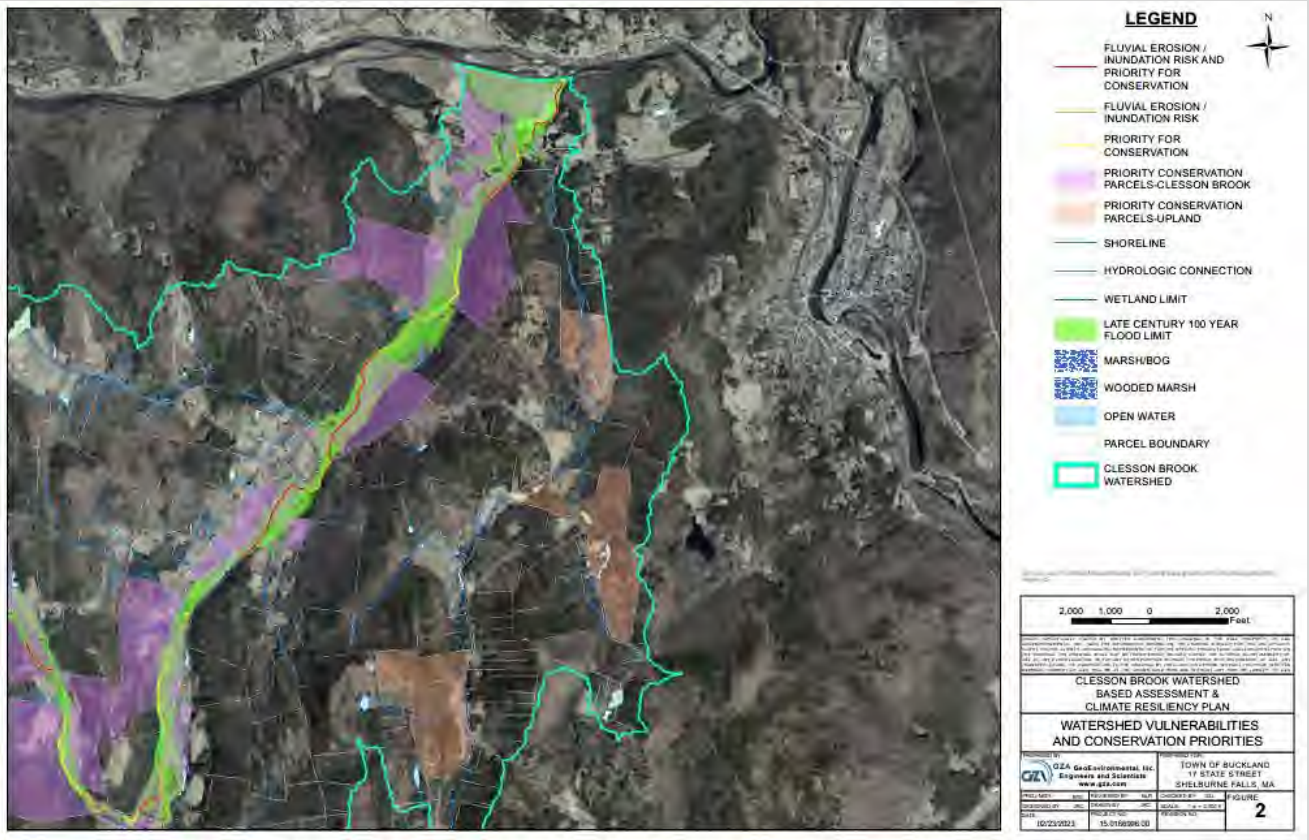
Next Steps

- **FY24 MVP Action Grant**
  - Seeking funding to implement recommended projects & continue landowner outreach
  - River Corridor Mapping
  - Develop 25%-level designs for the Route 112 Bridge enlargement
    - Includes preliminary subsurface explorations to establish design parameters for bridge foundations, wetland resource delineation, and summary of permitting needs and costs
  - Develop 25%-level designs for the Clessons River Farm Bank Stabilization Project

The mapped river corridor shows the room a river needs and the land vulnerable to flooding and fluvial erosion. The 100-year floodplain maps produced by FEMA do not address fluvial erosion hazards.

Next Steps

- **FY24 MVP Action Grant (Cont.)**
  - Reach out to landowners who own the land included in the priority projects/restoration designs
  - Engage private landowners in discussions and demonstrations of climate resilient management practices for private lands
  - Community Open House to share lessons learned
  - Continue working with MTRS students



Outreach in FY24 will focus on landowners who own the Priority Conservation Parcels highlighted in purple and brown on the Watershed Vulnerabilities and Conservation Priorities map produced by GZA GeoEnvironmental. Outreach in FY25 will focus on the wider community.

Next Steps

- **Finalize Climate Resilient Watershed Based Plan**
  - WBP will meet EPA's recommended format and incorporate the road-stream crossing study, H&H model, and the fluvial geomorphic assessment
  - This will be available for public review later this summer

Project website: bit.ly/clessonbrookmap

Questions?

Downstream view of the Clesson Brook, September 2022