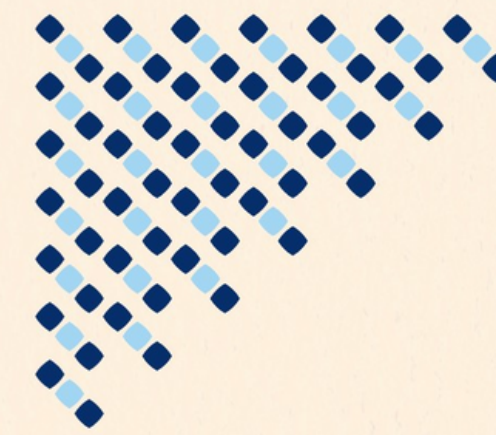


SOUTHERN NEW HAMPSHIRE
PLANNING COMMISSION

Climate Action Toolkit

Suzanne Nienaber, Principal Planner
Zachary Swick, Senior GIS Analyst

November 16, 2023



CLIMATE ACTION TOOLKIT



ROADWAY ADAPTATIONS

Southern New Hampshire
Planning Commission

November 2023



TABLE OF CONTENTS

Introduction

Chapter 1 – Temperature Check: State of The Region

Chapter 2 – Technical Analysis: Corridor-Level Vulnerability

Chapter 3 – Menu of Strategies: Roadway Adaptation

Chapter 4 – Adaptation in Action

Appendices



TABLE OF CONTENTS

Introduction

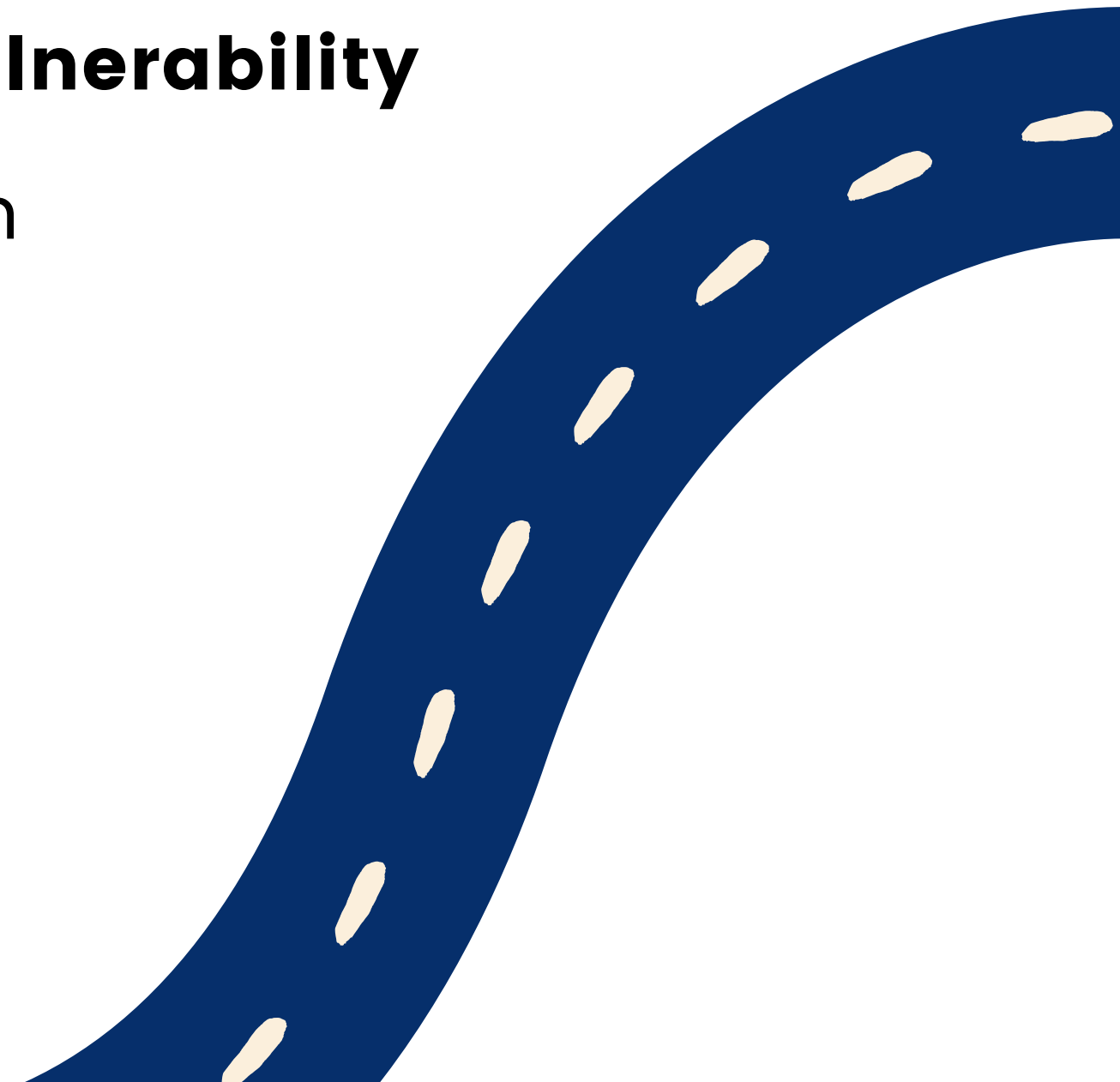
Chapter 1 – Temperature Check: State of The Region

Chapter 2 – Technical Analysis: Corridor-Level Vulnerability

Chapter 3 – Menu of Strategies: Roadway Adaptation

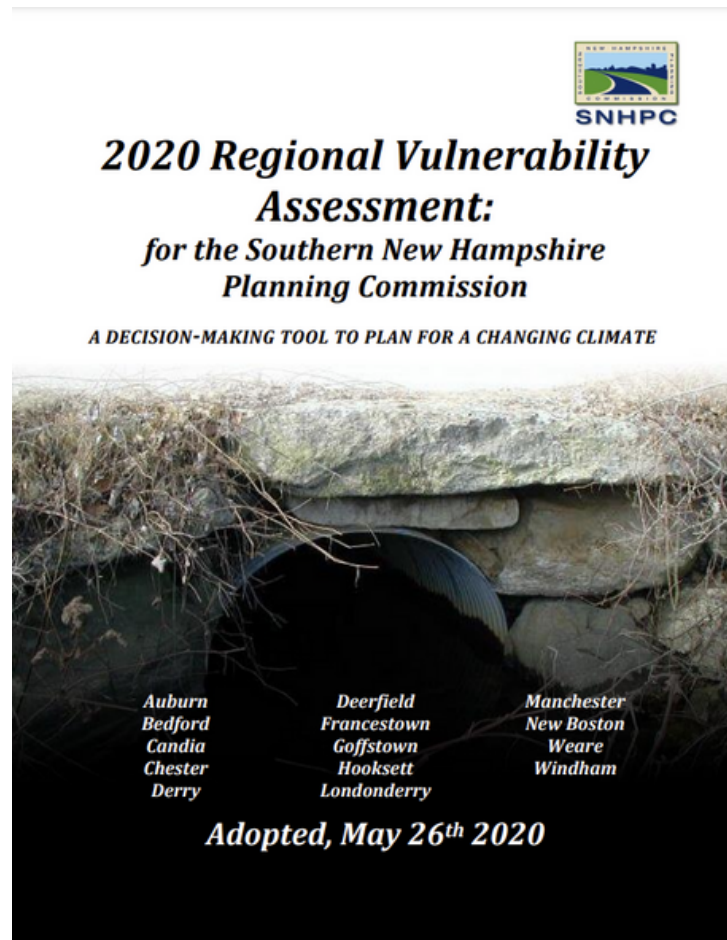
Chapter 4 – Adaptation in Action

Appendices



Introduction

Toolkit inputs, Value of a collaborative regional approach



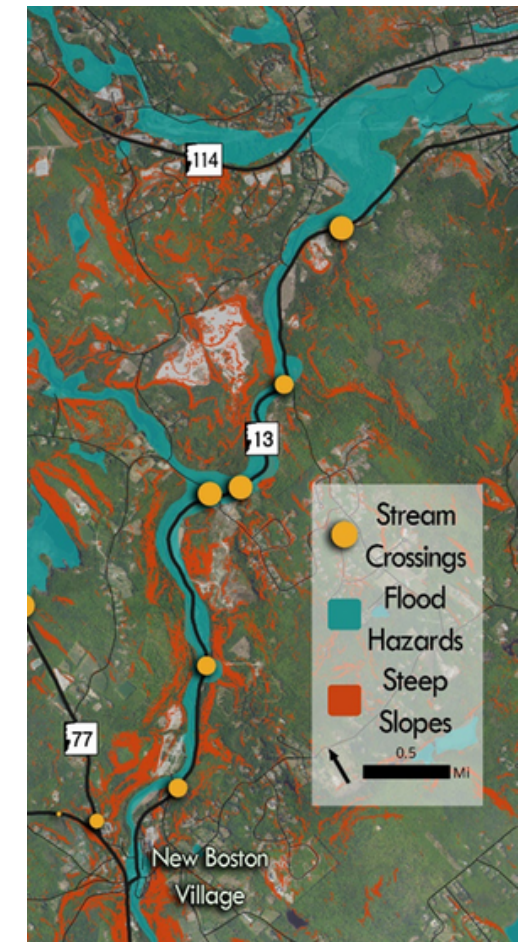
2020 Vulnerability
Assessment



Resource review +
RPC outreach



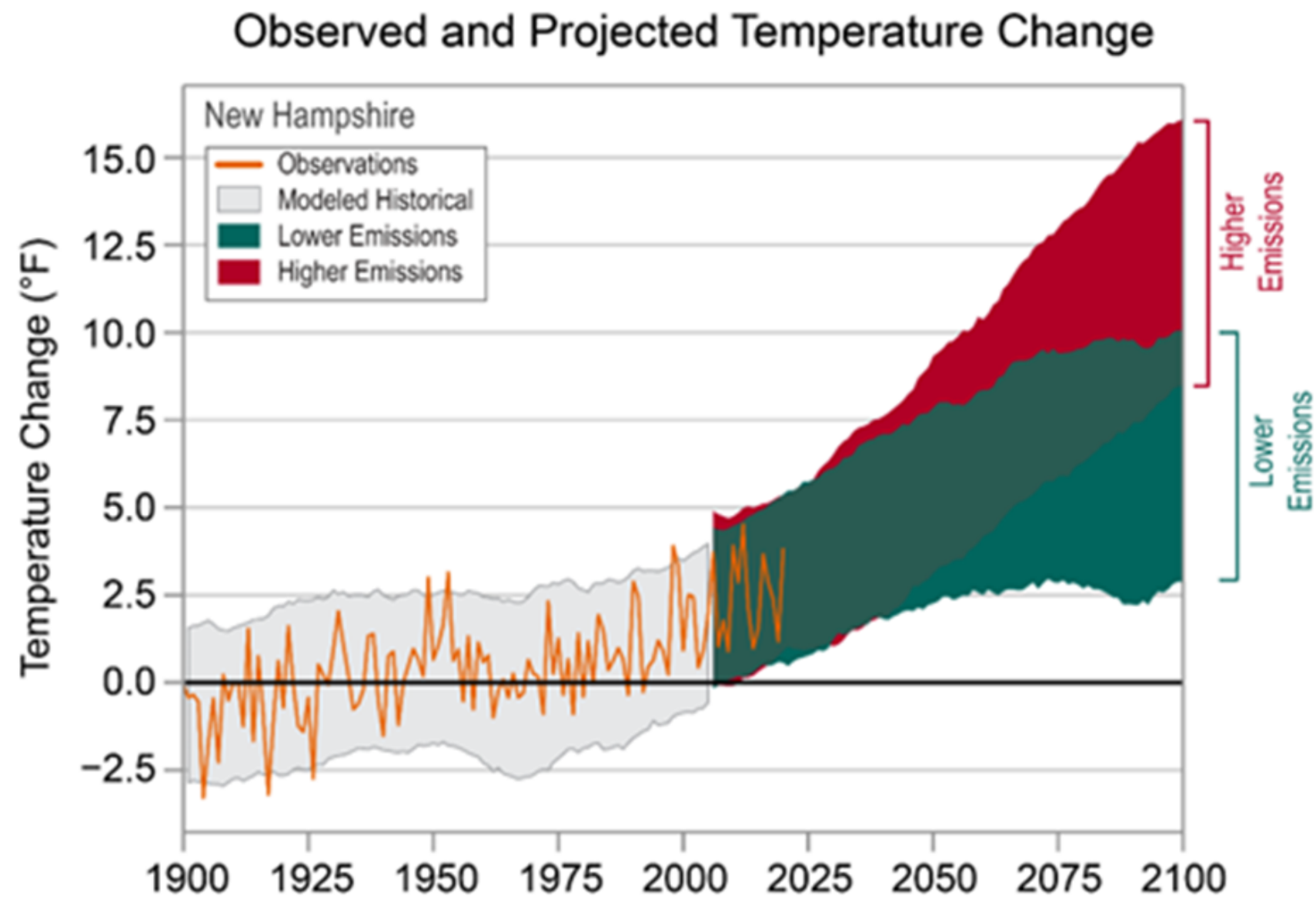
Stakeholder insights



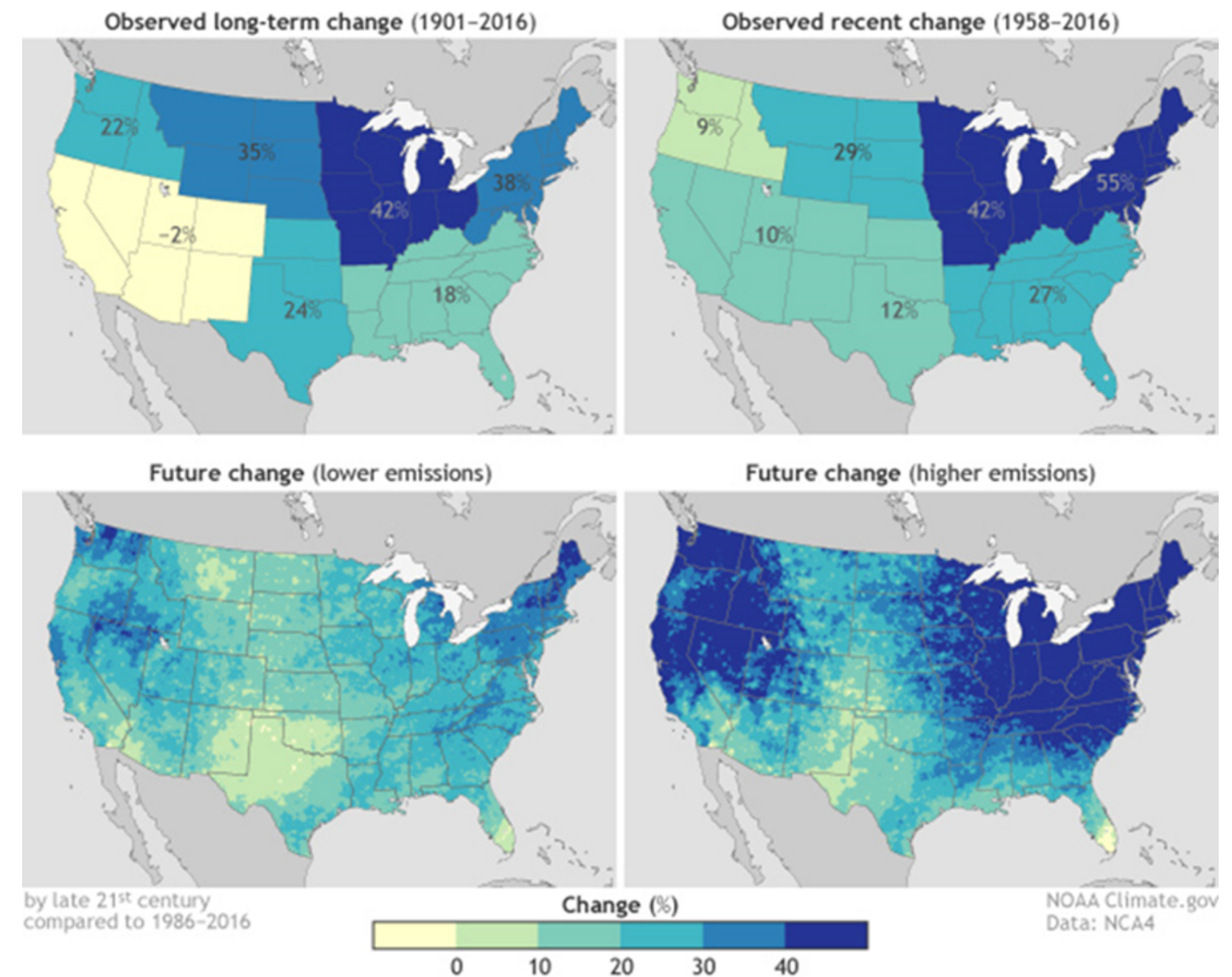
Corridor analysis

1. Temperature Check: State of the region

Climate data and trends



Change in extreme precipitation across the United States



1. Temperature Check: State of the region

Climate impacts

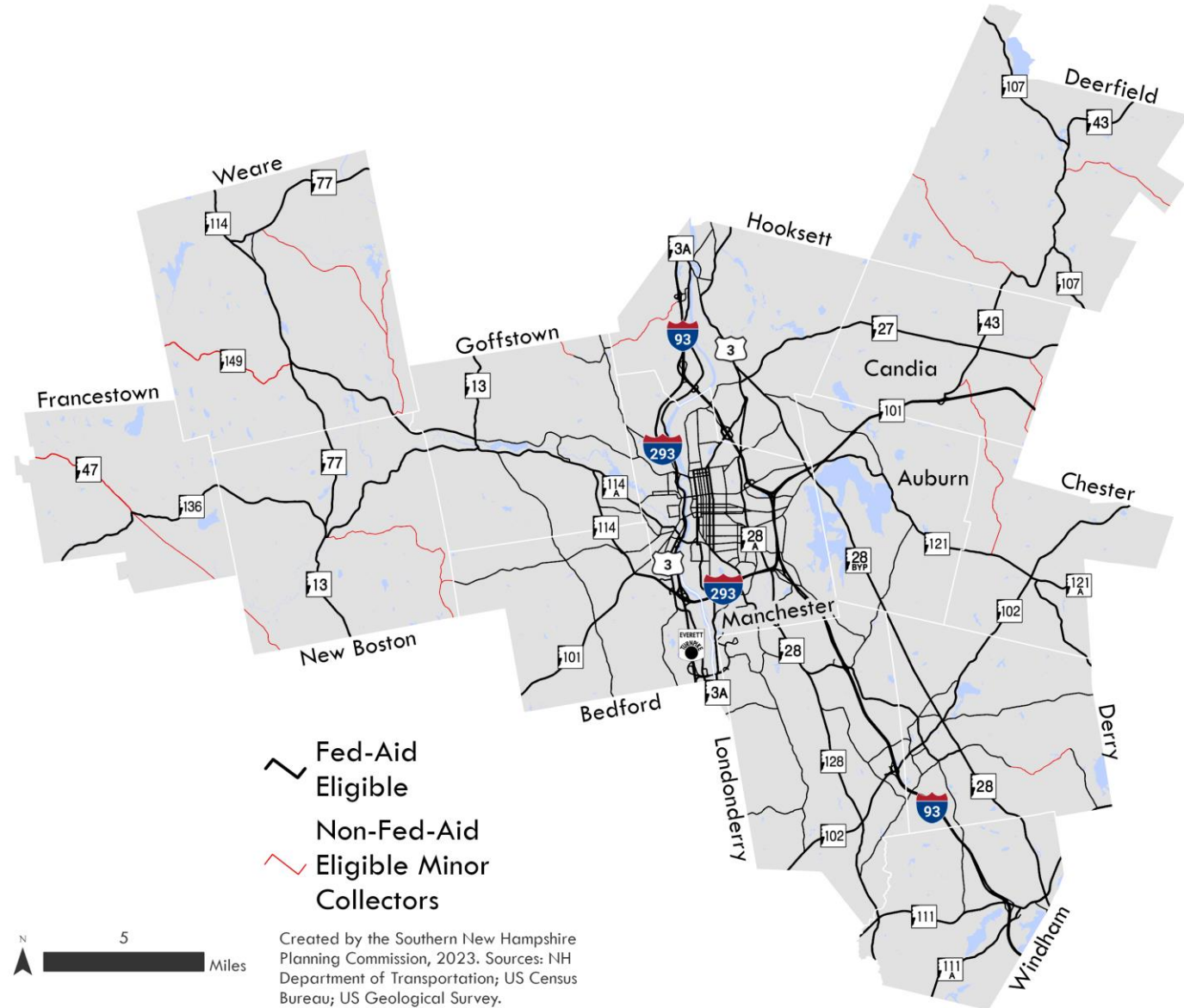
- Greater frequency of heavy rainfall events
- Higher risk of flooding
- Infrastructure vulnerability



2. Technical Analysis: Corridor-level vulnerability

Focus: Federal-Aid Eligible Roads

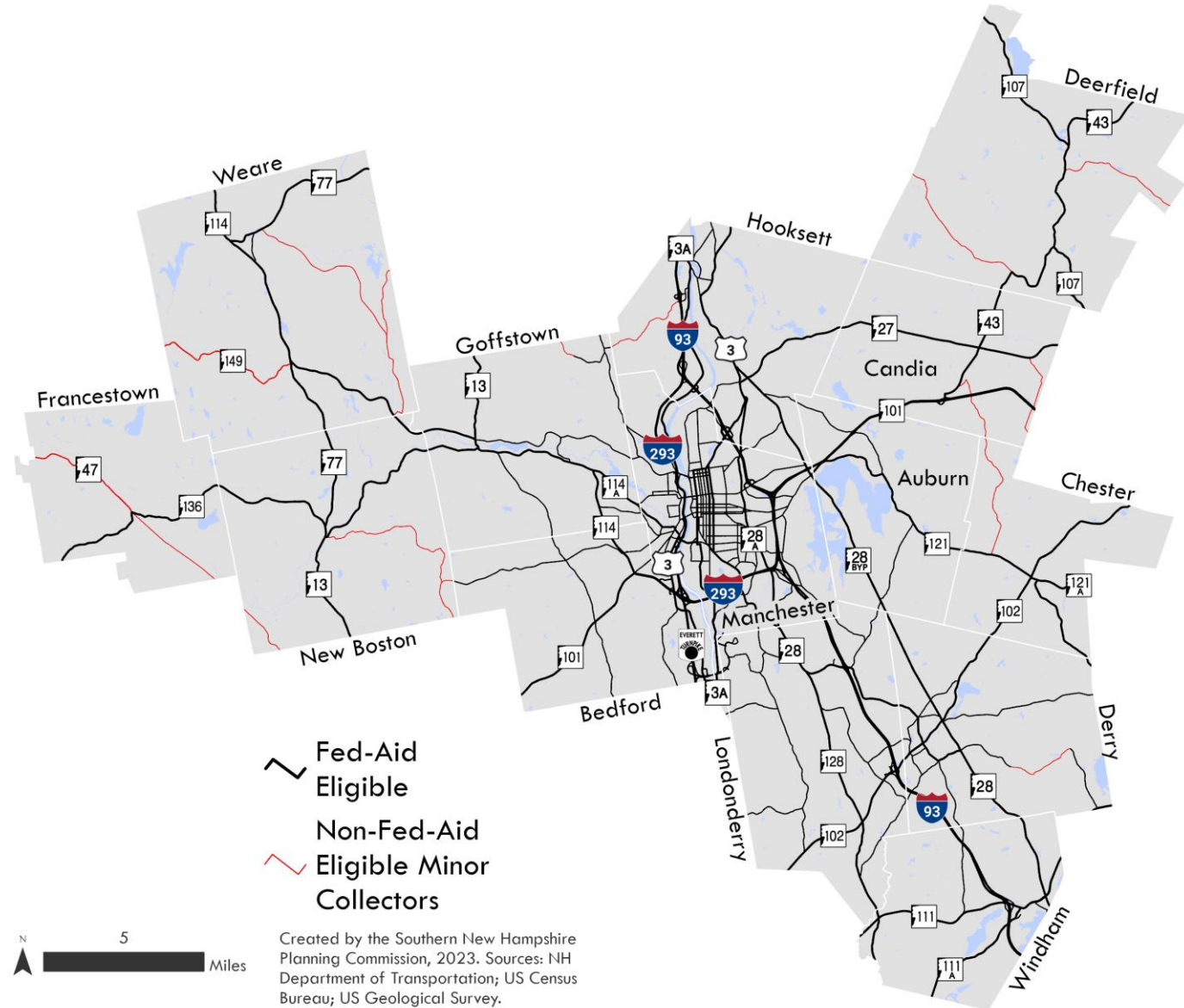
- 1,200 fed-aid eligible lane-miles
- 530 National Highway System (NHS)
- 330 interstates, other freeways, or expressways
- 870 are other arterials & collectors
- 2 are local NHS roads



2. Technical Analysis: Corridor-level vulnerability

Focus: Federal-Aid Eligible Roads

- Stream crossings
- Steep slopes
- Flood prone areas
- Corridor-level approach




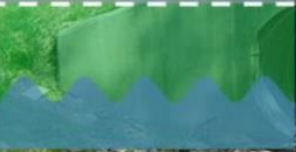



Stream Crossings: An Updated Scoring Rubric

AADT	Scored 0 to 5 with 0 representing zero AADT and 5 representing the highest AADT among the scored stream crossings	
Structural Condition	5 =	Poor condition or on bridge redlist
	2.5 =	Fair condition
	0 =	Good condition
10-Year Hydraulic Vulnerability	5 =	Overtop
	4 =	Vulnerable
	2 =	Unknown
	0 =	Pass or not applicable
Geomorphic Compatibility	5 =	Fully incompatible
	4 =	Mostly incompatible
	3 =	Unknown
	2 =	Partially compatible
	1 =	Mostly compatible
	0 =	Fully compatible or not applicable
Flooding	5 =	FEMA floodway
	4 =	FEMA 1% chance annual floodzone or hazard mitigation plan identified flood hazard
	3 =	FEMA 0.2% chance annual floodzone
	0 =	FEMA minimal flood risk floodzone

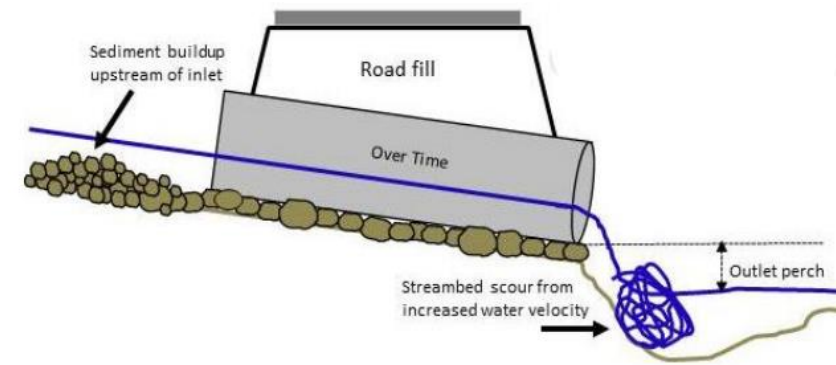
Stream Crossings: An Updated Scoring Rubric

Hydraulic Vulnerability

OVERTOP	Flood water level at or above road		Modeled Headwater Depths 
VULNERABLE	Flood water level above top of culvert and below top of road		
PASS	Flood water level at or below top of culvert		
	Upstream end of culvert		

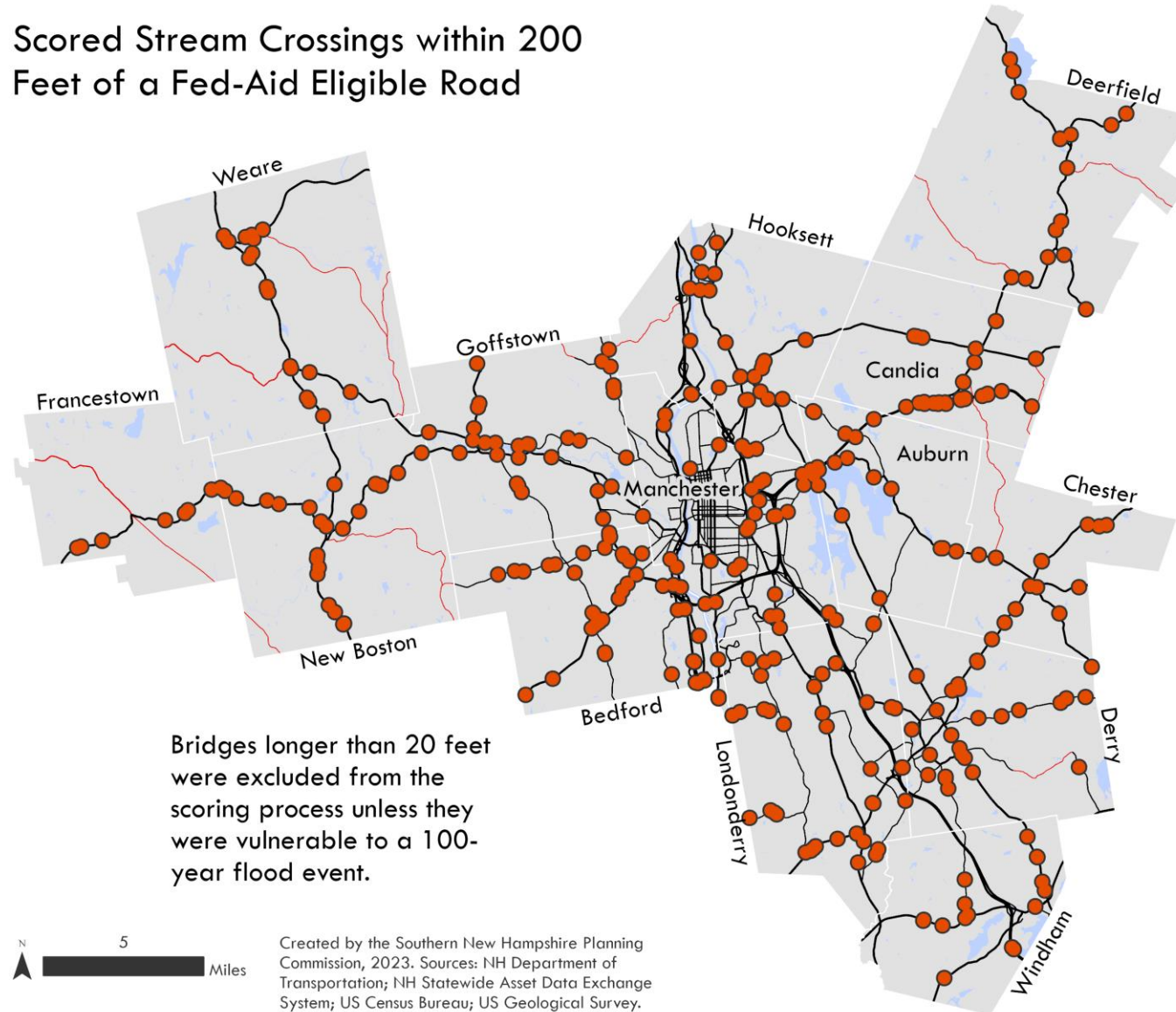
Geomorphic Compatibility

“the long-term compatibility of a stream crossing with river channel form and sediment transport”



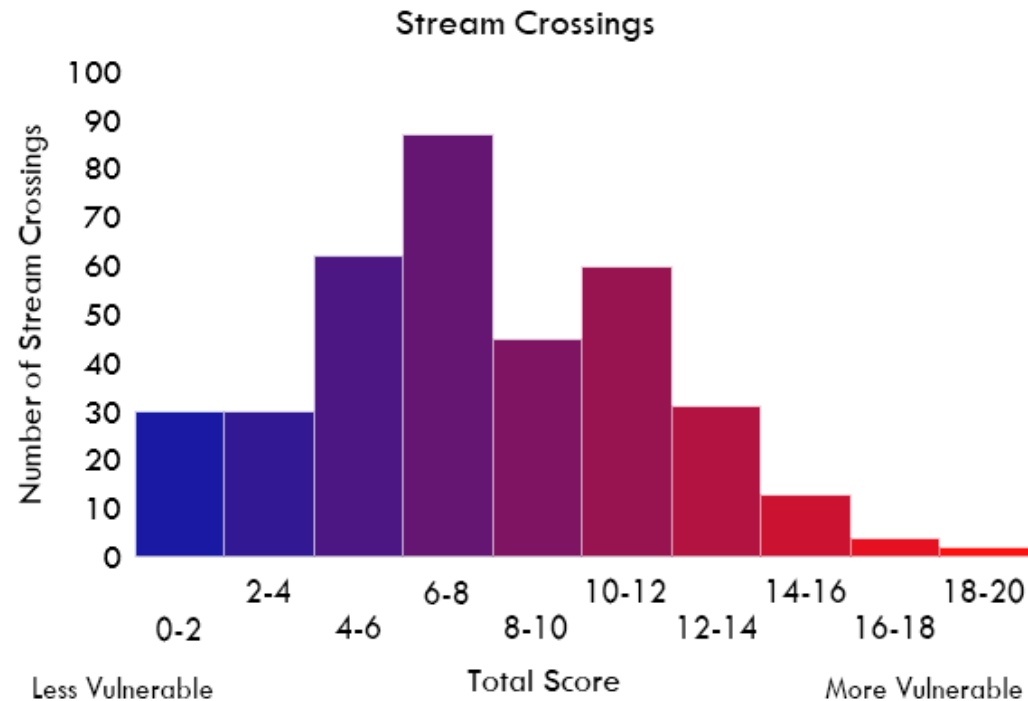
Stream Crossings: An Updated Scoring Rubric

Scored Stream Crossings within 200 Feet of a Fed-Aid Eligible Road



- 364 stream crossings scored
- National Bridge Inventory bridges (20 ft. or more) excluded
 - unless vulnerable/fail 100-year hydraulic vulnerability

Stream Crossings: An Updated Scoring Rubric



Out of 25 total score

- Highest scoring: #5926
Parmenter Rd in Londonderry – 19.9
 - Not directly on fed-aid road
- 2nd highest scoring: #6232 N
High St in Derry – 18.3
- 3rd highest scoring: #2743
Raymond Rd (NH-107) in
Deerfield – 17.8

Stream Crossings: An Updated Scoring Rubric

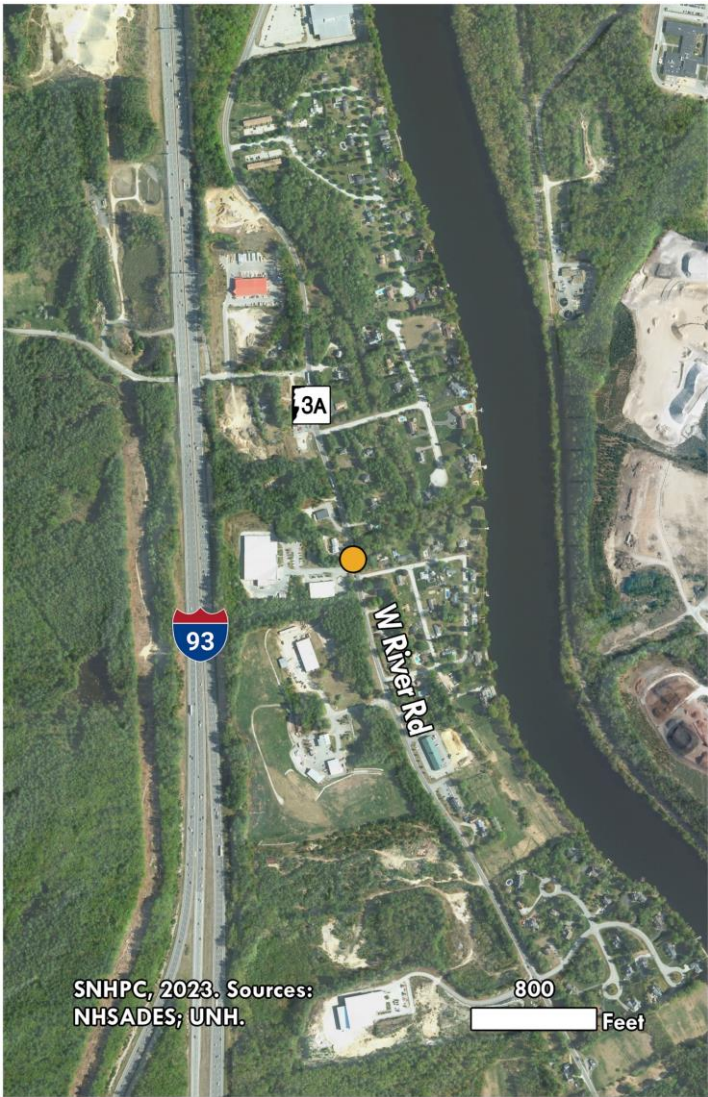
Top Twenty Highest Scoring Stream Crossings Regionwide

SADES ID	Town	Facility	Route	Address	Longitude	Latitude	Transverses Fed-Aid Road	Ownership	Total Score
5926	Londonderry	Parmenter Rd		12 Parmenter Rd	-71.3928	42.8361	No	Londonderry	19.9
6232*	Derry	N High St		94 N High St	-71.3319	42.8897	Yes	Derry	18.3
2743	Deerfield	Raymond Rd	NH-107	53 Raymond Rd	-71.2386	43.1193	Yes	NHDOT	17.8
12603	Manchester	Candia Rd		1163 Candia Rd	-71.4080	42.9884	Yes	Manchester	17.6
8911	Goffstown	E Dunbarton Rd		350 E Dunbarton Rd	-71.5170	43.0544	Yes	Goffstown	17.2
191	Bedford	NH Route 114	NH-114	Old Bedford Rd	-71.5058	42.9665	Yes	NHDOT	16.8
5927	Londonderry	Nashua Rd	NH-102	316 Nashua Rd	-71.3942	42.8352	Yes	NHDOT	15.9
10248	Hooksett	W River Rd	NH-3A	226 W River Rd	-71.4678	43.0659	Yes	NHDOT	15.8
149	Deerfield	Raymond Rd	NH-107	71 Raymond Rd	-71.2417	43.1154	Yes	NHDOT	15.8
5469	Candia	Old Candia Rd	NH-43	51 Old Candia Rd	-71.2925	43.0558	Yes	NHDOT	15.5
5994	Derry	Windham Rd		48 Windham Rd	-71.3097	42.8631	Yes	Derry	15.5
5930	Londonderry	Nashua Rd	NH-102	302 Nashua Rd	-71.3915	42.8371	Yes	NHDOT	15.4
10887	Hooksett	Pleasant St		28 Pleasant St	-71.4513	43.1103	Yes	NHDOT	15.2
8916	Goffstown	Wallace Rd		183 Wallace Rd	-71.5750	43.0015	Yes	Goffstown	14.9
7199	Windham	Rockingham Rd	NH-28	64 Rockingham Rd	-71.2522	42.8206	Yes	NHDOT	14.8
5995	Derry	Sunset Ave		1 Sunset Ave	-71.3112	42.8684	No	Derry	14.5
19728**	Manchester	CSX Railroad		400 Gay St	-71.4588	42.9470	No	NHDOT	14.4
200	Derry	Chester Rd	NH-102	76 Chester Rd	-71.3027	42.9082	Yes	NHDOT	14.4
6022	Deerfield	North Rd	NH-107	340 North Rd	-71.2643	43.1779	Yes	NHDOT	14.4
6774	Chester	Derry Rd	NH-102	220 Derry Rd	-71.2679	42.9440	Yes	NHDOT	13.9
12551	Hooksett	Auburn Rd		47 Auburn Rd	-71.4110	43.0395	Yes	Hooksett	13.8
9118	Bedford	New Boston Rd		NH Route 114	-71.5091	42.96866	Yes	NHDOT	13.8

*Culvert to be replaced as part of the construction of I-93 Exit 4A.

**Railroad bed. Close proximity to I-293 but significant grade separation severely limits interaction.

Stream Crossings: An Updated Scoring Rubric



SADES ID: 10248		
Municipality	Hooksett	
Facility	W River Rd	
AADT	20,700	2.3
Structural Condition	Fair	2.5
10-Year Hydraulic Vulnerability	Overtop	5
Geomorphic Compatibility	Partially Compatible	2
Flooding	1% Chance Annual Floodzone	4
Total Score	15.8	

Prioritizing Corridors: Stream Crossing Density and Vulnerability

$$\text{Stream Crossing Density} = \frac{\text{Number of Stream Crossings}}{\text{Linear-Miles}}$$

$$\text{Aggregate Stream Crossing Vulnerability} = \frac{\text{Combined Vulnerability Scores}}{\text{Linear-Miles}}$$

Prioritizing Corridors: Stream Crossing Density and Vulnerability

Stream Crossing Density

0 to 100 With 100 Being the Highest

F.E.E.T.	100
NH-101 (Expressway)	85
NH-101 (Non-Expressway)	79
NH-102	73
NH-136	66
NH-13	58
NH-114	58
NH-28A	55
NH-43	53
NH-121	48
NH-107	46
NH-77	42
NH-111	41
NH-28	40
NH-3A	37
NH-27	35
US-3	34
NH-128	33
NH-28B	29
NH-121A	20
NH-114A	17
NH-111A	8
I-293	6
I-93	5

Aggregate Stream Crossing Vulnerability

0 to 100 With 100 Being the Highest

F.E.E.T.	100
NH-101 (Non-Expressway)	69
NH-101 (Expressway)	67
NH-102	58
NH-114	43
NH-43	39
NH-107	35
NH-28A	35
NH-3A	33
NH-28	32
NH-136	29
US-3	25
NH-77	24
NH-27	24
NH-111	24
NH-121	24
NH-13	23
NH-128	22
NH-114A	18
NH-28B	18
I-293	7
NH-111A	6
I-93	4
NH-121A	2

Prioritizing Corridors: Stream Crossing Density and Vulnerability

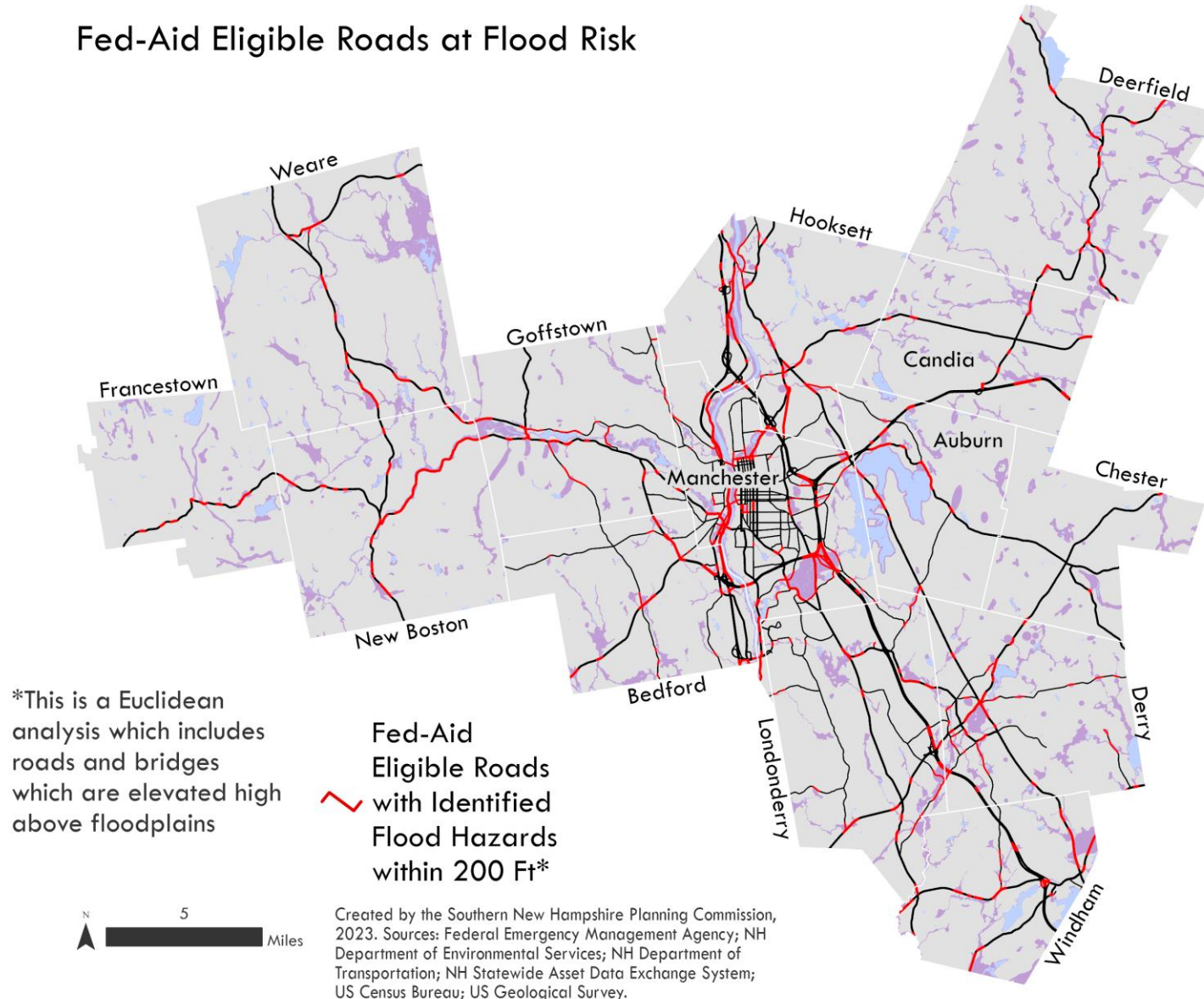
Non-Expressway State Route Priorities Based on Aggregate Stream Crossing Vulnerability*

NH-101 (Non-Expressway)		NH-121		NH-28		NH-77	
Bedford	30	Auburn	12	Derry	9	New Boston	5
		Chester	5	Londonderry	19	Weare	12
NH-102		Derry	N/A	Manchester	3		
Chester	21	Manchester	N/A	Windham	44	US-3	
Derry	16					Bedford	19
Londonderry	38	NH-121A		NH-28A		Hooksett	10
		Chester	1	Hooksett	40	Manchester	4
				Londonderry	N/A		
NH-107				Manchester	8		
Deerfield	15	NH-128					
		Londonderry	12				
NH-111		Windham	0	NH-28B			
Derry	N/A			Auburn	7		
Windham	11	NH-13		Derry	13		
NH-111A		Goffstown	4	Hooksett	3		
Windham	2	New Boston	13	Manchester	N/A		
NH-114		NH-136		NH-3A			
Bedford	100	Francestown	9	Hooksett	17		
Goffstown	14	New Boston	17	Manchester	12		
New Boston	0						
Weare	3	NH-27		NH-43			
		Candia	9	Candia	24		
NH-114A		Hooksett	12	Deerfield	14		
Goffstown	15						
Manchester	0						

*Road segments less than 1 miles excluded

Prioritizing Corridors: Flooding Vulnerability

Fed-Aid Eligible Roads at Flood Risk



130 linear-miles & 270 lane-miles are w/in 200 ft. of a FEMA floodzone or a flood hazard

Prioritizing Corridors: Flooding Vulnerability

% of the Non-Expressway Route in Each Municipality w/in 200 Ft. of a Floodzone or Flood Hazard*

NH-101 (Non-Expressway)		NH-121		NH-28		NH-77	
Bedford	11%	Auburn	19%	Derry	4%	New Boston	5%
		Chester	0%	Londonderry	8%	Weare	8%
NH-102		Derry	N/A	Manchester	11%		
Chester	2%	Manchester	N/A	Windham	25%	US-3	
Derry	16%					Bedford	4%
Londonderry	12%	NH-121A		NH-28A		Hooksett	11%
		Chester	0%	Hooksett	27%	Manchester	12%
				Londonderry	N/A		
NH-107				Manchester	13%		
Deerfield	10%	NH-128					
		Londonderry	3%				
NH-111		Windham	10%	NH-28B			
Derry	N/A			Auburn	15%		
Windham	15%	NH-13		Derry	8%		
NH-111A		Goffstown	8%	Hooksett	5%		
Windham	7%	New Boston	42%	Manchester	N/A		
NH-114		NH-136		NH-3A			
Bedford	24%	Francestown	11%	Hooksett	33%		
Goffstown	9%	New Boston	8%	Manchester	14%		
New Boston	9%						
Weare	4%	NH-27		NH-43			
		Candia	3%	Candia	9%		
NH-114A		Hooksett	10%	Deerfield	12%		
Goffstown	3%						
Manchester	21%						

*Road segments less than 1 miles excluded.

Prioritizing Corridors: Steep Slopes



% of the Area within 200
Feet of a Route Which Is
25 Rise Over Run or
Steeper

NH-3A	19%
I-93	18%
I-293	18%
NH-101 (Expressway)	15%
NH-111	14%
NH-77	13%
NH-13	12%
NH-114	11%
NH-101 (Non-Expressway)	9%
FEET	9%
NH-43	7%
NH-28B	7%
NH-136	7%
US-3	6%
NH-111A	6%
NH-107	6%
NH-102	6%
NH-121	5%
NH-28A	5%
NH-114A	5%
NH-28	5%
NH-121A	4%
NH-27	4%
NH-128	3%

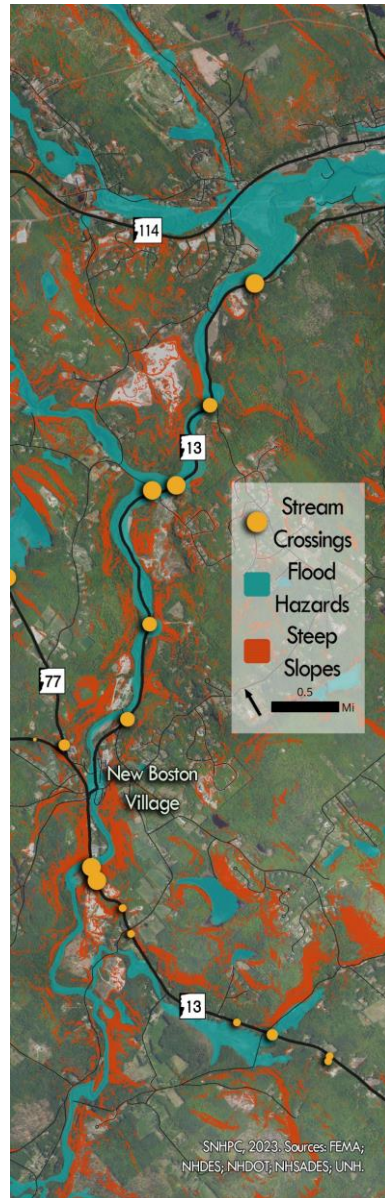
Prioritizing Corridors: Steep Slopes

% of the Area w/in 200 Ft. of a Non-Expressway Route in Each Municipality Which Is 25 Run Over Rise or Steeper*

NH-101 (Non-Expressway)		NH-121		NH-28		NH-77	
Bedford	9%	Auburn	8%	Derry	4%	New Boston	12%
		Chester	3%	Londonderry	7%	Weare	13%
NH-102		Derry	N/A	Manchester	3%		
Chester	4%	Manchester	N/A	Windham	7%	US-3	
Derry	6%					Bedford	7%
Londonderry	7%	NH-121A		NH-28A		Hooksett	8%
		Chester	4%	Hooksett	7%	Manchester	3%
NH-107				Londonderry	N/A		
Deerfield	6%	NH-128		Manchester	5%		
		Londonderry	3%				
NH-111		Windham	3%	NH-28B			
Derry	N/A			Auburn	8%		
Windham	14%	NH-13		Derry	3%		
NH-111A		Goffstown	6%	Hooksett	10%		
Windham	6%	New Boston	15%	Manchester	N/A		
NH-114		NH-136		NH-3A			
Bedford	16%	Francestown	7%	Hooksett	24%		
Goffstown	9%	New Boston	7%	Manchester	14%		
New Boston	18%						
Weare	12%	NH-27		NH-43			
		Candia	4%	Candia	8%		
NH-114A		Hooksett	4%	Deerfield	6%		
Goffstown	2%						
Manchester	8%						

*Road segments less than 1 miles excluded.

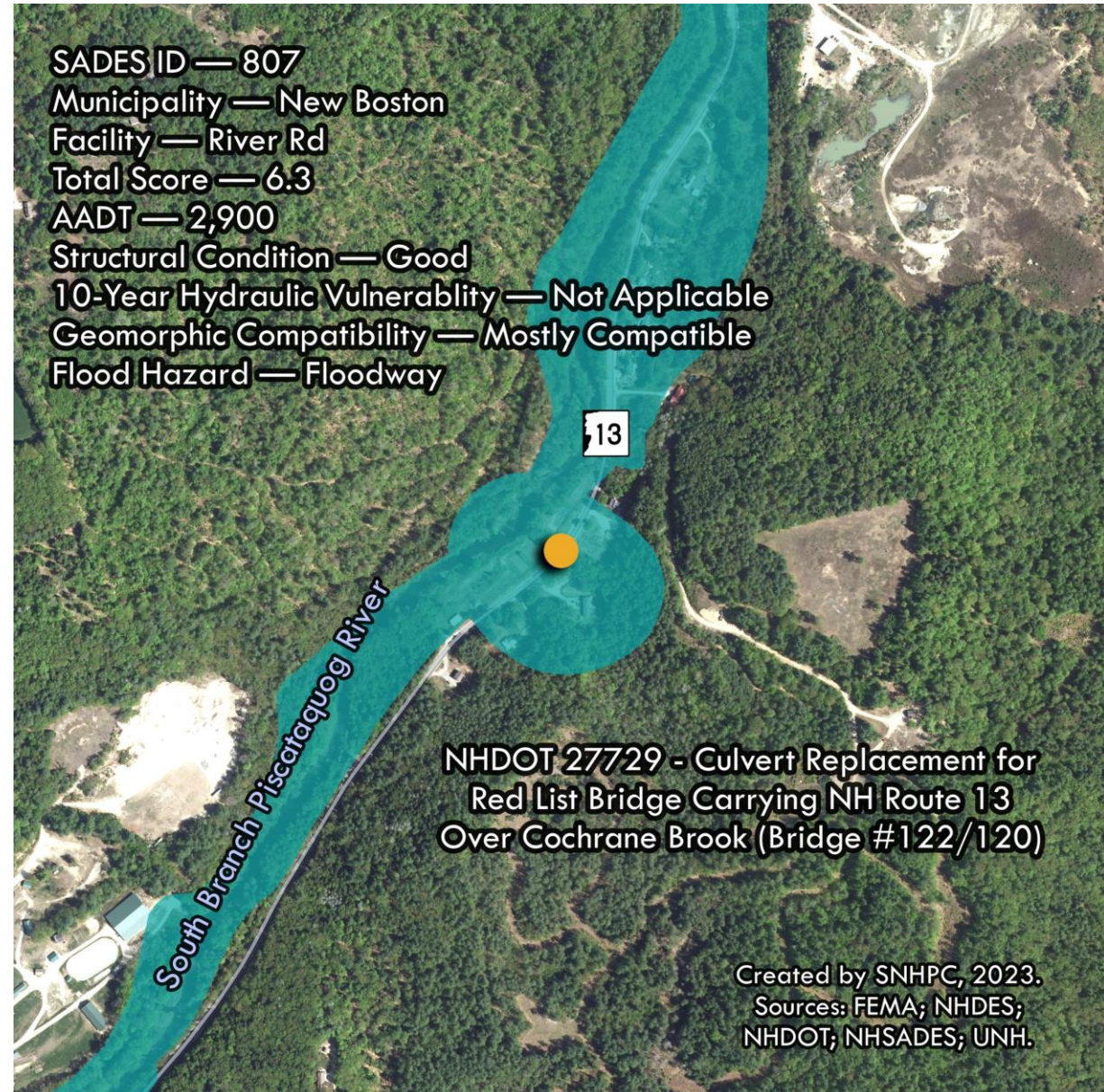
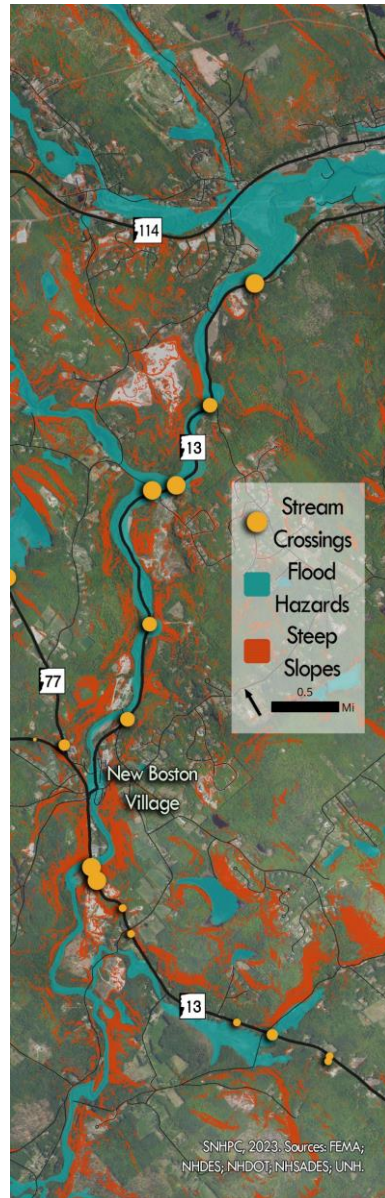
Prioritizing Corridor Vulnerability: Putting It All Together



NH-13 in New Boston

Type of vulnerability	Score	Risk assessment (relative to mean score)
Aggregate stream crossing vulnerability	13 out of 100	Lower risk
Flooding vulnerability	42%	Higher risk
Steep slope vulnerability	15%	Moderate risk

Prioritizing Corridor Vulnerability: Putting It All Together



3. Menu of Strategies: Roadway adaptation

5 Key Themes:

- A. Design & Engineering
- B. Nature-based Solutions
- C. Operations & Maintenance
- D. Outreach & Collaboration
- E. Data, Planning, & Policy

3 Scales of Intervention

- Site
- Corridor
- Systems change

MENU OF STRATEGIES: ROADWAY ADAPTATION



Design and Engineering

	<u>STRATEGY</u>	<u>SCALE</u>	<u>EXAMPLES</u>
<input type="checkbox"/>	A1. Retrofit vulnerable sites to withstand extreme weather events	Site-level	<ul style="list-style-type: none"> • Culvert upgrades (e.g. improved hydraulic capacity/geomorphic compatibility) • Enhanced drainage design • Stream bank armoring • Riprap to prevent bridge scour • Rockfall barriers • Elevation of roadways or bridges
<input type="checkbox"/>	A2. Model wear and asset lifespan to account for climate hazards	Corridor-wide/ Systems change	<ul style="list-style-type: none"> • Performance parameters for asset upgrades • Anticipating climate and land use changes
<input type="checkbox"/>	A3. Update roadway design standards to reflect latest climate data	Systems change	<ul style="list-style-type: none"> • Developing climate-resilient design guidelines/"climate-ready" standards • Applying updated precipitation models and asset risk assessments based on latest climate data • Updating design calculations (e.g. hydraulic capacity, flood frequency)



Nature-Based Solutions

	<u>STRATEGY</u>	<u>SCALE</u>	<u>EXAMPLES</u>
<input type="checkbox"/>	B1. Preserve wetlands and floodplains to improve stormwater retention	Site-level/ Corridor	<ul style="list-style-type: none"> • Right-of-way acquisitions for flood storage • Wetlands management strategy
<input type="checkbox"/>	B2. Improve river and stream environments	Site-level/ Corridor	<ul style="list-style-type: none"> • Riverbank protection/armoring with vegetated erosion control method • Re-naturalized streambeds • Infrastructure setbacks from river channels

A. Design & Engineering

- ✓ A.1 Retrofit vulnerable sites to withstand extreme weather events
- ✓ A.2 Model wear and asset lifespan to account for climate hazards
- ✓ A.3 Update roadway design standards to reflect latest climate data



B. Nature-based Solutions

- ✓ B.1 Preserve wetlands and floodplains to improve stormwater retention
- ✓ B.2 Improve river and stream environments
- ✓ B.3 Enhance stormwater management via green infrastructure / Low Impact Development
- ✓ B.4 Update vegetation control practices



Image from "Beyond the Beaver Dam: The success of the NHDES ARM Fund"

C. Operations & Maintenance

- ✓ C.1 Optimize monitoring, maintenance, and replacement of bridges and culverts
- ✓ C.2 Update seasonal maintenance programs in response to climate change
- ✓ C.3 Establish flexible, responsive maintenance capabilities



D. Outreach & Collaboration

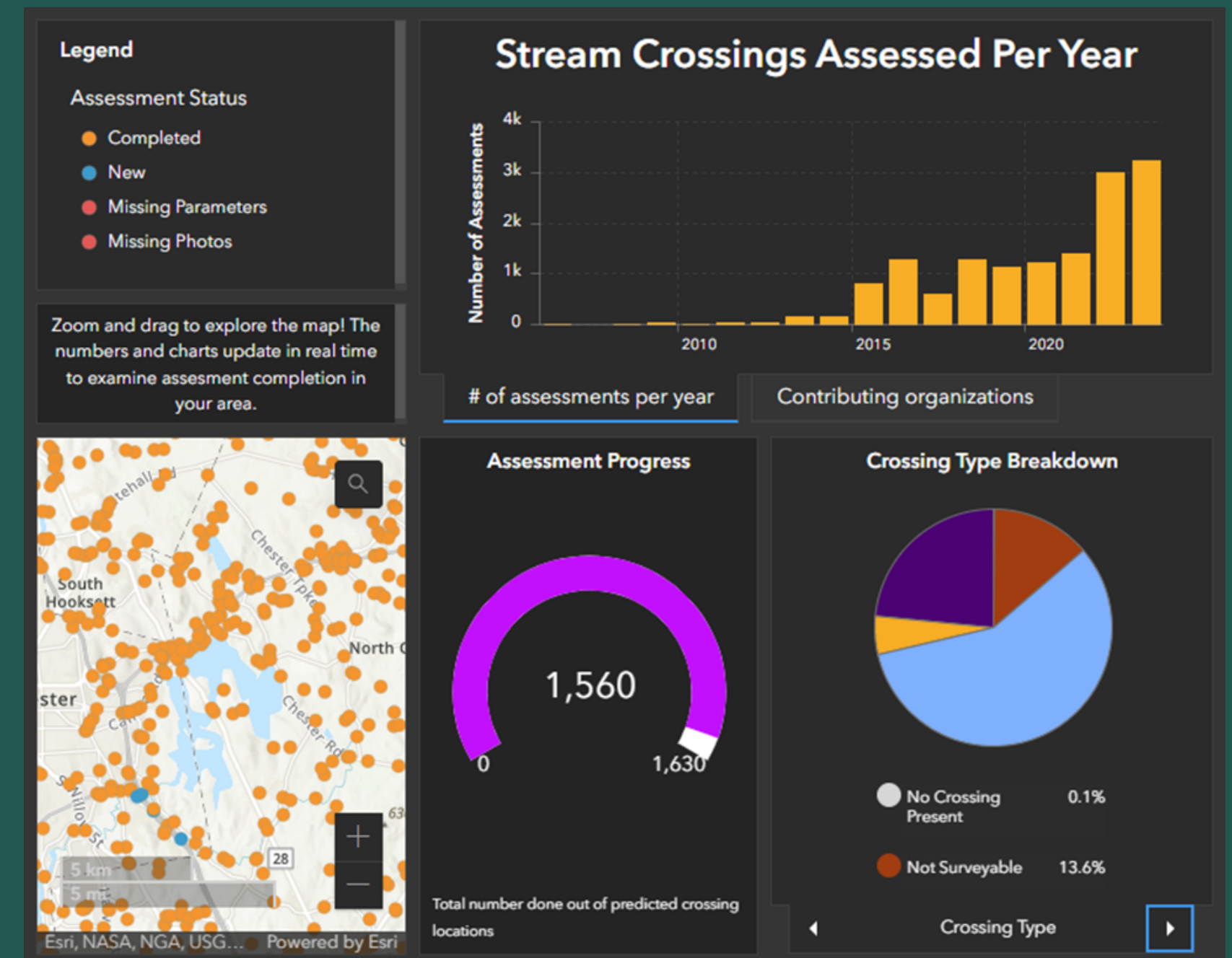
- ✓ D.1 Support staff training and knowledge sharing about climate priorities
- ✓ D.2 Increase public awareness of climate-related risks to infrastructure
- ✓ D.3 Strengthen multi-sector partnerships and collaboration



Image courtesy of NH Coastal Adaptation Workgroup - nhcaw.org

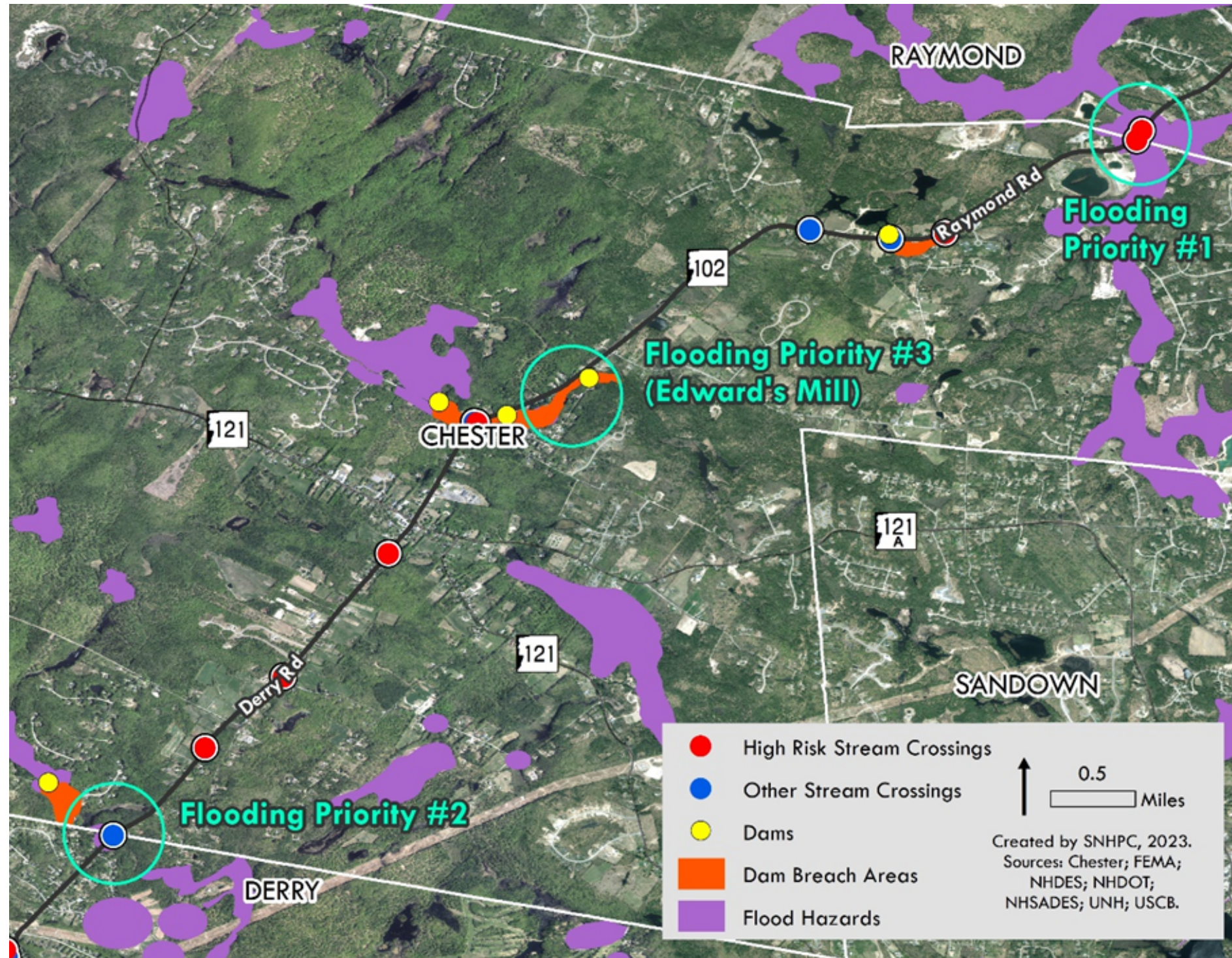
E. Data, Planning & Policy

- ✓ E.1 Regularly inventory vulnerable assets using up-to-date climate data
- ✓ E.2 Develop climate priorities and incorporate into plans and policies
- ✓ E.3 Integrate climate data to guide ongoing decision-making



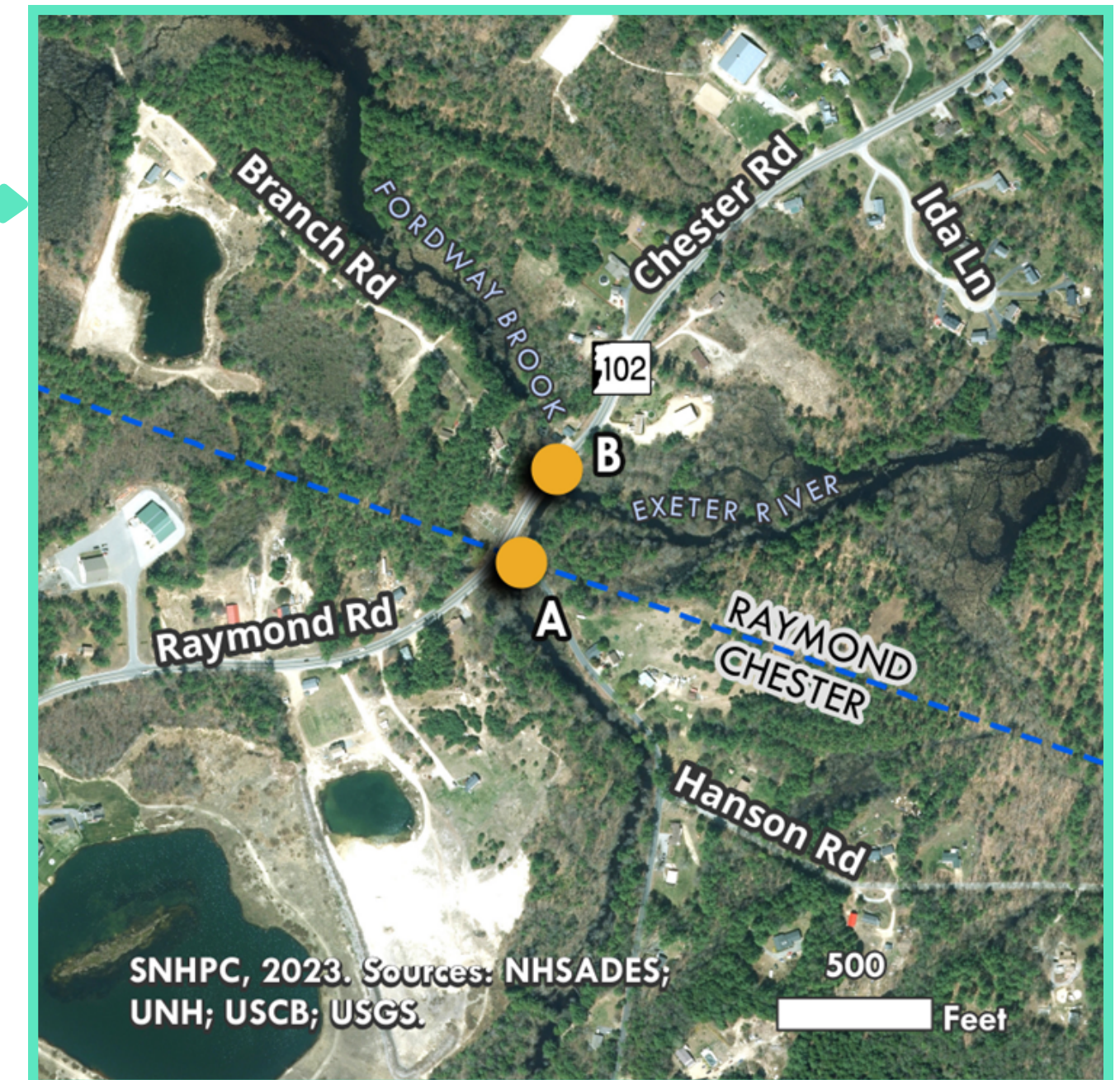
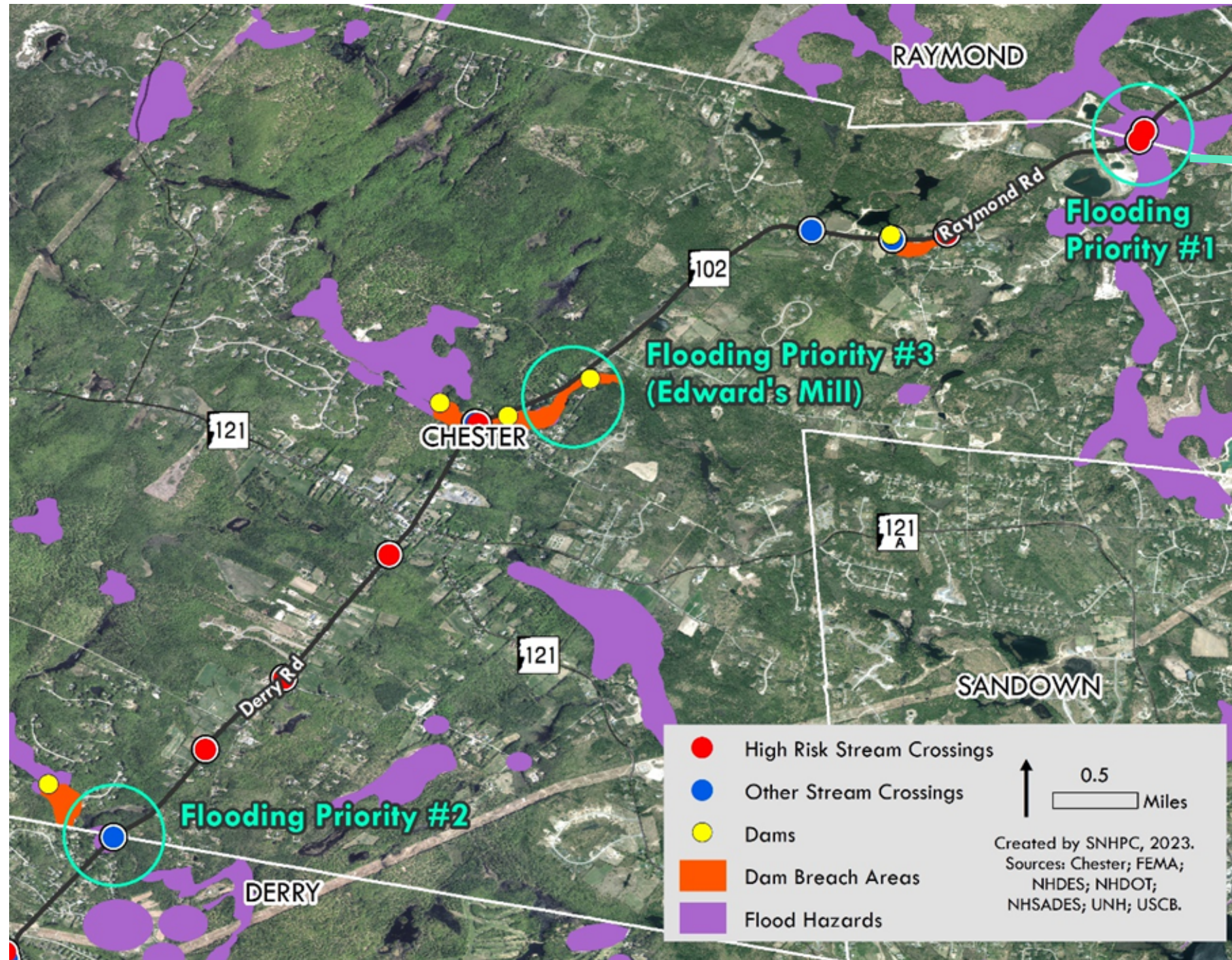
4. Adaptation in Action

Corridor case study: NH-102 in Chester



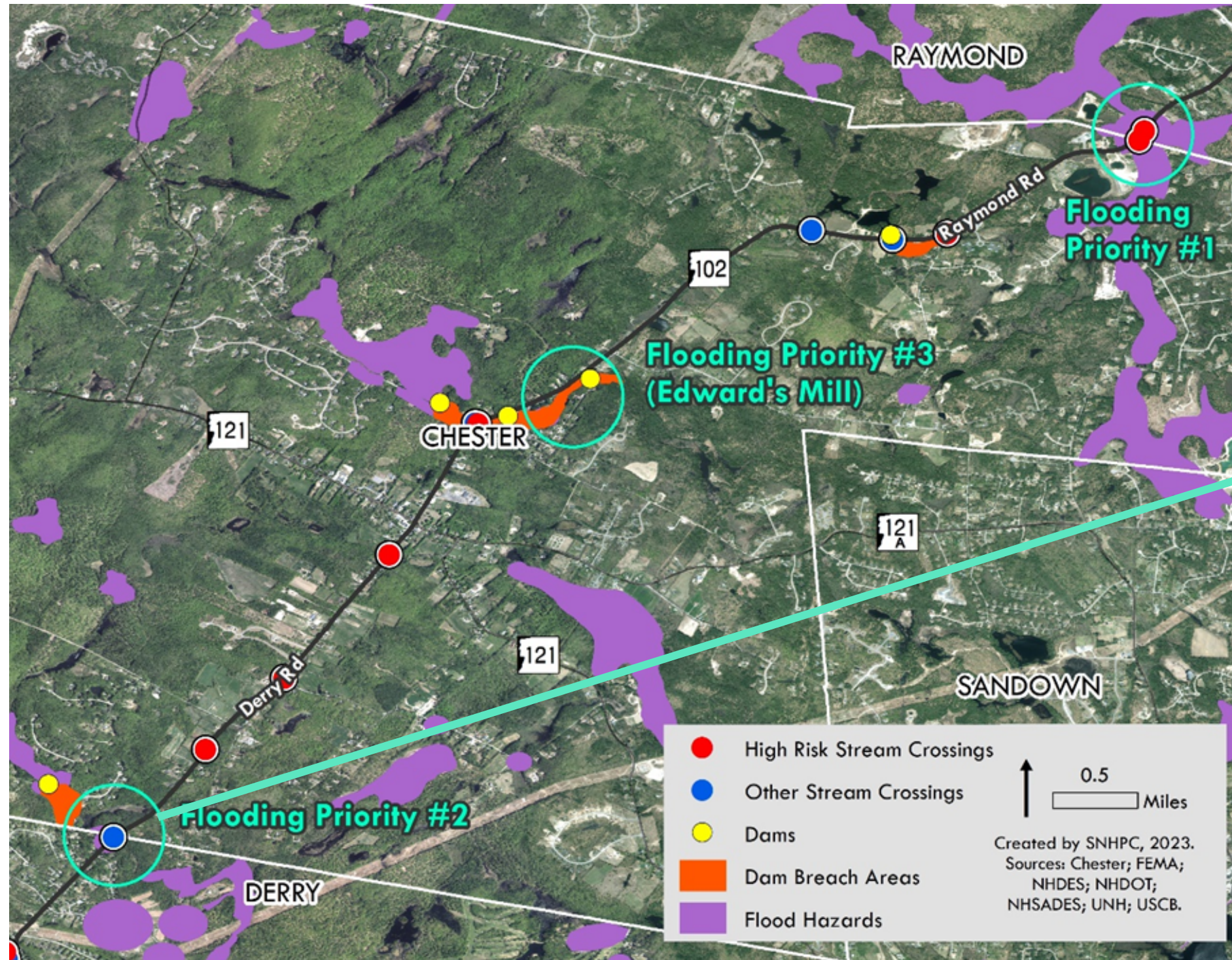
4. Adaptation in Action

Priority site #1: NH-102 at Hanson Road



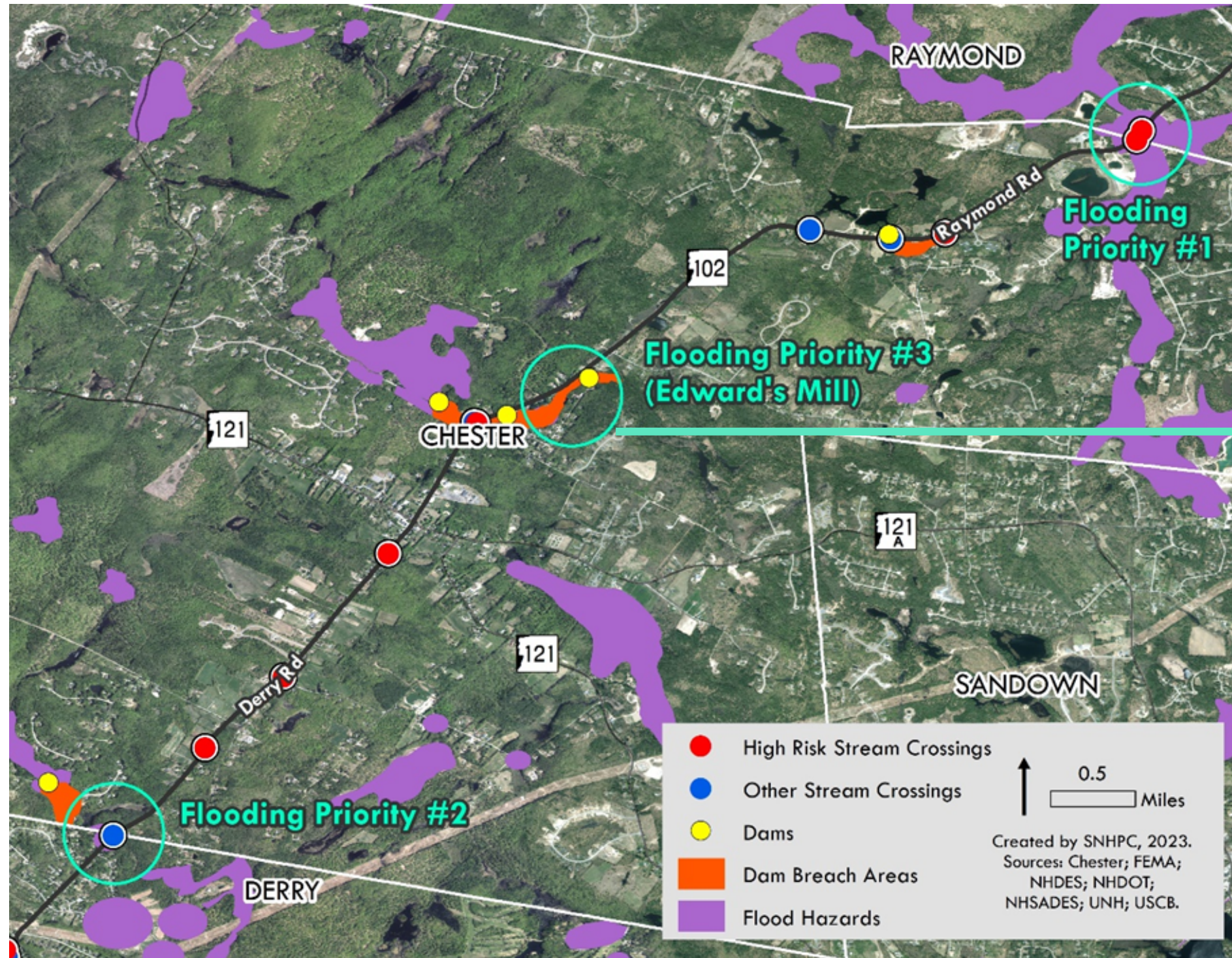
4. Adaptation in Action

Priority site #2: NH-102 at Derry Town Line



4. Adaptation in Action

Priority site #3: NH-102 at Edwards Mill Road



4. Adaptation in Action

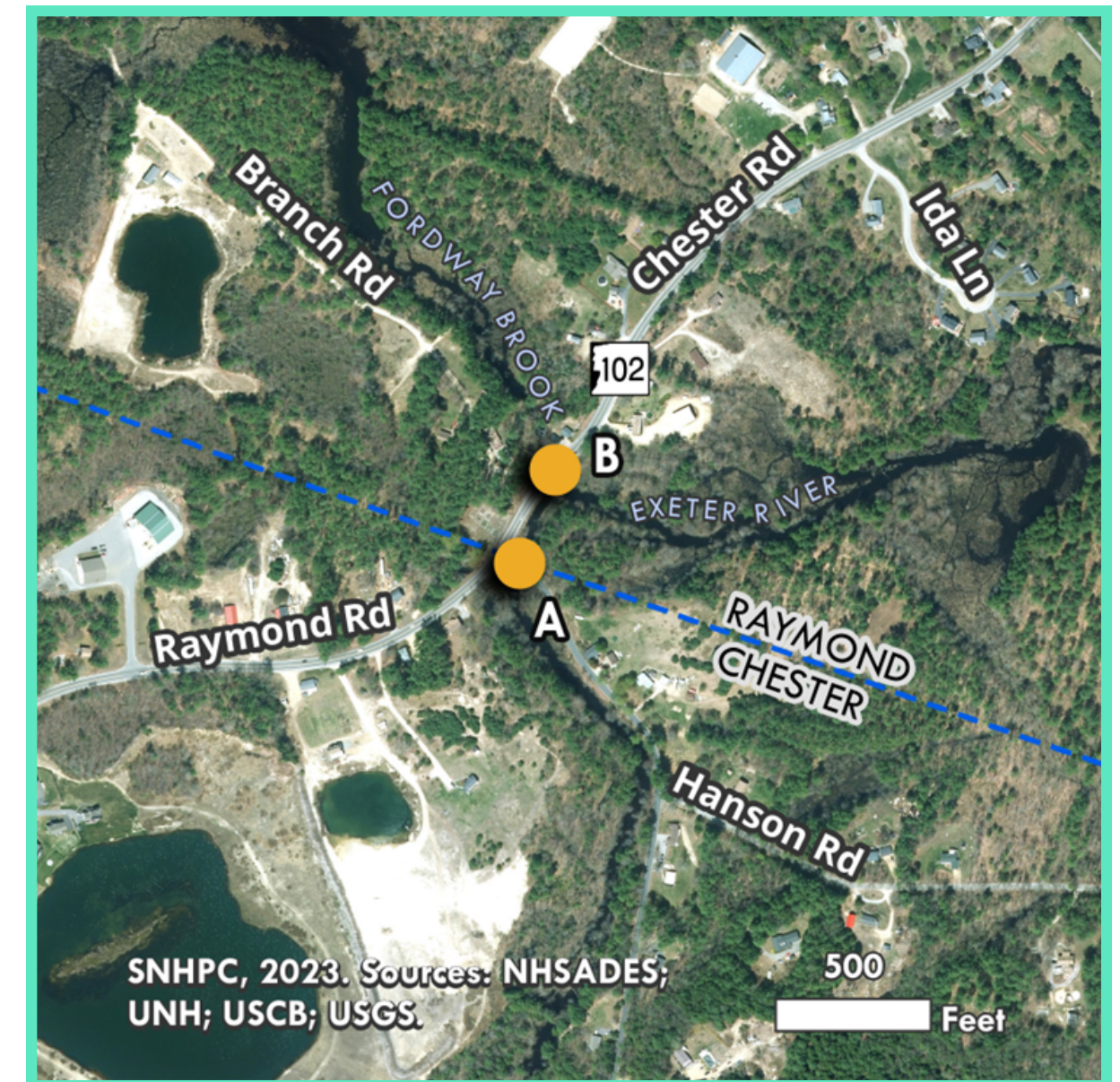
Corridor case study: Key insights & opportunities

A corridor analysis helps call attention to cascading flood impacts across property and town lines

A. Design & Engineering

D. Outreach & Collaboration

E. Data, Planning & Policy



4. Adaptation in Action

Corridor case study: Key insights & opportunities

It's essential to identify symbiotic solutions to address tensions between human development and wildlife

B. Nature-based Solutions

C. Operations & Maintenance



4. Adaptation in Action

Corridor case study: Key insights & opportunities

Staffing shortages are impacting the region's climate readiness – and public engagement is key

C. Operations & Maintenance

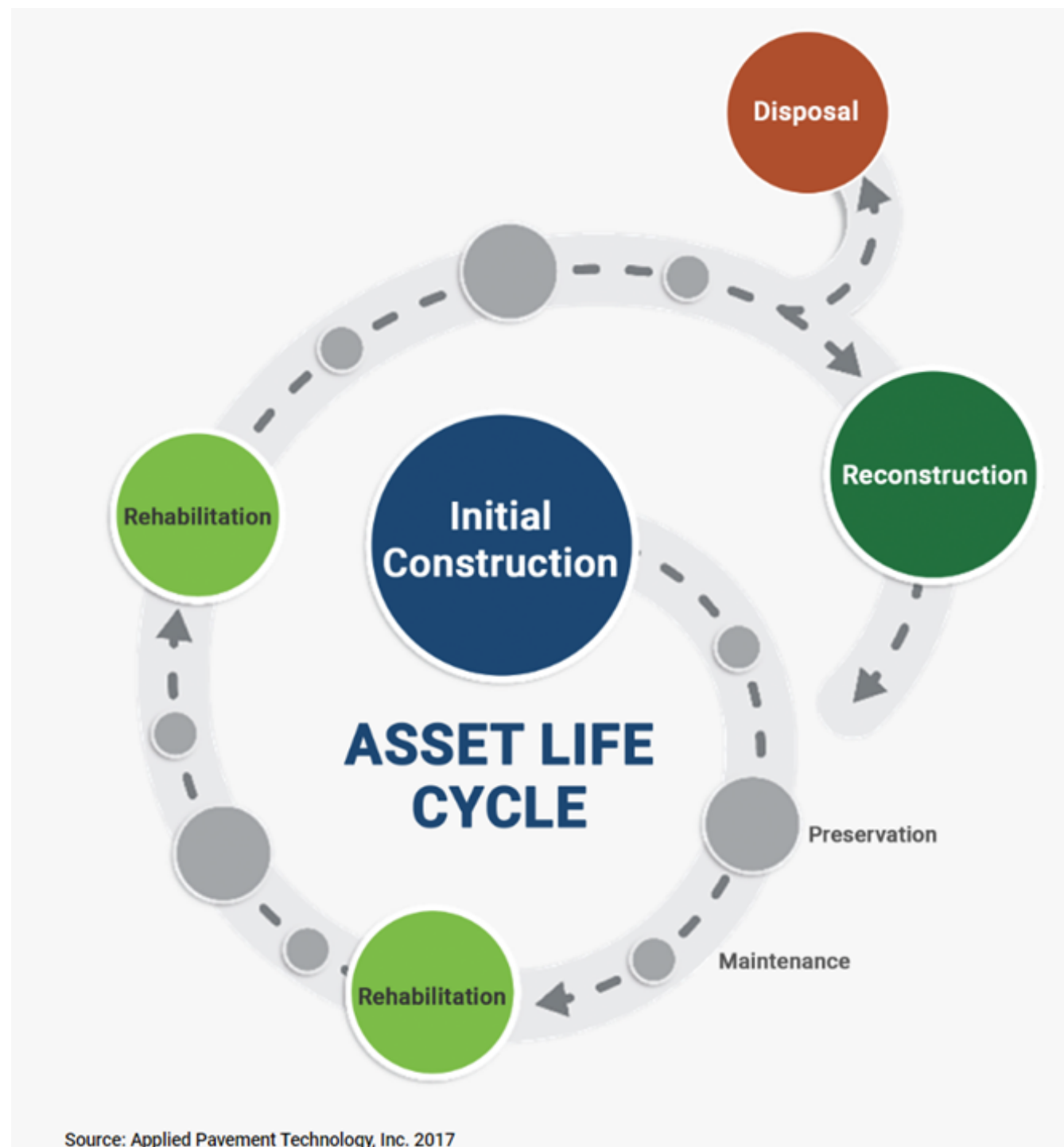
D. Outreach & Collaboration



Falls Brook stream restoration project, Swanzey, NH; © Emily Lord

4. Adaptation in Action

Life cycle & cost considerations



Cost implications

Neumann et al, "Climate effects on US infrastructure: the economics of adaptation for rail, roads, and coastal development." *Climate Change* (2021) 167:44.

To contain costs...

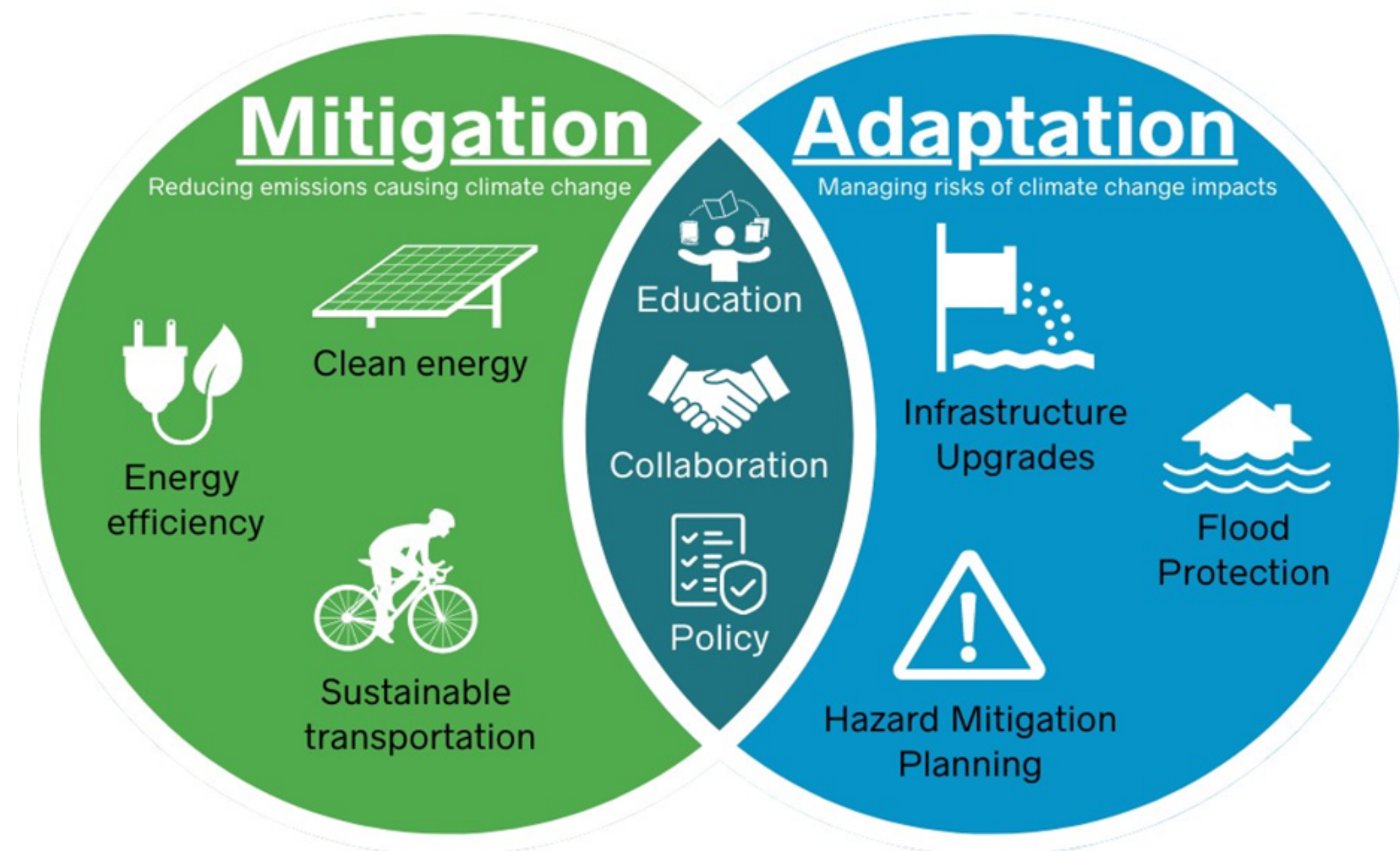
- Pursue proactive adaptation strategies
- Reduce greenhouse gases
- Build public awareness

4. Adaptation in Action

Implications for future planning

- Regional transportation plans (MTP, TYP, TIP)
- Resilience Improvement Plans (SNHPC, Statewide)
- Climate Action Plans (NH, MAPC)

Building Climate Resilience



Putting the Toolkit to use...

1. Identify high-priority vulnerable corridors and stream crossing sites (Ch. 2)
2. Explore the menu of strategies to identify specific adaptation opportunities (Ch. 3)
3. Convene local stakeholders to talk about climate adaptation priorities (Ch. 4)
4. Stay engaged with regional climate planning activities!

SOUTHERN NEW HAMPSHIRE
PLANNING COMMISSION

THANK YOU!

Contact:

Suzanne Nienaber – snienaber@snhpc.org

Zachary Swick – zswick@snhpc.org

603-669-4664



ROADWAY ADAPTATIONS

Southern New Hampshire
Planning Commission

DRAFT for review
September 2023

