

We all live downstream



VT DEC Rivers Program vermont.gov/watershed/rivers

Staci Pomeroy, River Scientist, staci.pomeroy@vermont.gov

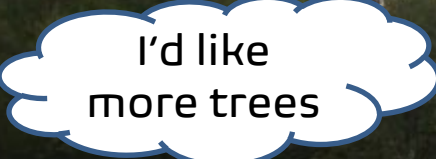
Ned Swanberg, Flood Hazard Map Coordinator, ned.swanberg@vermont.gov



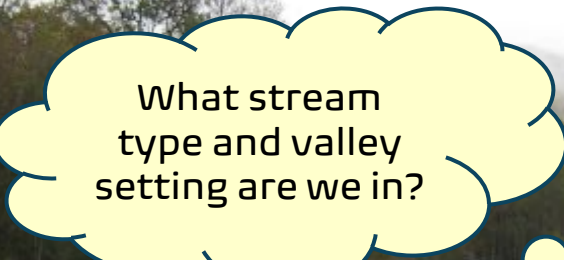
Vermont River Program's Work to Meet Multiple Goals of Flood Resiliency,
Water Quality and Habitat Improvement in our River Systems




When you step out on the River to do a project; What are the things you should be thinking about?




I'd like more trees



What stream type and valley setting are we in?




What are right channel dimensions?



Can we build in flood resiliency elements?



I'd like wood and big rocks



What habitat features do we maintain/add?



**IMPACT ASSESSMENT
OF INSTREAM
MANAGEMENT PRACTICES
ON CHANNEL
MORPHOLOGY**

**FINAL DRAFT REPORT
(Abbreviated)**

TO THE
*Vermont Geological Survey
Agency of Natural Resources
Department of Environmental Conservation*
103 South Main Street
Old Laundry Building
Waterbury, Vermont

PREPARED BY
**THE CENTER FOR WATERSHED PROTECTION
AQUAFOR BEECH LIMITED
&
STEP BY STEP**

September, 1999

**OPTIONS FOR STATE FLOOD CONTROL POLICIES
AND A FLOOD CONTROL PROGRAM**



West Hill Brook, Montgomery

Prepared for the Vermont General Assembly
Pursuant to Act 137 Section 2 (1998)

Prepared by the
Vermont Agency of Natural Resources
Department of Environmental Conservation
Water Quality Division
Waterbury, Vermont

February, 1999

Traditional Approach to River Management & Structures sizing

August, 1932 AMERICAN FORESTS 205

How DYNAMITE streamlines streams

CROOKED STREAMS are a menace to life and crops in the areas bordering on their banks. The twisting and turning of the channel retards the flow and reduces the capacity of the stream to handle large volumes of water. Floods result. Crops are ruined.

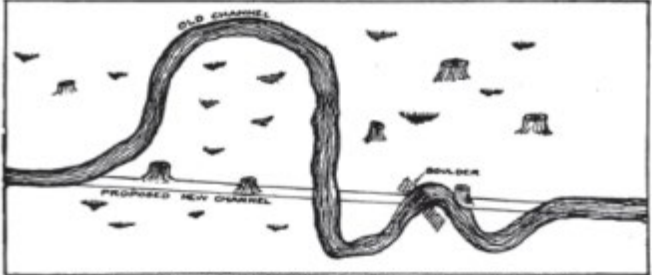
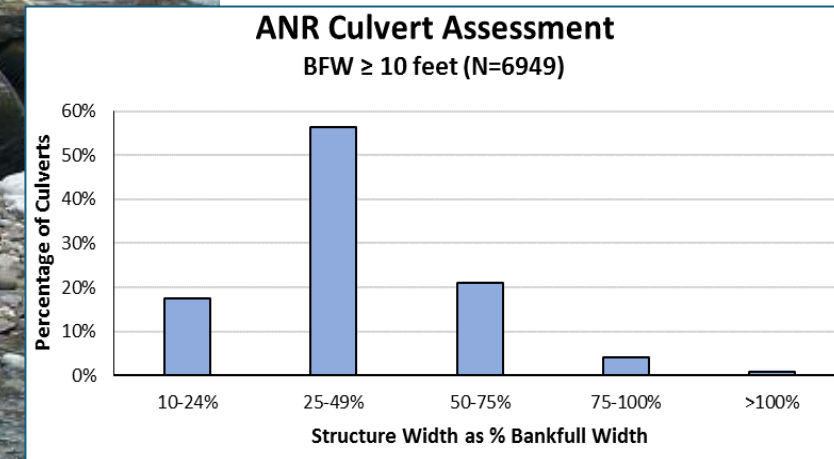
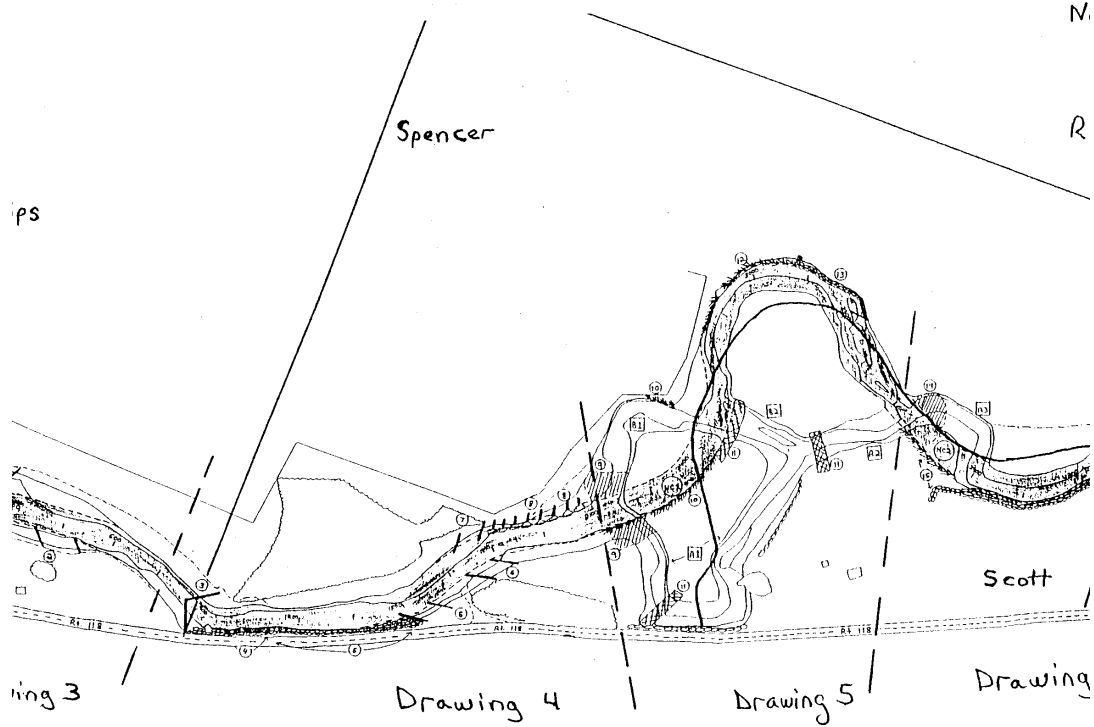


FIG. 54. DIAGRAM OF STREAM TROUBLES THAT MAY BE CORRECTED BY BLASTING.

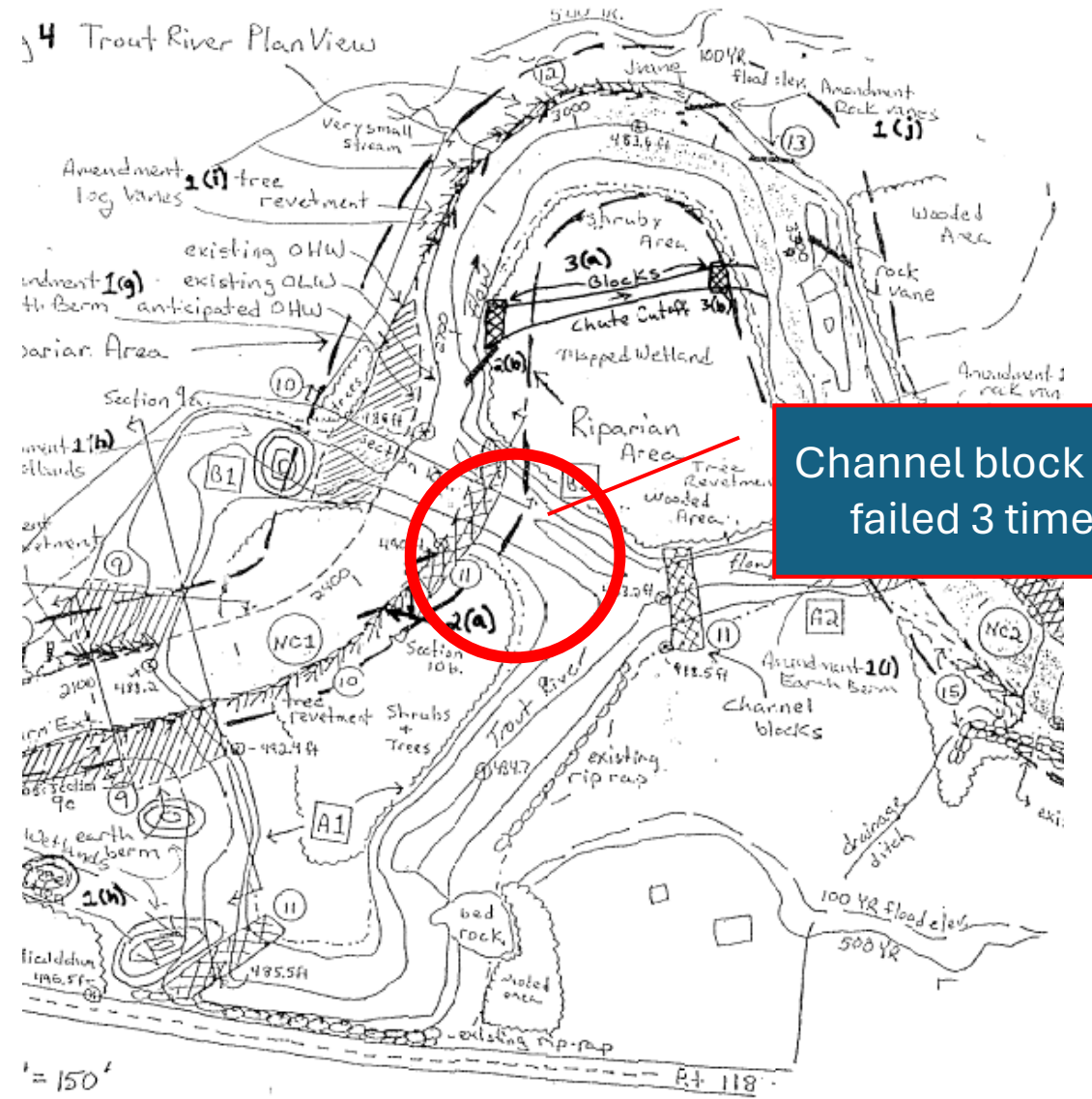


Trout River Natural Channel Design Restoration Project

1 Plan View of Trout River Stable Channel Restoration Project



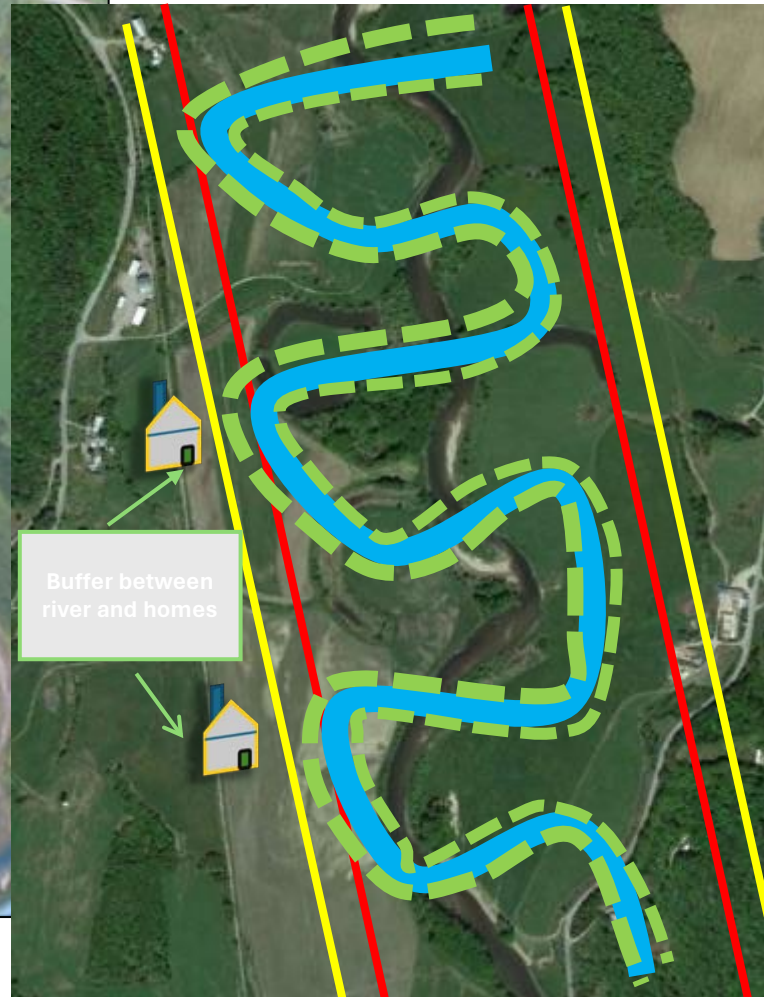
4 Trout River Plan View



Channel block that failed 3 times



River Corridors – What Are They




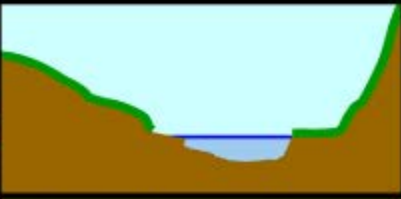
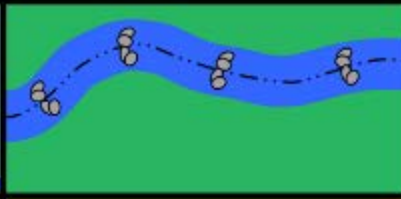

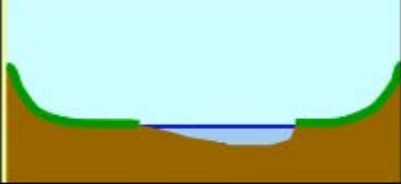


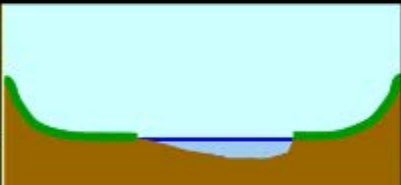


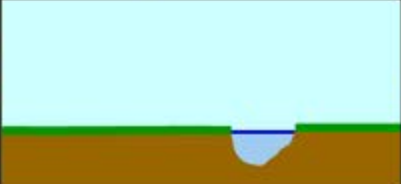
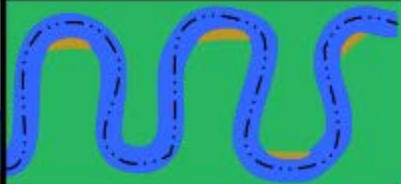
Protect current & future development

Stream Characteristics

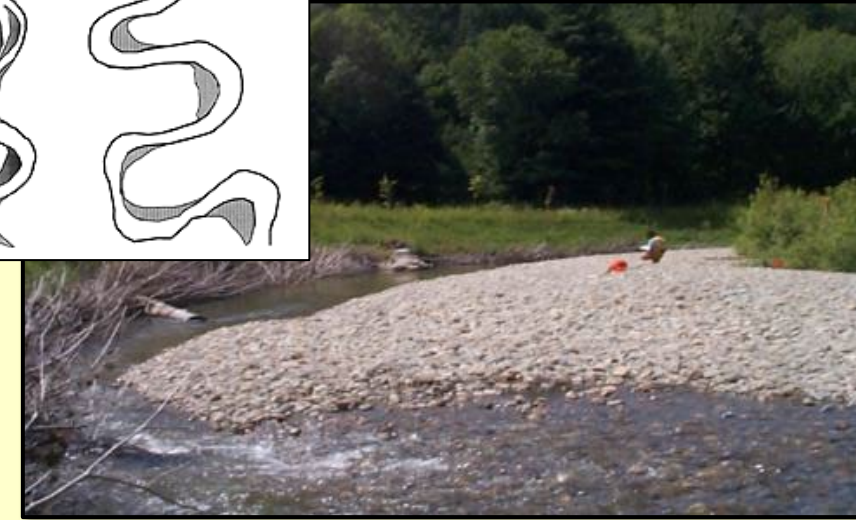
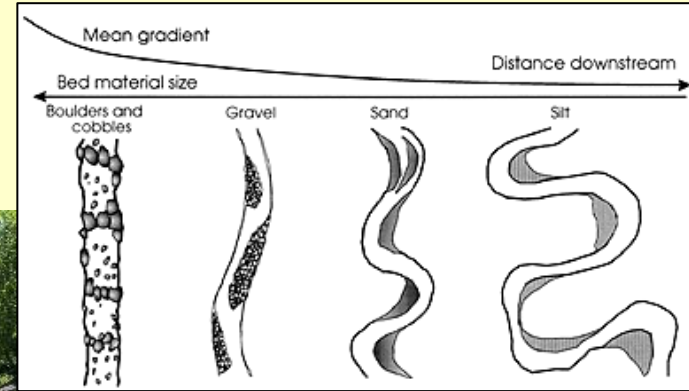
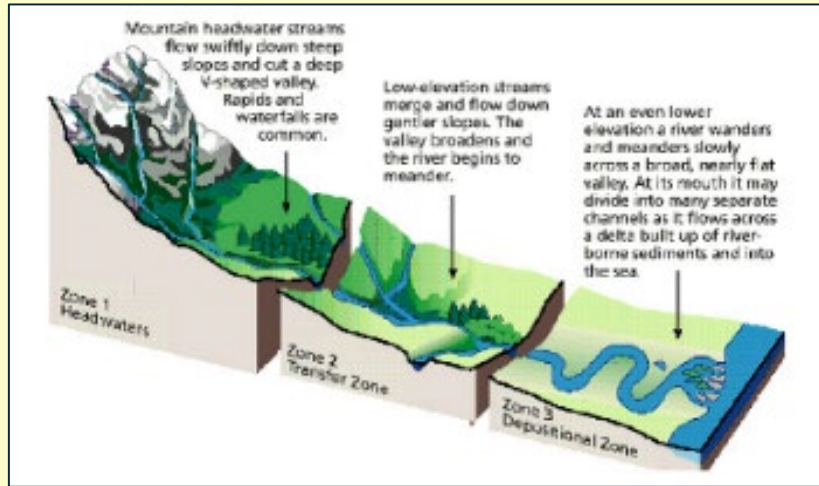


What type of stream are on our landscape?

A basic overview of the type of stream we see in our landscape

Valley Type	Cross Section	Slope - Bedforms		Planform
		3% min.	Cascade/Step - Pool Cobble - Boulder	
Steep - Narrow	Entrenchment: 1.4 - 2.2 Width Depth Ratio: 12 - 20			Sinuosity: 1.2 max.
		1 - 3%	Plane Bed Gravel - Cobble	
Moderate	Entrenchment: 2.2 min. Width Depth Ratio:			Sinuosity: 1.2 max.
		0.1 - 2%	Riffle - Pool Gravel - Cobble	
Flat - Broad	Entrenchment: 2.2 min. Width Depth Ratio: 20 - 30			Sinuosity: 1.2 - 1.5
		0.1 % max.	Ripple - Dune Silt - Sand	
	Entrenchment: 2.2 min. Width Depth Ratio: 12 max.			Sinuosity: 1.5 min.

Sediment & Large Wood Material



Aquatic & Terrestrial Habitat

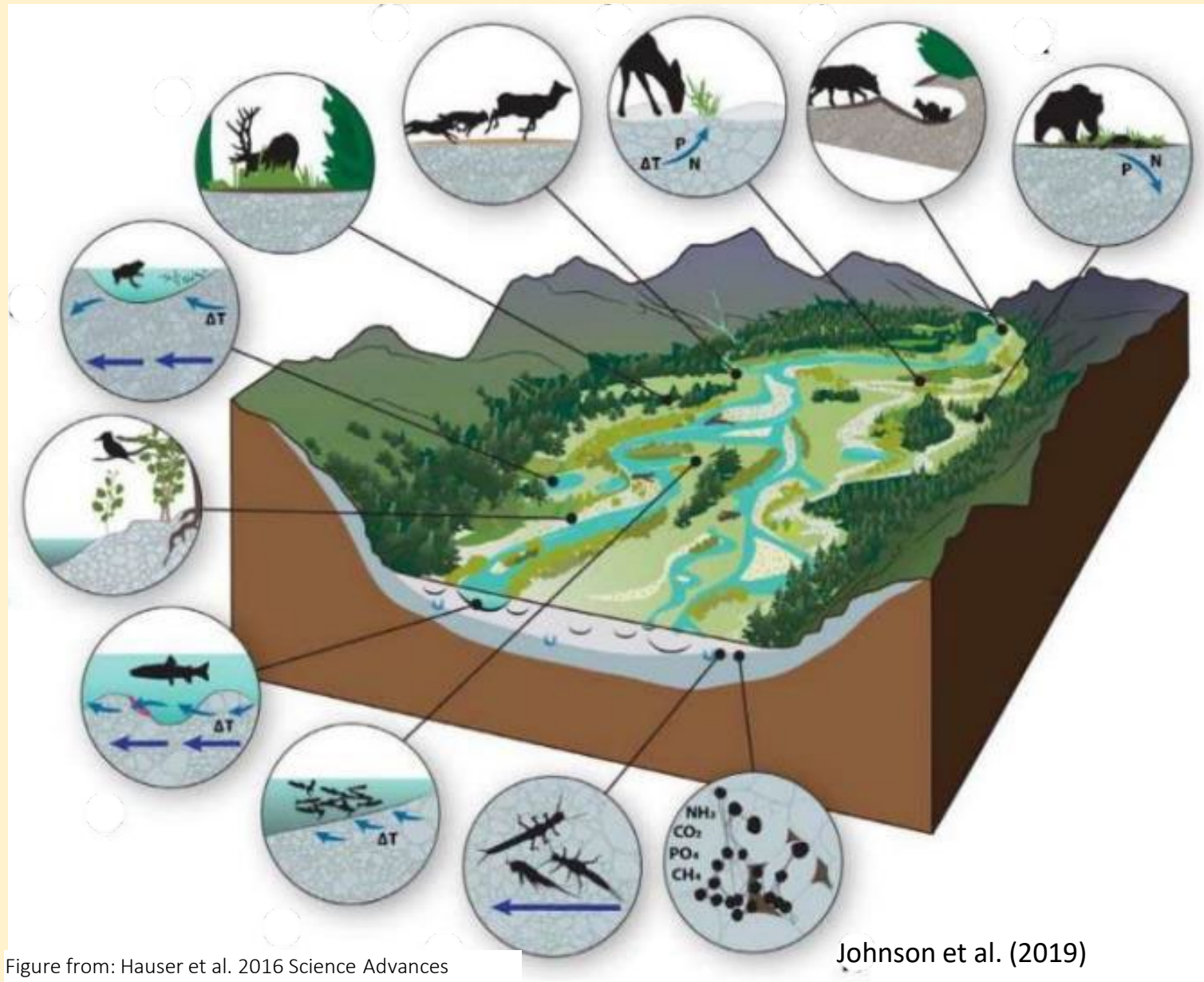
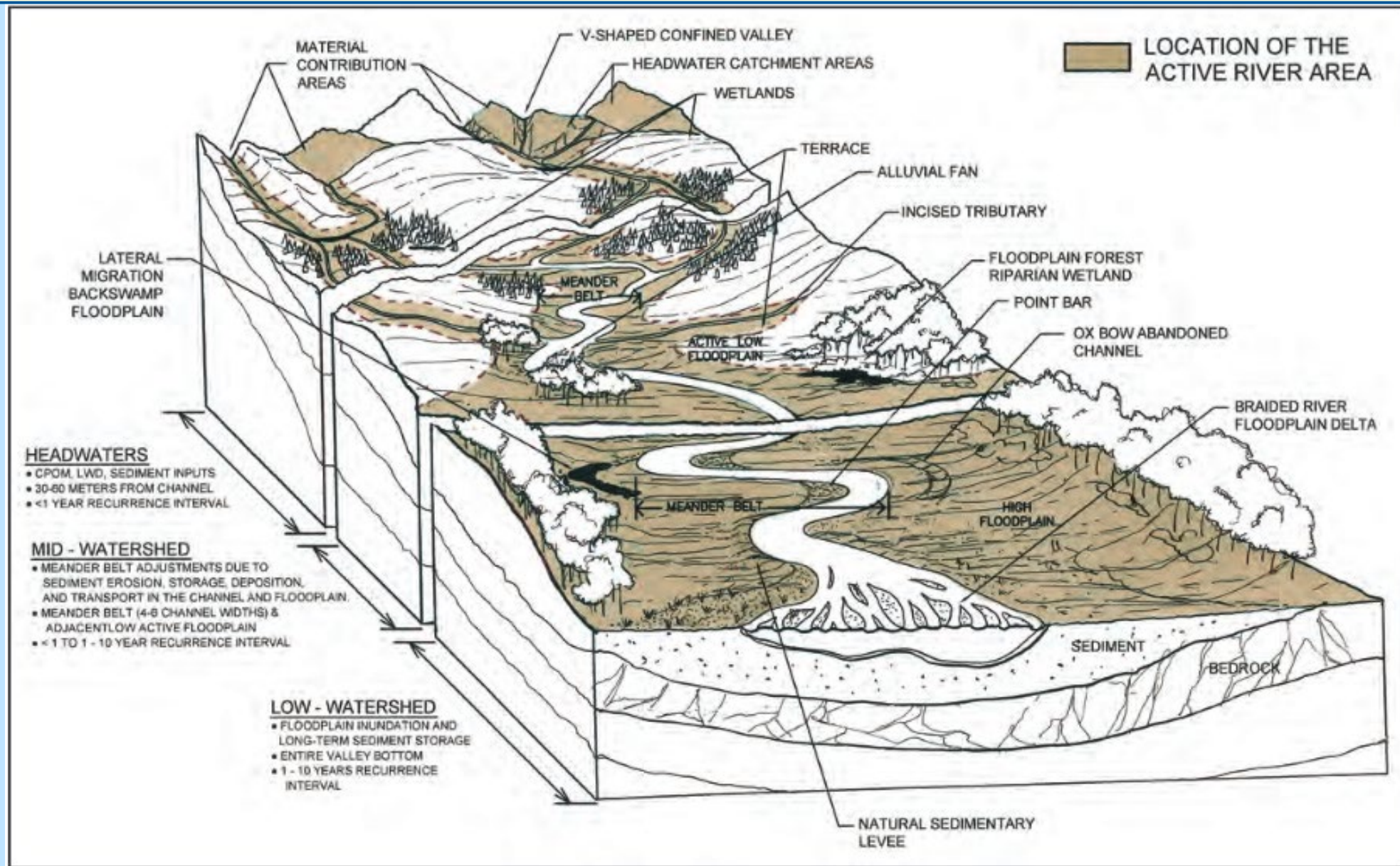


Figure from: Hauser et al. 2016 Science Advances

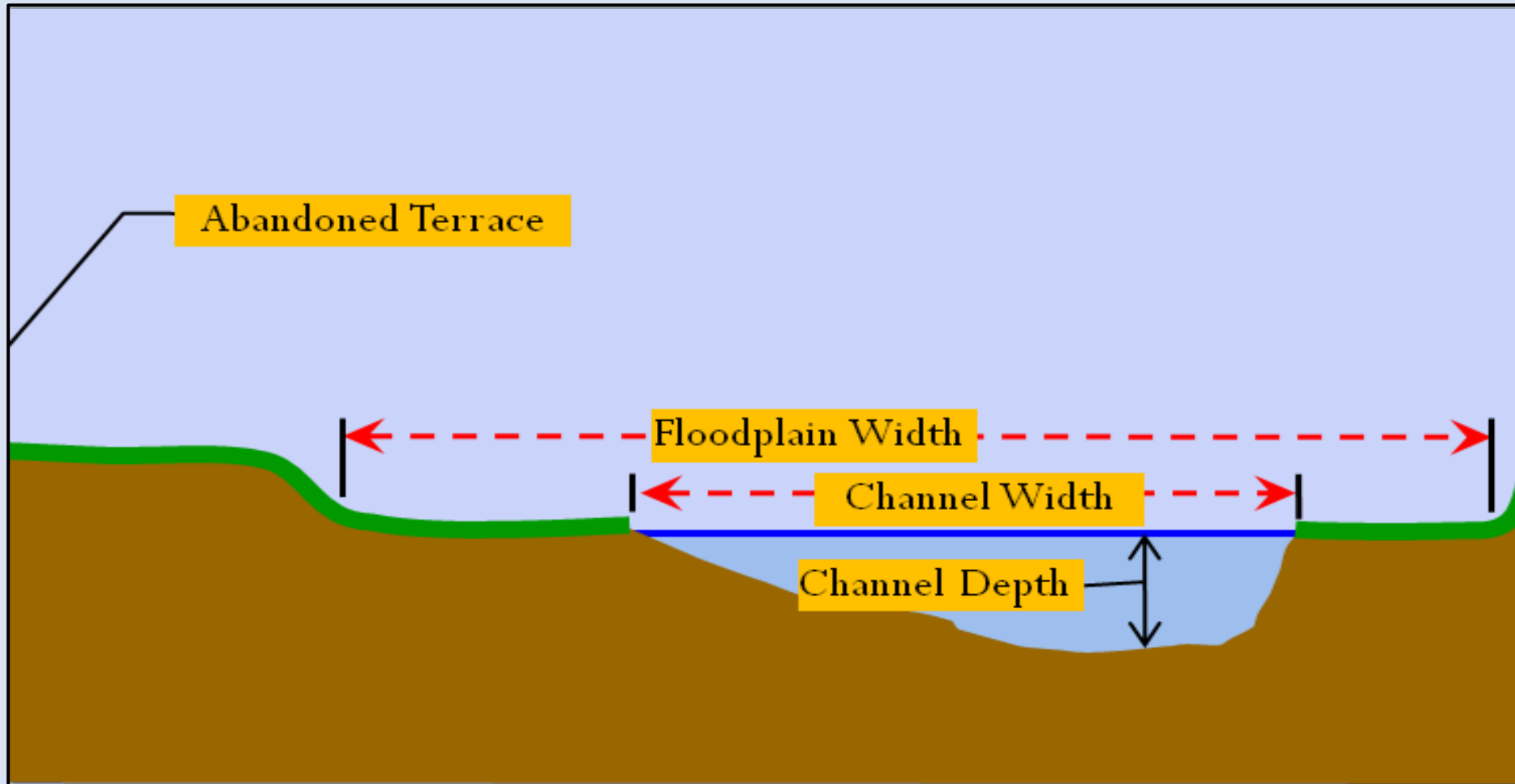
Johnson et al. (2019)

The strategies we use for flood mitigation are affected by where we are & what stream type we're working on



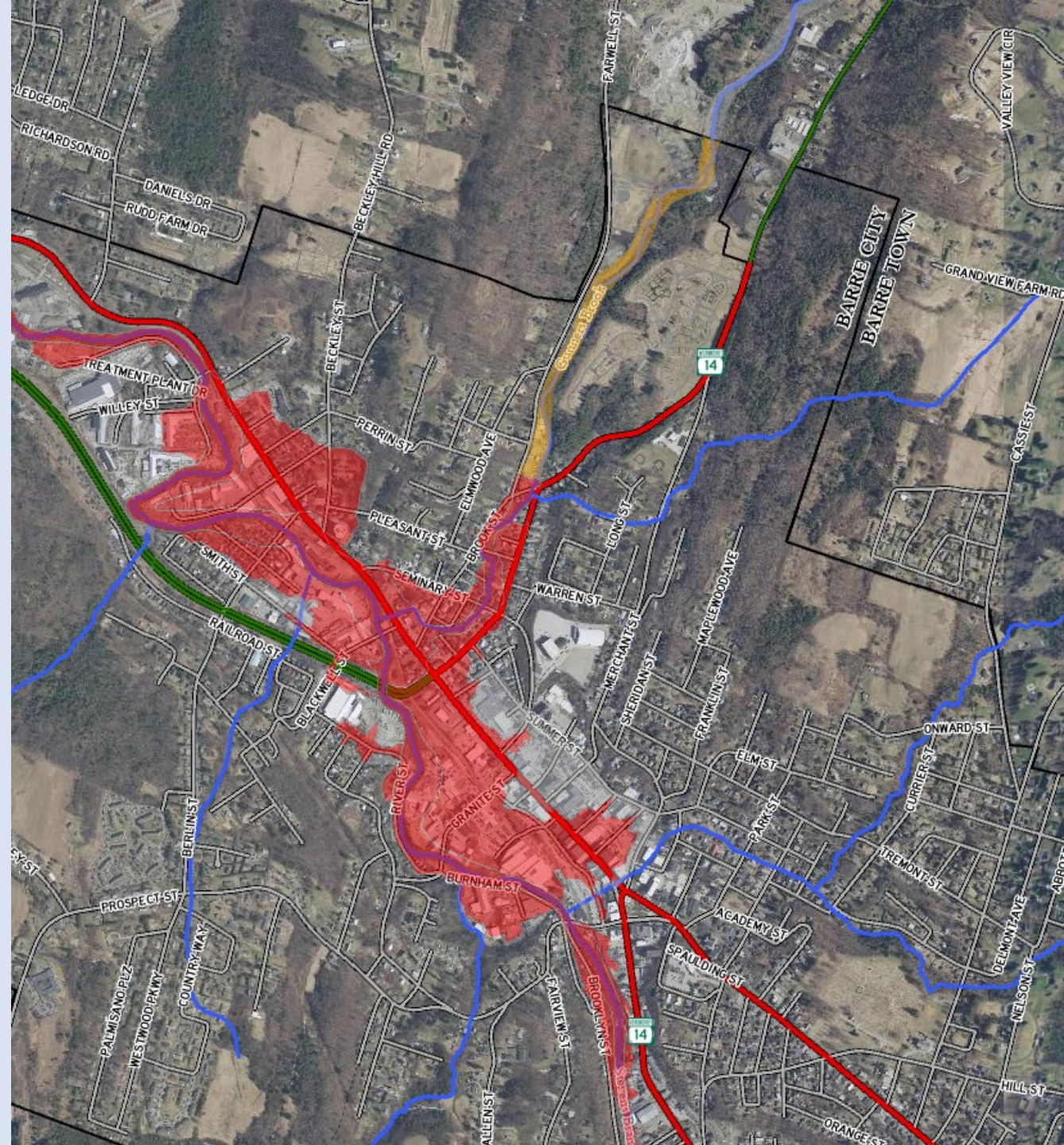
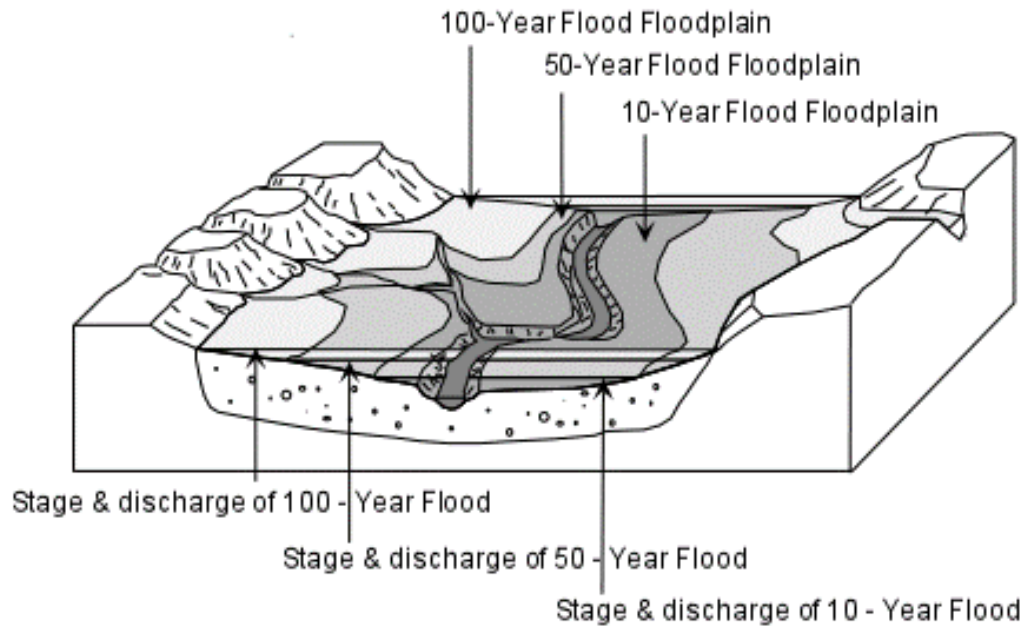
Looking at Vertical & Lateral Connection

How connected the Channel and Floodplain are to each other



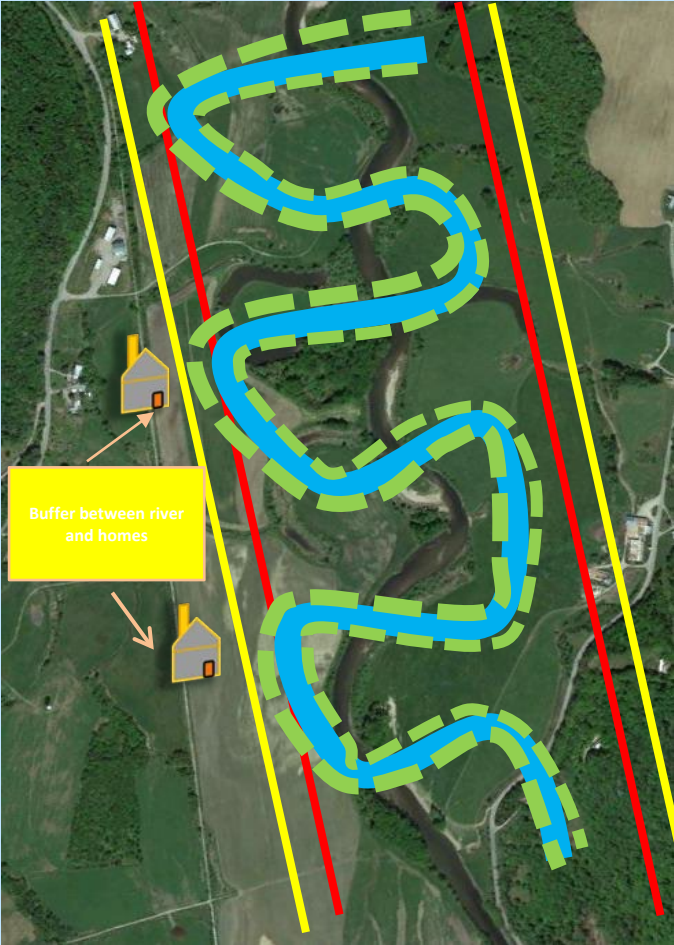
Inundation Flooding

Vertical connection of the channel to the Floodplain



Erosion Flooding

Lateral connection of the channel to the Floodplain



LONGITUDINAL CONNECTIVITY

*How well things move
up/downstream*



Steep gradient at head



Headwaters

Longitudinal Stream Profile

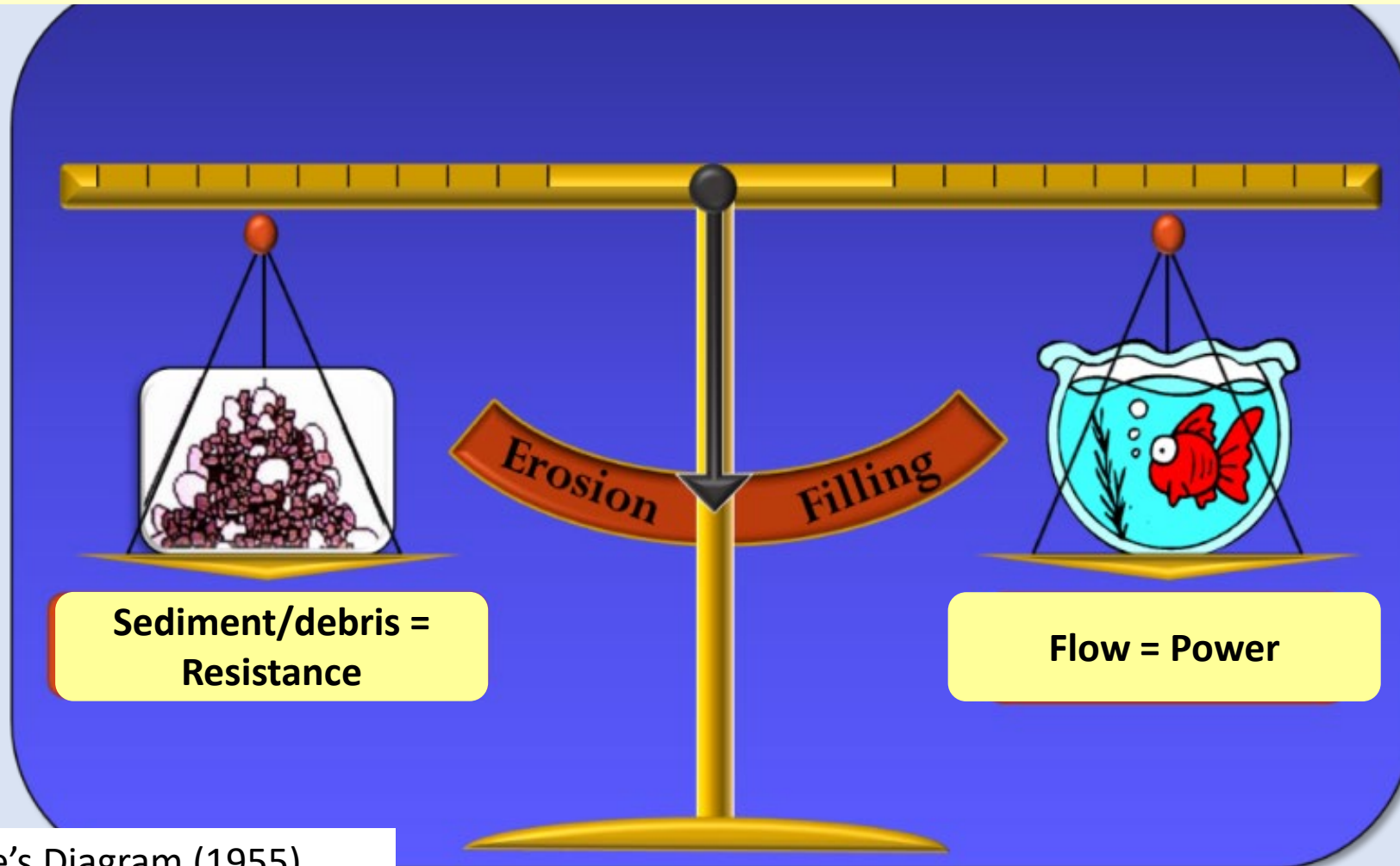
Transfer Zone

Gentle gradient near mouth

Depositional Zone

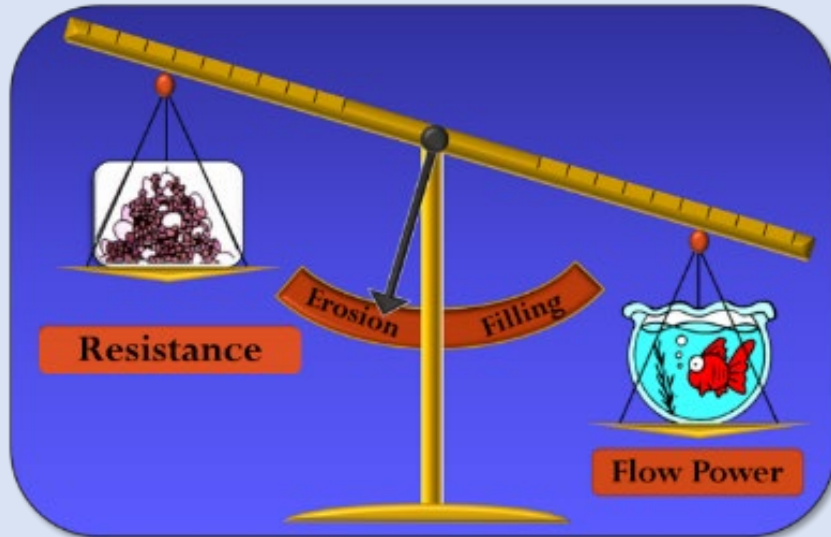
Equilibrium Condition: POWER is in balance with RESISTANCE

Changes in water, sediment, debris, and bed/banks can tip the scale

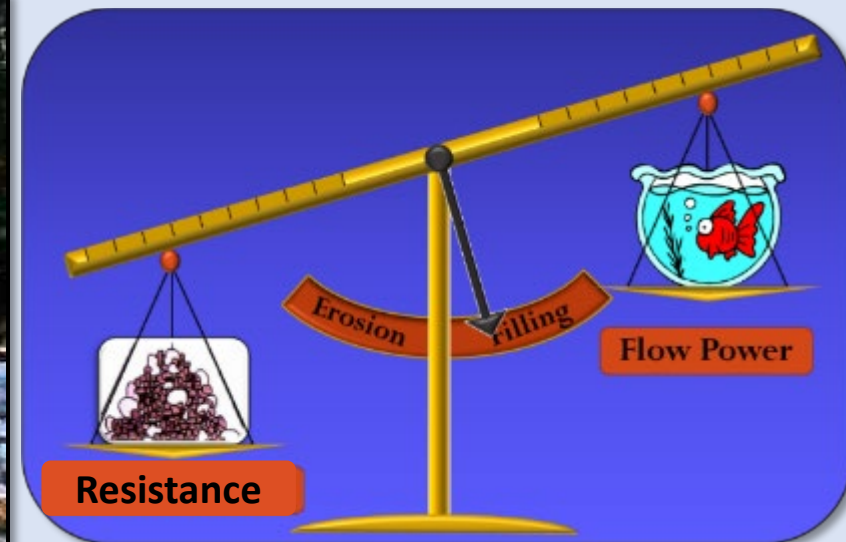


Lane's Diagram (1955)


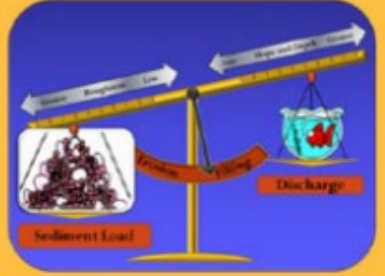
Erosion = Flow Power exceeds burden of the resistance.



Aggradation = Resistance exceeds power of the flow



To be successful,
we need to
understand how
our project tips
the Balance.

Activity	Resulting Change to Equilibrium Factors	Channel Response
Over Dredging	Increased Depth	<p data-bbox="1312 357 1516 406">Erosion</p> 
Over Dredging	Decreased Resistance & Sediment Volume	
Channel Narrowing	Increased Depth	
Channel Berming	Increased Depth	
Channel Straightening	Increased Slope	
Increased Runoff Rate	Increased Depth & Slope	
Undersized Culvert Channel Widening Upstream Landslides	Decreased Slope Upstream	<p data-bbox="1312 978 1516 1028">Filling</p> 
	Decreased Depth	
	Increased Sediment Volume	



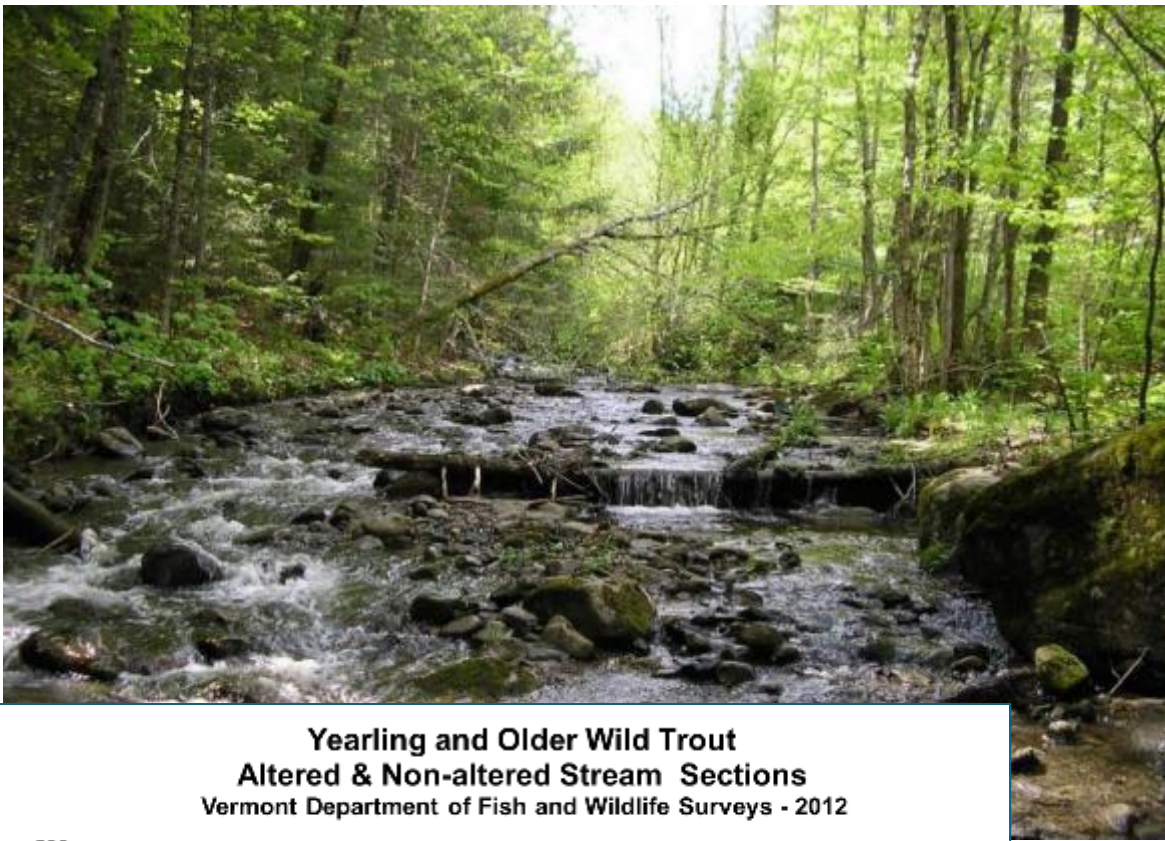


2011 – Tropical Storm Irene

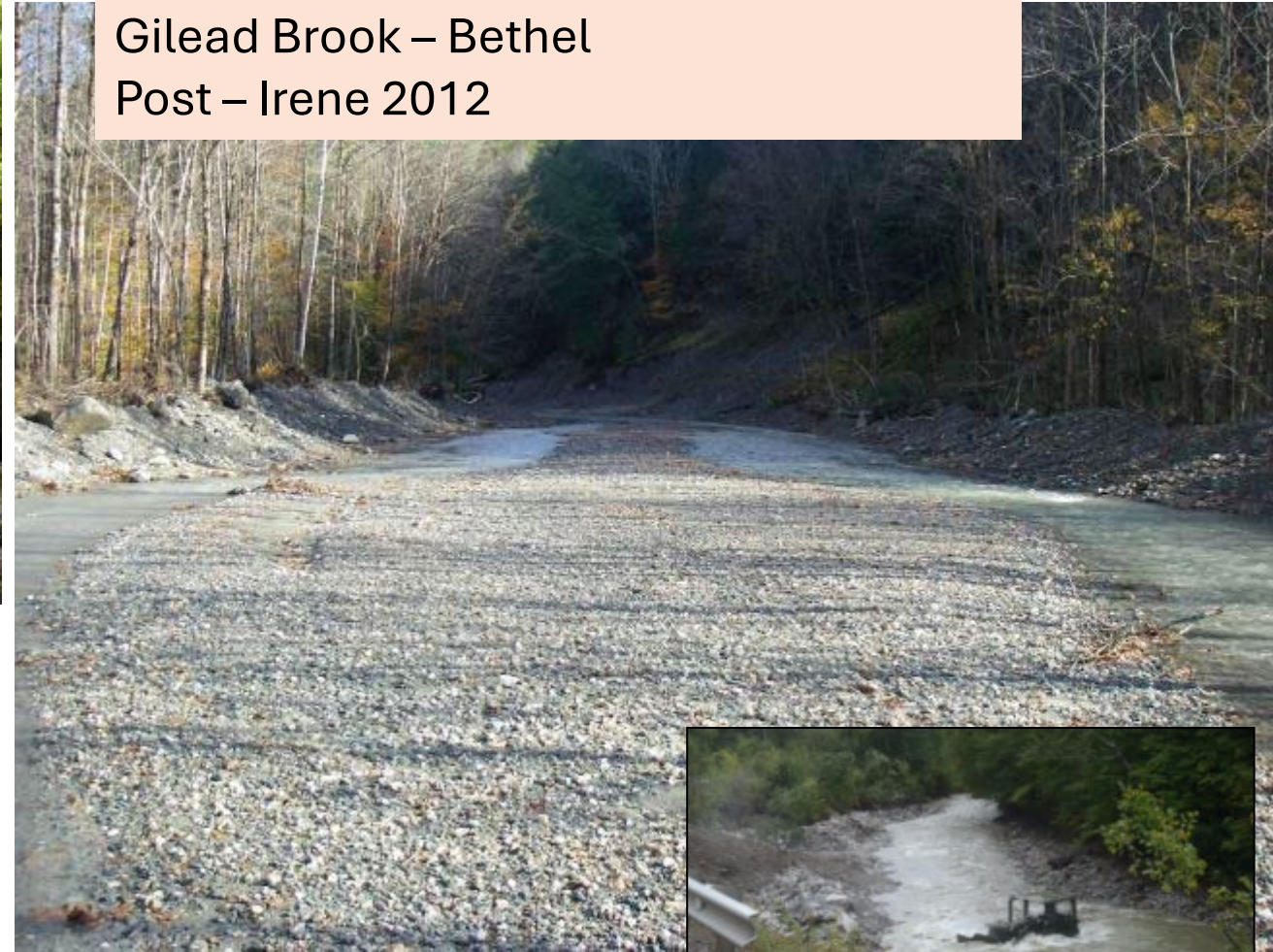
(Governor Shumlin) "We're going to have to go in and do some digging - continue digging as they fill up with gravel."



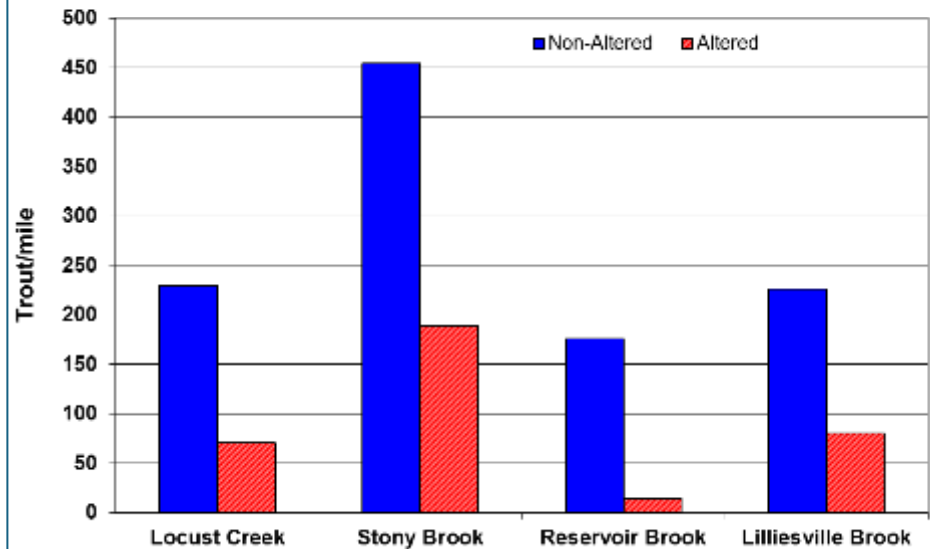
Habitat Matters



Gilead Brook – Bethel
Post – Irene 2012



**Yearling and Older Wild Trout
Altered & Non-altered Stream Sections**
Vermont Department of Fish and Wildlife Surveys - 2012



Vermont Agency of Transportation Expands Emphasis on Managing Roads in Concert with Streams and Rivers



Center for Environmental Excellence
by AASHTO



FEMA NFIP Flood Maps no sufficient to show all of VT's flood hazards

* Only cover 20% of VT's Rivers mapped & Focus is Inundation , not Erosion





Without Statewide standards.
FEMA
Would only replace with
“in-kind” structures



JEFFERSONVILLE RESIDENTS BLOCK MAJOR DEVELOPMENT IN FLOODPLAIN

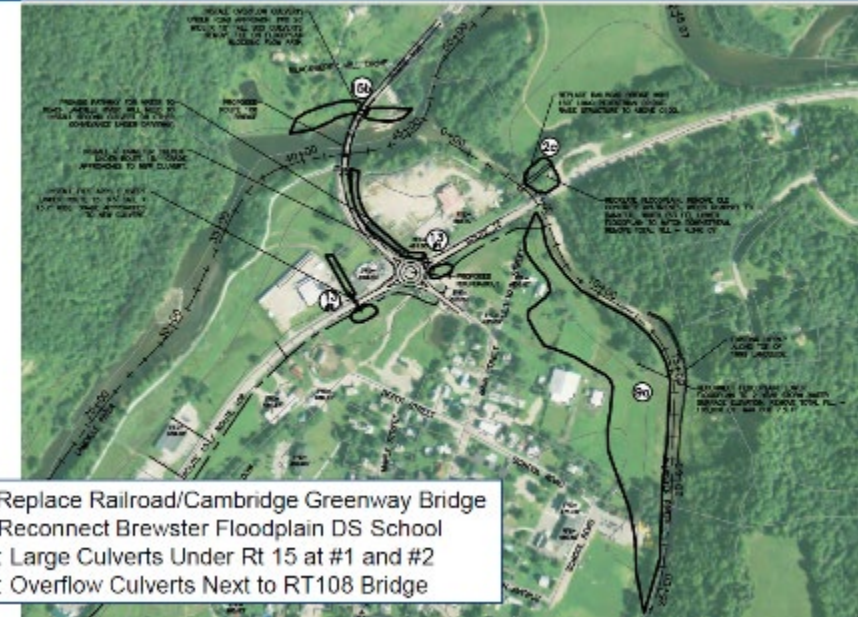
16-Pump Gas Station & Convenience Store Complex Had Been Planned

April 27, 2012 Flooding in Jeffersonville



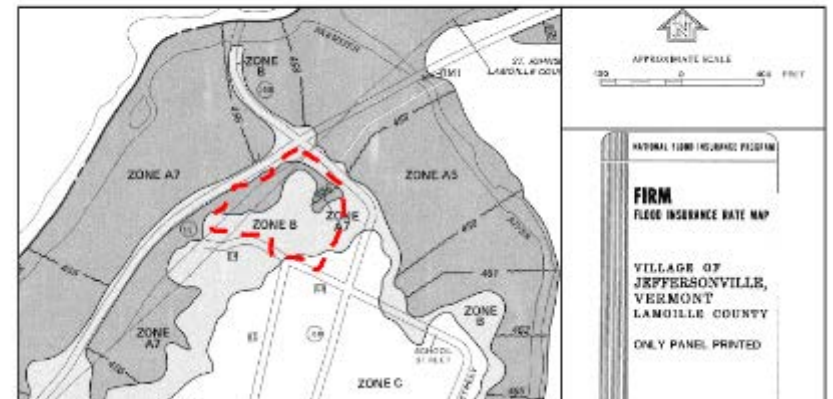
Photo courtesy of Jean Jenauskas

Preferred Alternatives:



- 2c: Replace Railroad/Cambridge Greenway Bridge
- 9a: Reconnect Brewster Floodplain DS School
- 13e: Large Culverts Under Rt 15 at #1 and #2
- 15b: Overflow Culverts Next to RT108 Bridge

Location of Jolley Property within the FEMA 1983 Designated Flood Plain

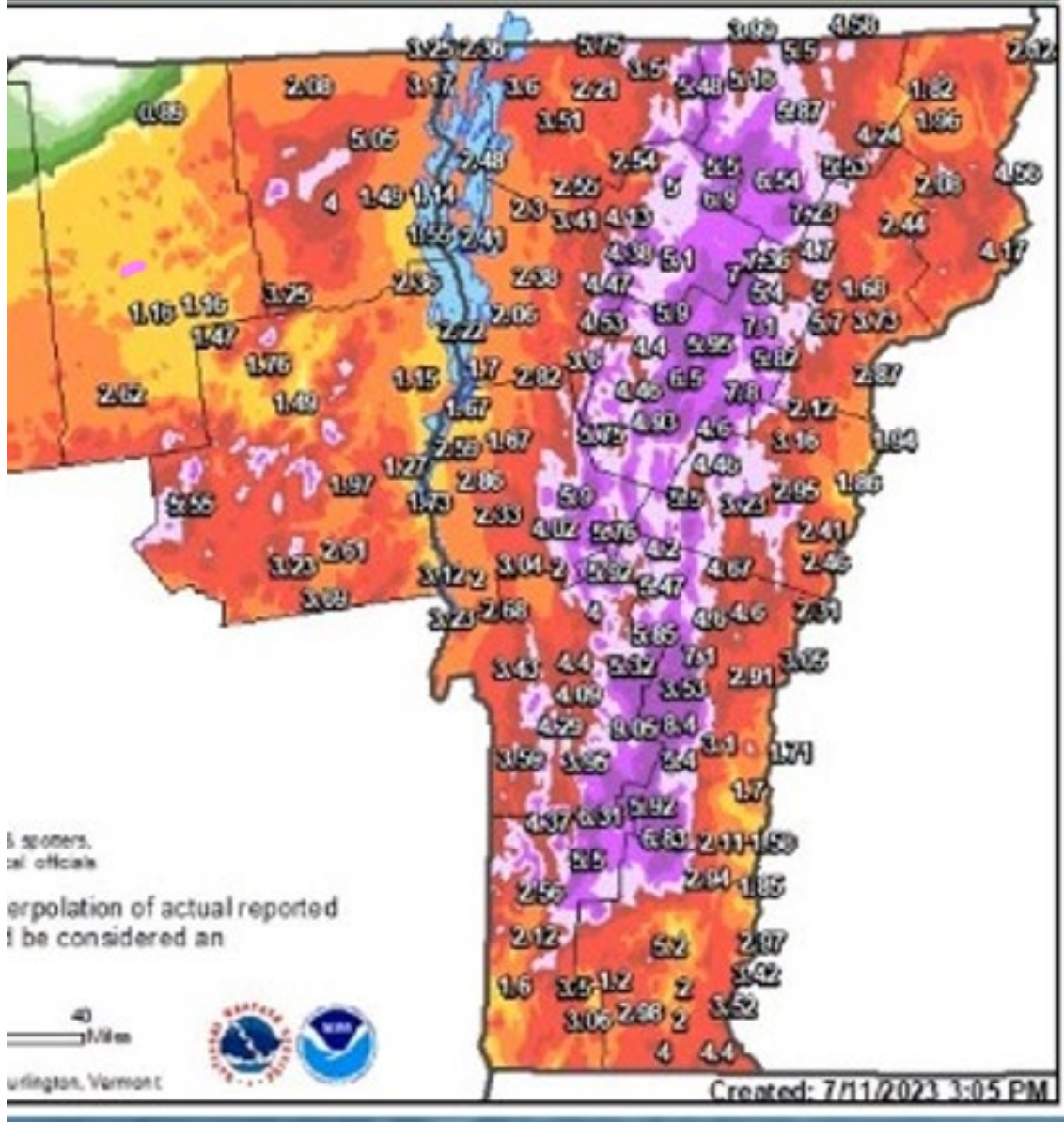


Act 138(2012)

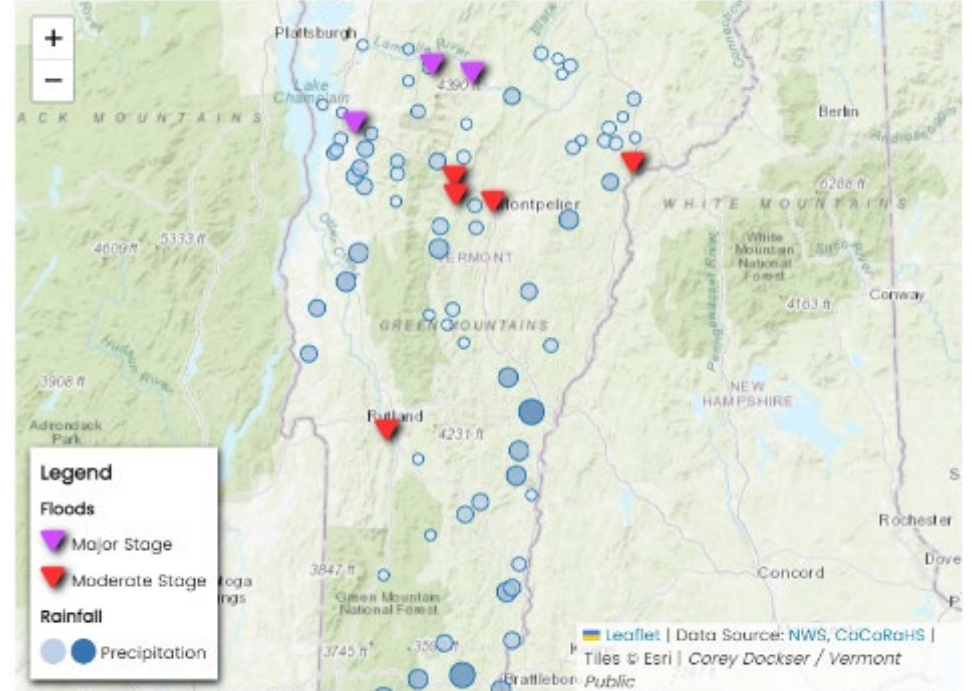
- ANR - regulate activities exempt from municipal regulation
- ANR -develop and make available river corridor maps for all municipalities and incentives for adoption
- Stream Alteration Rule – Emergency protective measures standards developed
- Develop training to improve response and reduce impact from future flooding



Total Rainfall ending July 11, 2023

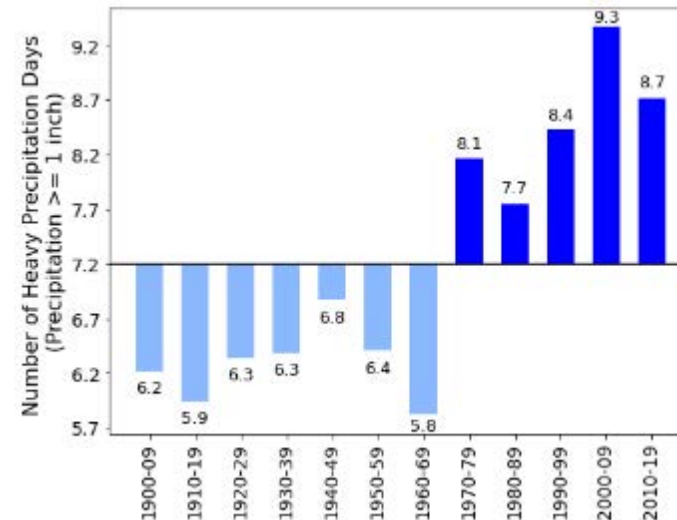


Rainfall totals greater than 2 inches and river gauges which reached major or moderate flood stage during the Dec 18-19 storm.



The entire state was inundated with rainfall, with five rivers reaching major or moderate flood stage, the two highest levels on the National Weather Service's flooding scale.

Map from Vermont public radio



River Management Standards Matter

2017: FEMA Approves ANR Stream Alteration Rule as “Codes and Standards”

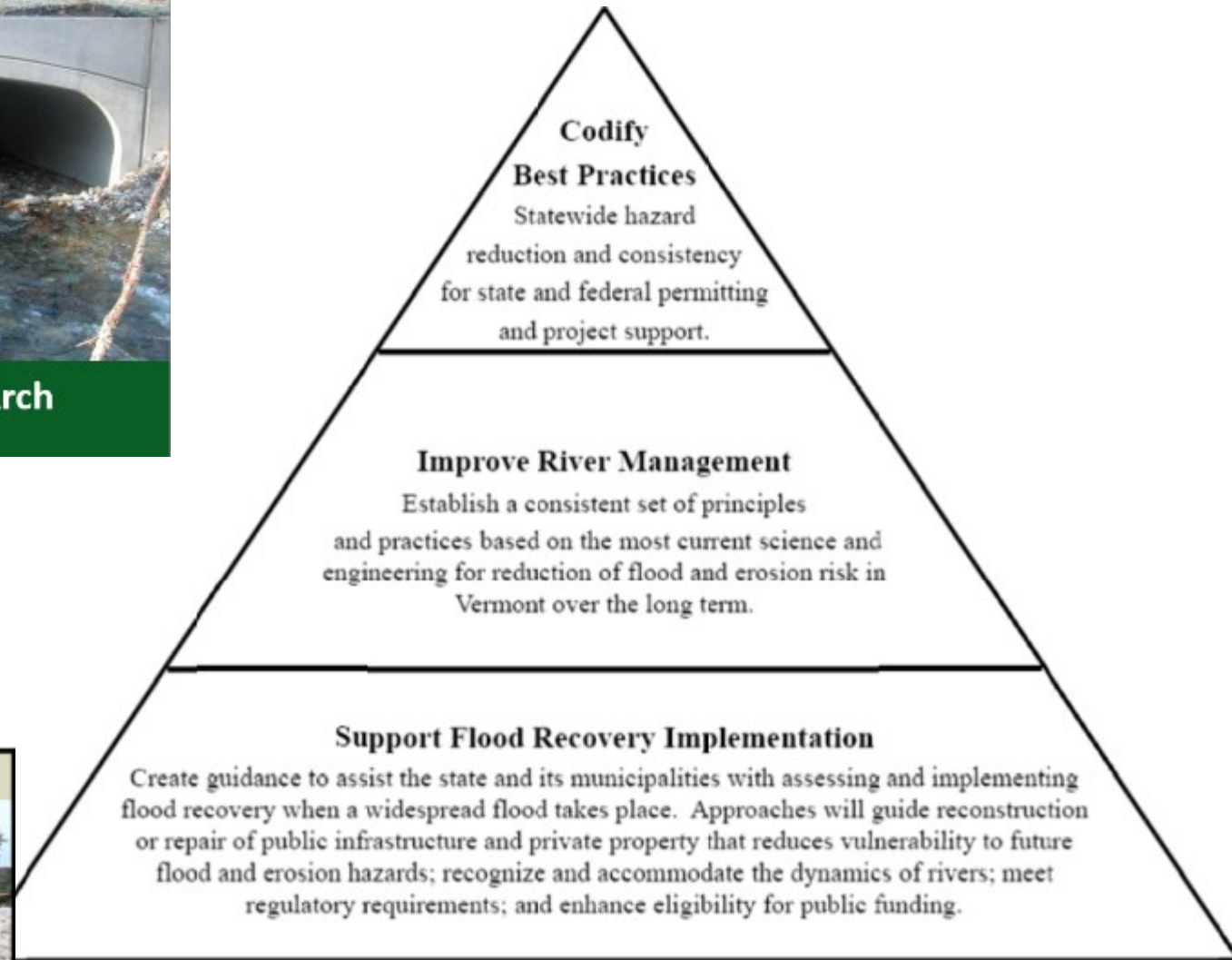
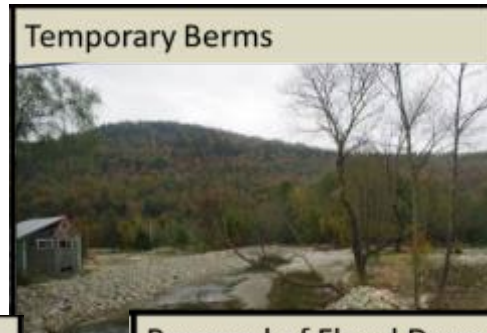


Figure 1.1: Purpose of the principles and practices.

Rivers & Roads Training

(Act 138 -2012)

Understanding and working with river processes improves flood resilience



Classroom



Field Time



Hands-on activities



New legislation proposed around flood recovery

Feb 21, 2024

Vermont Senate Committee Advances Flood Safety Act (S.213)

Governor Scott's Cabinet Secretaries from Agency of:

- Administration
- Agriculture
- Education
- Digital Services
- Human Services
- Department of Labor
- Agency of Transportation
- Department of Public Safety
- Department of Public Service
- Agency of Natural Resources
- Agency of Liquor and Lottery
- Department of Financial Regulation
- Commerce & Community Development



Flood Resilient Communities Fund Selected Projects

Projects selected for implementation under the Flood Resilient Communities Fund (FRCF).



Welcome

Buyouts

Floodplain Restoration

Scoping

Other



About FRCF



How To Use This Map



Huntington Buyouts



Tri Park Cooperative Housing Corporation Mobile Home...



Rockingham Landslide Buyout



Berlin Buyout



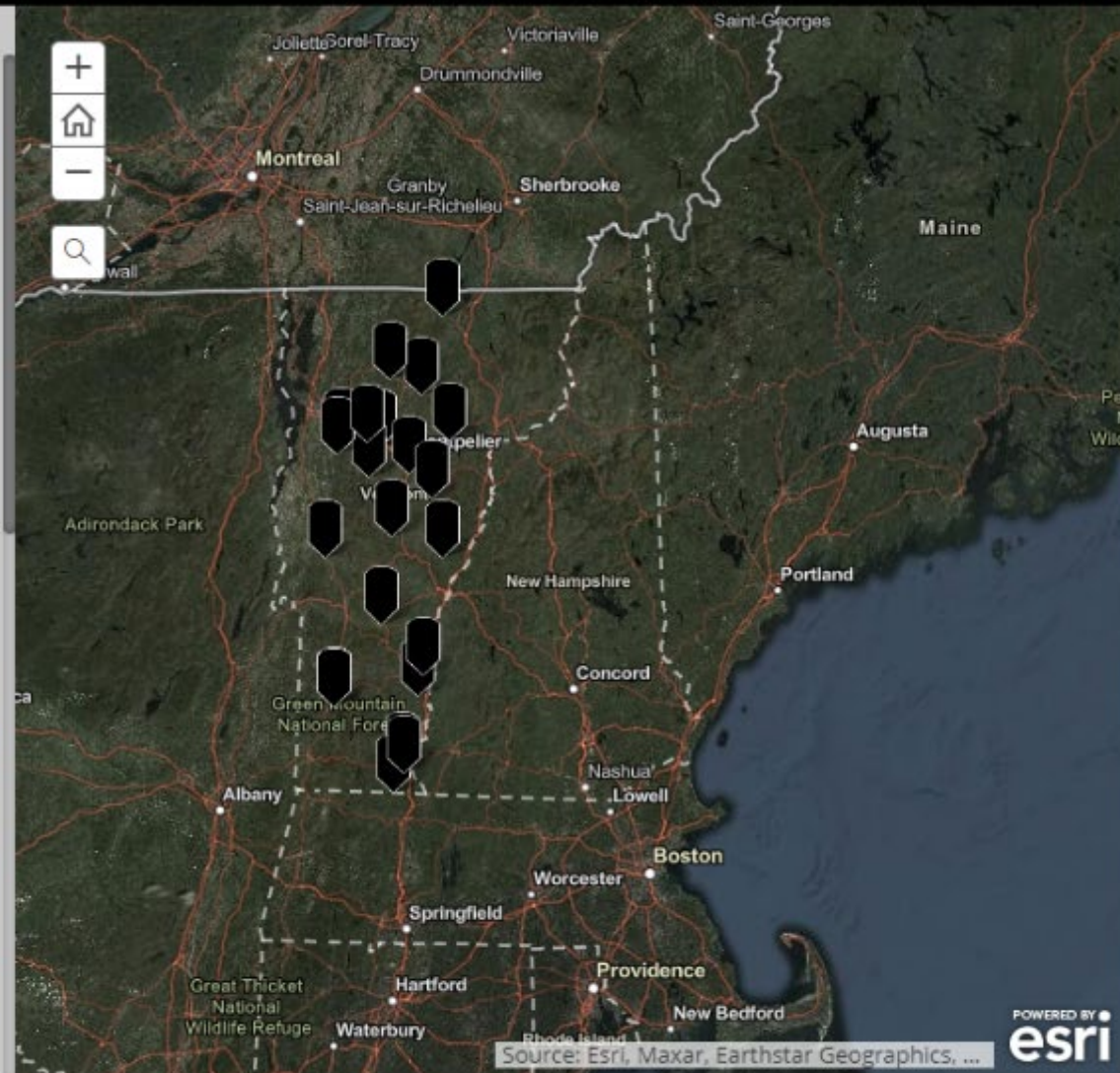
Brandon Buyouts



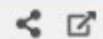
Randolph Buyout

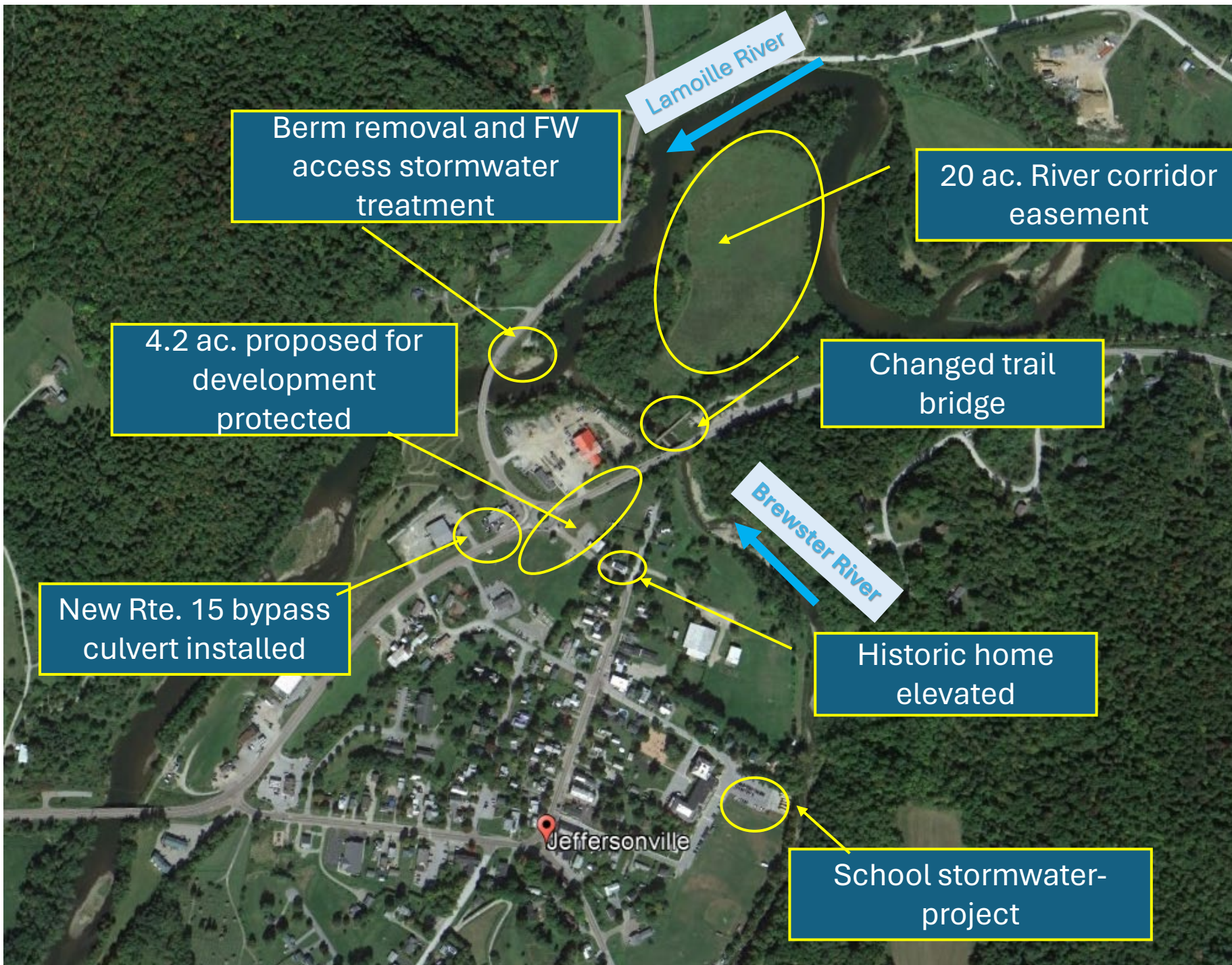


North Wolcott Road Recreation Fields Floodplai...



Source: Esri, Maxar, Earthstar Geographics, ...

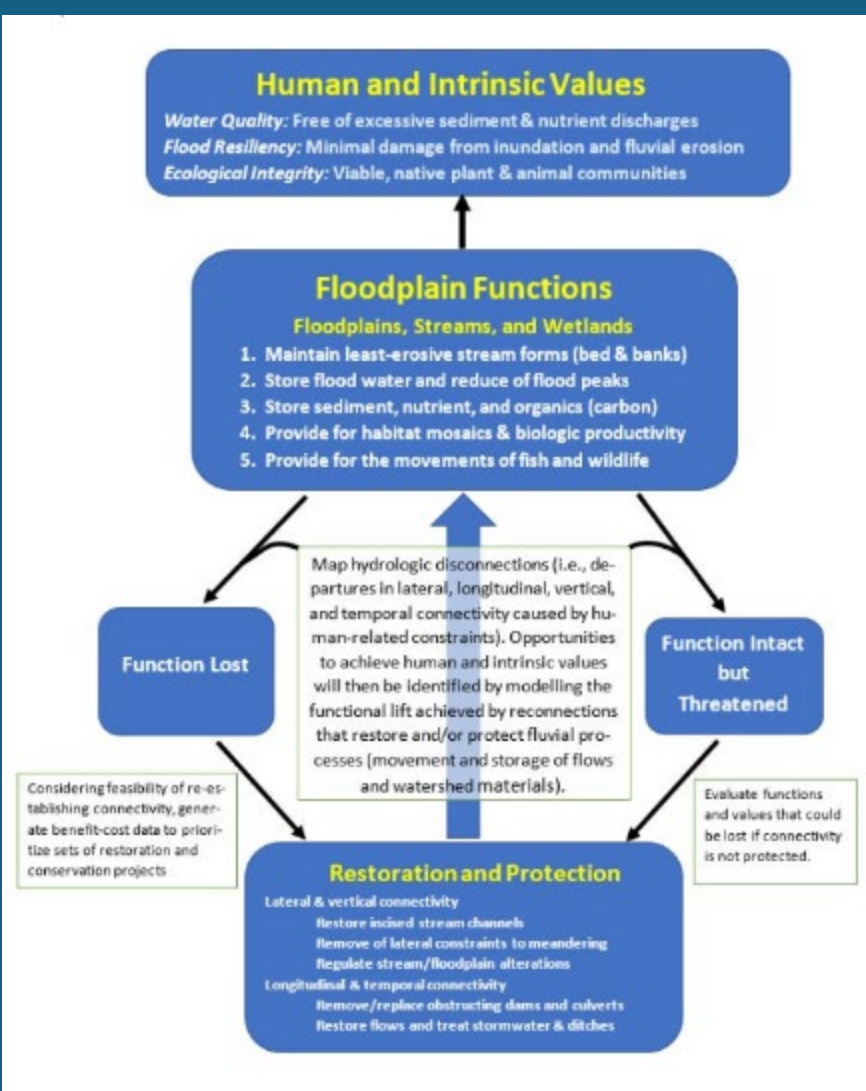




Jeffersonville Flood Hazard Mitigation Plan Project Successes



Vermont's Functioning Floodplain Initiative



FEMA

MITIGATION POLICY – FP-108-024-01

III. POLICY STATEMENT:

FEMA will allow the inclusion of environmental benefits in benefit-cost analyses (BCA) to determine cost effectiveness of acquisition projects.

IV. PURPOSE:

The purpose of this policy is to identify and quantify the types of environmental benefits that FEMA will consider in the BCA for acquisition projects.

Table I: Annual Estimated Monetary Benefits per Acre per Year

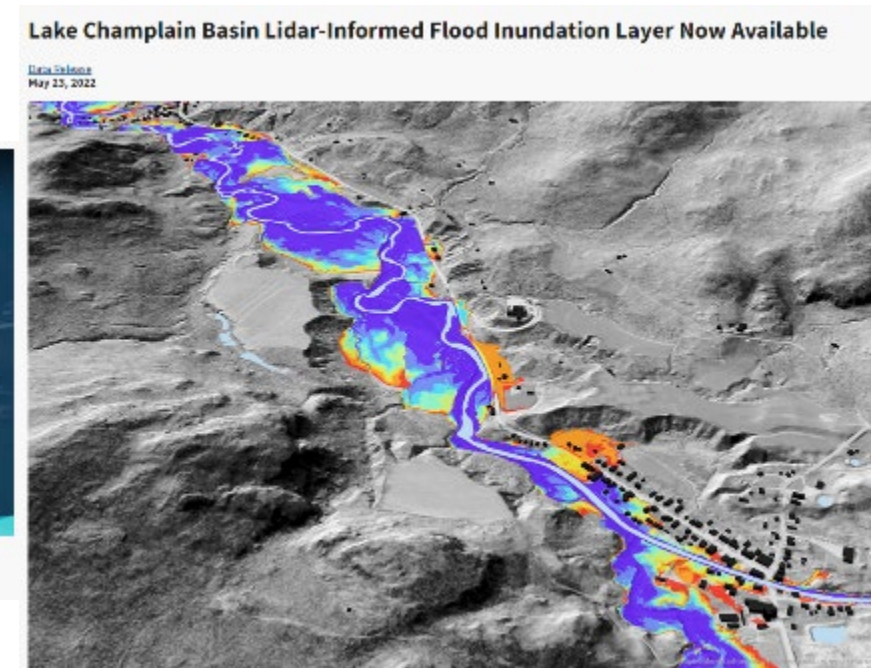
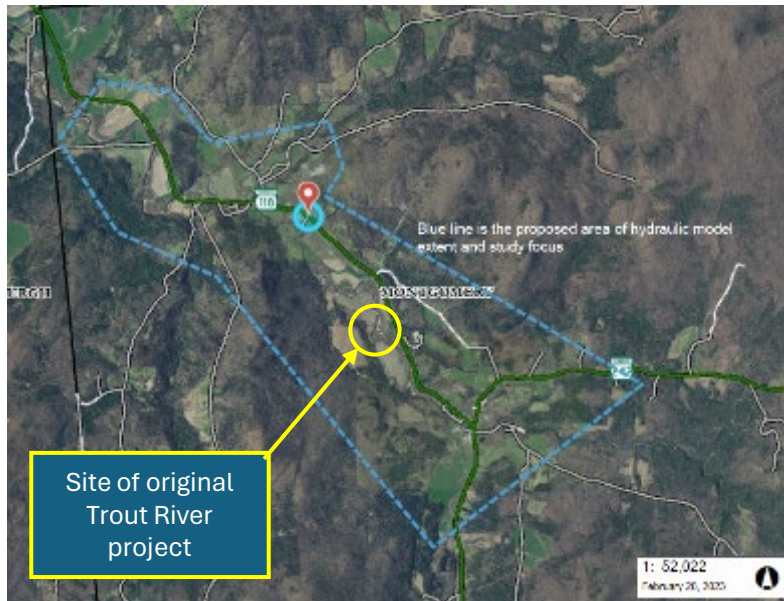
Environmental Benefit	Green Open Space	Riparian
Aesthetic Value	\$1,623	\$582
Air Quality	\$204	\$215
Biological Control	--	\$164
Climate Regulation	\$13	\$204
Erosion Control	\$65	\$11,447
Flood Hazard Reduction	--	\$4,007
Food Provisioning	--	\$609
Habitat	--	\$835
Pollination	\$290	--
Recreation/Tourism	\$5,365	\$15,178
Storm Water Retention	\$293	--
Water Filtration	--	\$4,252
Total Estimated Benefits	\$7,853	\$37,493

Table II: Green Open Space and Riparian Benefits Allowed in the BCA Toolkit

Land Use	Total Estimated Benefits	Total Estimated Benefits (projected for 100 years with 7 percent discount rate)
Green Open Space	\$7,853 per acre per year	\$2.57 per square foot
Riparian	\$37,493 per acre per year	\$12.29 per square foot

(FEMA, 2013)

We're still learning



Montgomery Flood Resilience and Hazard Mitigation Study Kickoff Meeting

Monday, March 18th, 2004 at 5pm



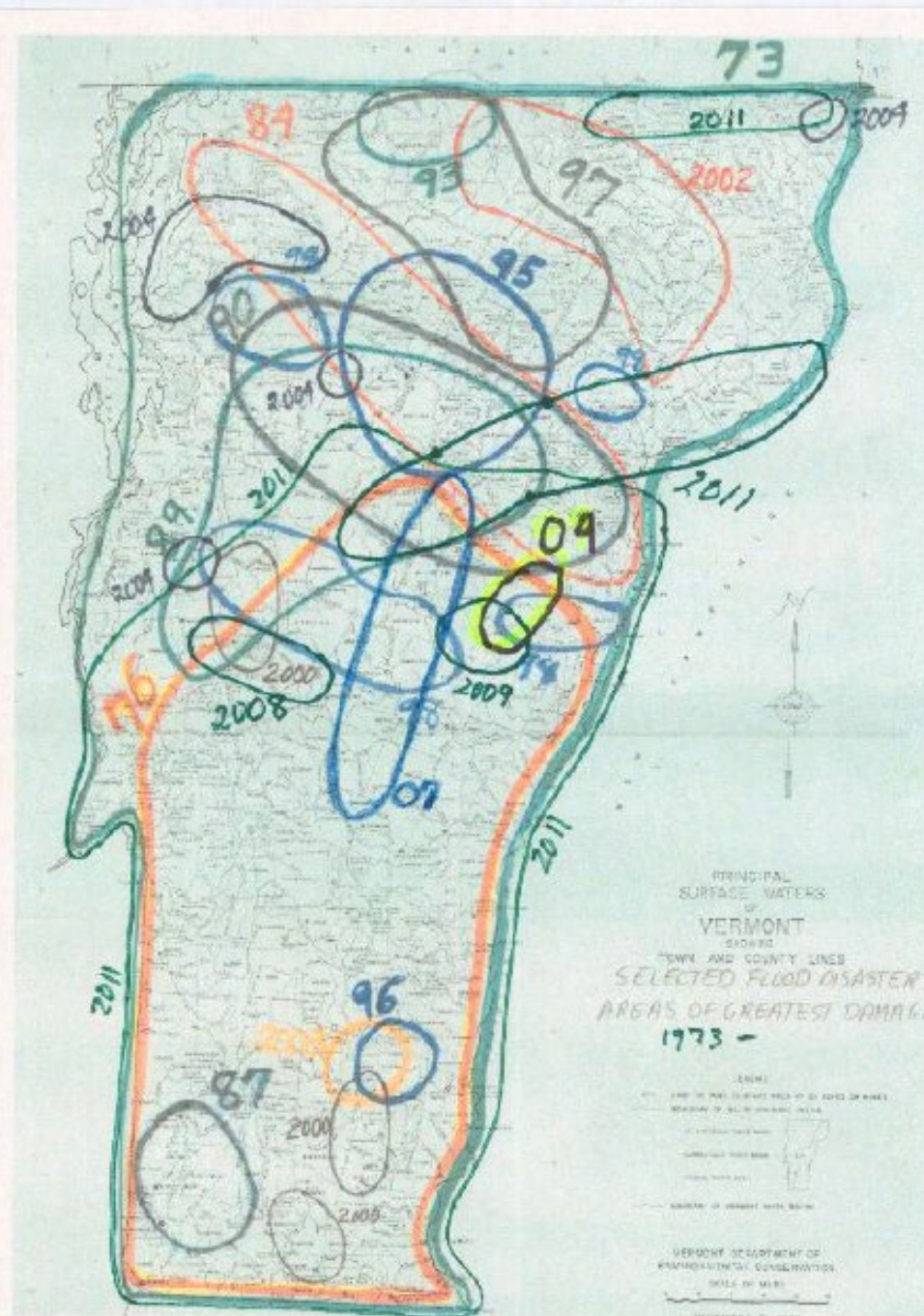
Resources

- Vermont River Program:
<https://dec.vermont.gov/watershed/rivers>
- Vermont Standard River Management Principles and Practices:
https://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/SRMPP_1.3_lowres.pdf
- River & Roads Training site link:
<https://dec.vermont.gov/event/vermont-rivers-roads-tier-2-and-tier-3-training>
 - Watch this fun video of our Tier 2 River & Roads training from VPR Outdoors Edition:
https://www.youtube.com/watch?v=YOBMq2gYP_k
- VT Flood Ready web page: <https://floodready.vermont.gov/>
- VT Flood Resilient Communities Fund:
<http://vem.vermont.gov/flood-resilient-communities-fund>
- VT Functioning Floodplain Initiative:
<https://dec.vermont.gov/rivers/ffi>

Flooding

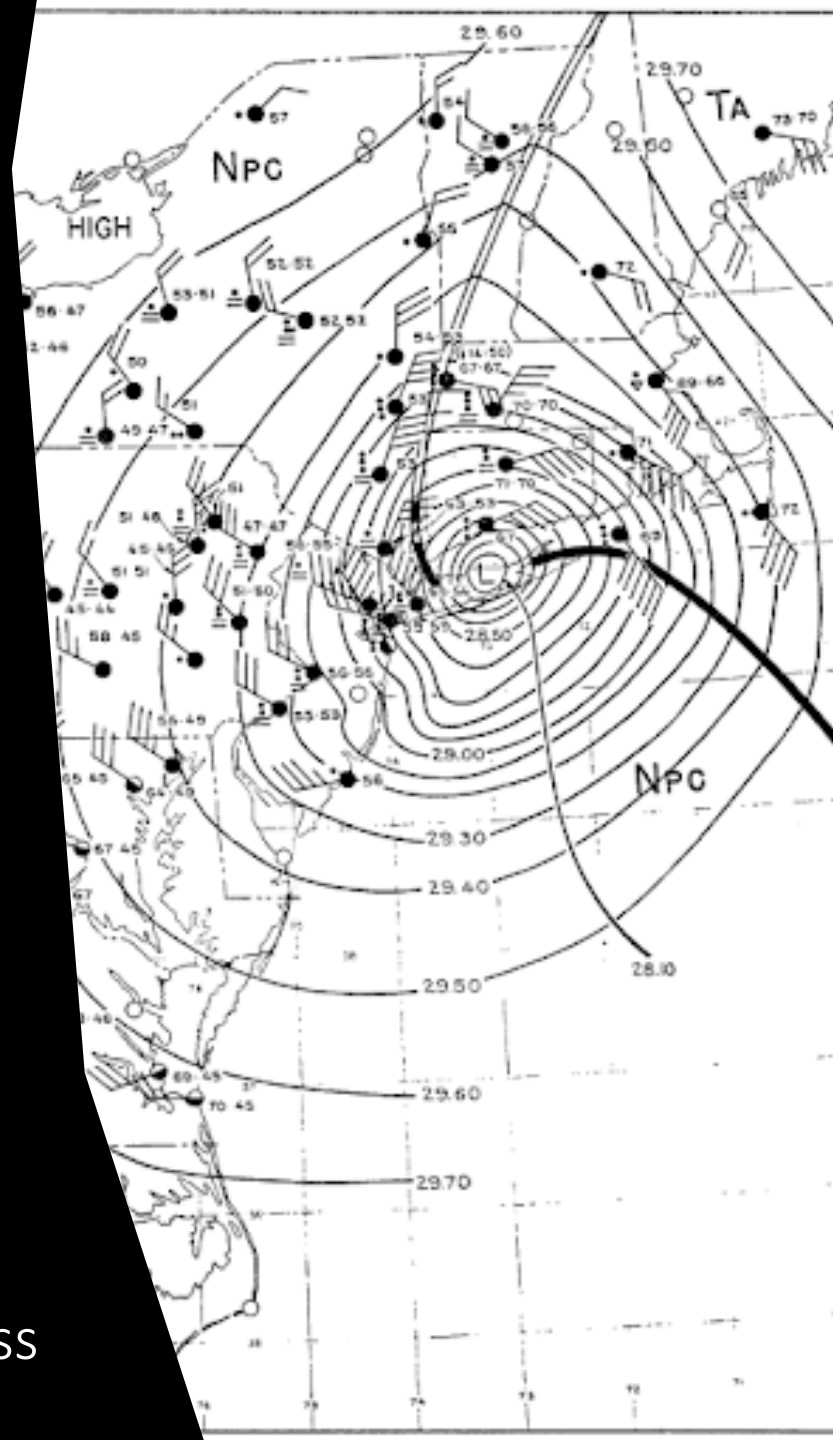
Natural. Expected. Common.

Should flooding be a *disaster*?

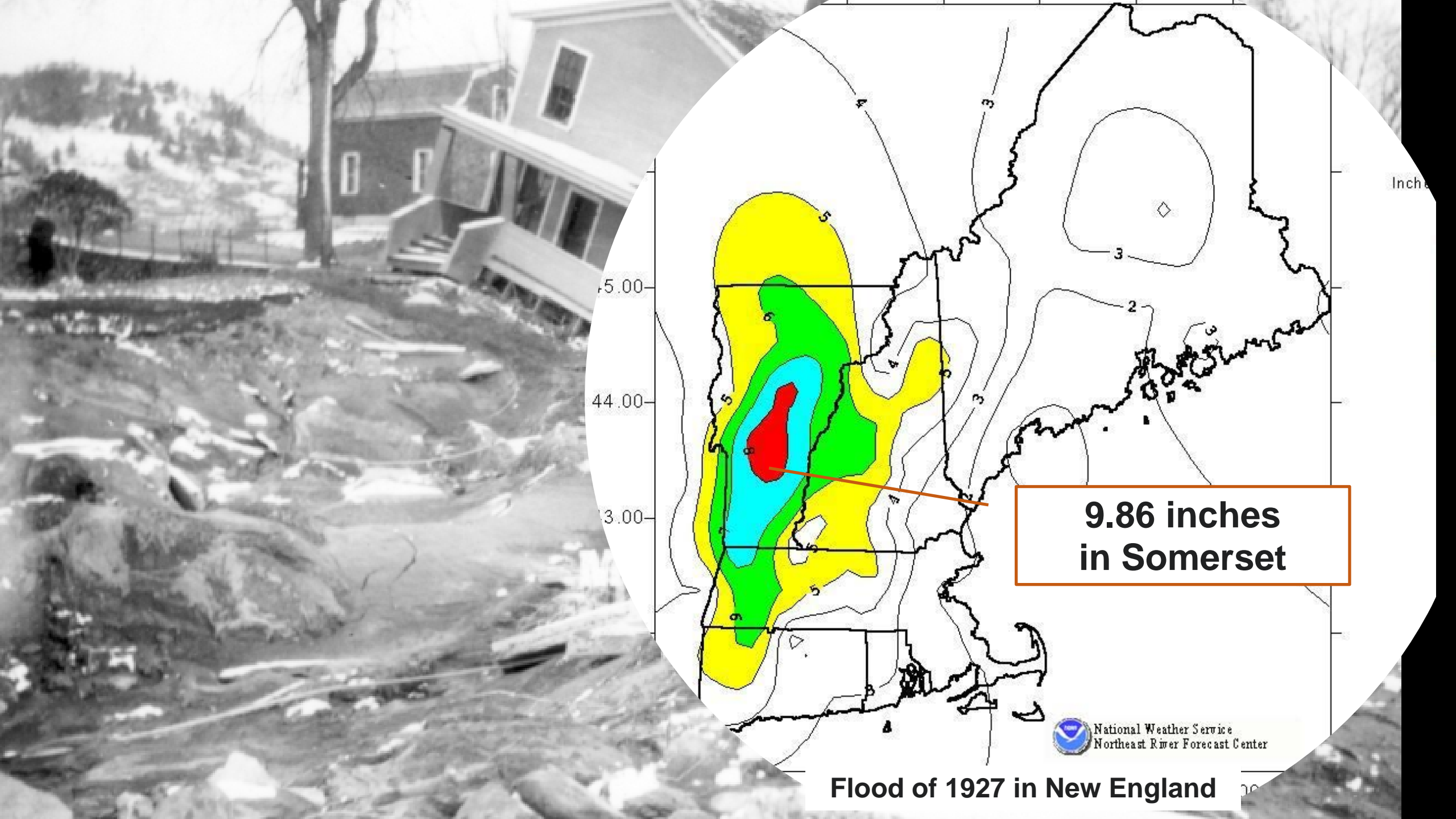


Major floods in Vermont

- 1830
- 1869
- 1927
- 1936
- 1938
- 1971
- 1973
- 1976
- 2011
- 2023



9/21/1938
The Long Island Express



Inch

45.00
44.00
3.00

**9.86 inches
in Somerset**

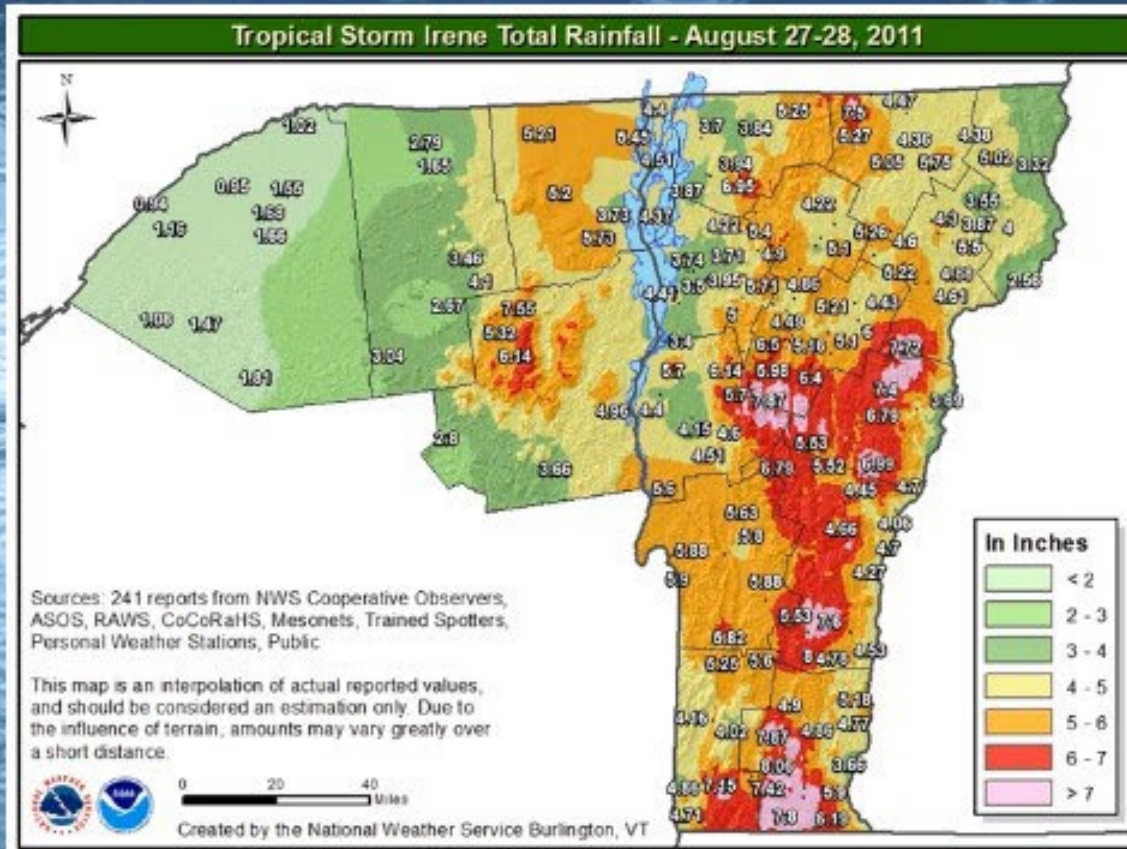
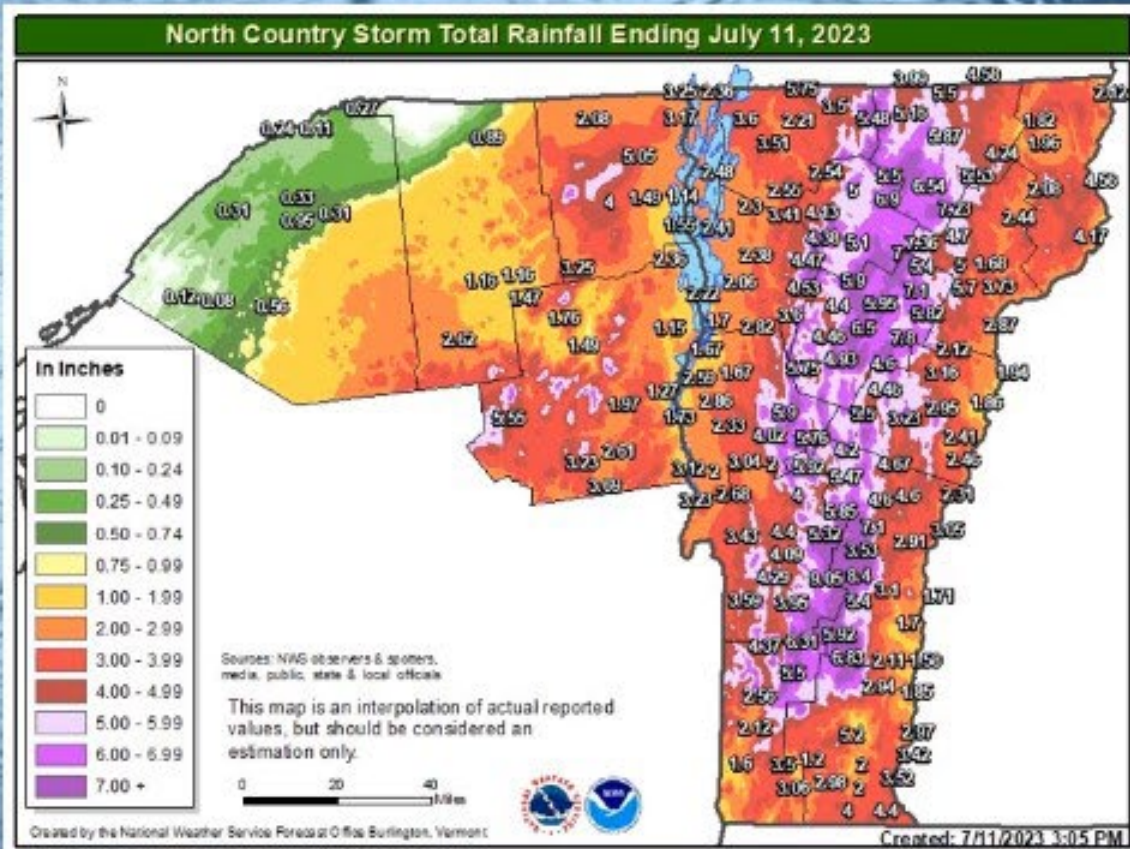
National Weather Service
Northeast River Forecast Center

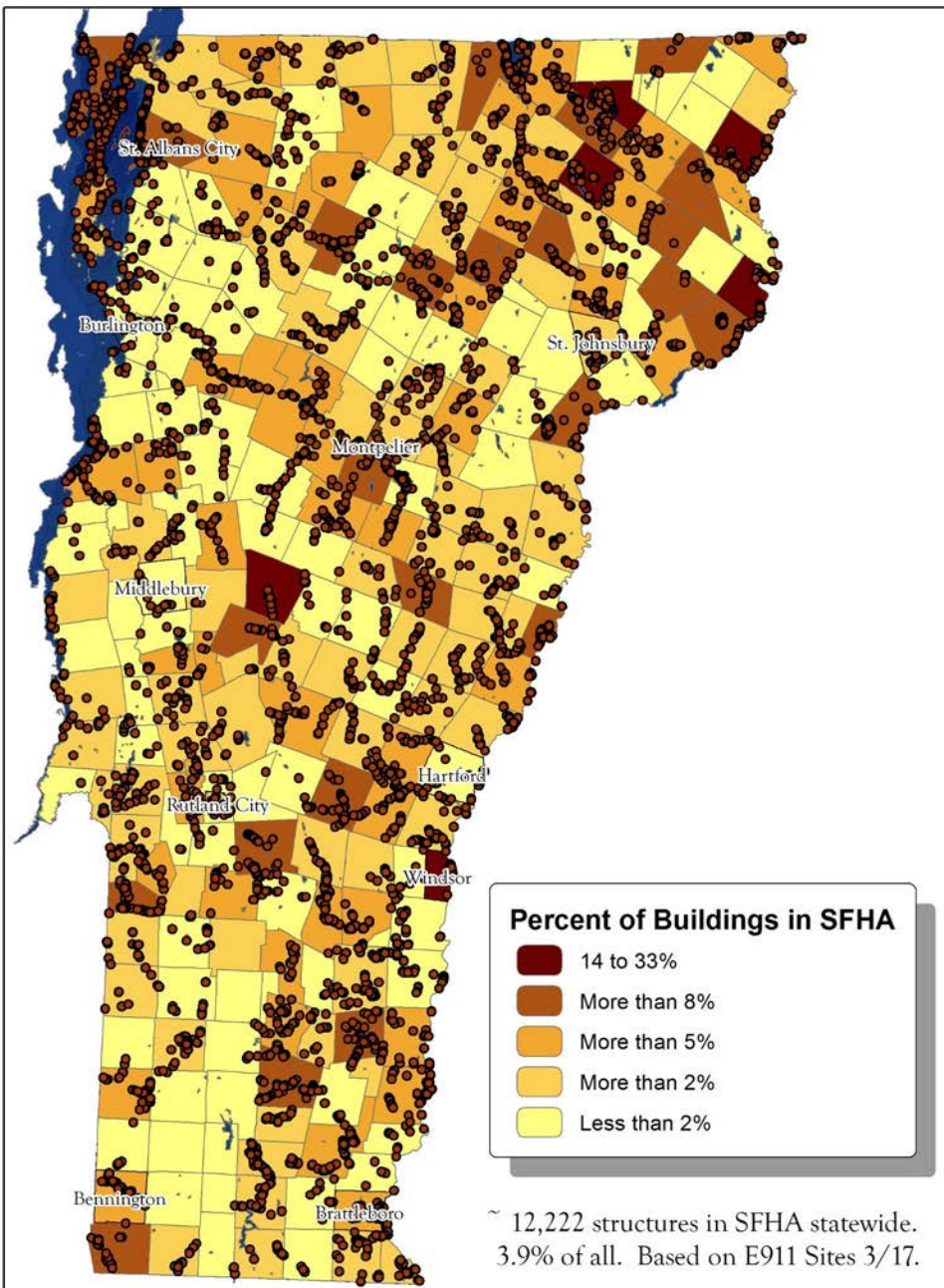
Flood of 1927 in New England

Total Rainfall compared to TS Irene

July 2023

August 2011





Structures in SFHA

1	BENNINGTON	452
2	BARRE CITY	342
3	MONTPELIER	302
4	SAINT ALBANS TOWN	289
5	WINDSOR	249
6	BRATTLEBORO	234
7	WATERBURY	190
8	LUDLOW	177
9	POWNAI	162
10	RICHMOND	160
11	BERLIN	158
12	WOODSTOCK	145
13	FERRISBURGH	135
14	RUTLAND CITY	133
15	DOVER	129
16	JOHNSON	126
17	JAMAICA	121
18	LYNDON	113
19	NORTHFIELD	108
20	WELLS	108

Expanded Community Report for Wilmington

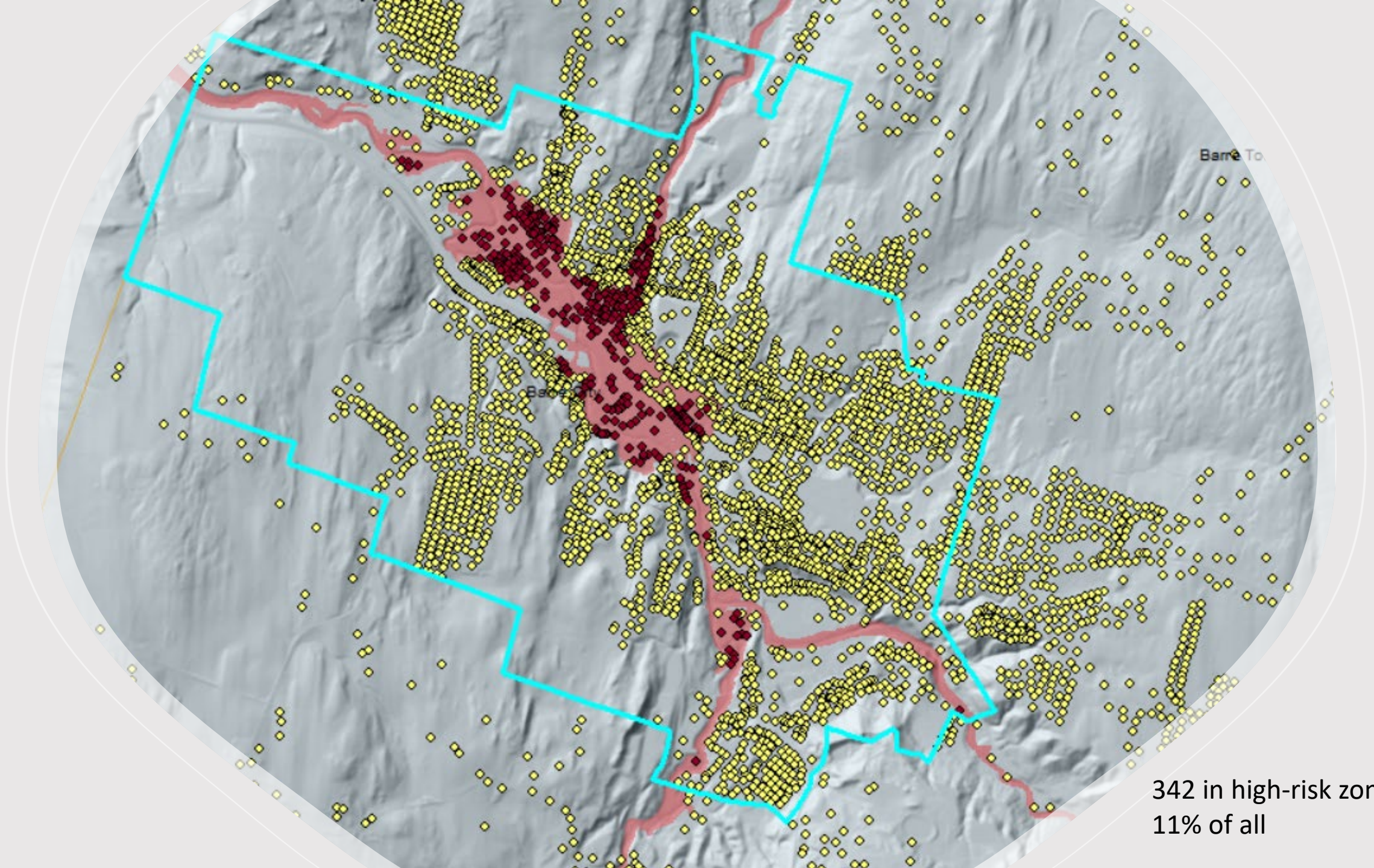
1/23/2024
3:59:04 PM

Emergency Relief and Assistance Fund (ERAF) - State Post-Disaster Funding

Flood Hazard Mitigation Actions	Action Dates		Responsible	ERAF Status
1. Road and Bridge Standards	08/24/2019		Wilmington	Yes
2. Local Emergency Management Plan	04/04/2023		Wilmington	Yes
3. National Flood Insurance Program	05/01/1978		Wilmington	Yes
4. Local Hazard Mitigation Plan	07/28/2020		Wilmington	Yes
5. River Corridor Protection				No
ERAF Rate for Actions 1 - 4: 12.5%, Actions 1 - 5: 17.5%		ERAF Rate for:	Wilmington	12.5%

100	Buildings in the Special Flood Hazard Area (SFHA) (estimated from e911 sites).
Hazard Maps For Manufactured Home Communities	None
10	Flood Insurance Policies in SFHA (Zone A, AE, AO, A 1- 30)
10%	Percent of buildings in the SFHA with flood insurance in force.
3	Critical or public structures in SFHA or 0.2% flood hazard area (est. from e911 sites.)
4%	Percent of buildings in the SFHA.
05/01/1978	<u>National Flood Insurance Program (NFIP)</u> (Enrollment Date)
DFIRM	<u>Flood Insurance Rate Map Standard (Digital FIRM (DFIRM), Rough Digital, Paper)</u>
Wilmington	NFIP Status: Regular Program
0	<u>Community Rating System (CRS) Class</u>

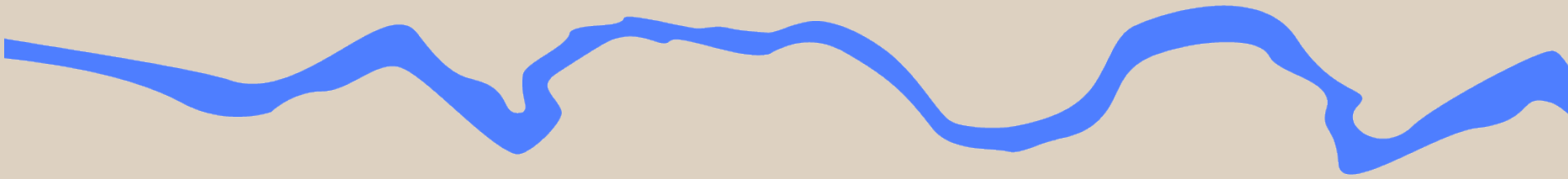
www.floodready.vt.gov



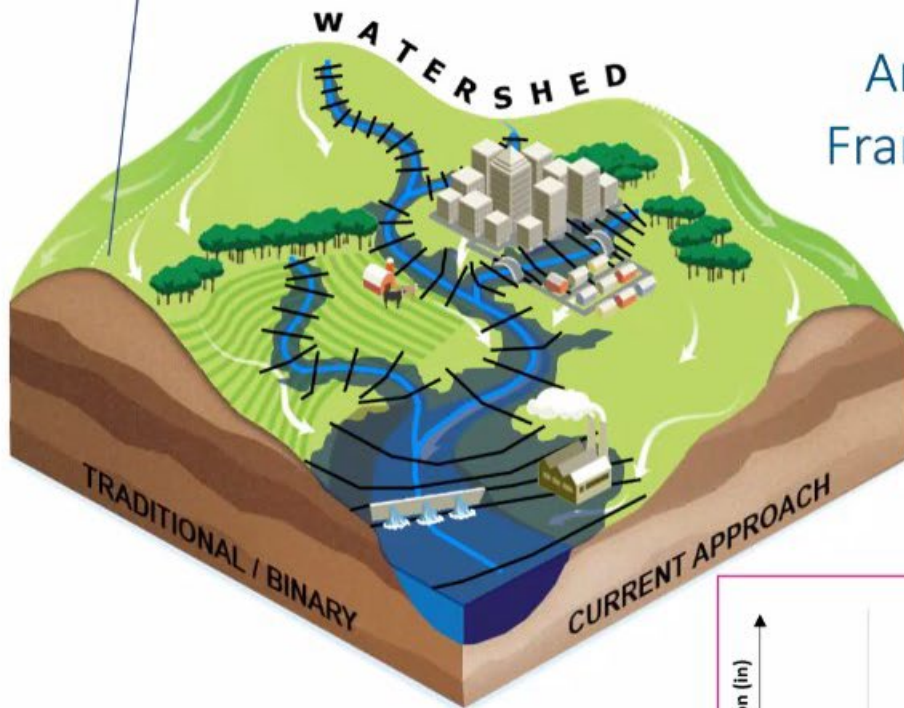
342 in high-risk zone
11% of all

FEMA Flood Studies Underway

1. **Zone A** from 1D or 2D Base Level Engineering (BLE)
2. Redelineated **Zone AE** using the new 1' contours
3. Selected new detailed studies with Zone AE and Floodways

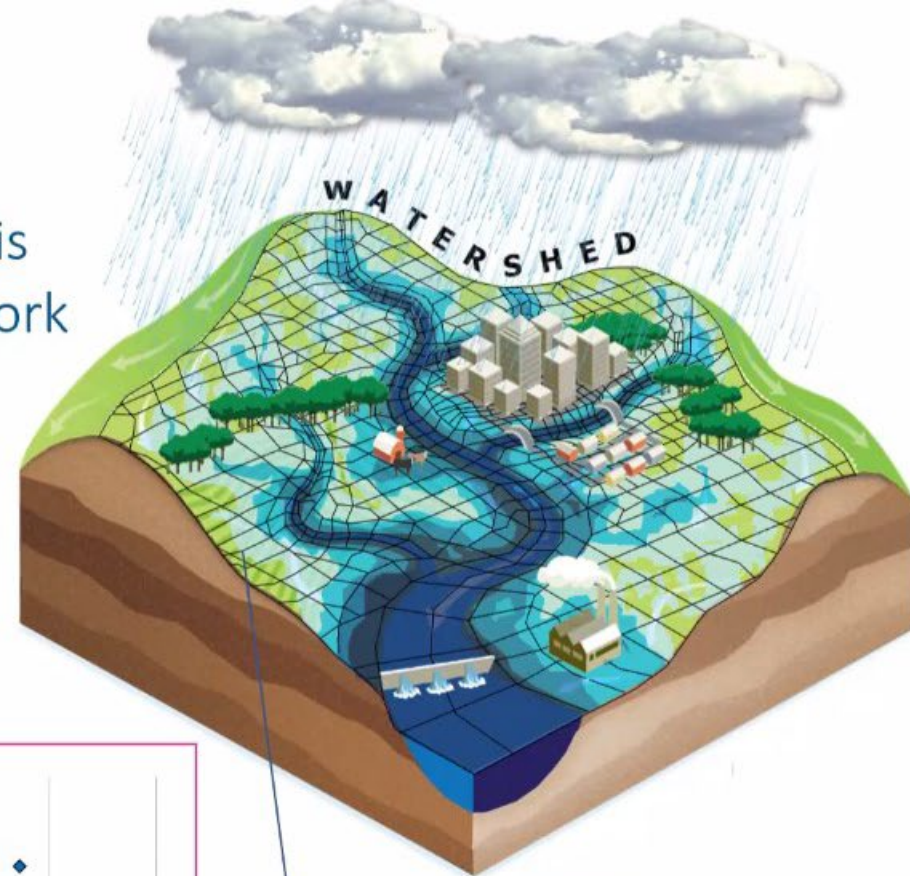


- 1D Modeling
- Fluvial flooding only
- Event-based analyses

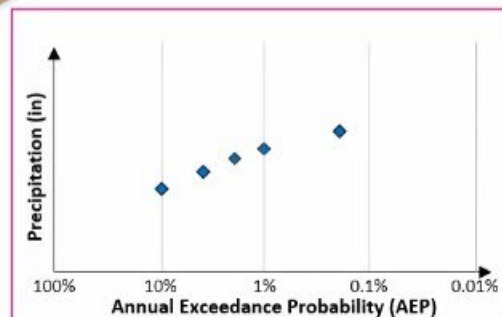


Inland/Riverine Flooding Examples

Analysis Framework



- 2D Modeling
- Fluvial and pluvial flooding



FEMA's Future of Flood Risk Data (FFRD)
From binary to probabilistic

Zone A existing map

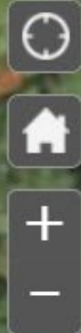


Zone A from 2D Base Level Engineering





Find address or place



bit.ly/fema-map-update

Legend

Preliminary National Flood Hazard Layer








Preliminary FIRM Panel Index



Preliminary Water Lines



Preliminary Flood Hazard Zones

-  1% Annual Chance Flood Hazard
-  Regulatory Floodway
-  Special Floodway
-  Area of Undetermined Flood Hazard
-  0.2% Annual Chance Flood Hazard
-  Future Conditions 1% Annual Chance Flood Hazard
-  Area with Reduced Risk Due to Levee

Effective FIRM



Draft Work Map for next FIRM





Nov 1927

Aug 2011

Q100

HIS...
PE...
NOV 03.1927
AUG 28.2011
SEP 22.1938
JUN 27.1998
MAR 06.1979
AUG 10.1977
APR 18.1982
MAR 31.1987
JAN 19.1996
JUN 03.1947
JUN 30.1973
DEC 31.1948
OCT 24.1990
1889
1922
1972
2014
1971
2002



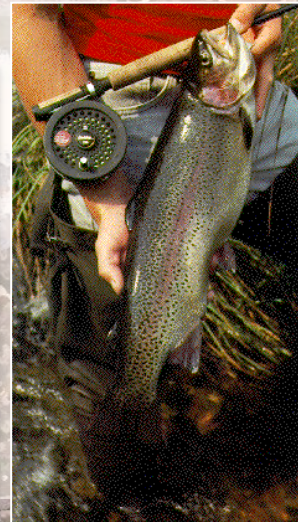
Detailed Studies
(yellow)

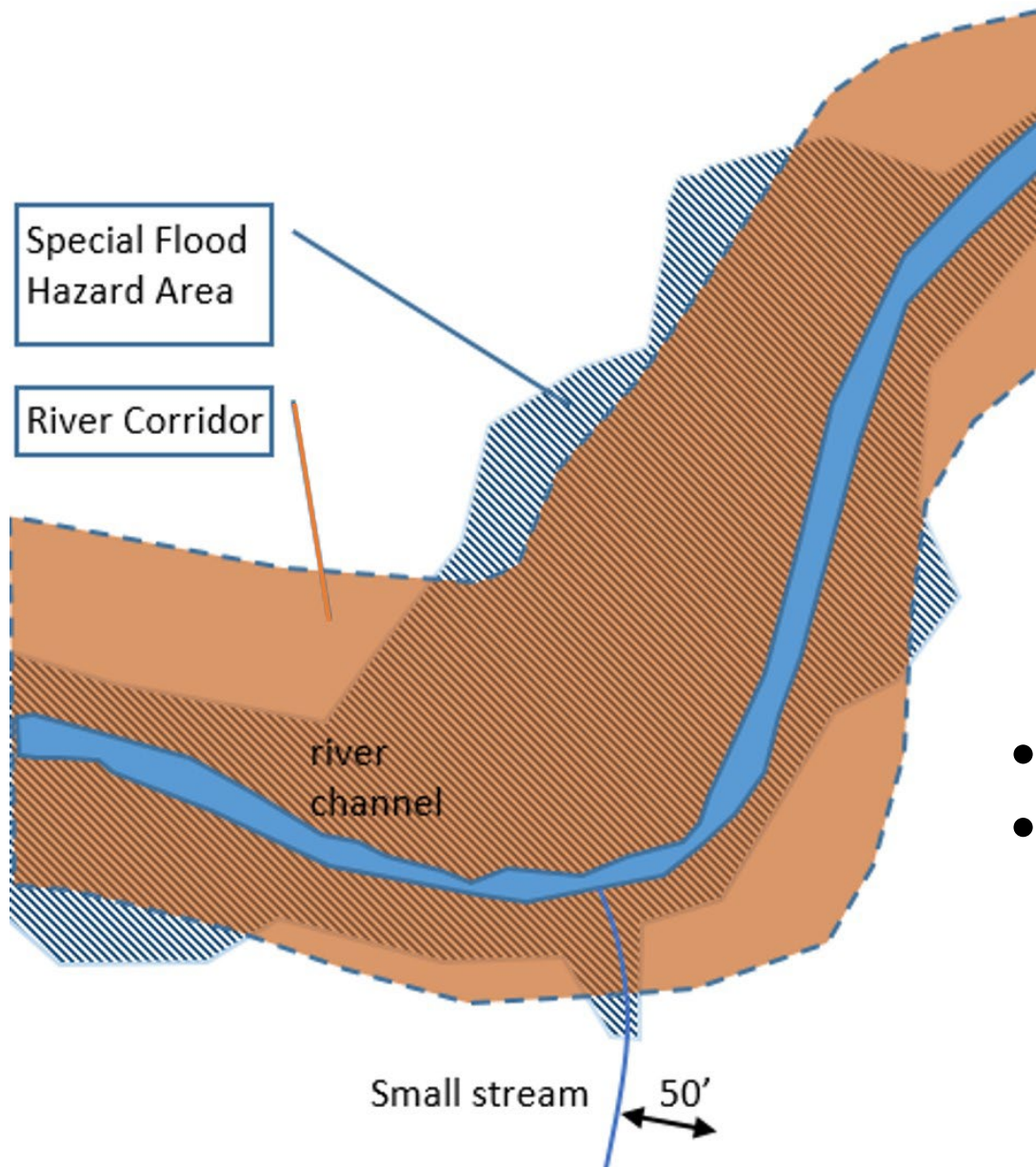
Prep Deadlines for
Updated FIRMs

Counties	Deadline
Chittenden	Spring 2026
Franklin	Spring 2026
Grand Isle	Spring 2026
Lamoille	Spring 2026
Orleans	Spring 2026
Caledonia	Fall 2026
Essex	Fall 2026
Orange	Fall 2026
Washington	Fall 2026
Windsor	Fall 2026
Addison	Winter 2027
Bennington	Winter 2027
Rutland	Winter 2027
Windham	Winter 2027

Floodplain Natural and Beneficial Functions

- Store and move floodwater, ice, debris
- Keep water clean (trapping sediments, nutrients)
- Enrich soil
- Recharge water supply
- Provide space for agriculture, forestry
- Wildlife and natural communities
- Recreation, beauty, inspiration
- Reduce flood levels and flood power.





- *Protect the room needed by the river*
- *Protect floodplain functions*

No adverse impact

No Adverse Impact - Model Bylaws

1. River Corridor Protection

Don't build closer than what is already there.

Leave room for rivers

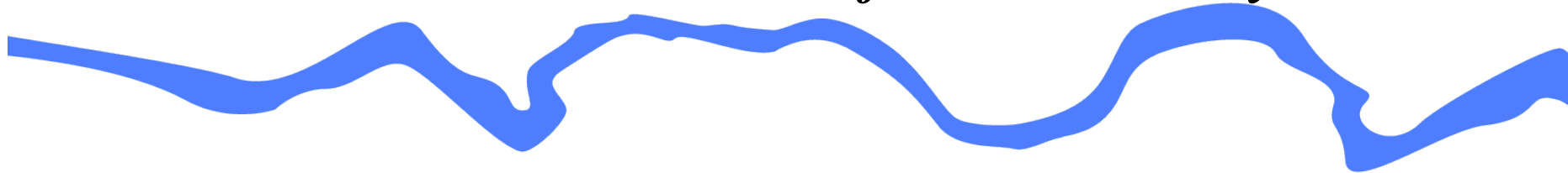
2. Special Flood Hazard Area

No net fill

Lowest floor 2 feet above flood water

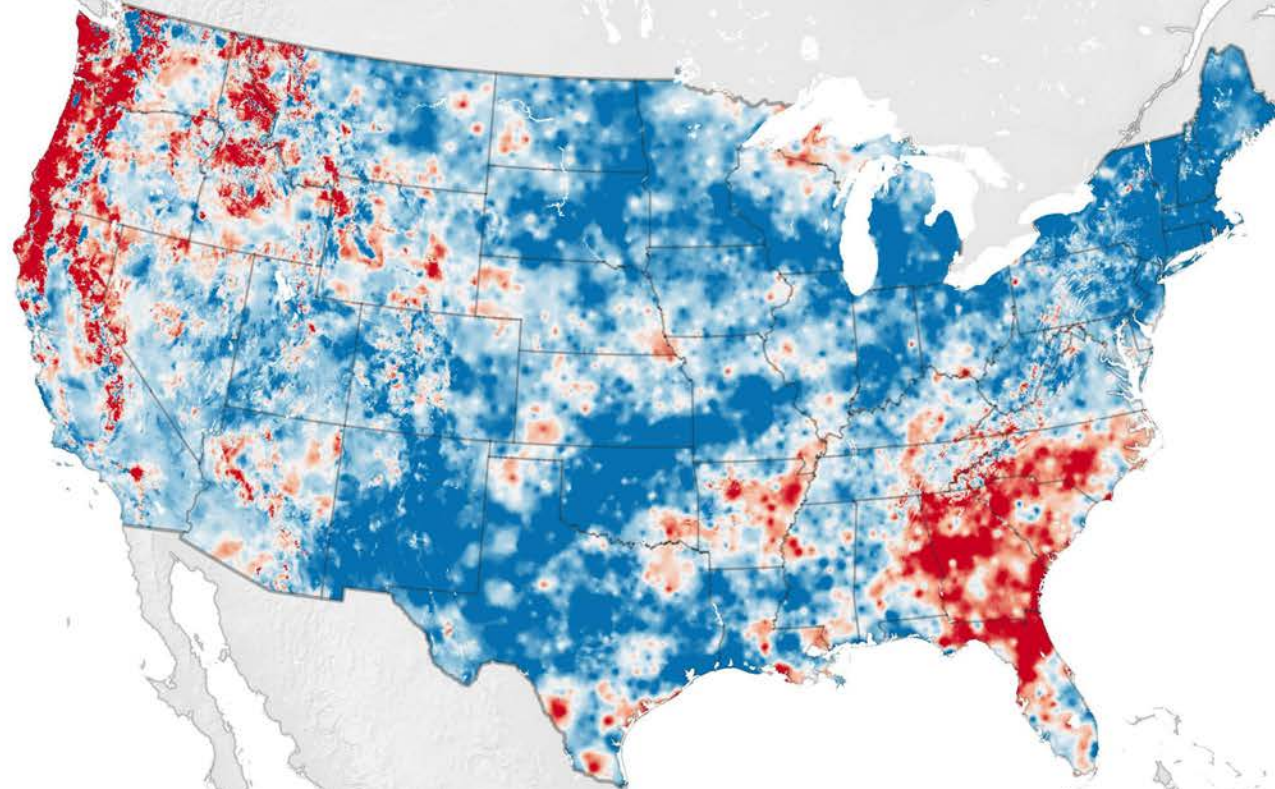
Let floodplains work for all of us.

Don't increase the risk for those already at risk.



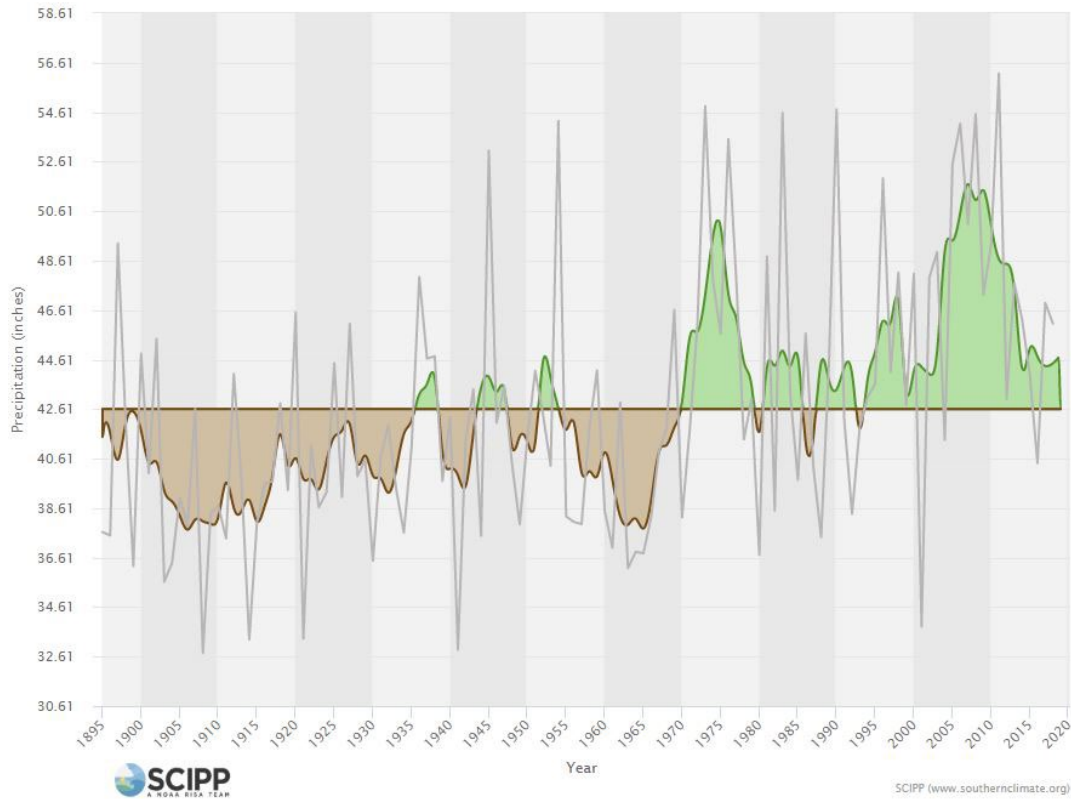
bit.ly/model-regulations

This map shows where the water cycle has been intensifying or weakening across the continental U.S. from 1945-1974 to 1985-2014



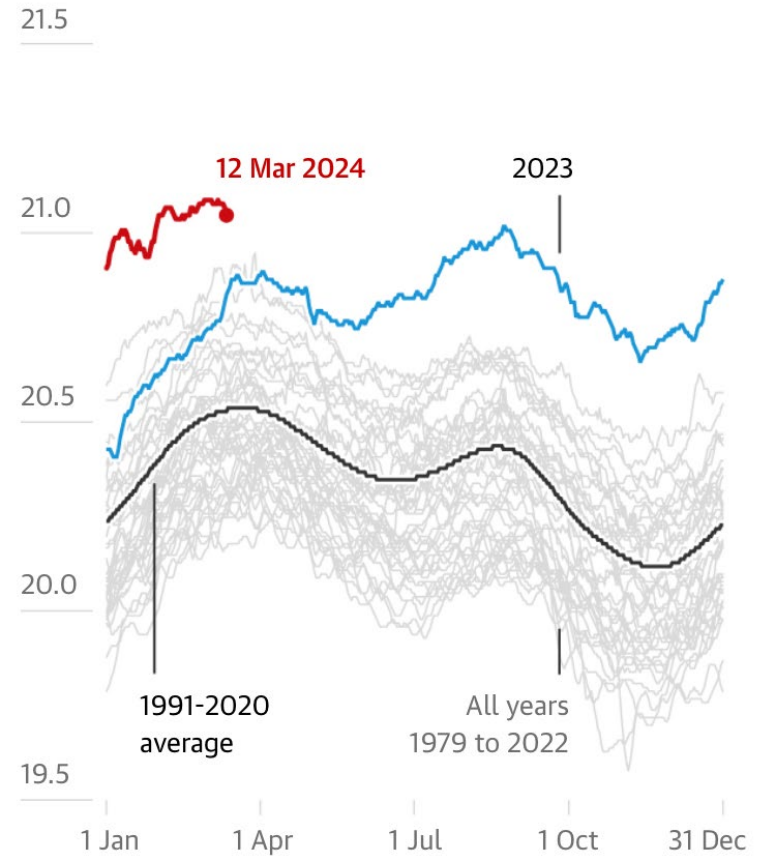
Credit: NASA Earth Observatory image by Lauren Dauphin, using data from Huntington, Thomas, et al. (2018).

Climate Trends – State: VT, Climate Division: 01, Season: Annual



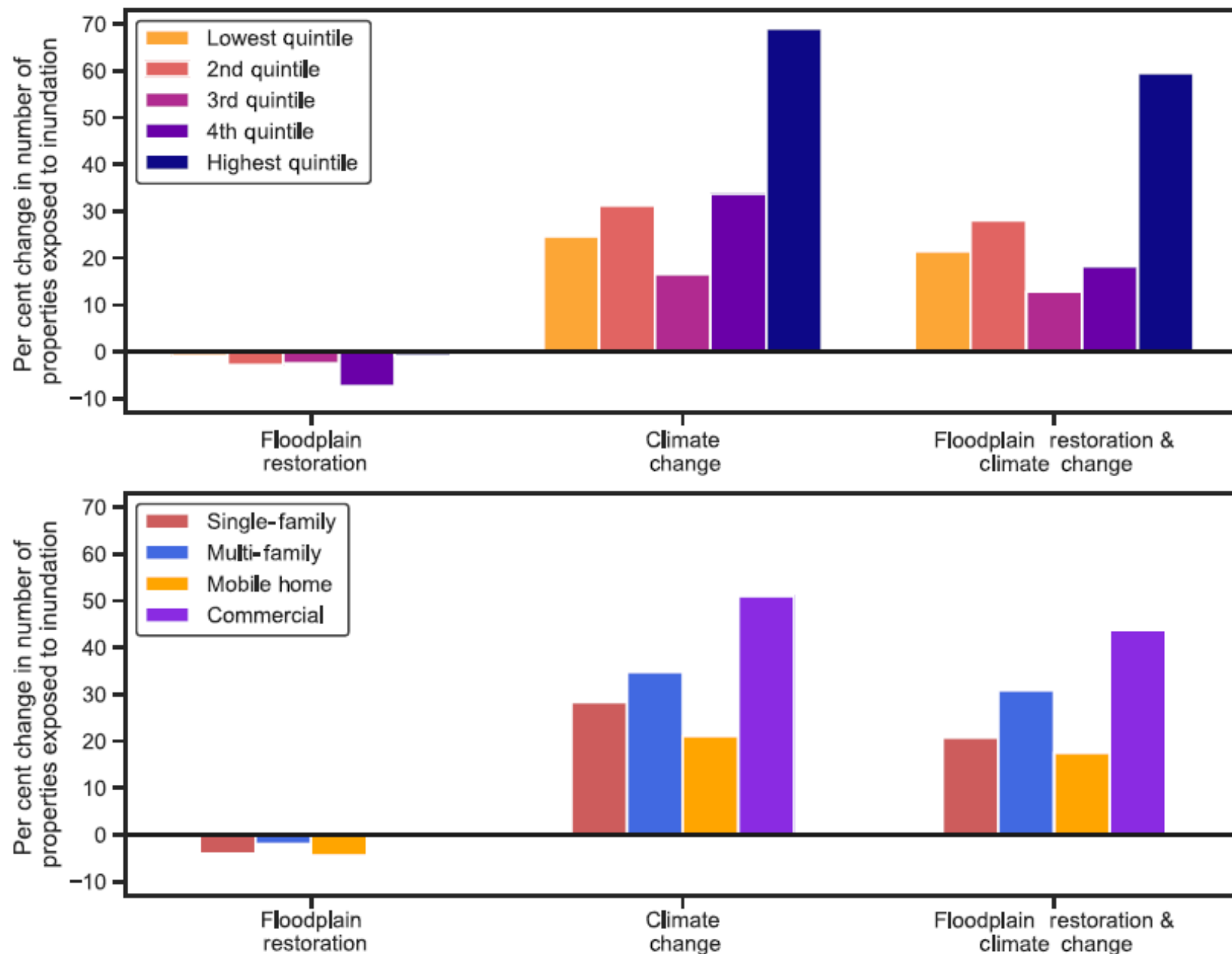
Sea surface temperatures are at record highs

Average daily sea surface temperature, 60S to 60N, C



Guardian graphic. Source: Copernicus C3S/ECMWF Era5

FIGURE 7 Percent change in number of properties exposed to flood inundation, as compared to the baseline scenario. Damages are disaggregated by property value (top) and by property type (bottom). Bars are grouped by scenario and coloured by property characteristics



- **Protect what works – room for rivers and floodplains**
- **Improve floodplain functions where they are already lost**
- **Reduce risk for existing families, workplaces, and critical services**
- **Plan for flood response and flood resilience**
Bounce ahead after disaster

