VT Department of Environmental Conservation
River Management Program

Building Sustainable Individual and Community Relationships with Fluvial Systems through Education, Collaboration, Incentives, and Application of a Science-Based, Watershed Scale, Natural Systems Approach to River Corridor Management, Protection, & Restoration

Presentation Objectives:

1) Build a spatial and temporal understanding of rivers as dynamic systems; why this recognition and approach is critical;

2) Define and design Flood Hazard Mitigation as a vehicle for achieving multi-objective benefits and sustainability of ecosystem services;

3) Postulate an incentives-based approach to establishing effective federal/state/local partnerships in support of Flood Hazard Mitigation.

“Floods are ‘acts of God”, but flood losses are largely acts of man.”

- Gilbert F. White, Geographer, 1942

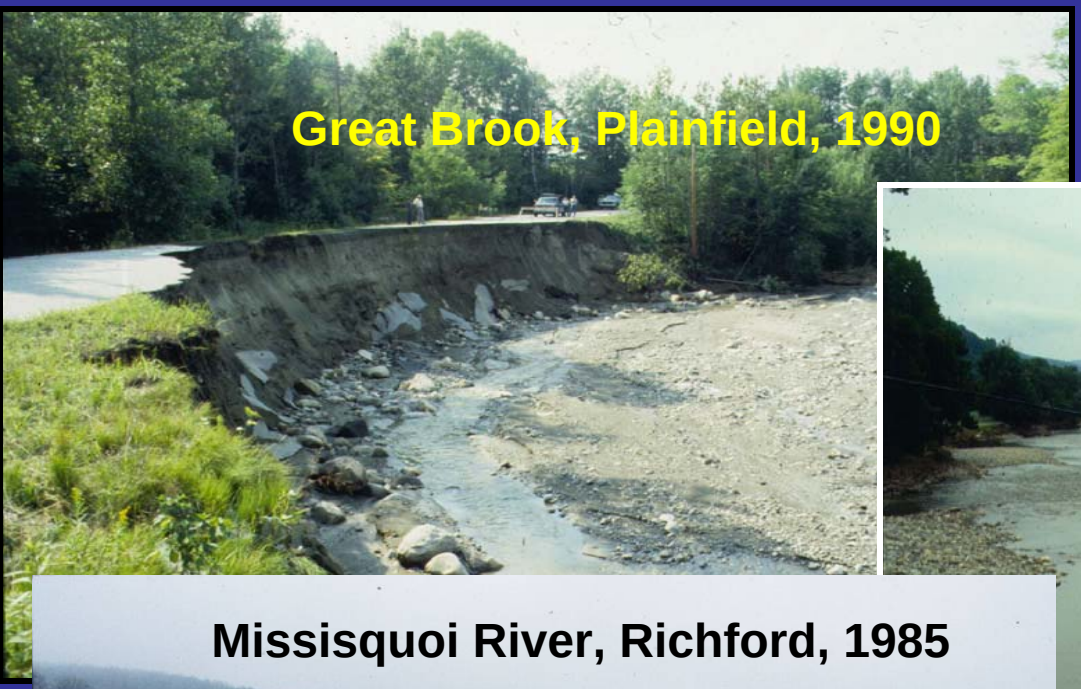
(considered the “father of flood plain management”)

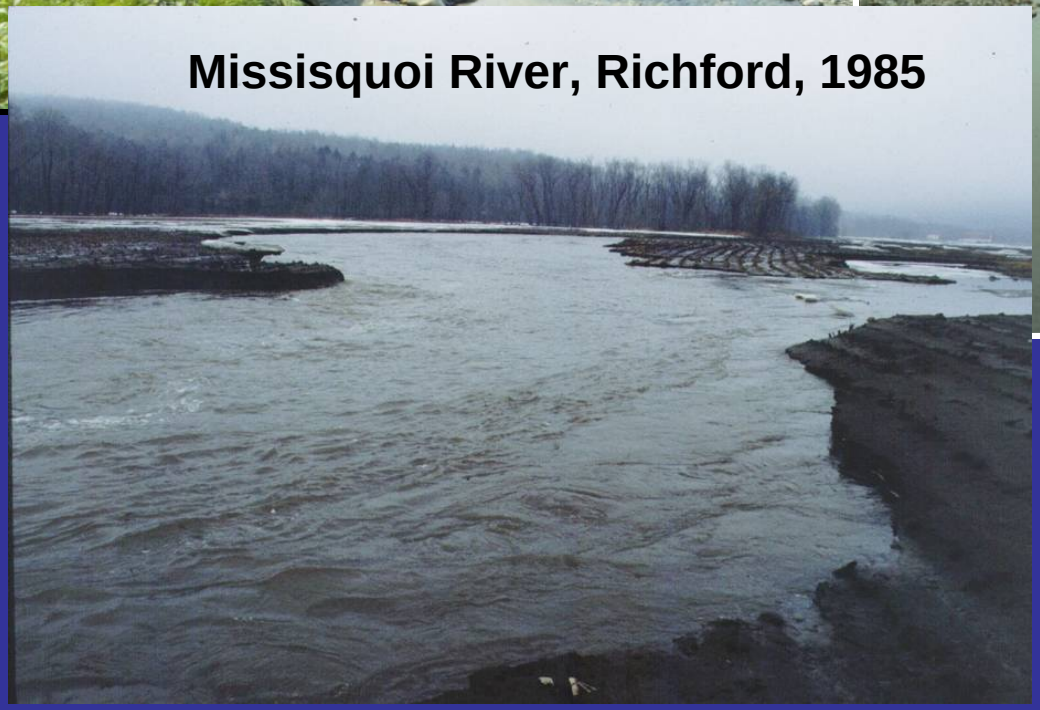
“A flood is never a disaster until people get in the way.”

- Barry Cahoon, P.E., River Management Engineer, 1995

(considered not much more than anything but a “River Rat”)

Periodic Economic Loss and Social Disruption Result from Frequent Devastating Flood Events on Statewide, Regional and Subwatershed Scales.



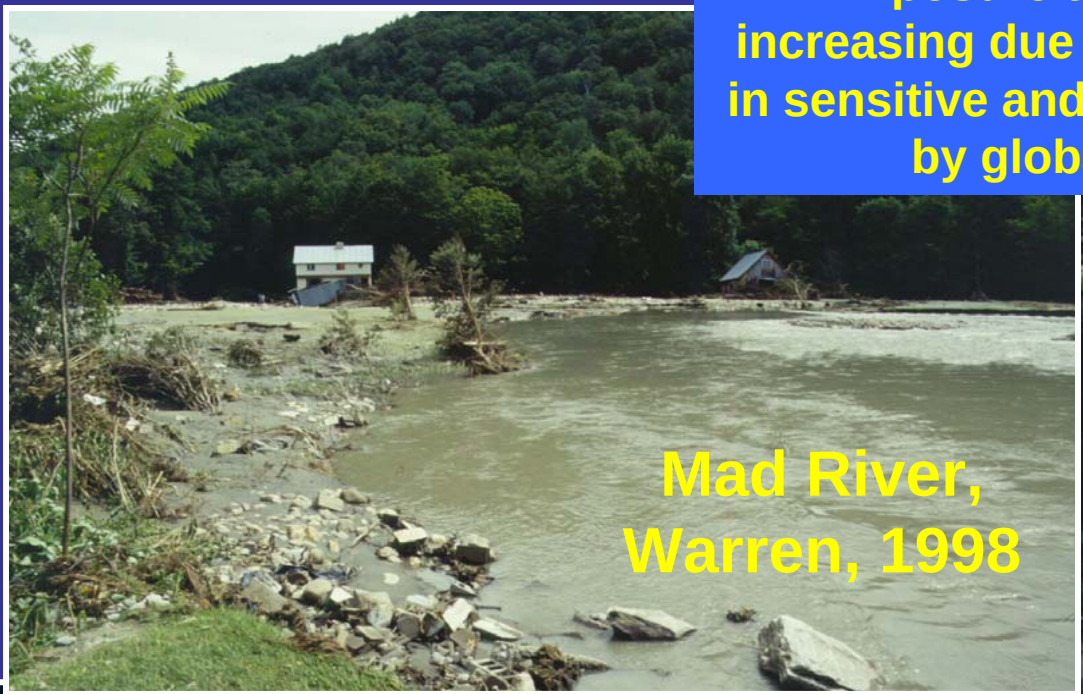


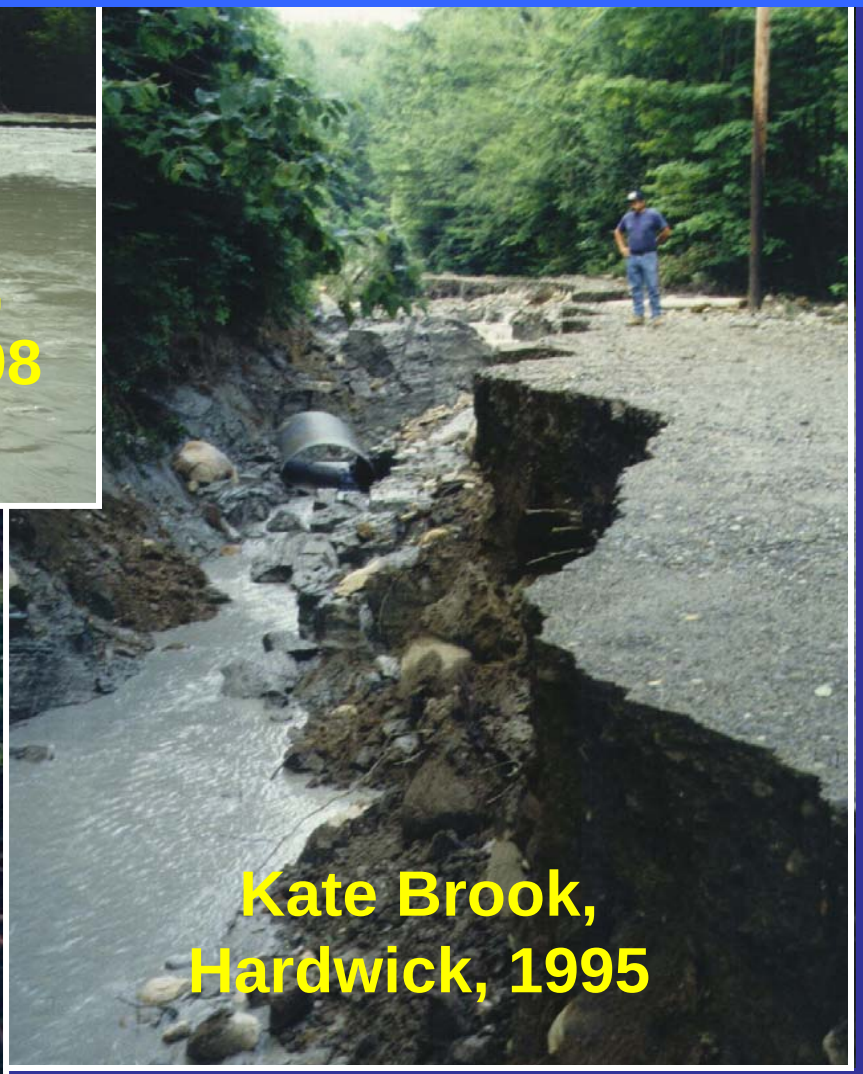
Pervasive stream channel instability and water quality degradation profoundly diminish the ecological and economic potential of riparian lands, river systems and receiving waters for Vermont's communities.

Community relationships with fluvial systems are typically unsustainable, squander remaining flood attenuation assets, and degrade and devalue available ecosystem benefits.

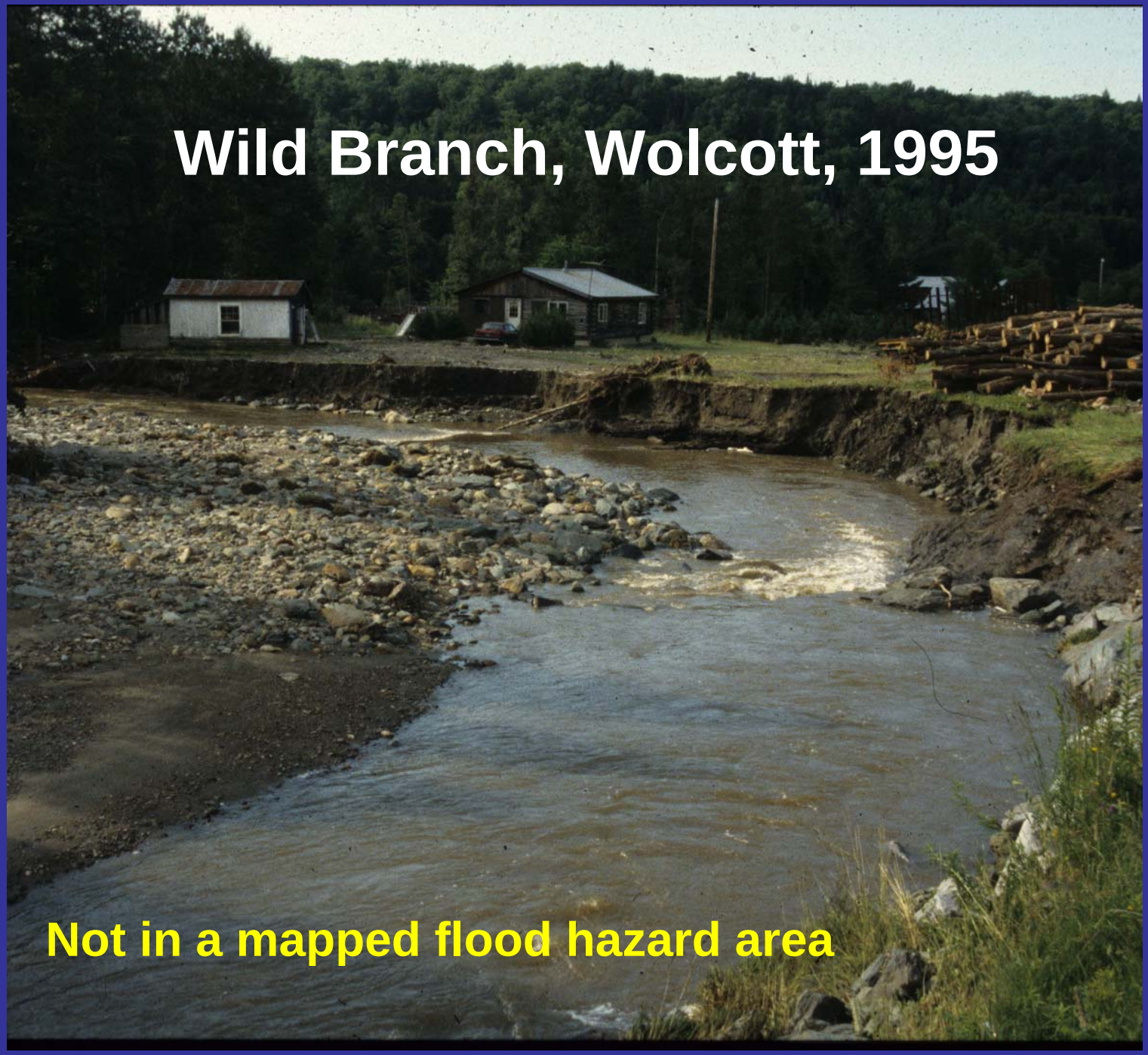
Roaring Branch, Bennington

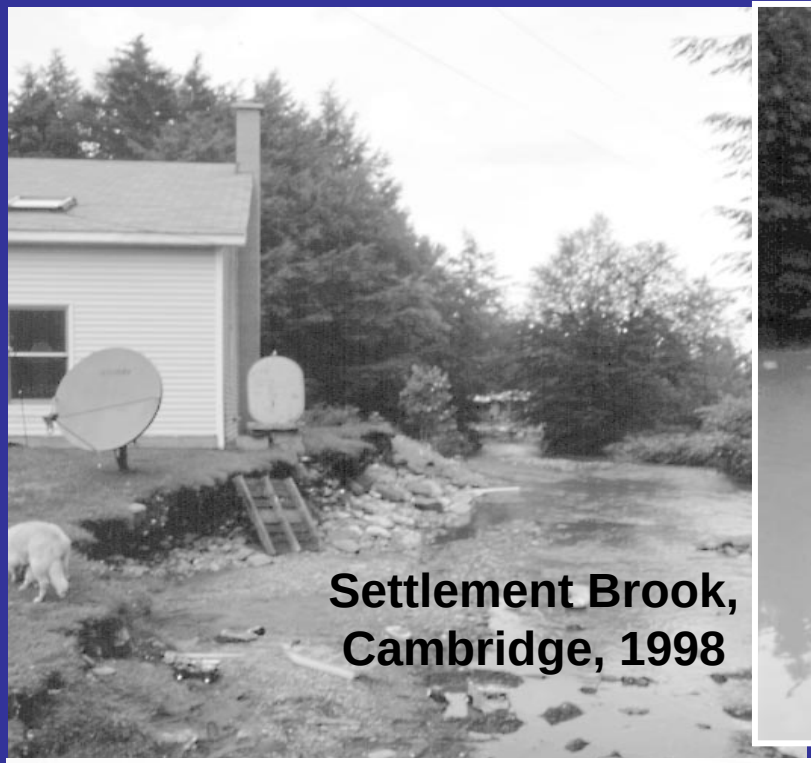
Exposure to devastating flood events is increasing due to intensifying land development in sensitive and vulnerable areas, and potentially by global climate destabilization.





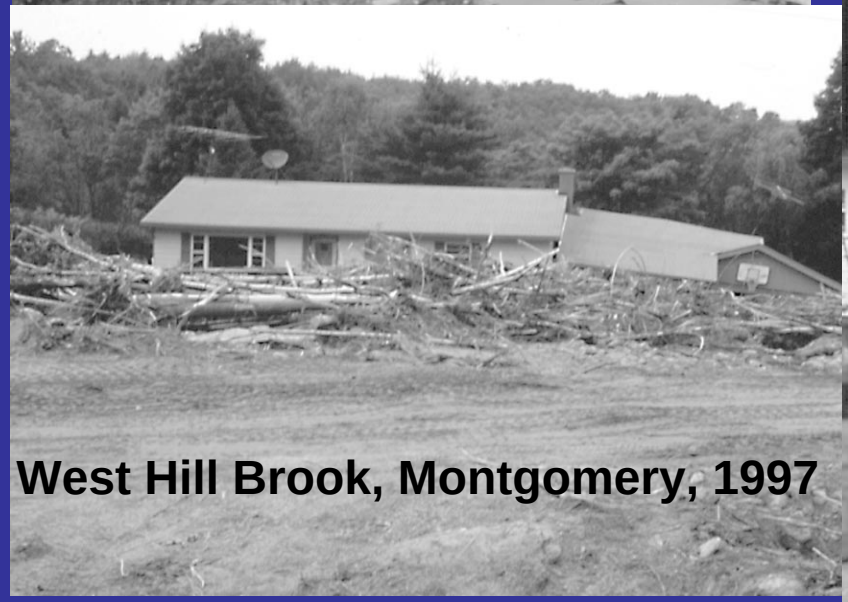
Current state and federal policies and programs provide a disaster response safety net that rewards all eligible individuals and towns regardless of how recklessly or how responsibly public and private investment and growth management decisions are made at the state or local level.


Wild Branch, Wolcott, 1995
Not in a mapped flood hazard area

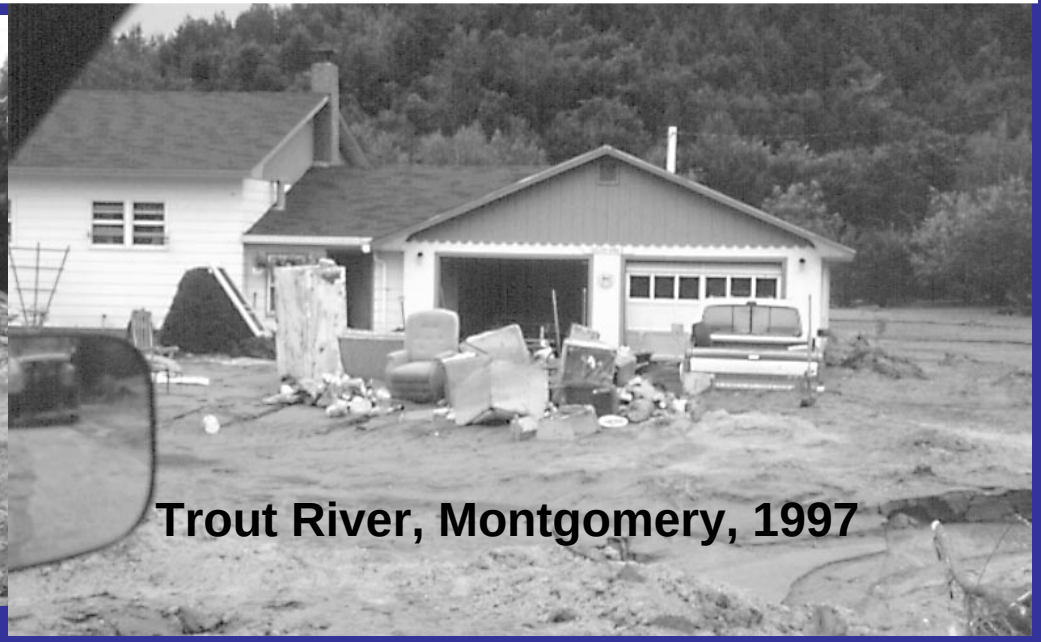


Settlement Brook, Cambridge, 1998

Roaring Brook, Underhill, 1998

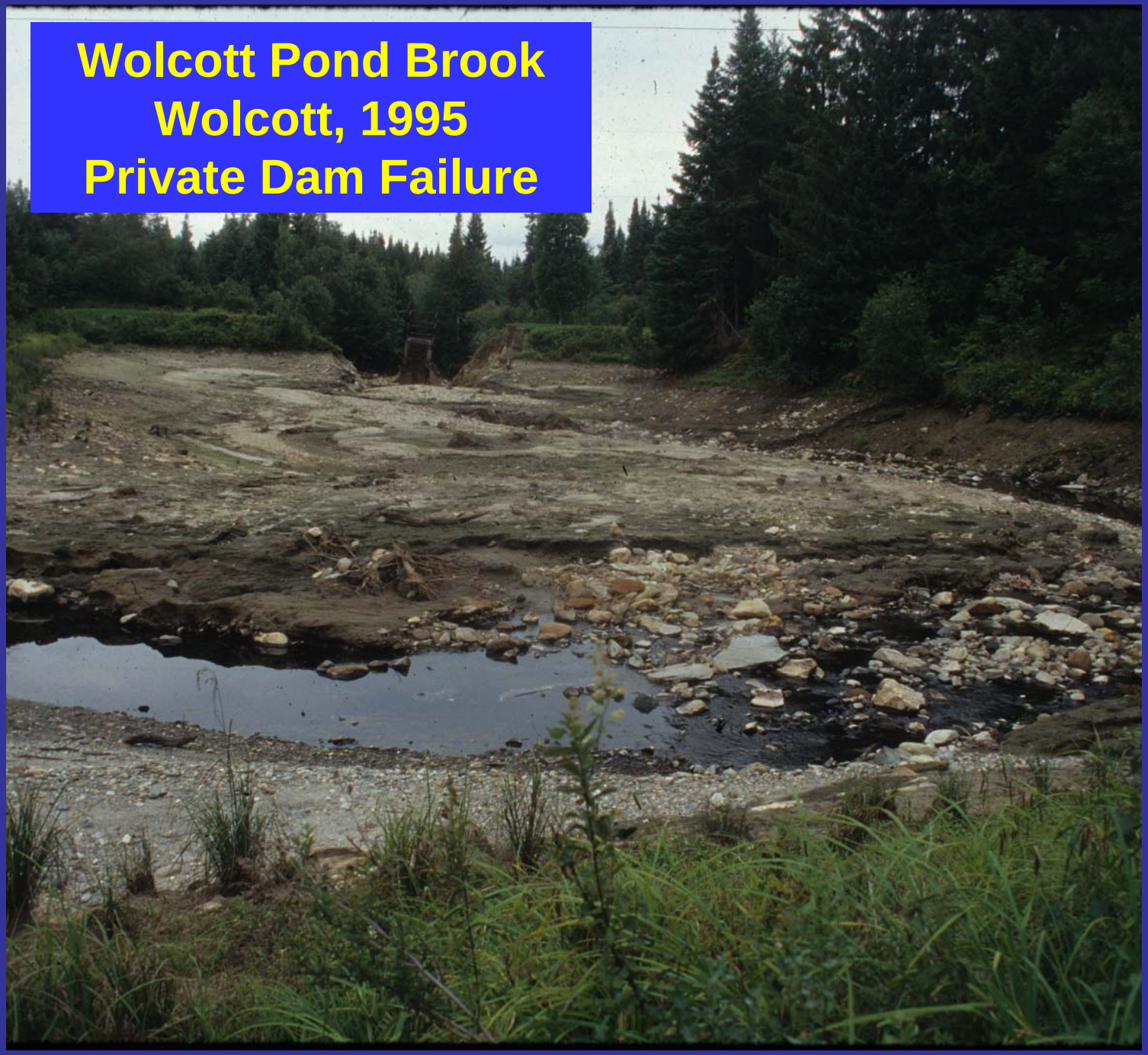


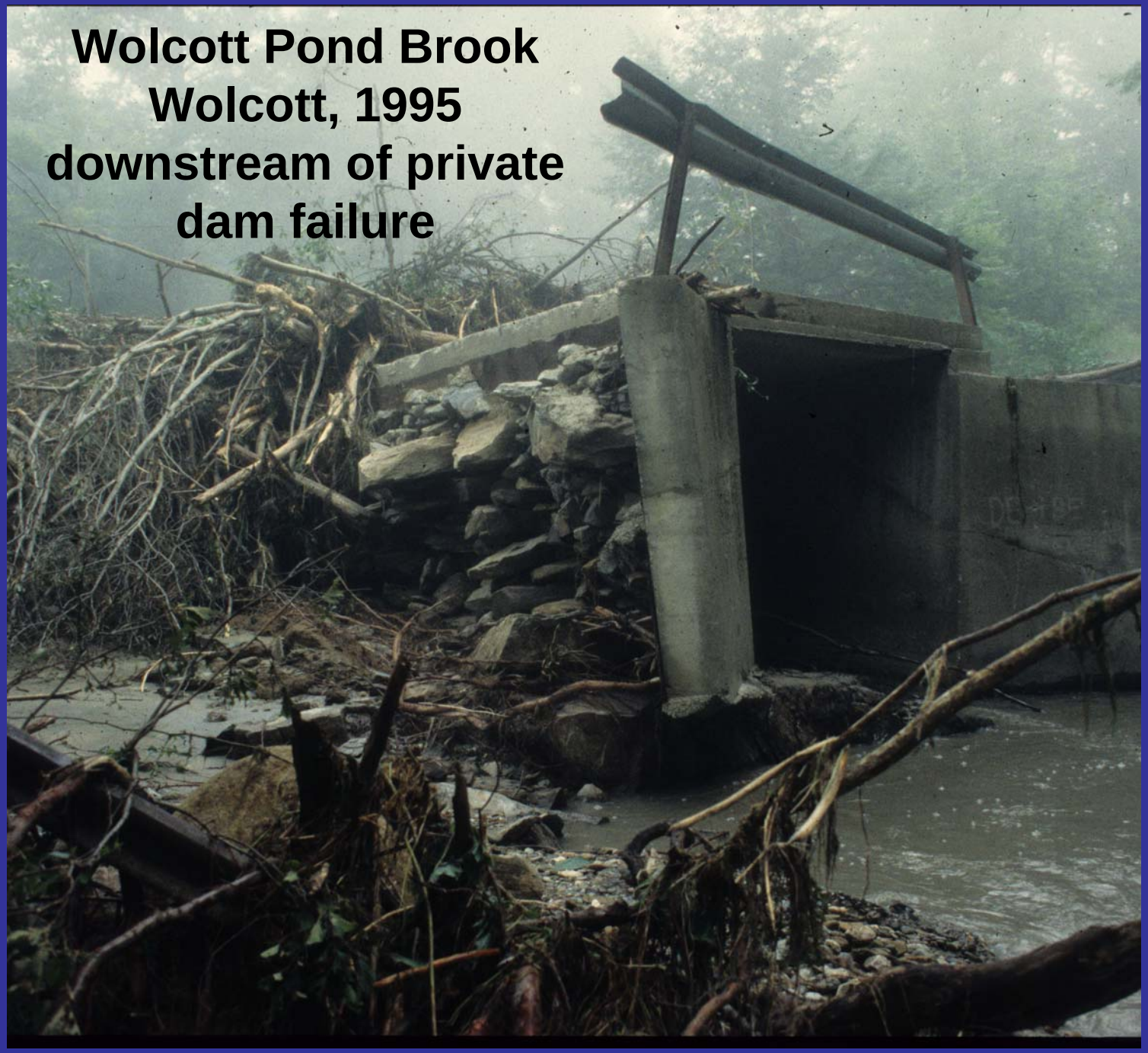
West Hill Brook, Montgomery, 1997



Trout River, Montgomery, 1997

Roaring Brook, Underhill, 1998


Wolcott Pond Brook
Wolcott, 1995
Private Dam Failure

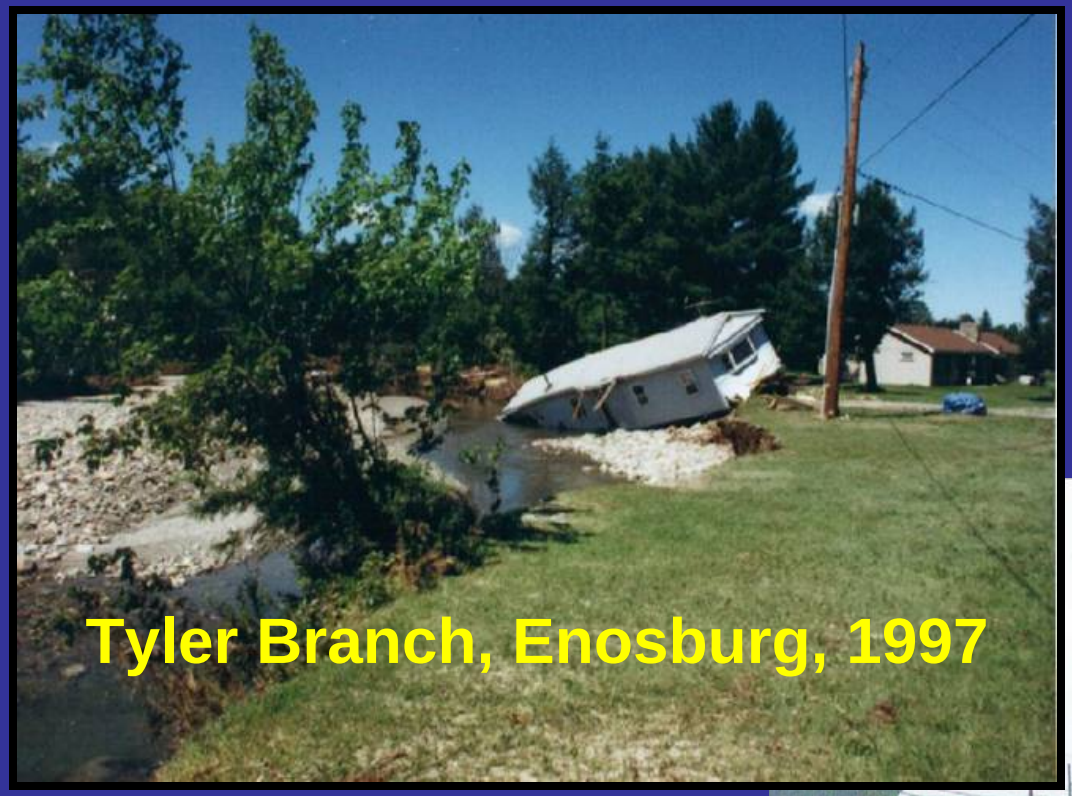

Wolcott Pond Brook
Wolcott, 1995
downstream of private
dam failure

Rowell Brook, Bradford, 1998

Little or no meaningful policies, programs, or incentives exist to support, encourage, or reward municipalities that are proactive, beyond NFIP minimum standards, in mitigating existing and avoiding increasing flood or fluvial erosion exposure.

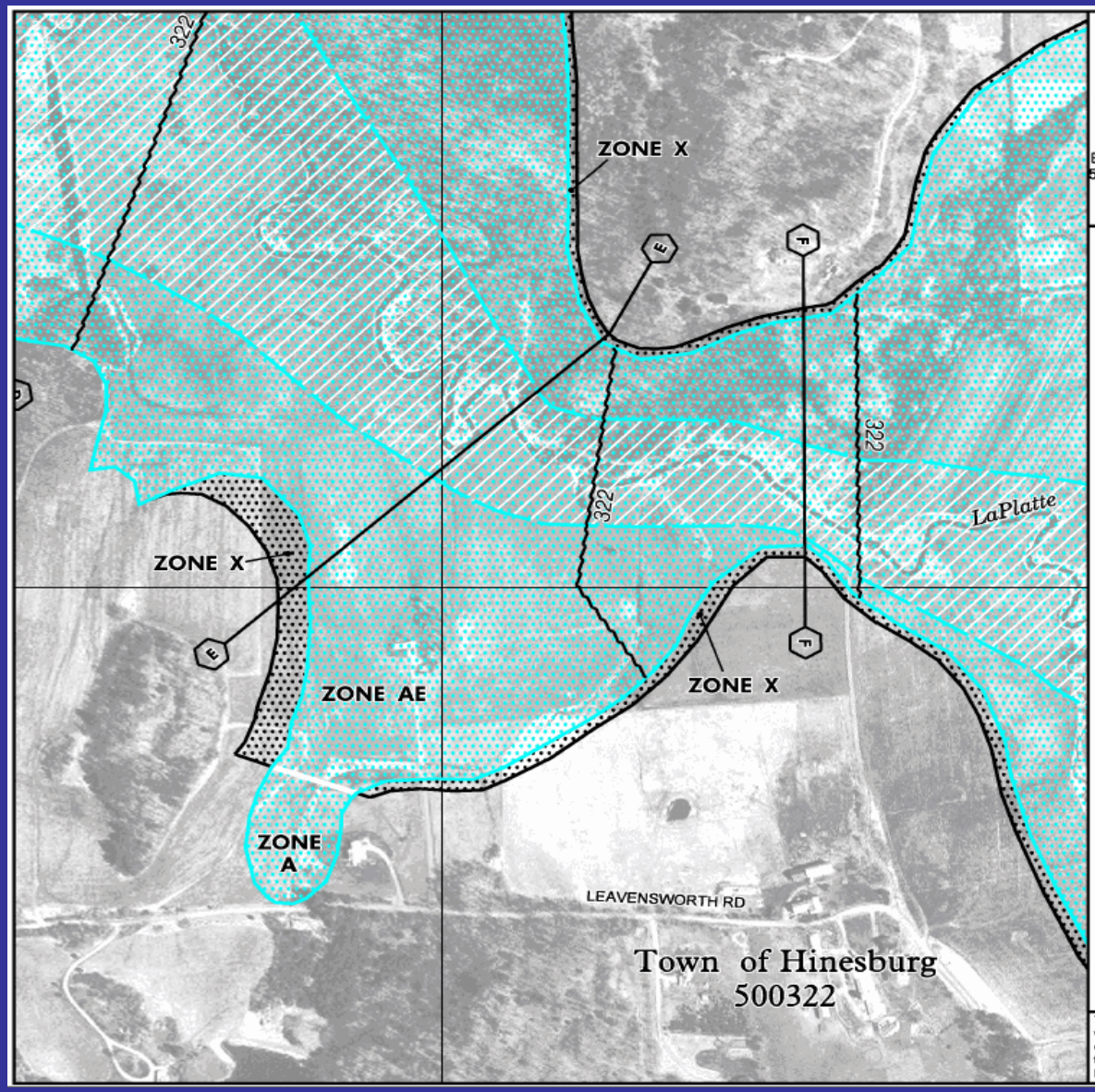
West Hill Brook
Montgomery
March, 2007

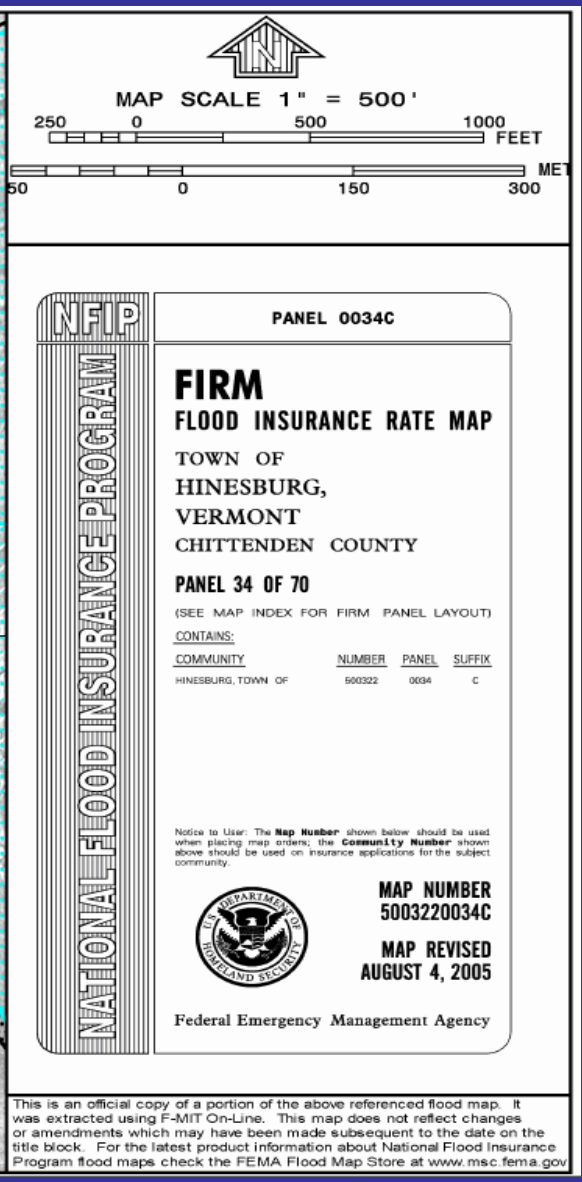
Erosion And Inundation



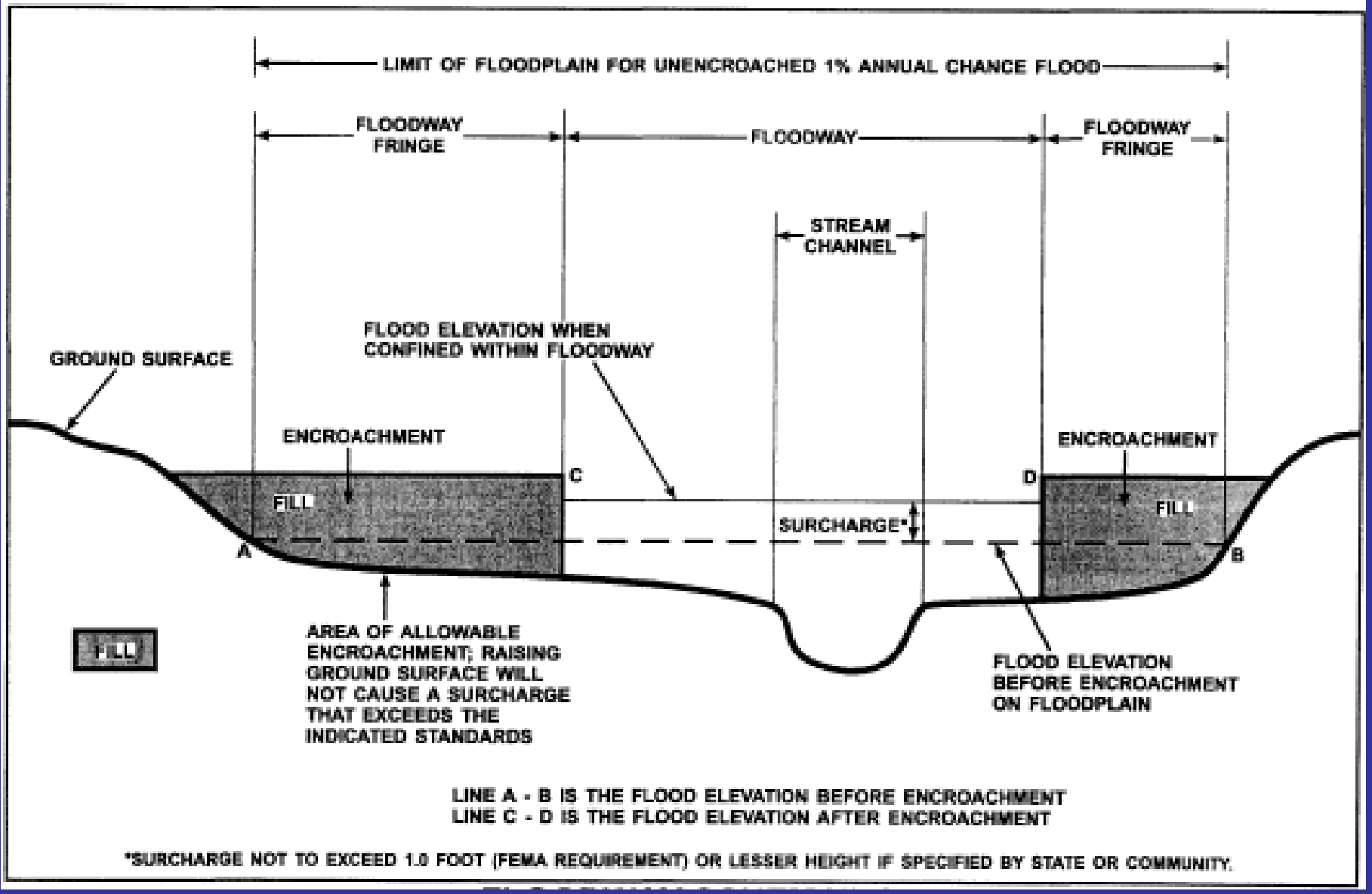
Neither Erosion Nor Inundation Can Be Effectively Mitigated Without Considering the Dynamic Nature of Fluvial Systems

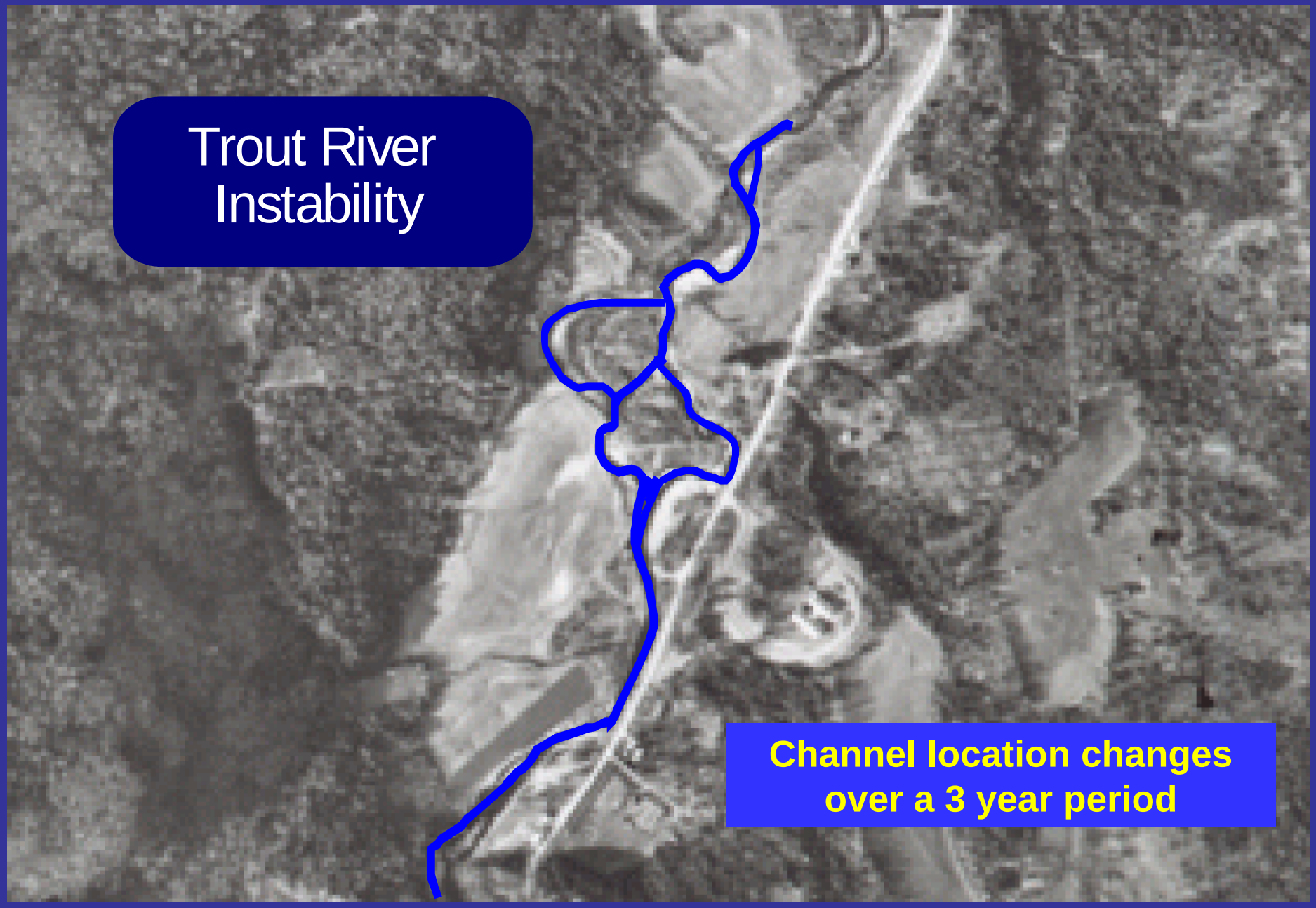
Yet that's exactly what NFIP regulations assume & rely upon (static fluvial systems)



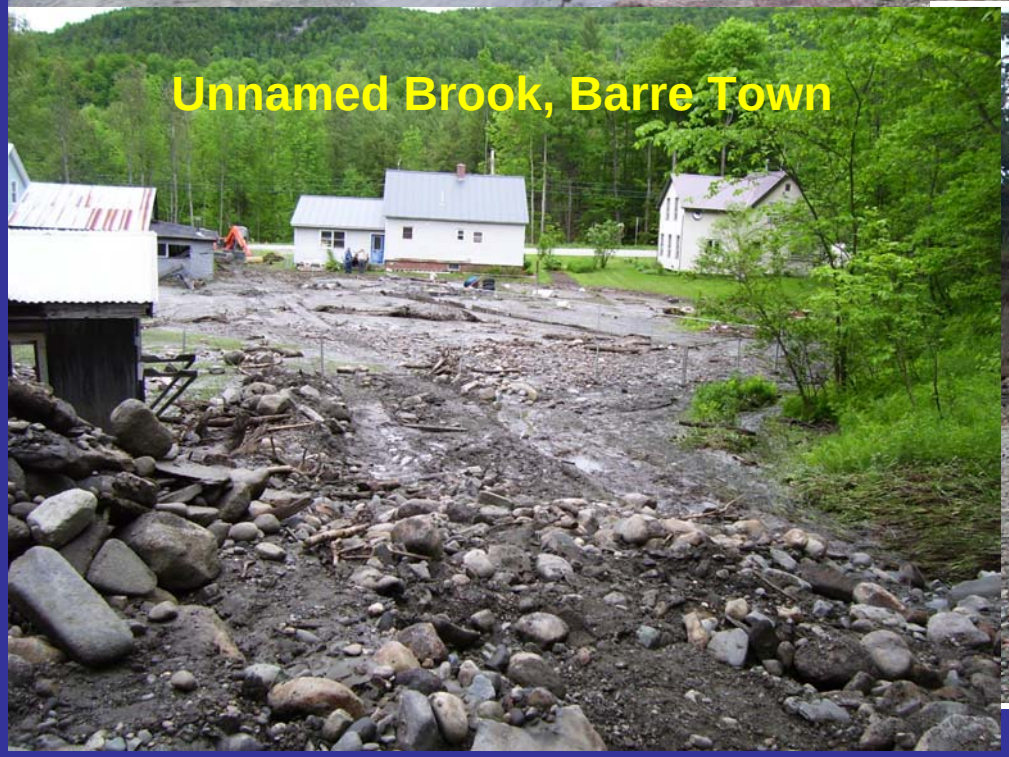


Floodway Schematic

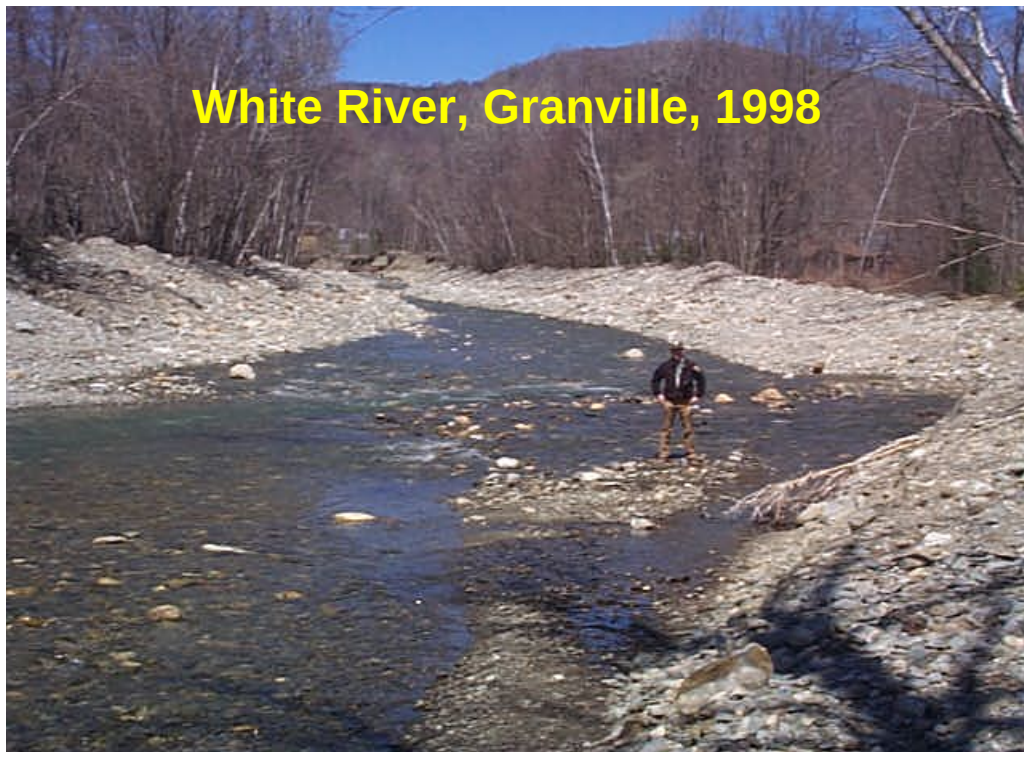



Trout River
Instability
Channel location changes
over a 3 year period

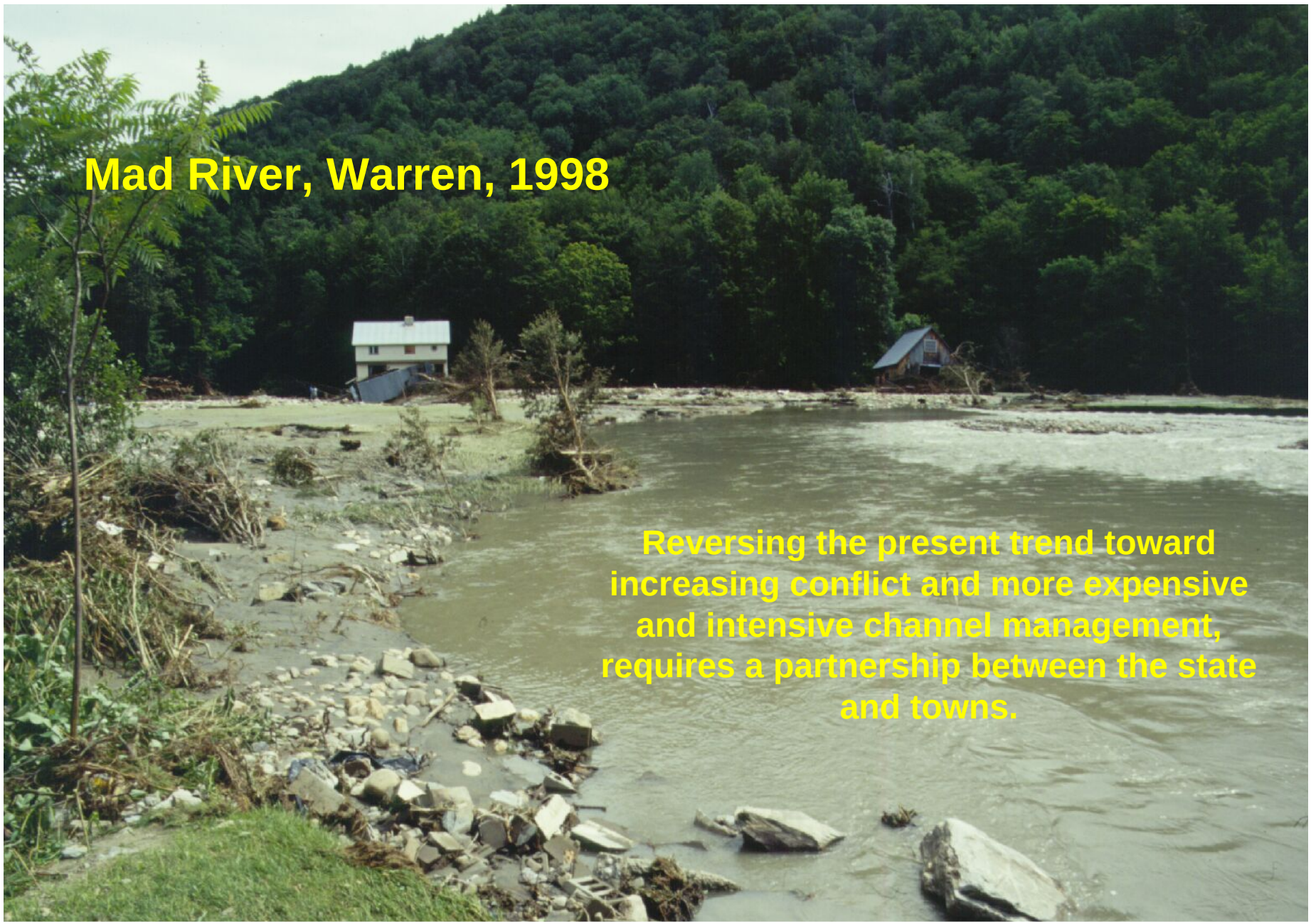
The Consequences of Treating Streams as Static Elements of the Landscape



Flooding, stream channel erosion, and water quality and aquatic resource degradation are primarily a result of the watershed pattern of land use and infrastructure investment.

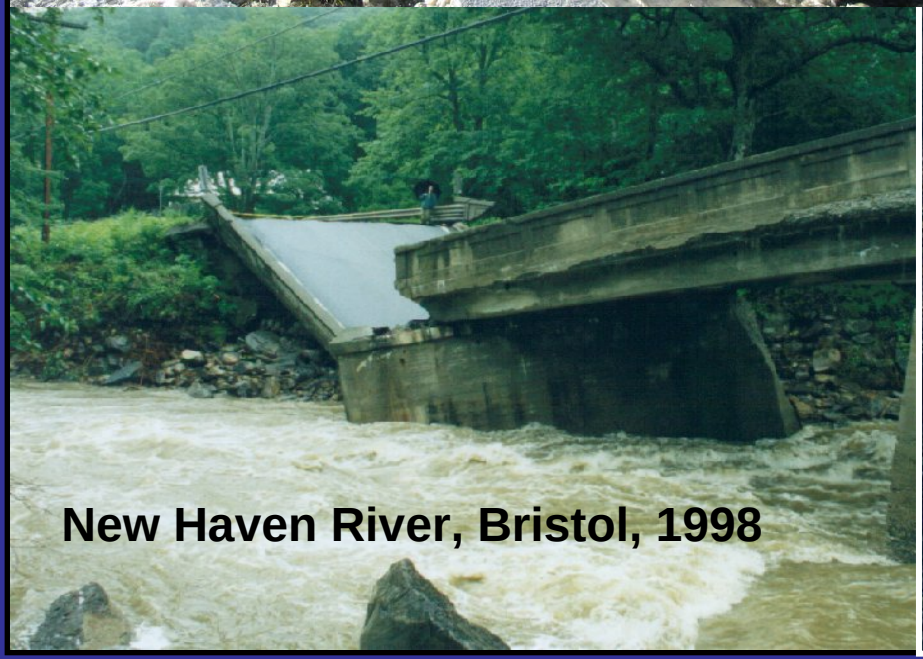


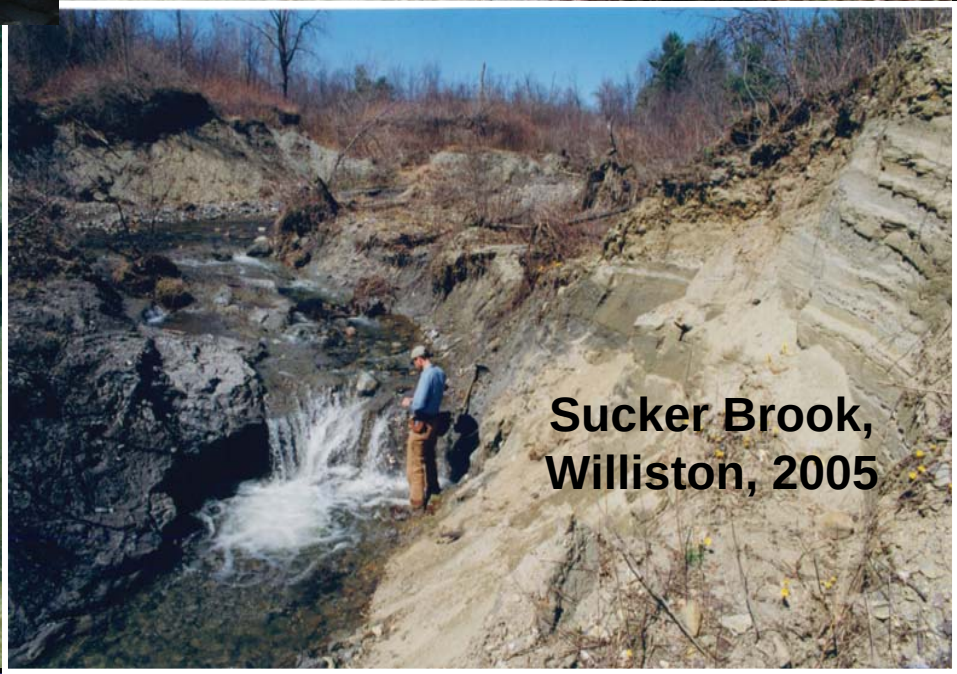
And are perpetuated by the historic channel and flood plain management activities intended to reconcile widespread conflicts with the dynamic nature of fluvial systems.


Mad River, Warren, 1998
Reversing the present trend toward increasing conflict and more expensive and intensive channel management, requires a partnership between the state and towns.

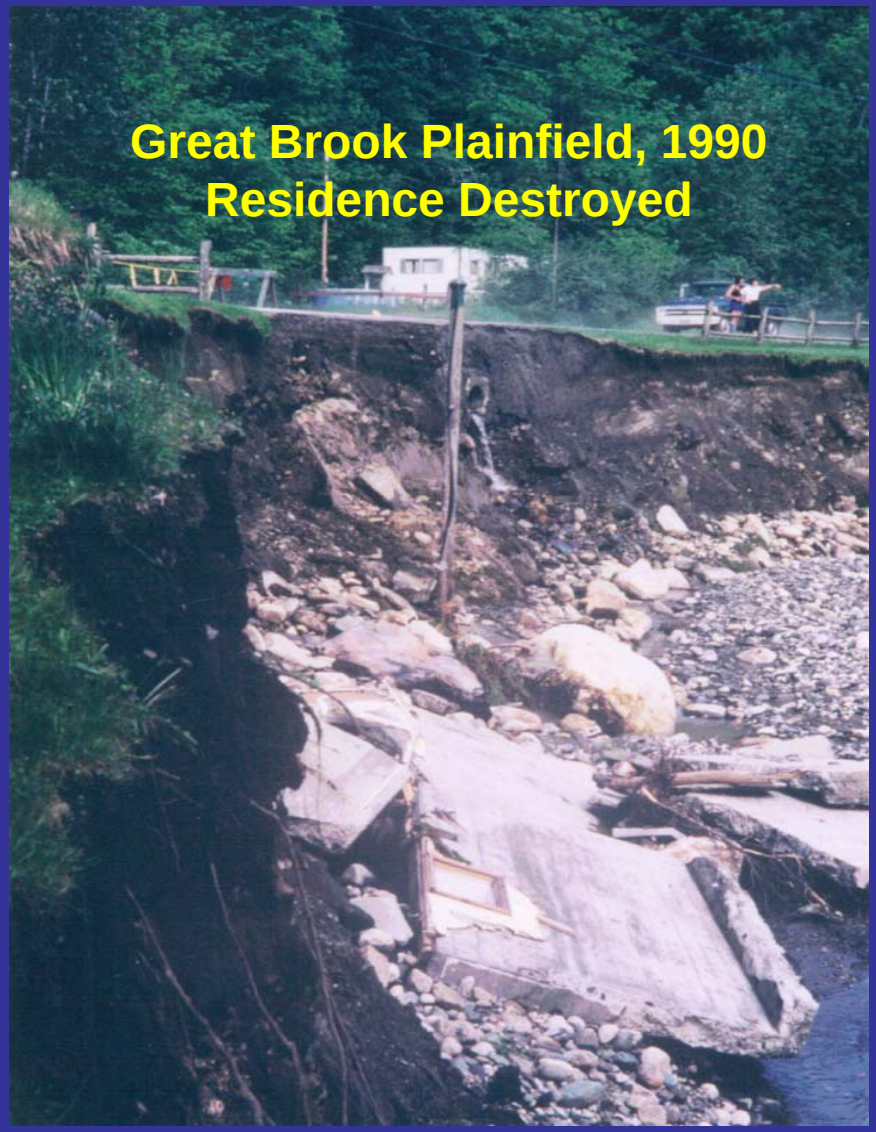
Honey Brook,
Barre, 2007

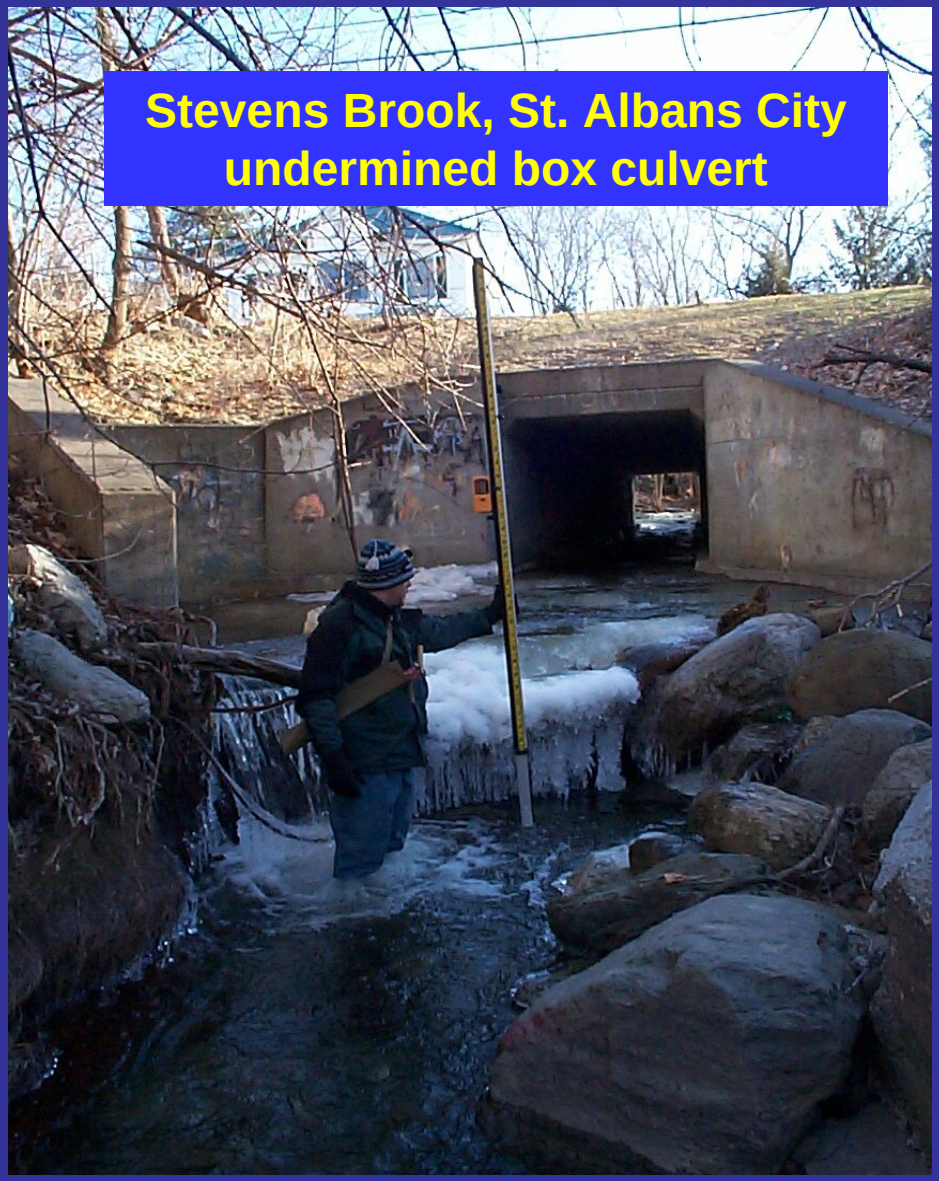
Cold River,
Shrewsbury, 2000


New Haven River, Bristol, 1998


Sucker Brook,
Williston, 2005

State, Regional & Local All-Hazards Mitigation Plans set high flood and fluvial erosion hazard mitigation priority on riparian corridor protection exceeding NFIP minimum standards as the most critical and cost effective option.





Land Use Investments Within River Corridors and Channelized Streams Result in these Kinds of Problems

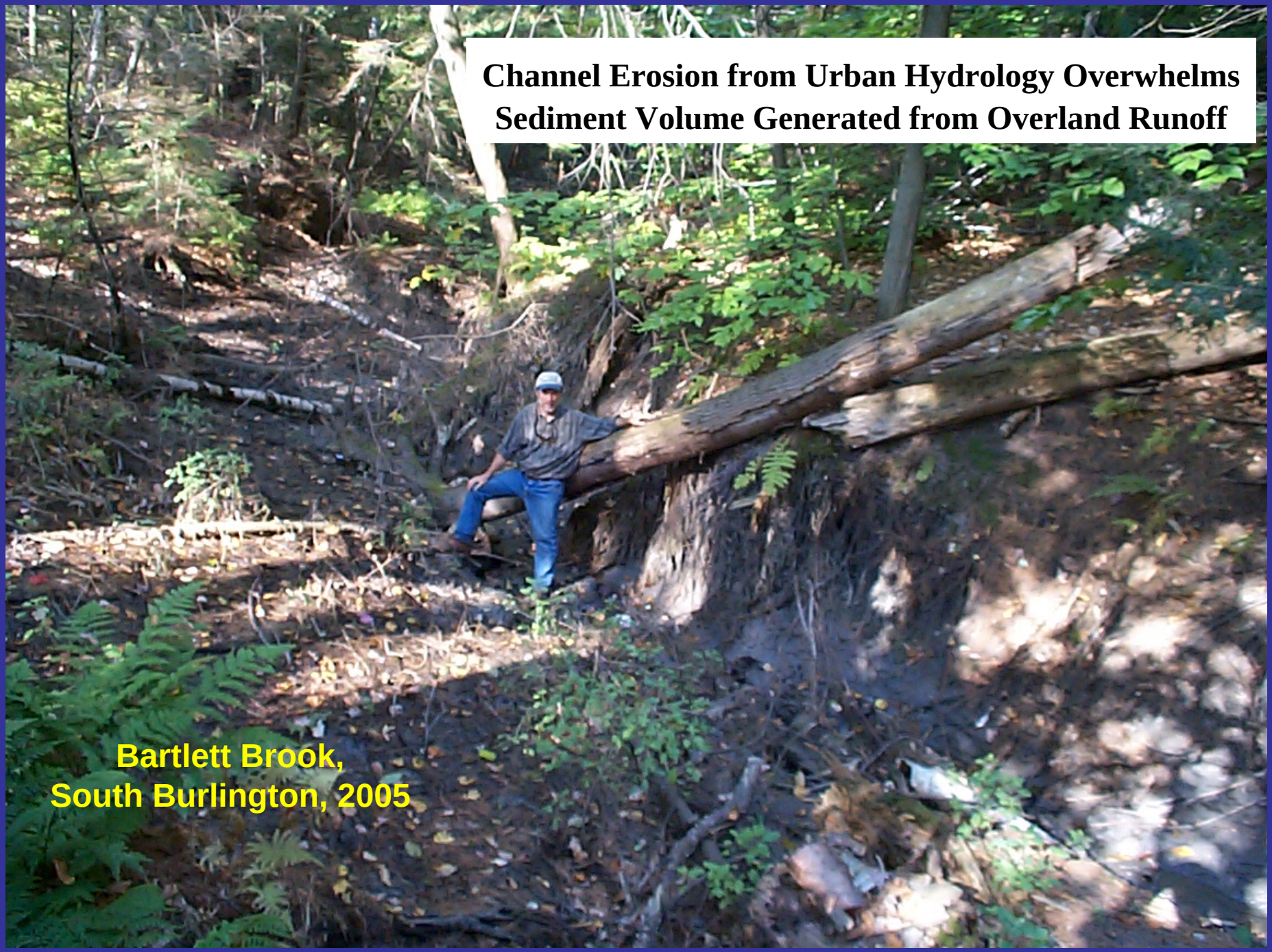
And Demand These Kinds of Solutions

Brewster River Jeffersonville, 1999

Brewster River, Jeffersonville, 1999

Brewster River,
Jeffersonville, 1999

Brewster River, Jeffersonville, 1999


Channel Erosion from Urban Hydrology Overwhelms
Sediment Volume Generated from Overland Runoff
Bartlett Brook,
South Burlington, 2005

Agricultural Ditching & Drainage

Inappropriate Riparian Corridor Land Use Result: 75,000 Cubic Yard Channel Avulsion

Consequences of Failing To Protect River Corridors from Continued Encroachments:

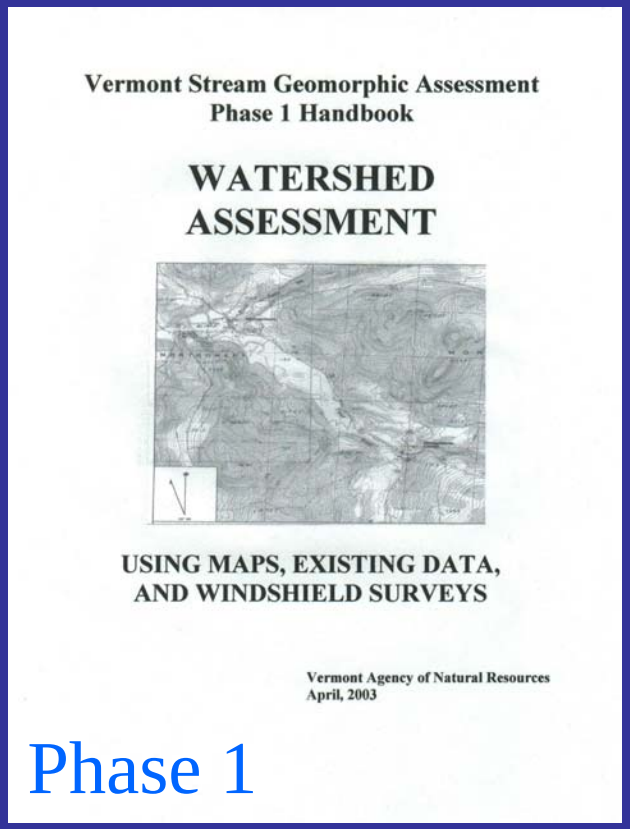
- Local governments and individuals increasingly vulnerable to disastrous flood and erosion loss
- Permanent, unrecoverable destruction of fluvial ecosystem services
- Upward spiral of state and municipal expenditures for flood and fluvial erosion hazard recovery and mitigation
- Ever increasing discharges of sediment and nutrients into downstream receiving waters
- Degradation of flood plain agricultural soils
- Devastation of aquatic and riparian habitats, ecological diversity, water quality and human recreational use
- The only remaining option to be implementation, and maintenance forever, of the European Model of river control (channelize, dredge, and armor), at enormous, unsustainable public cost.

Fluvial Geomorphology is a unifying principal supporting watershed scale resource management and Flood Hazard Mitigation.

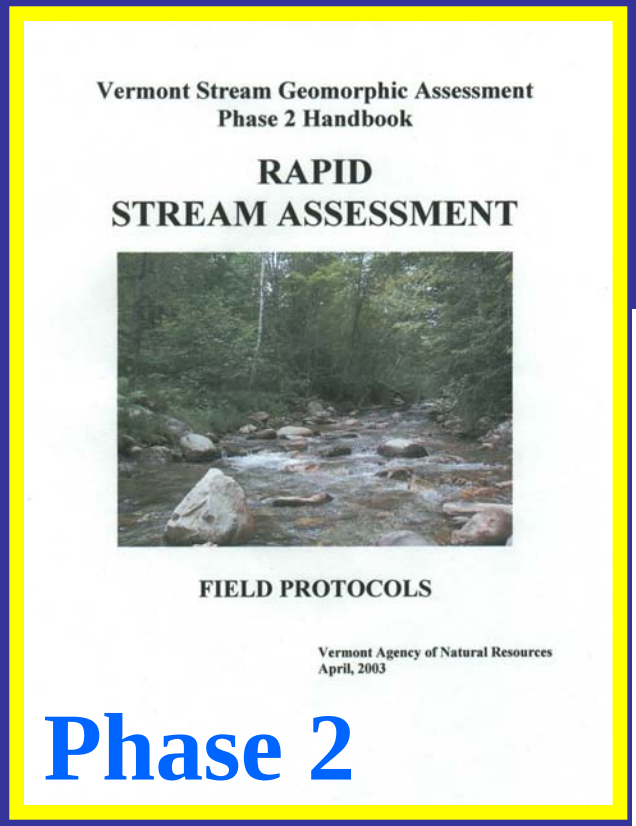
The physical condition of the fluvial system is a direct reflection of watershed health and a primary influence on public health, safety and welfare.

Stream Geomorphic Assessment Protocols

In a national survey by EPA and USACE, Vermont's SGAP were the highest rated published protocols. Stream Geomorphic Assessment is the foundation for all watershed and reach scale fluvial management, protection and restoration decision making.

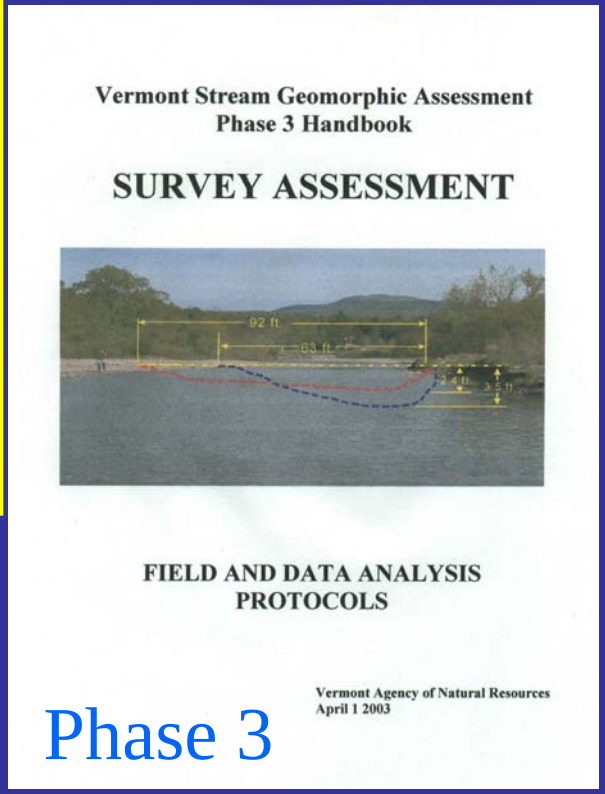


Remote Sensing



Qualitative & Rapid Field Assessment

Over 4000 stream miles have been assessed, dozens of professionals trained and communities actively engaged in developing a new river paradigm.

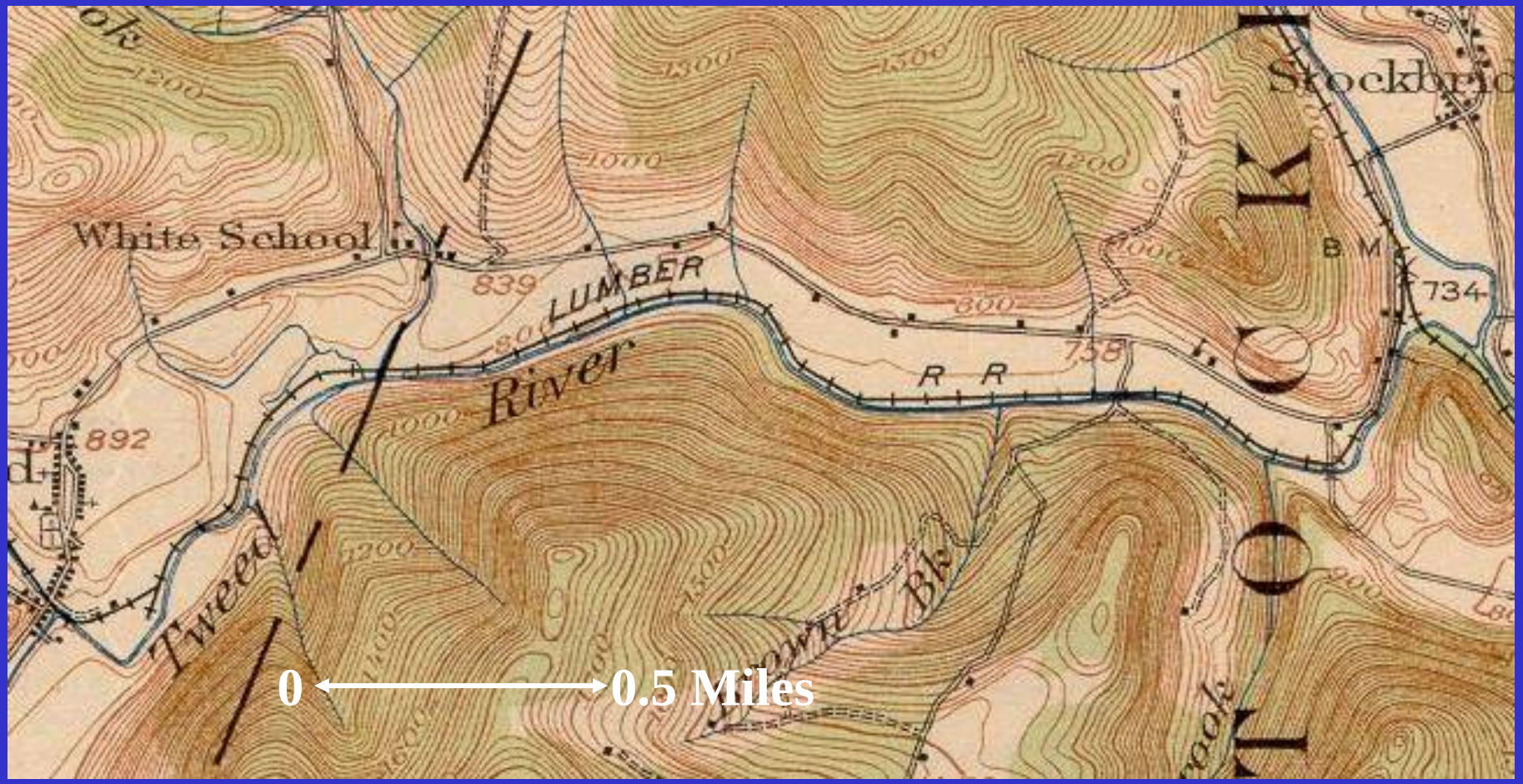


Quantitative Field Surveys

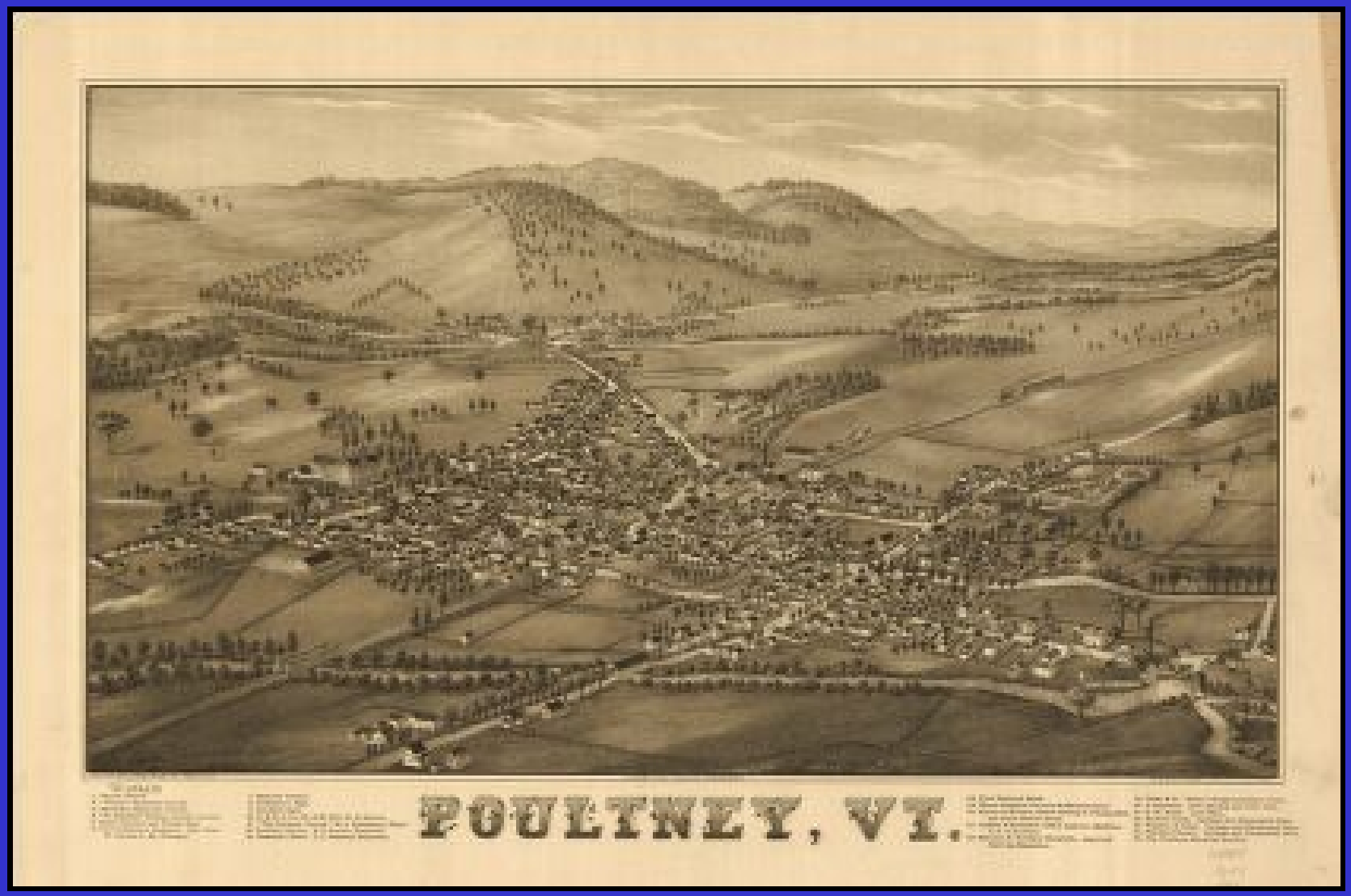
We have published guidance on how to apply geomorphic assessment data to develop river corridor plans, perform river management, restoration and protection alternatives analyses, produce fluvial erosion hazard zone maps, guide local land use decisions, and educate the public about their relationship with rivers. A web based accessible data management system is being developed.

The Primary Causes of Current Instability are Rooted in our History

This 1917 USGS map shows 3.5 miles of the Tweed River in Stockbridge channelized and shoved over against the valley wall for the construction of a railroad line and to improve the land for agricultural purposes. The river is now actively eroding, seeking to re-establish its equilibrium condition and threatening agricultural, residential and public infrastructure investments that encroached into the river corridor in the wake of the channelization. This is an extremely common, widespread condition throughout Vermont watersheds.



Watershed Inputs Changed - Rivers Straightened

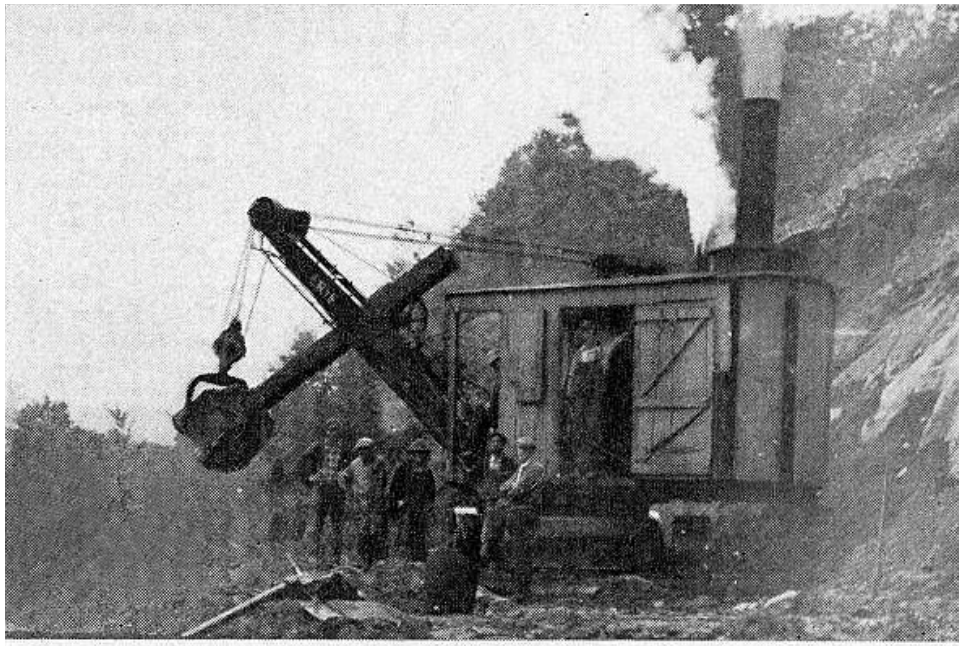


Poultney River in the 1830s already straightened. Landscape denuded leading to dramatically altered watershed hydrology and fluvial sediment regime.

Truncated (cut-off) meanders, to accommodate railroad construction, Winooski River, Middlesex, 1927

Increasing mechanization ramped up our ability to channelize and attempt to constrain rivers. Channelization activities increased dramatically after the 1927 and 1938 floods then reached a crescendo post WWII with most Natural Resource Conservation Districts obtaining surplus bulldozers, draglines and cable shovels putting them to work full time straightening and dredging throughout Vermont's landscape.

Third Branch White River Randolph, 1927



THE ANSWER

Straight Channels

Post Flood Channelization Castleton River, Castleton, 1927

Up to 70% of Stream Miles Statewide have been Modified to Accommodate Roads, Railroads, Agriculture and Other Land Uses

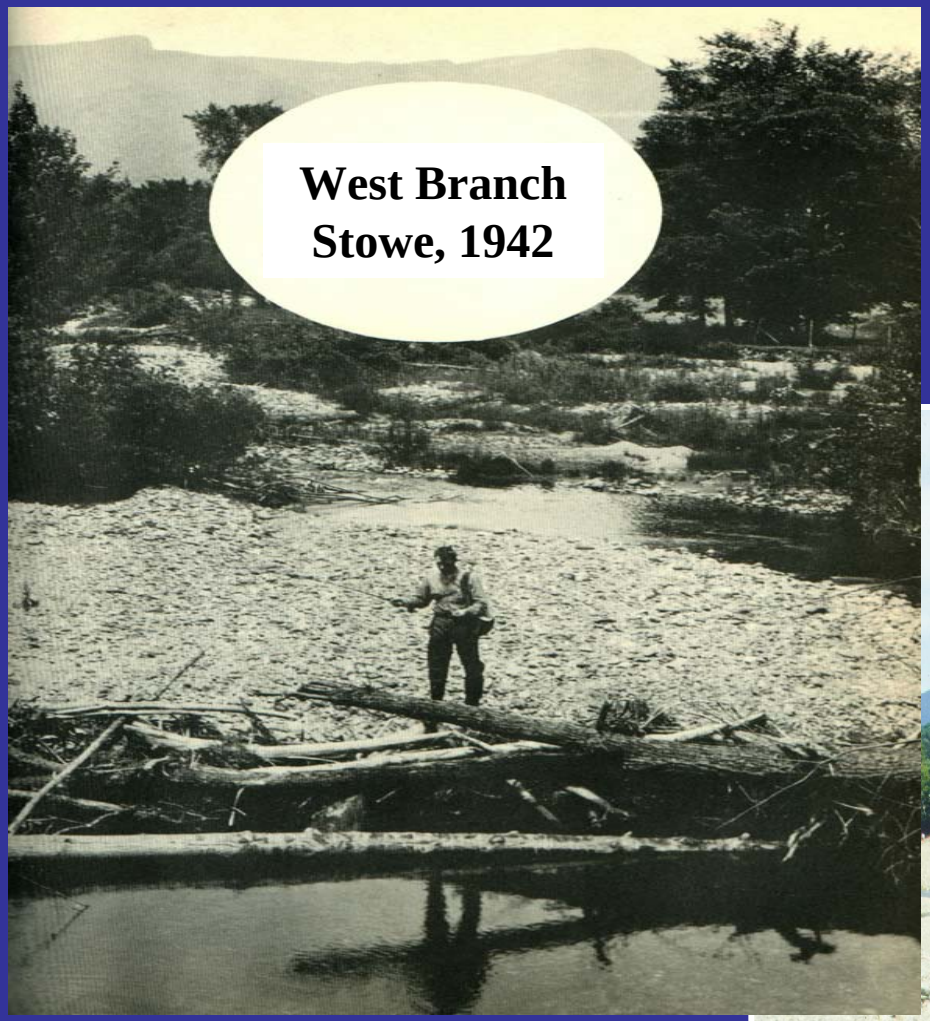
The Physical Imperatives of Fluvial Systems are Predictable and are Temporally Connected at Time Scales Spanning Generations

Explaining Channel Evolution and Fluvial Geomorphic Equilibrium

Stage		
1	Pre-1800	Equilibrium condition
2	Pre-1900	Geomorphic response begins
3	1927	Widening to balance energy with boundary conditions
4	1973	Developing new flood plain
5	20??	Equilibrium condition

Modification of watershed inputs, channels & floodplains

After Shumm, et.al.



1942 photo illustrates the equilibrium condition (Stage 1) Note the 3-4 ft. high bank in the background. Good access to flood plain, active sediment storage. Then decades of development, gravel mining and flood plain encroachment ensued.

1992 photo illustrates the incised and redeveloping flood plain (Stage 4). Former flood plain is top of right bank (10 ft. incision).

Stage 1 Equilibrium

Rock River, Highgate

Stage 1 Equilibrium

Black Creek, Fairfield

Bankfull Flow

Rock River
Franklin
Stage 2 Incised &
Straightened

Stage 2 Incised & Straightened

Rugg Brook, St. Albans Town

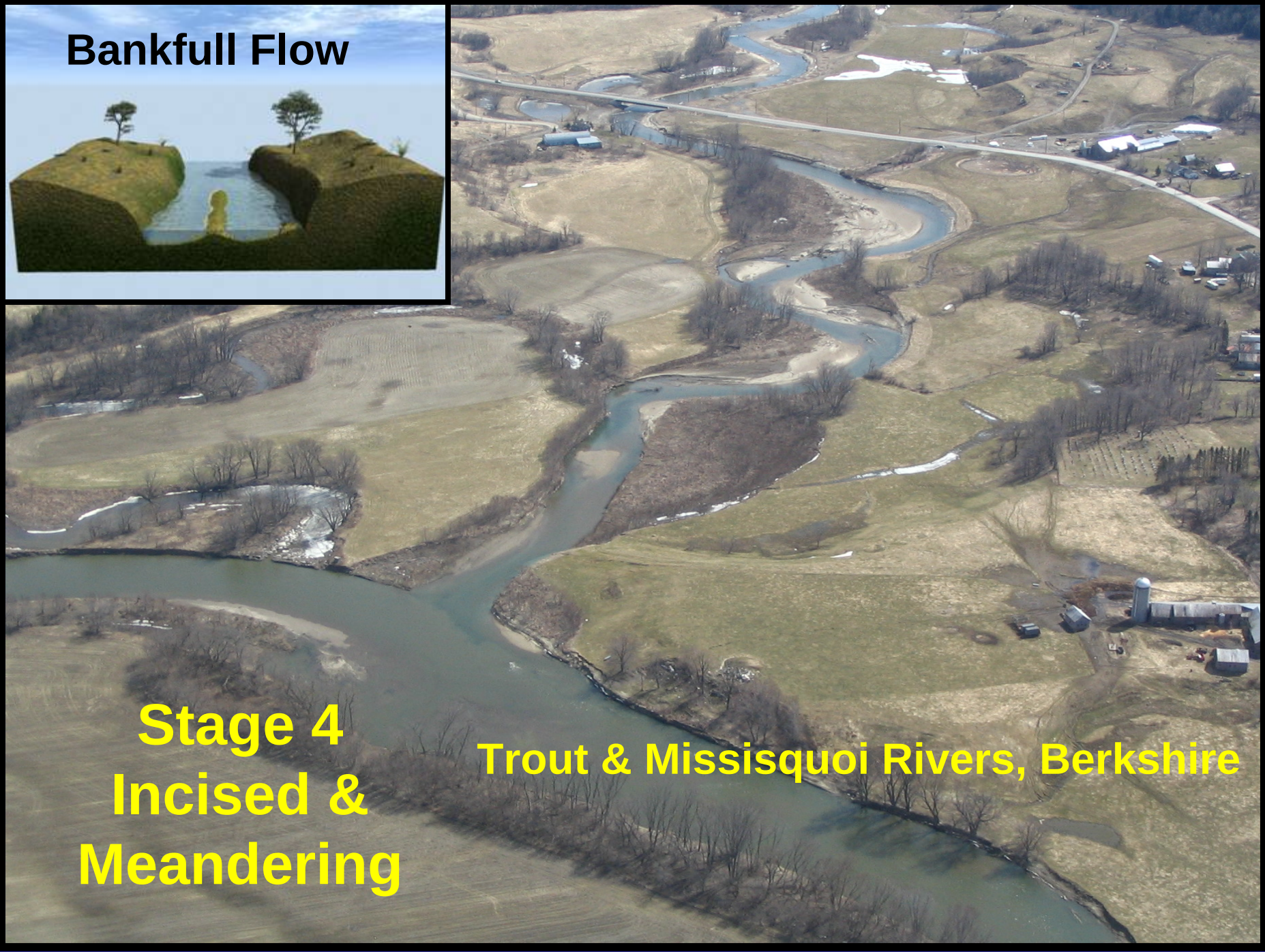
Stage 3 Incised and Widening

Trout River, Montgomery

Stage 3 Incised and Widening

Trout River, Montgomery

Bankfull Flow

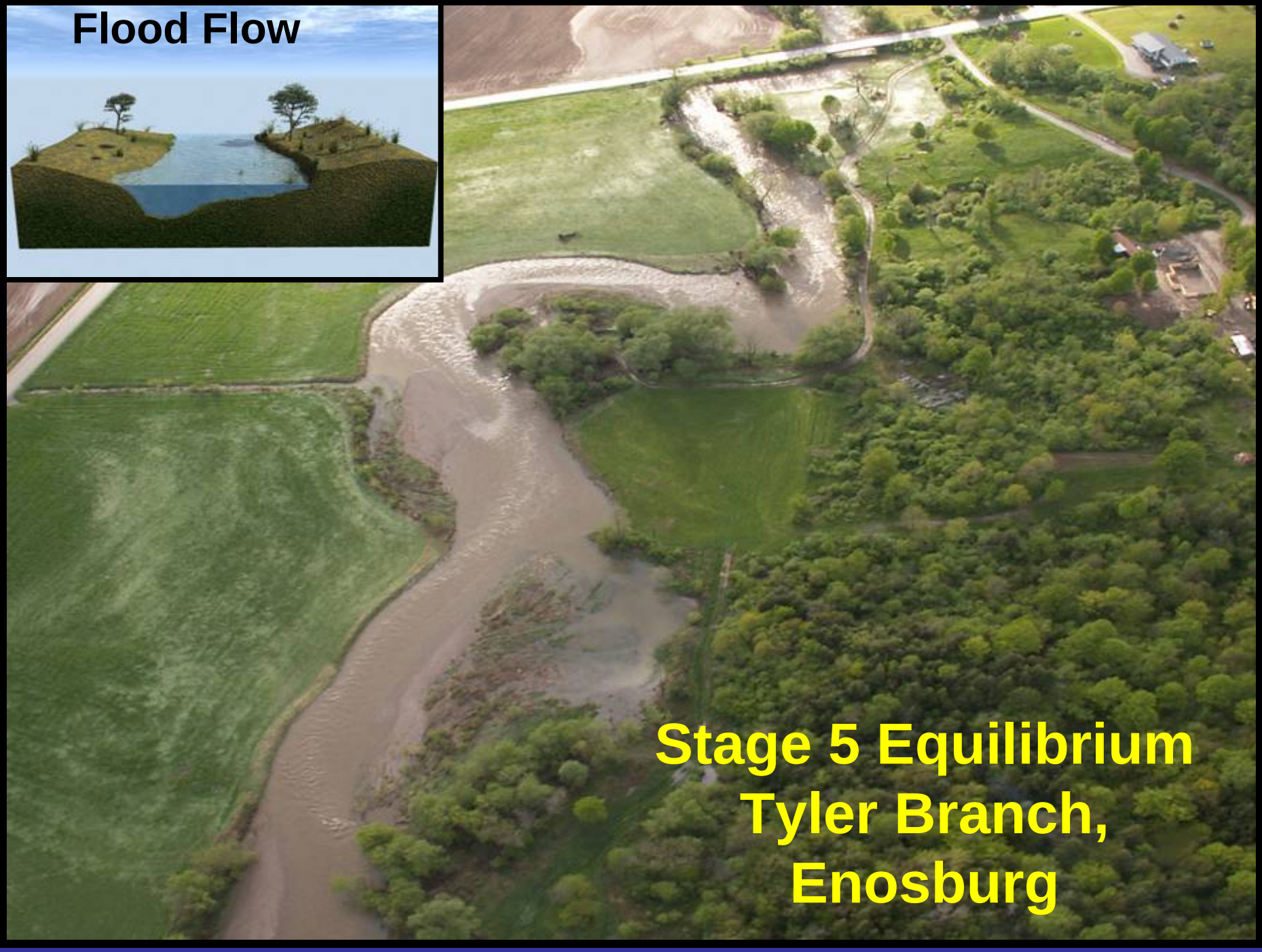

Stage 4
Incised &
Meandering
Trout & Missisquoi Rivers, Berkshire

Stage 4 Incised & Meandering, Building New Flood Plain at Lower Elevation

Bankfull Flow

Rock River, Highgate
Stage 5
Equilibrium

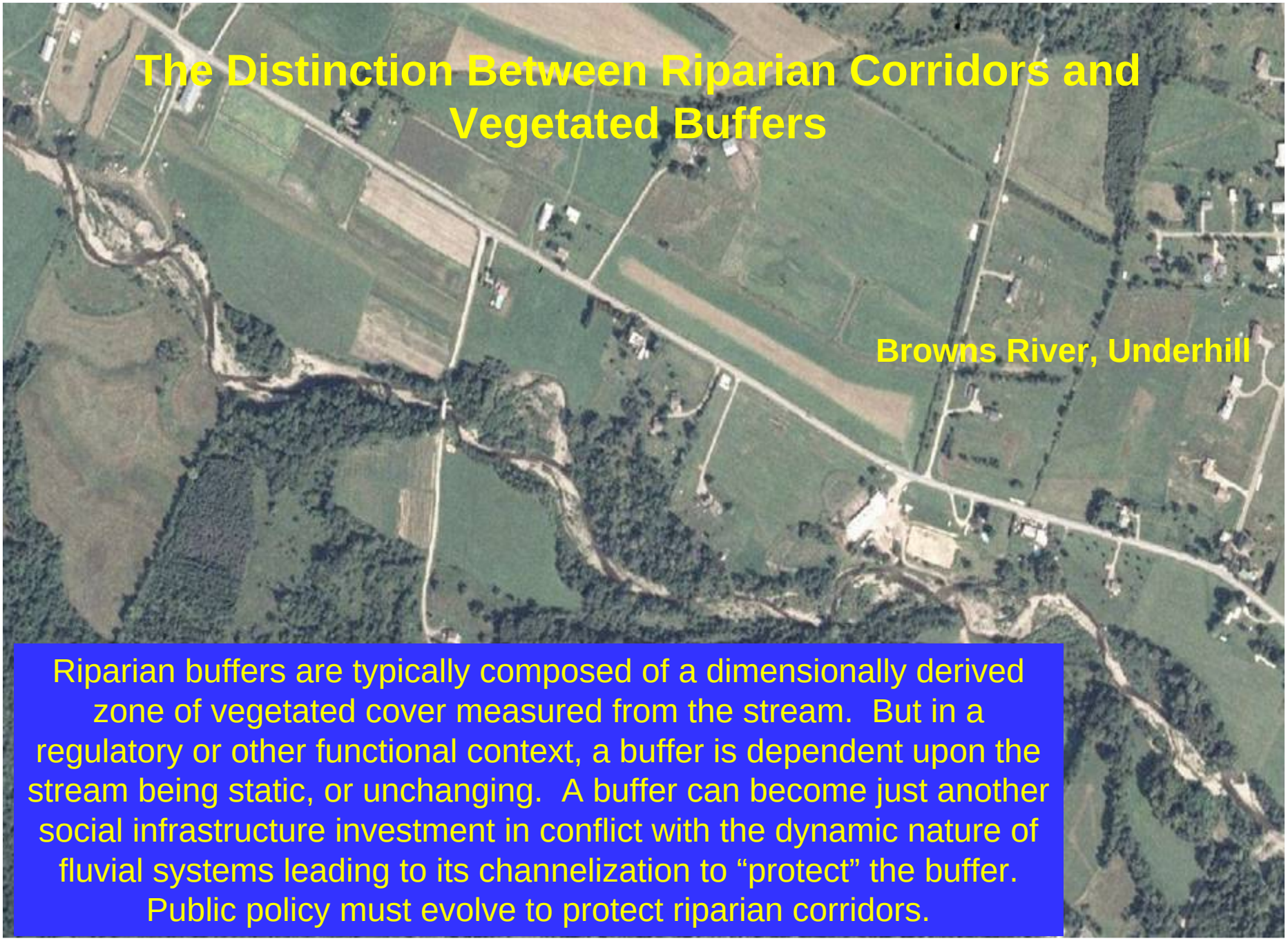
Flood Flow


Stage 5 Equilibrium
Tyler Branch,
Enosburg

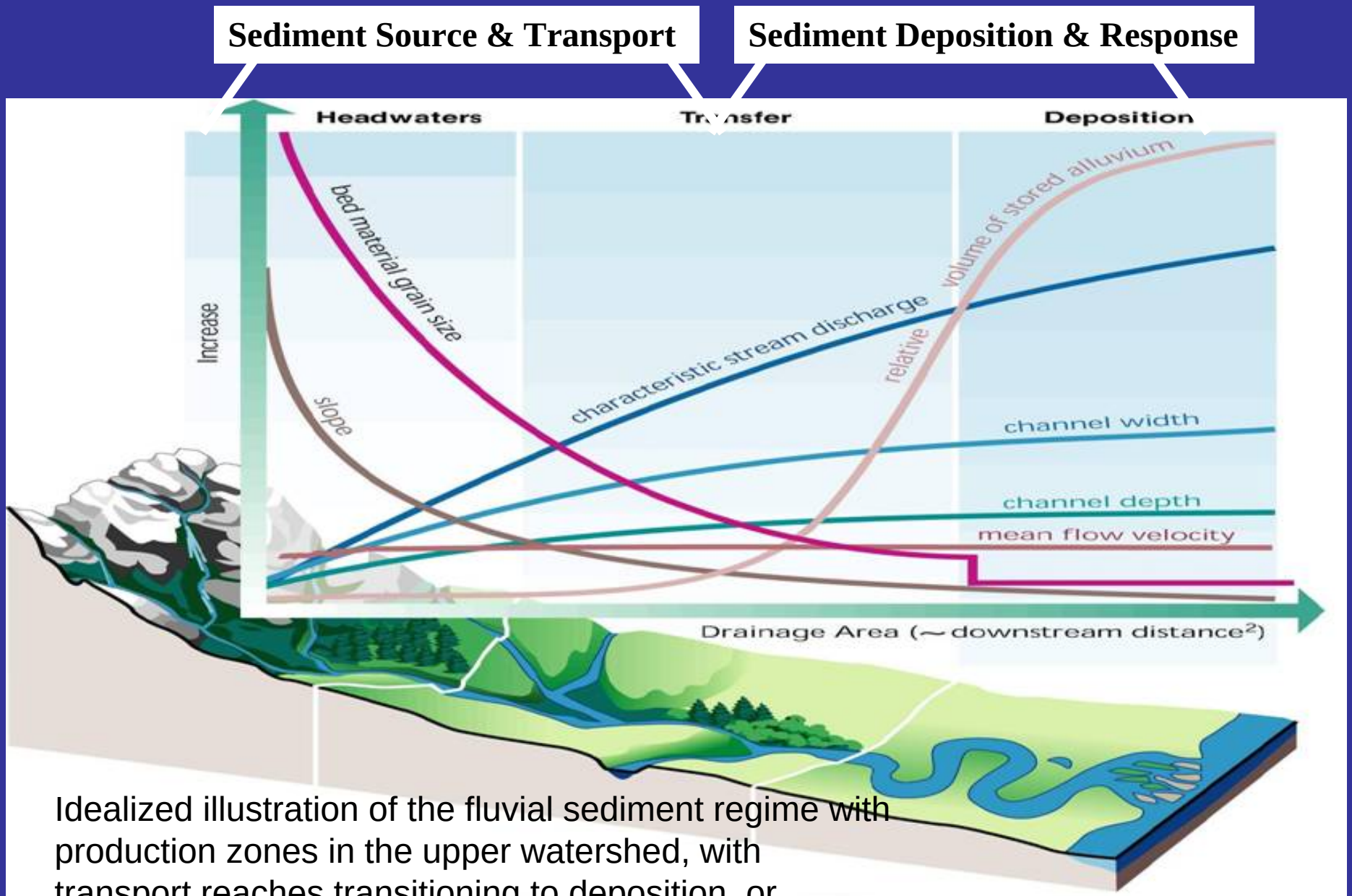
Stage 4
10.18.2006

Stage 5
Restored Flood Plain
Trout River, Montgomery
10.18.2006

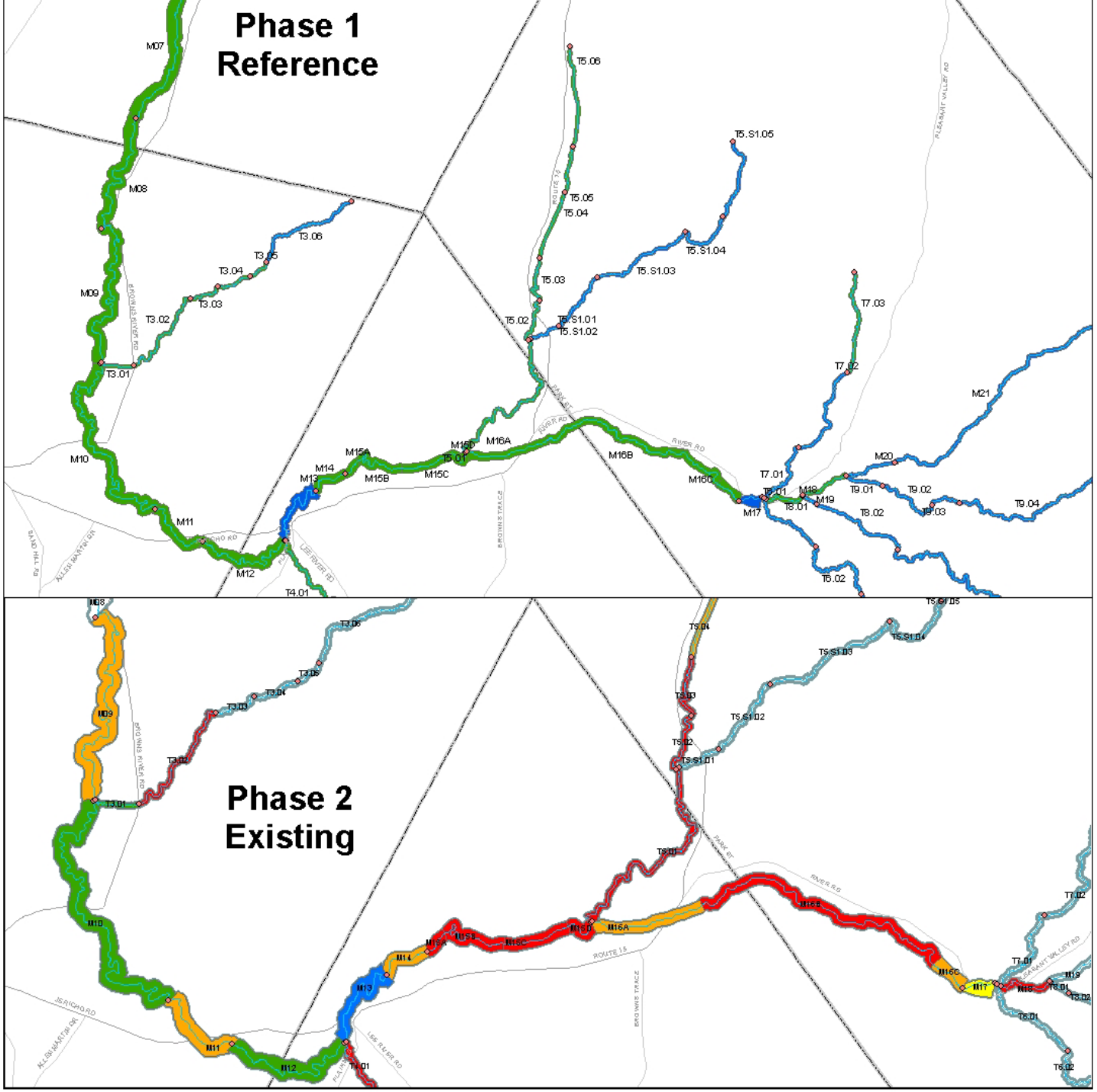
The Distinction Between Riparian Corridors and Vegetated Buffers



Riparian buffers are typically composed of a dimensionally derived zone of vegetated cover measured from the stream. But in a regulatory or other functional context, a buffer is dependent upon the stream being static, or unchanging. A buffer can become just another social infrastructure investment in conflict with the dynamic nature of fluvial systems leading to its channelization to “protect” the buffer. Public policy must evolve to protect riparian corridors.



Idealized illustration of the fluvial sediment regime with production zones in the upper watershed, with transport reaches transitioning to deposition, or sediment and hydrologic attenuation reaches.



This is a portion of the Browns River watershed in Underhill, Jericho, and Westford.

The Phase 1 Reference represents the pre-development condition. The green reaches represent the areas where sediment, hydrologic and nutrient attenuation assets functioned actively and sustainably, in which riparian and aquatic habitats could achieve and sustain their maximum potential, and by which flood and fluvial erosion hazards were minimized.

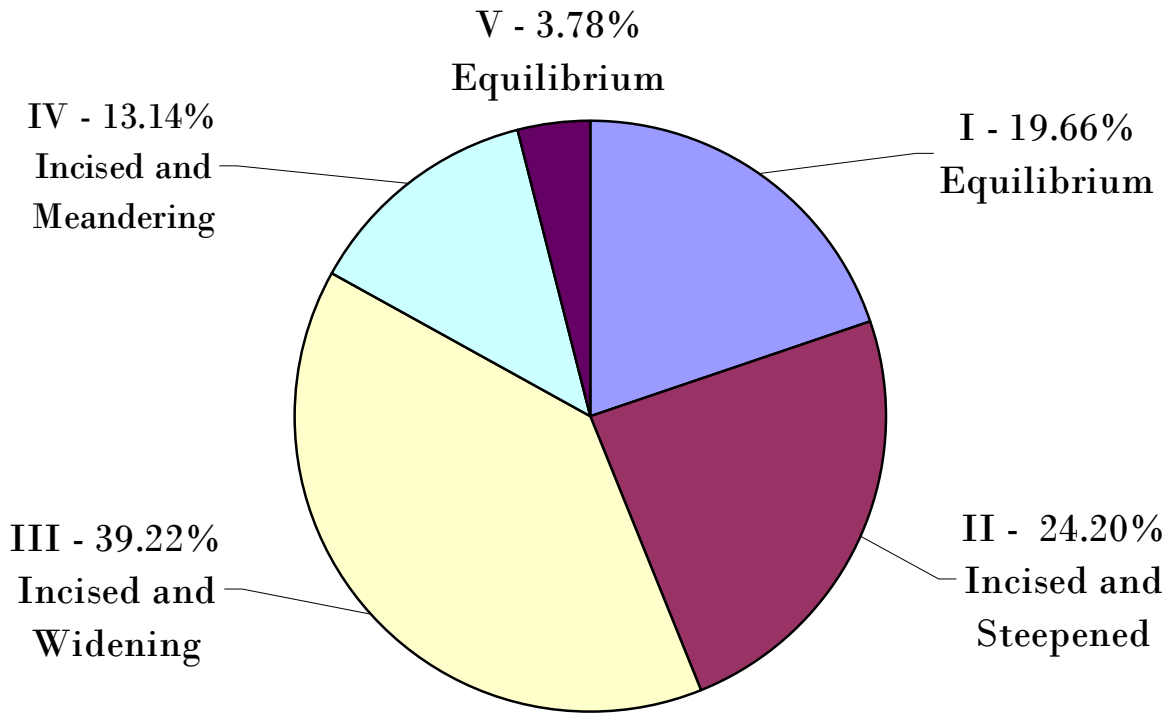
The Phase 2 represents the existing condition. The green reaches are the only remaining attenuation assets. All other reaches are hazardous, have degraded habitat, and are producing or transporting sediment and nutrients.

Virtually all watersheds in Vermont show this same dramatic loss of ecosystem services due to corridor encroachments and channel management activities.

Evolution Stage	*Number of Segments*	*Percent Segments*	*Number of Miles*	*Percent Length*
I	208.0	19.66%	167.5	22.13%
II	256.0	24.20%	147.5	19.49%
III	415.0	39.22%	316.8	41.84%
IV	139.0	13.14%	102.4	13.53%
V	40.0	3.78%	22.8	3.01%
Total	1,058.0	100.00%	757.1	100.00%

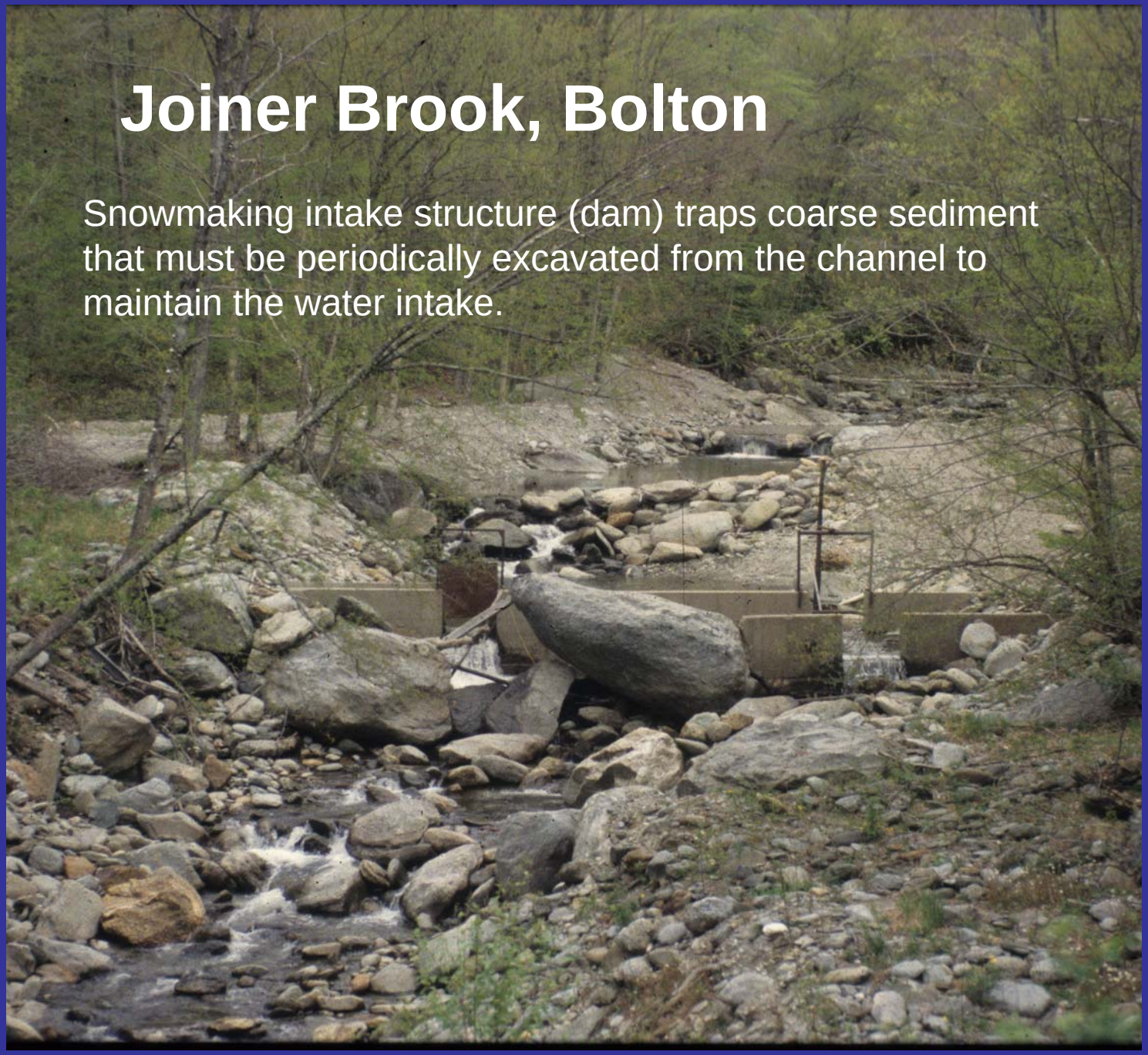
These statistics are representative of the statewide loss of 70% of the ecological potential of our fluvial systems. It is not too late to gain much of this back but we must act forcefully and decisively now.

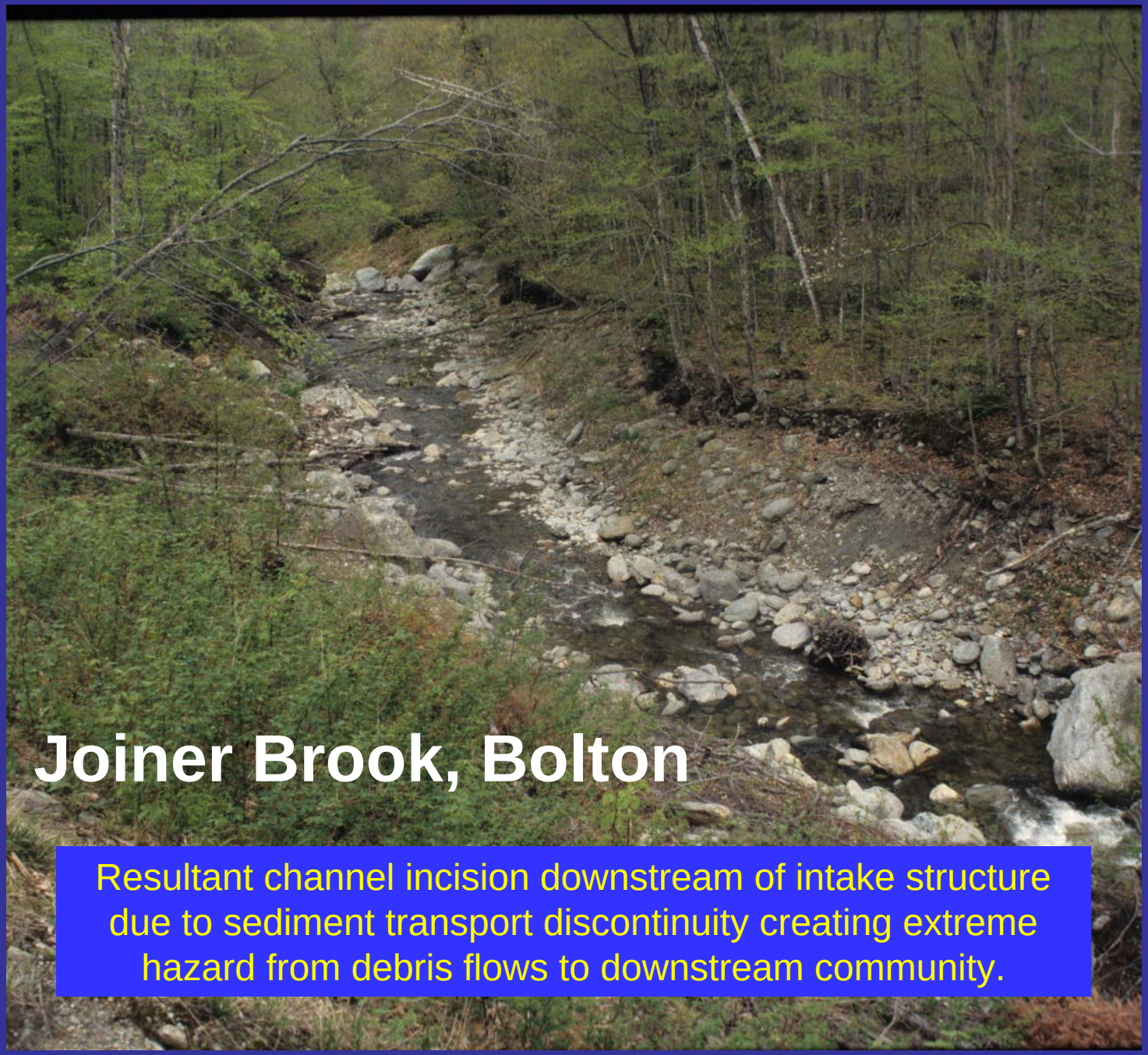
Percentage of Assessed Stream Segments in Various Stages of Evolution



Joiner Brook, Bolton

Snowmaking intake structure (dam) traps coarse sediment that must be periodically excavated from the channel to maintain the water intake.




Joiner Brook, Bolton
Resultant channel incision downstream of intake structure due to sediment transport discontinuity creating extreme hazard from debris flows to downstream community.

Consequences of Failing To Protect River Corridors from Continued Encroachments:

- Local governments and individuals increasingly vulnerable to disastrous flood and erosion loss
- Permanent, unrecoverable destruction of fluvial ecosystem services
- Upward spiral of state and municipal expenditures for flood and fluvial erosion hazard recovery and mitigation
- Ever increasing discharges of sediment and nutrients into downstream receiving waters
- Degradation of flood plain agricultural soils
- Devastation of aquatic and riparian habitats, ecological diversity, water quality and human recreational use
- The only remaining option to be implementation, and maintenance forever, of the European Model of river control (channelize, dredge, and armor), at enormous, unsustainable public cost.

How Do We Slow the Cycle??

Bank Erosion and loss of Riparian Function

Floods and Property Damage

Aggradation, Widening, and Planform Adjustments

Encroachment

Dredge, Berm and Armor

Channel Incision and loss of Floodplain Function

Sustainable Flood Hazard Mitigation Options:

1. Active Restoration of Equilibrium Conditions
    a. True equilibrium
    b. Modified equilibrium
2. Permanent riparian corridor protection combined with:
    a. Active restoration of equilibrium conditions
    b. Passive restoration of equilibrium conditions

Example of Active Restoration of Modified Equilibrium Conditions Sucker Brook, Williston

Post-Construction

Active Restoration of Equilibrium Conditions

This was formerly a deposition zone. Upstream urbanization caused the channel to incise, and completely lose access to its former flood plain.

Rugg Brook Riparian Corridor Restoration

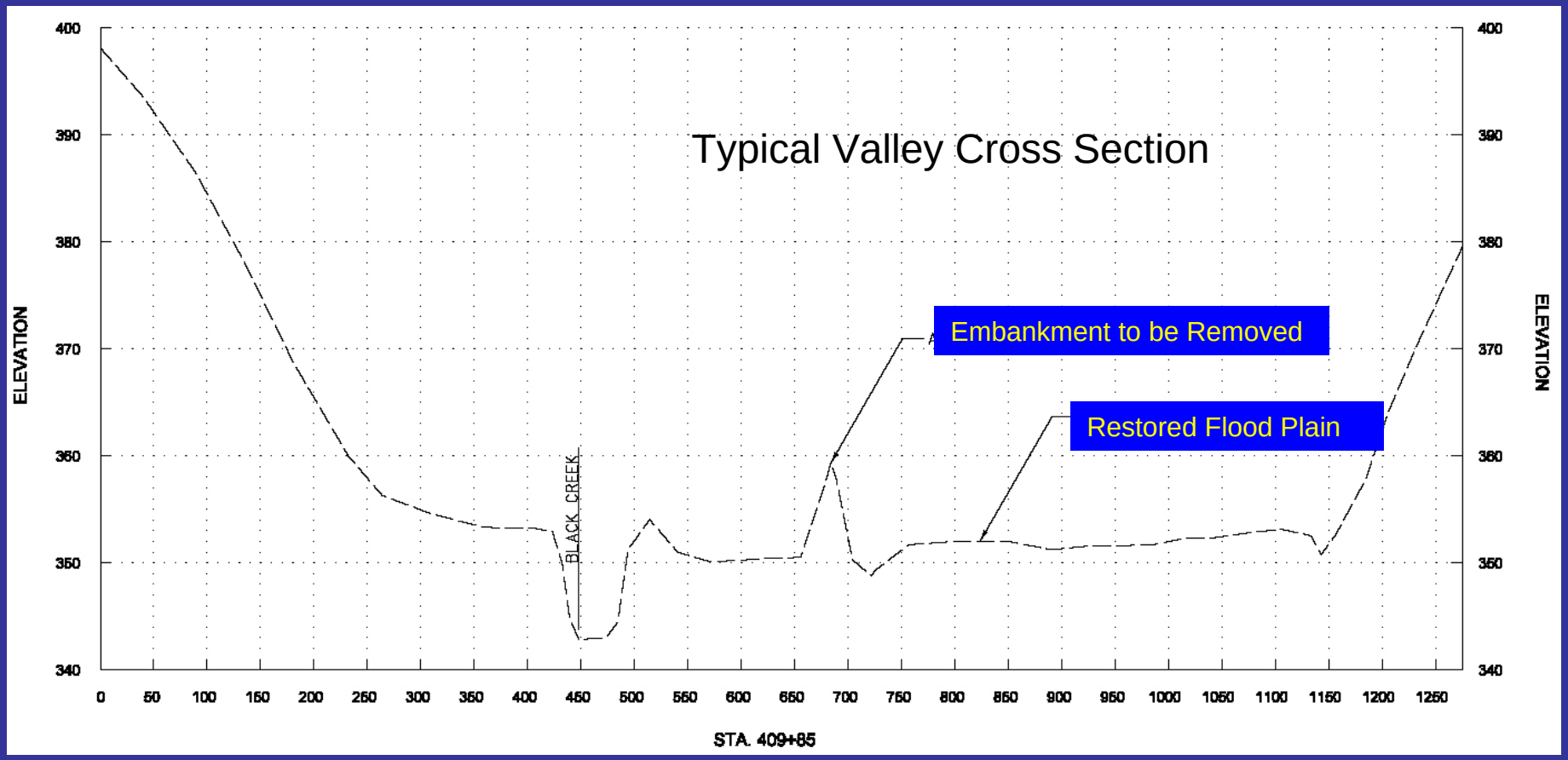
We excavated over 100,000 cubic yards of earth to construct 5 acres of new flood plain effectively pushing the channel evolution process ahead to the equilibrium condition.

Rugg Brook, St. Albans Town

Great Brook, Plainfield, 2006
Structural elevation of incised channel bed

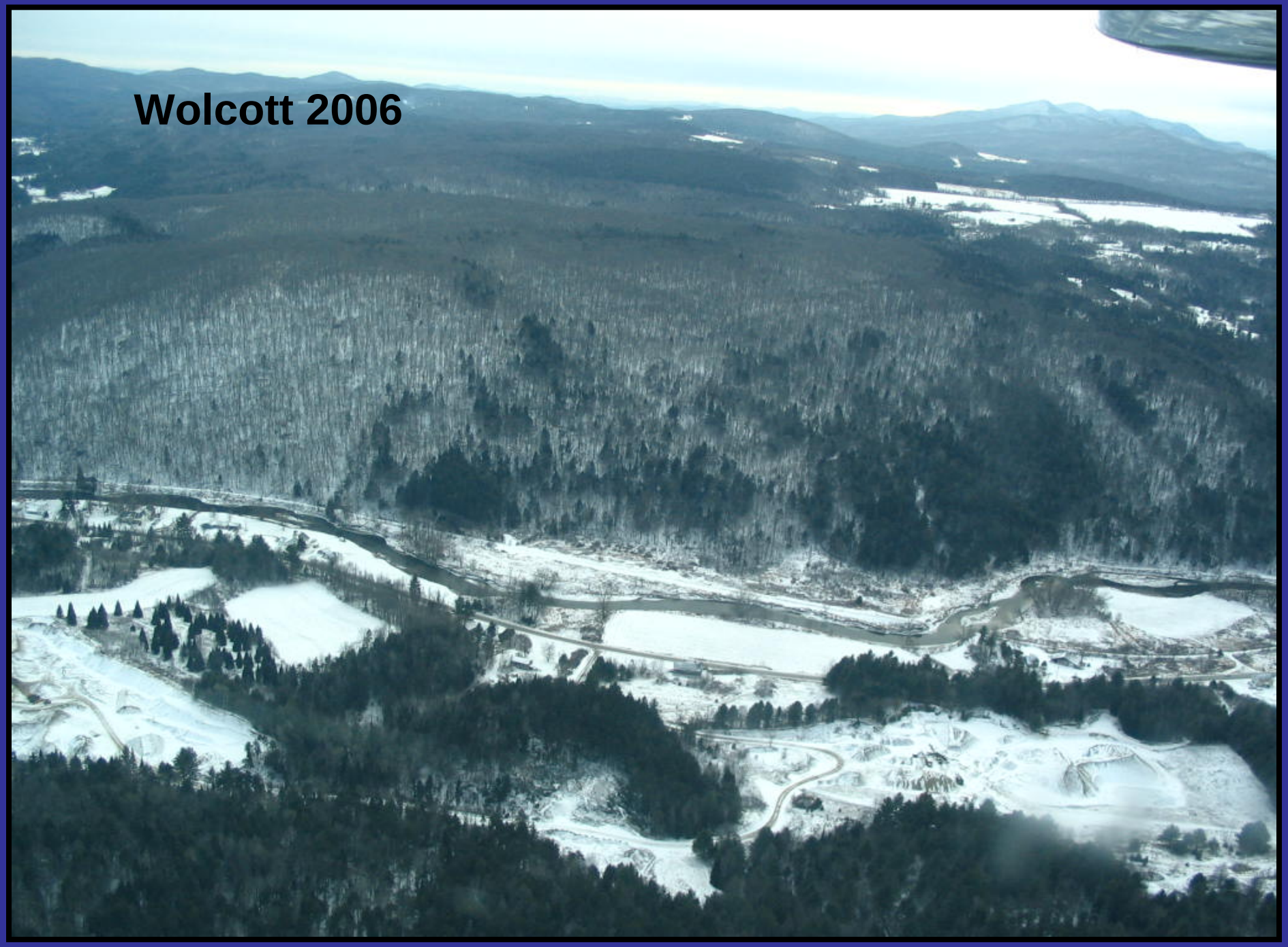
Removing constraints, restoring ecological function, enhancing sediment and nutrient storage and reducing flood & erosion hazards

This is a cross section of the Black Creek valley showing the magnitude of flood plain encroachment represented by the discontinued Lamoille Valley Railroad embankment. We established an MOA with VTrans (owner) to remove selected sections of the embankment to restore the river access to its historic flood plain to protect agricultural productivity, reduce channel erosion, and enhance sediment and nutrient attenuation capacity.



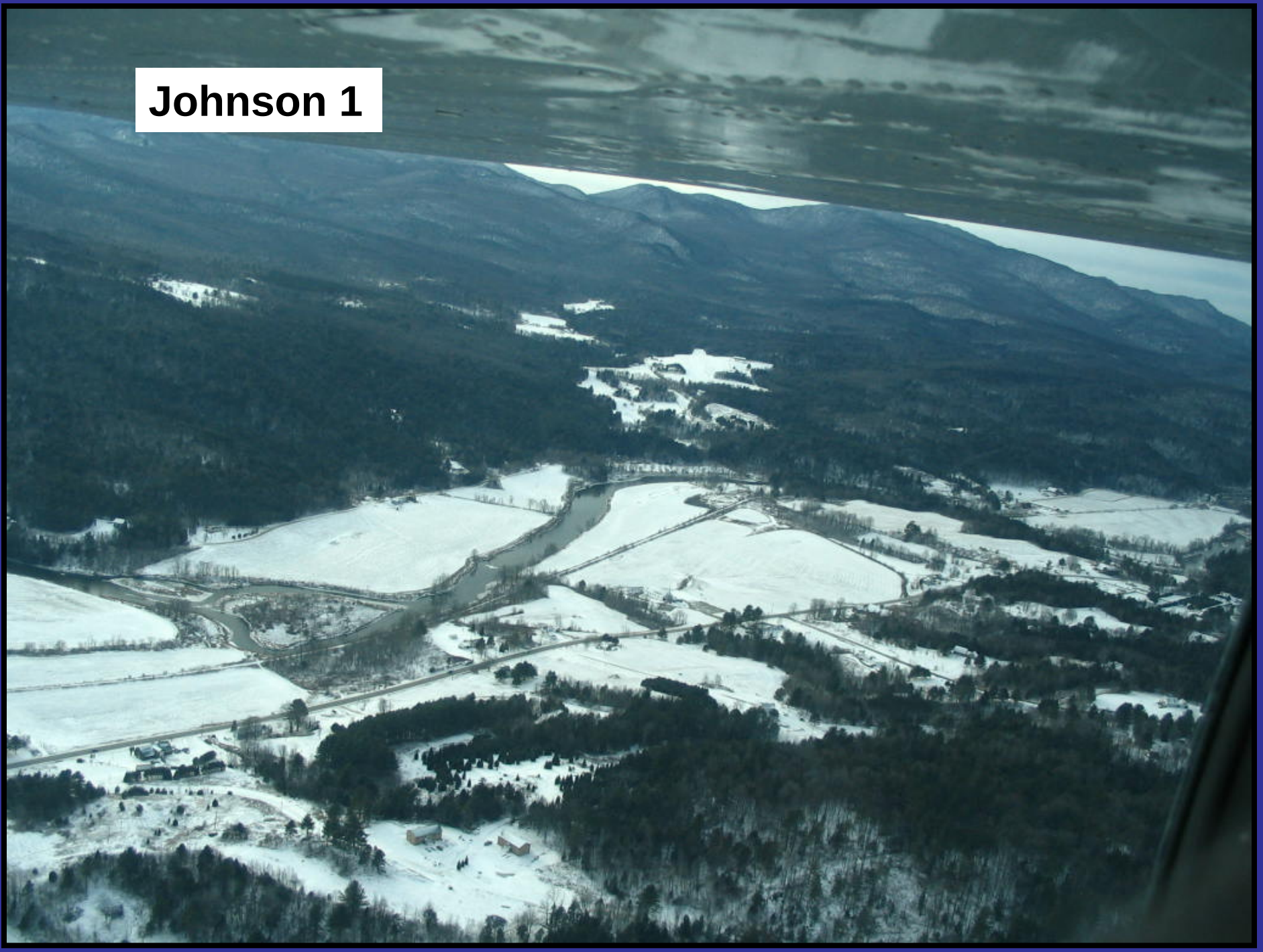
Active Flood Plain Restoration
One of eleven Lamoille Valley Railroad embankment sections removed in 2007. Six miles of embankment and over 200 acres of flood plain and wetlands have been restored.
Black Creek, Fairfield

Lamoille Valley Railroad Flood Plain Restoration Lamoille River, Wolcott, 2006

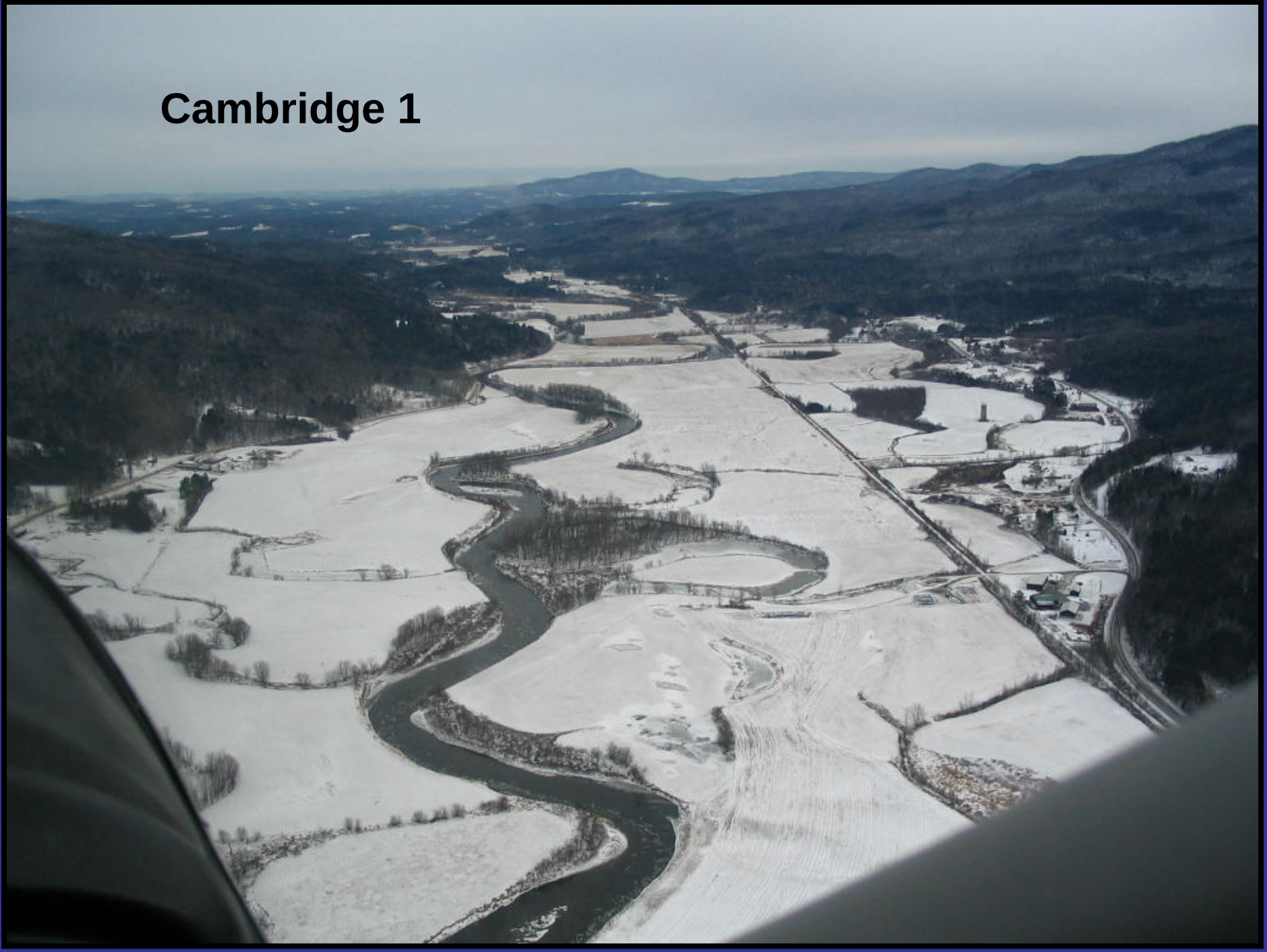

Wolcott 2006

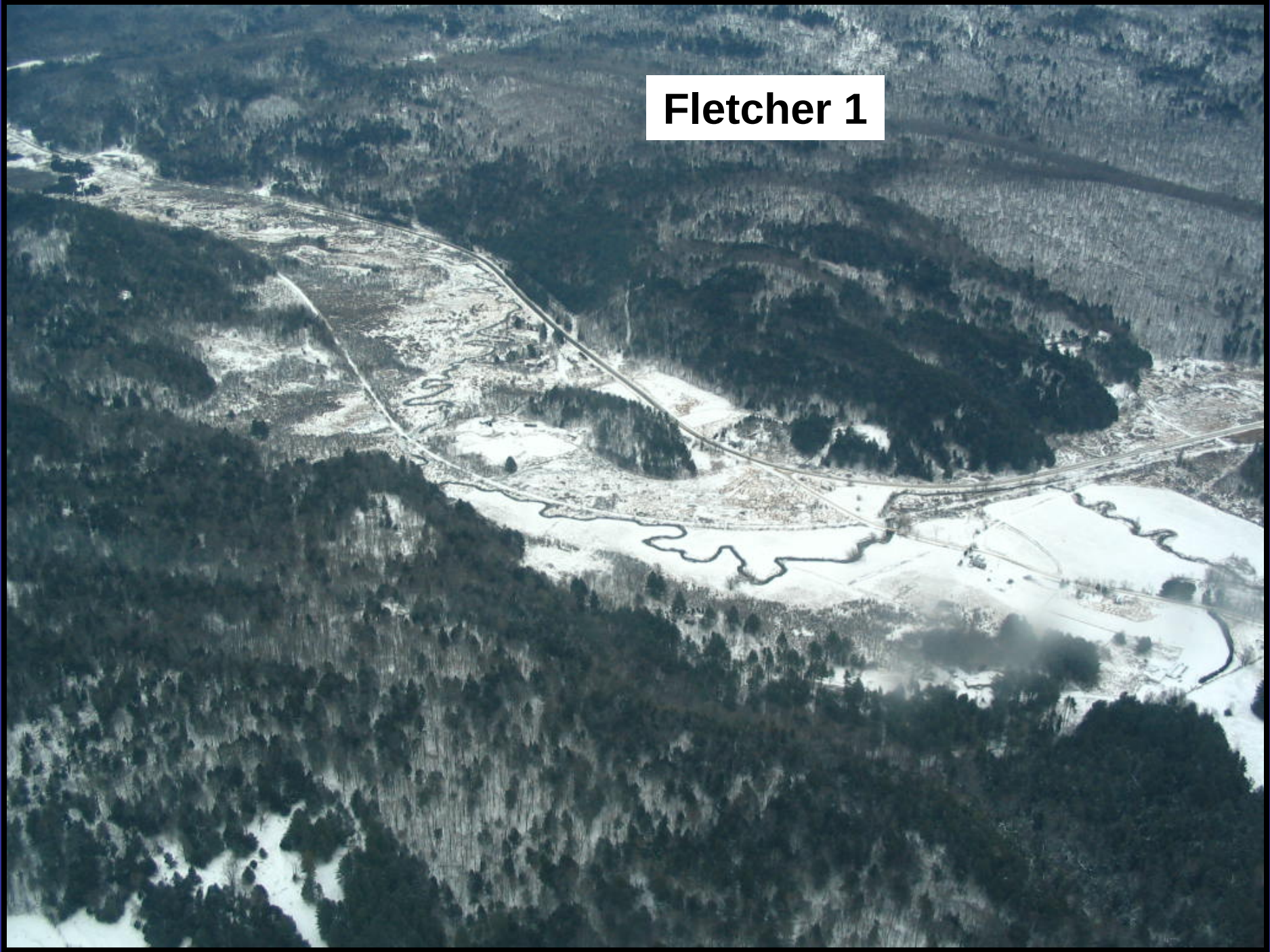
CAT

VOLVO


Johnson 1

Cambridge 1




Fletcher 1

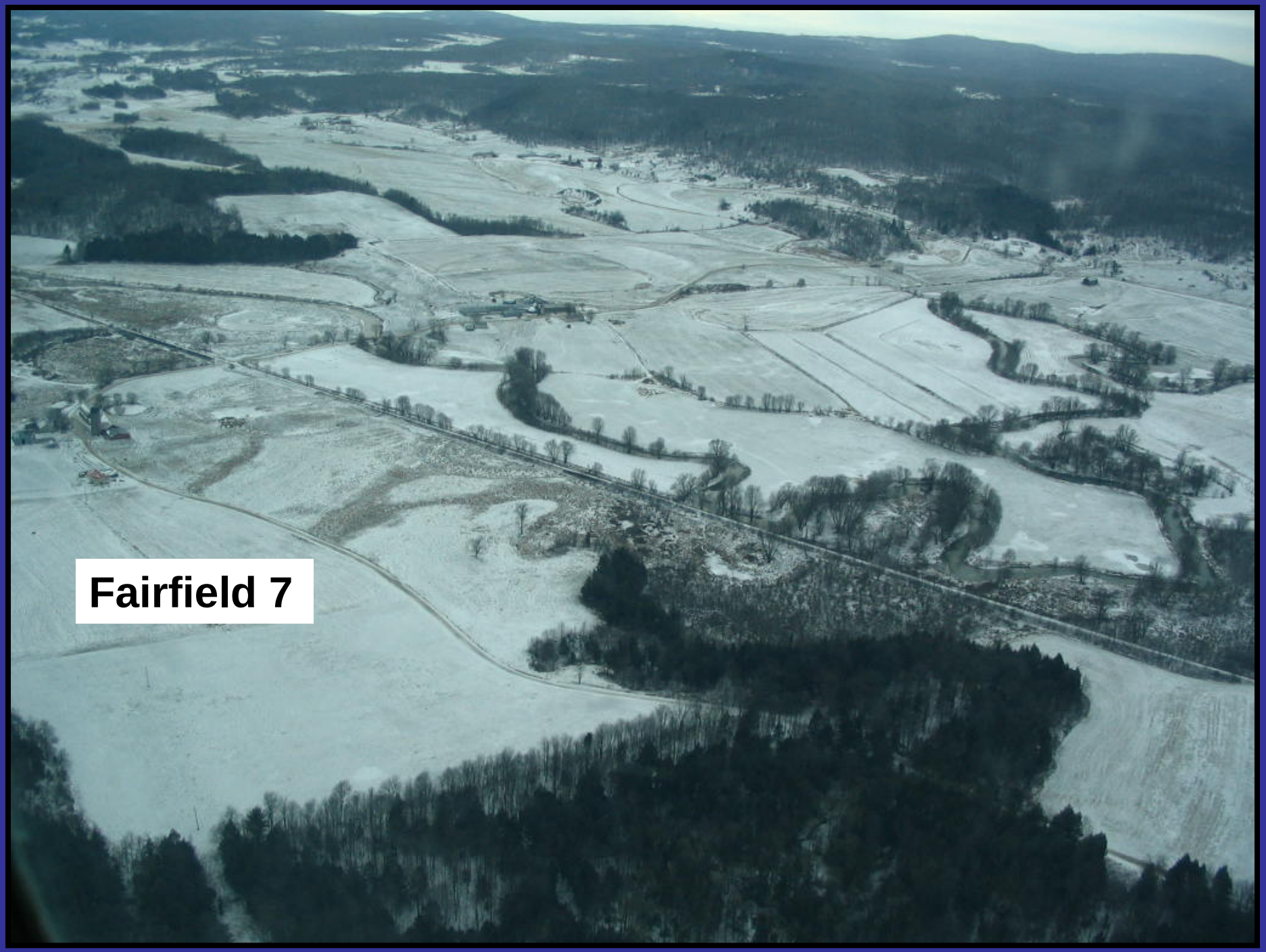
VOLVO

CATERPILLAR
G.W. TATRO
Jeffersonville, VT
CAT

Fairfield 3

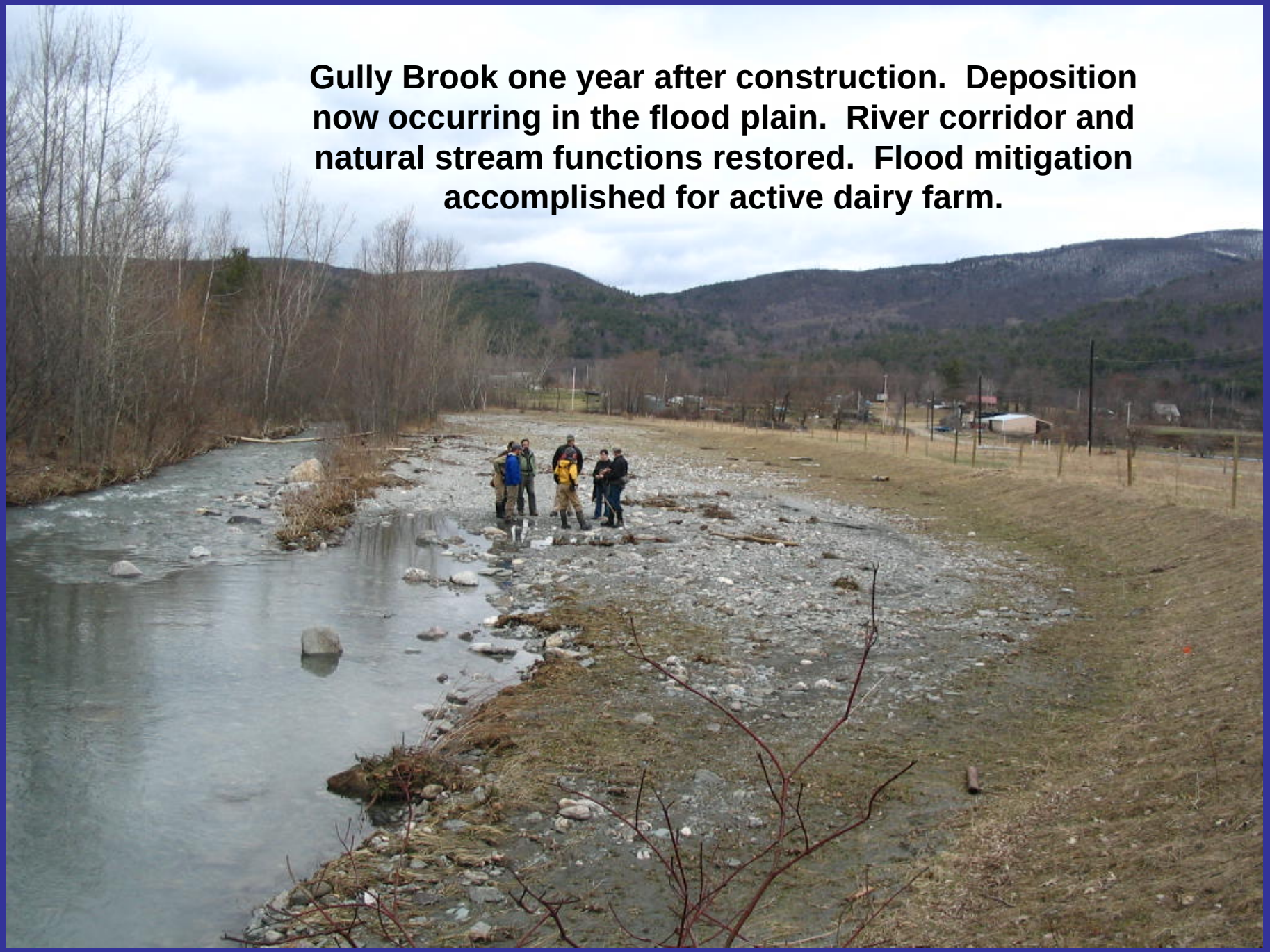
Fairfield 4

Fairfield 4


Fairfield 7

Fairfield 7

Gully Brook was channelized in the 1960s through a large historic depositional area. It resulted in the delivery of large volumes of sediment into the Castleton River causing chronic flooding of the Traverse Farm. We worked with the landowner to excavate the confining berm, lower the flood plain and converted the transport reach back to a deposition zone. No flooding has been experienced since the project was completed.


Gully Brook one year after construction. Deposition now occurring in the flood plain. River corridor and natural stream functions restored. Flood mitigation accomplished for active dairy farm.

Indian River, Rupert Pre-Berm Removal

Indian River, Rupert
Post Construction 2007

Riparian Corridor Protection

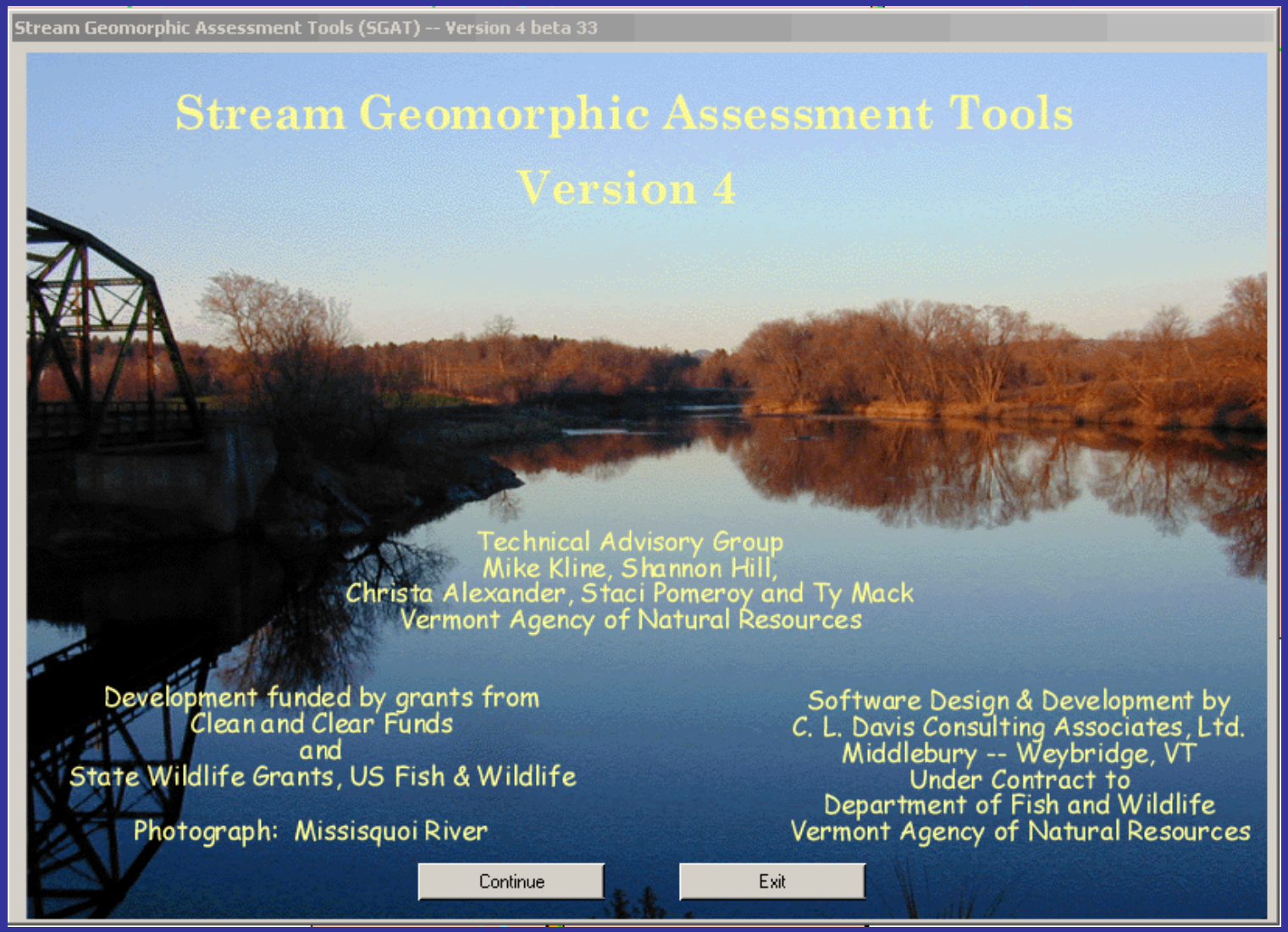
Flood and fluvial erosion hazard mitigation objectives unerringly converge with the goals of water quality and aquatic habitat protection as accomplished through riparian corridor protection

River Corridor Protection & Passive Restoration

This is a portion of a 3 mile reach of the Trout River in Montgomery that had been an area of constant conflict between ag uses and stream erosion. After the flood in 1997 we worked with all the landowners obtained river corridor protection agreements through a USDA program, implemented strategic structural elements and educated the community in a way that redefined the way they perceived and related to the river. No conflicts have been experienced over the past decade.

SGAT

An ArcView 3.x Extension



Inherent Sensitivity + Adjustment Processes

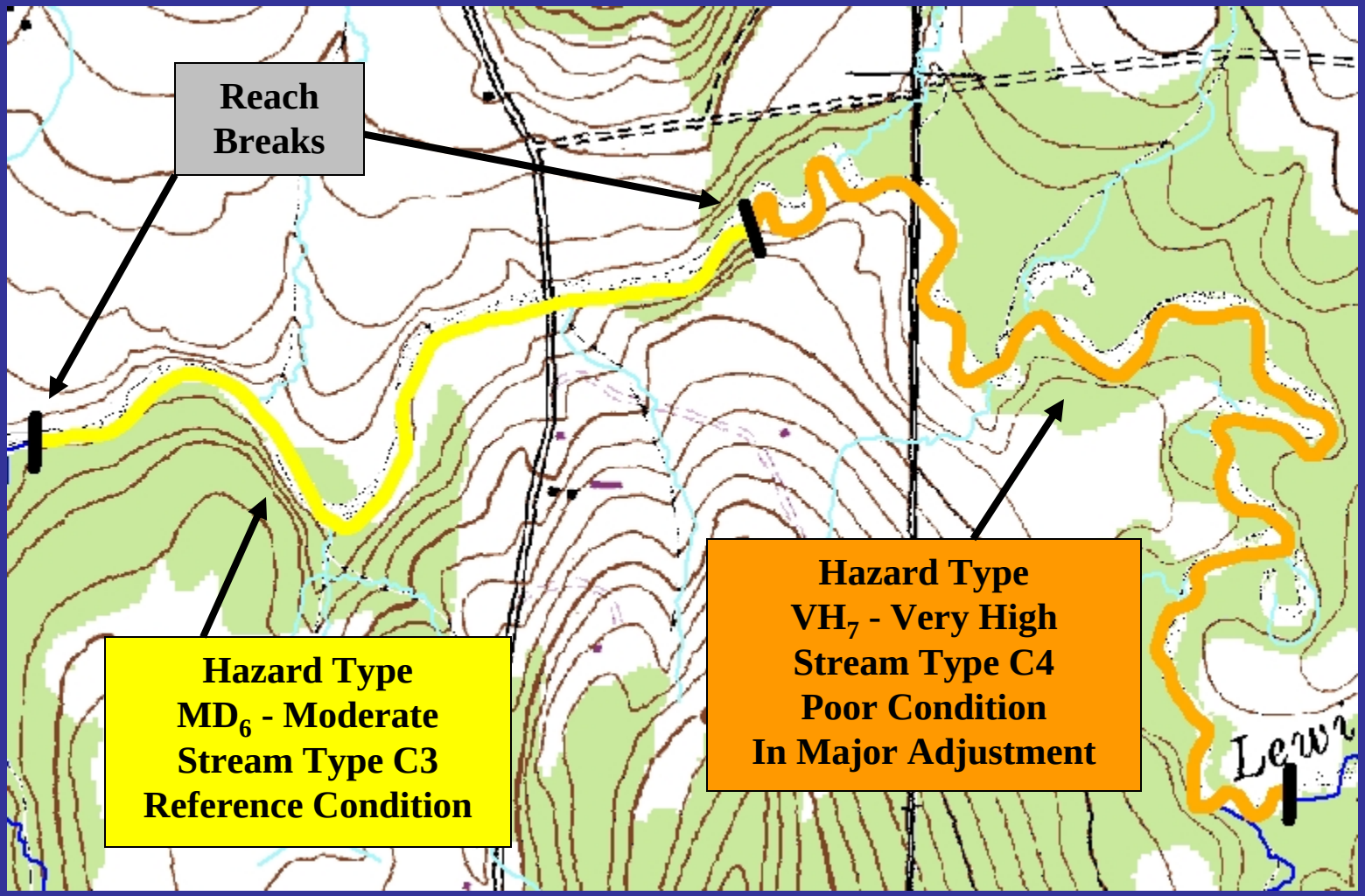
- Sediment Supply
- Transport Capacity
- Bed and Bank Materials

- Reference Condition
- Major Adjustment
- Stream Type Departure

Fluvial Erosion Hazard Ratings

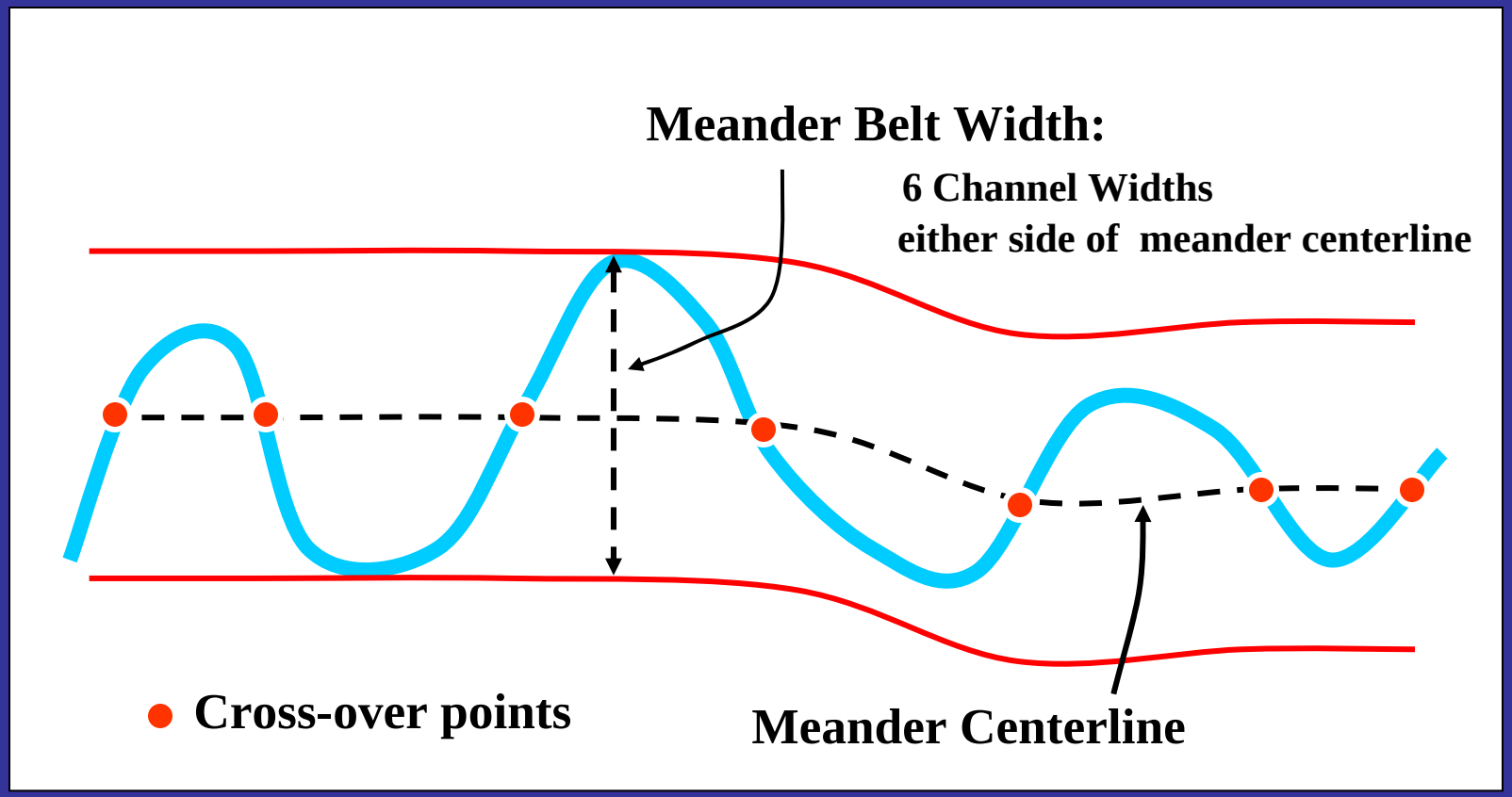
Existing Stream Type	In Regime Reference or Good Condition	Major Adjustment Fair Condition	Stream Type Depart. Poor Condition
A1, A2, B1, B2	Very Low	Very Low	Low
C1, C2	Very Low	Low	Moderate
G1, G2	Low	Moderate	High
F1, F2	Low	Moderate	High
B3, B4, B5	Moderate	High	High
C3, E3	Moderate	High	High
C4, C5, E4, E5	High	Very High	Extreme
A3, A4, A5, G3, F3	High	Very High	Extreme
G4, G5, F4, F5	Very High	Very High	Extreme
D3, D4, D5	Extreme	Extreme	Extreme

Assign Hazard Ratings to Stream Reaches



FEH Corridors are based on Meander Belt Width

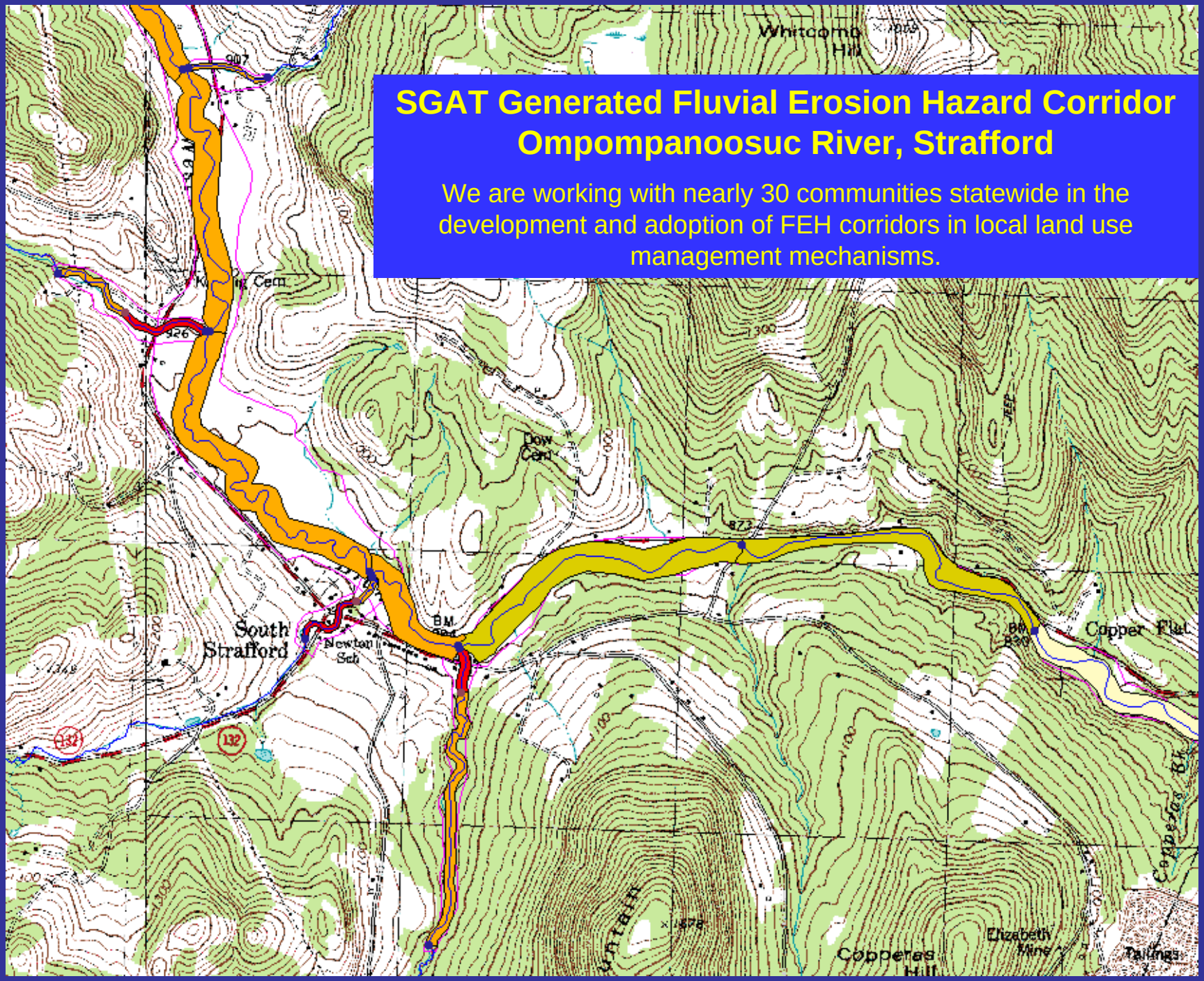
Multiples of reference channel width (from regional hydraulic geometry curves). Based on regime relations (Williams, 1986)



FEH Rating	Belt Widths based on reference channel widths
Very Low (VL)	Equal to the reference channel width
Low (LW)	Equal to the reference channel width
Moderate (MD)	Four (4) channel widths
High (HI)	Six (6) channel widths
Very High (VH)	Six (6) channel widths
Extreme (EX)	Six (6) channel widths

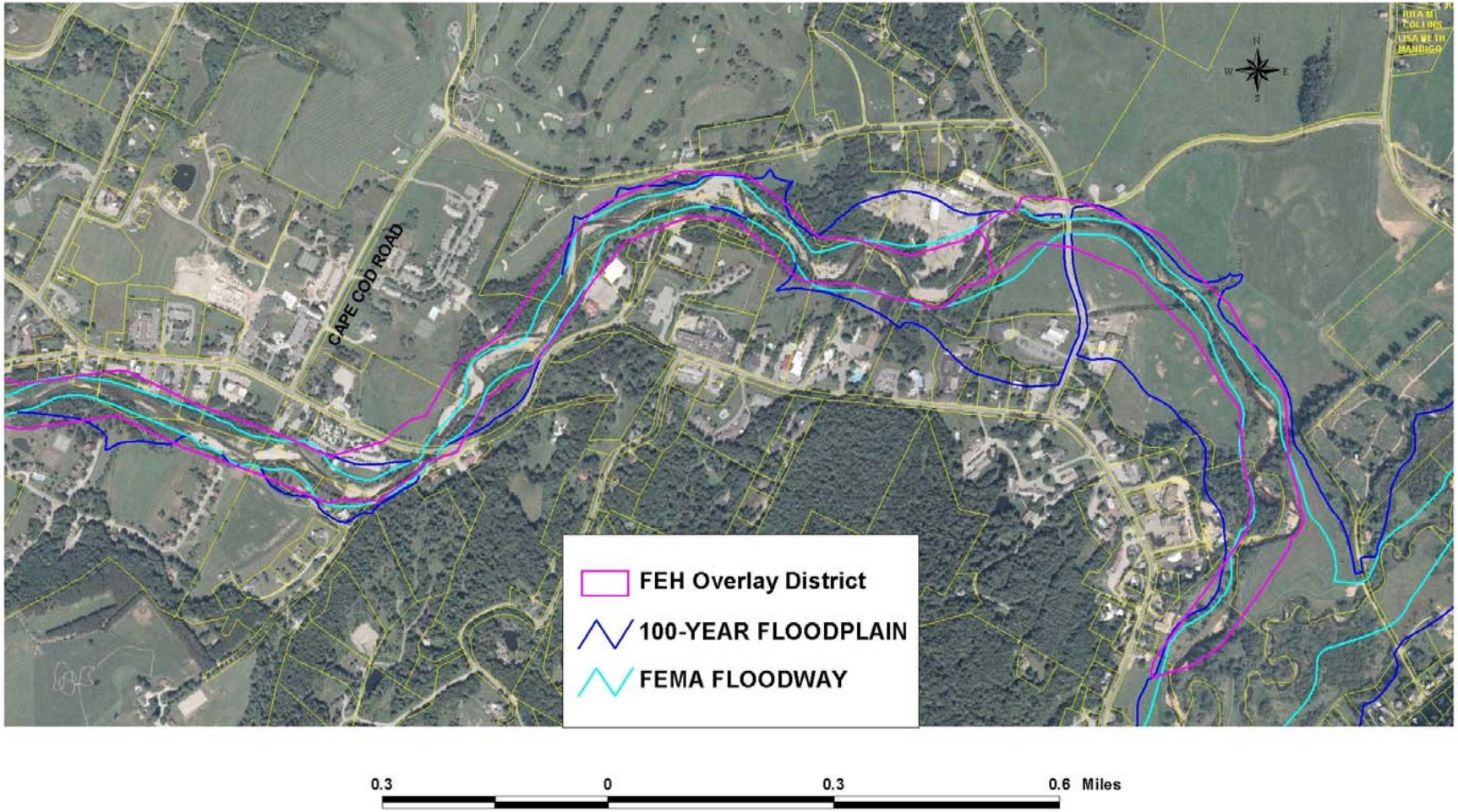
SGAT Generated Fluvial Erosion Hazard Corridor Ompompanoosuc River, Strafford

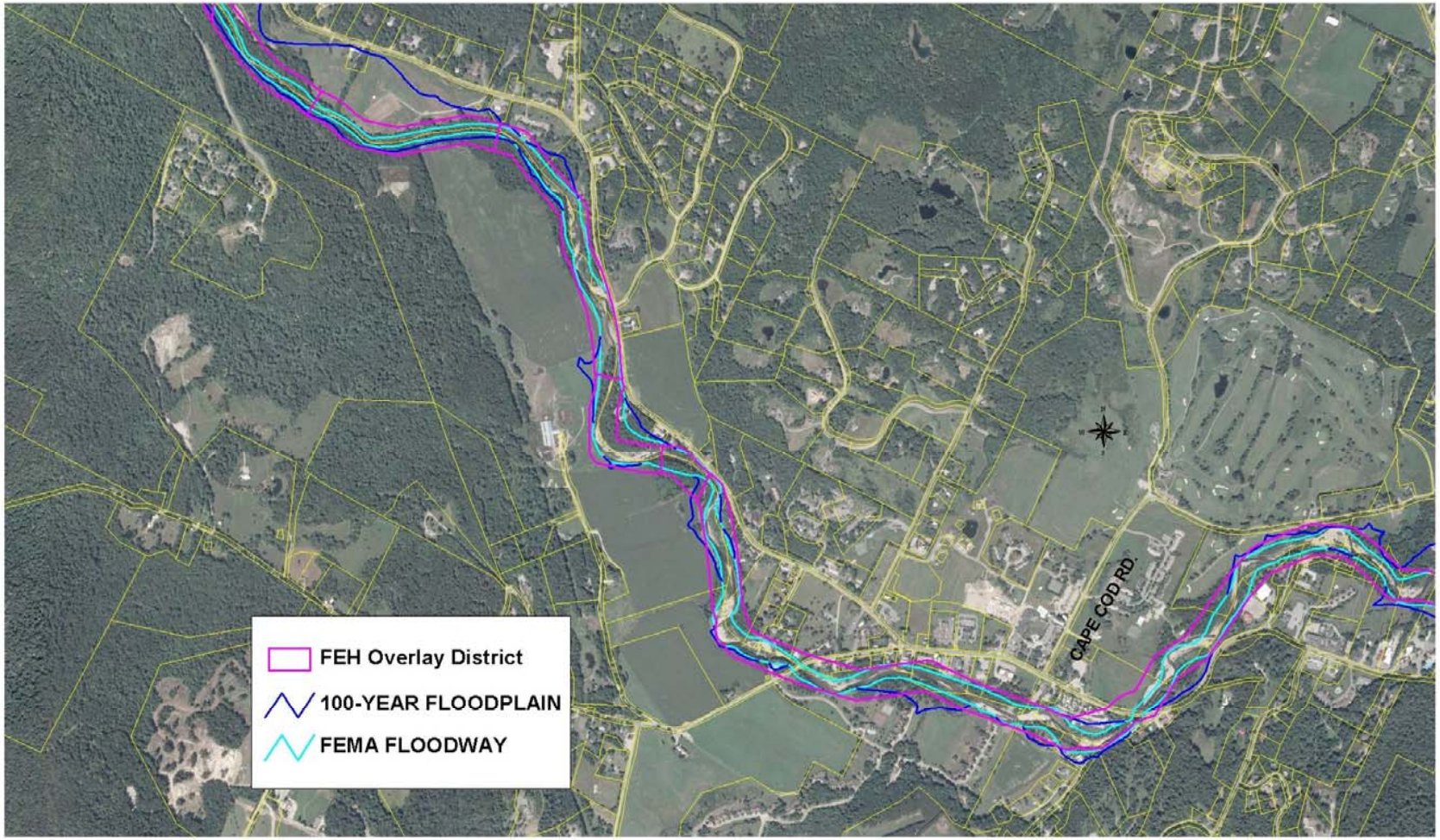
We are working with nearly 30 communities statewide in the development and adoption of FEH corridors in local land use management mechanisms.



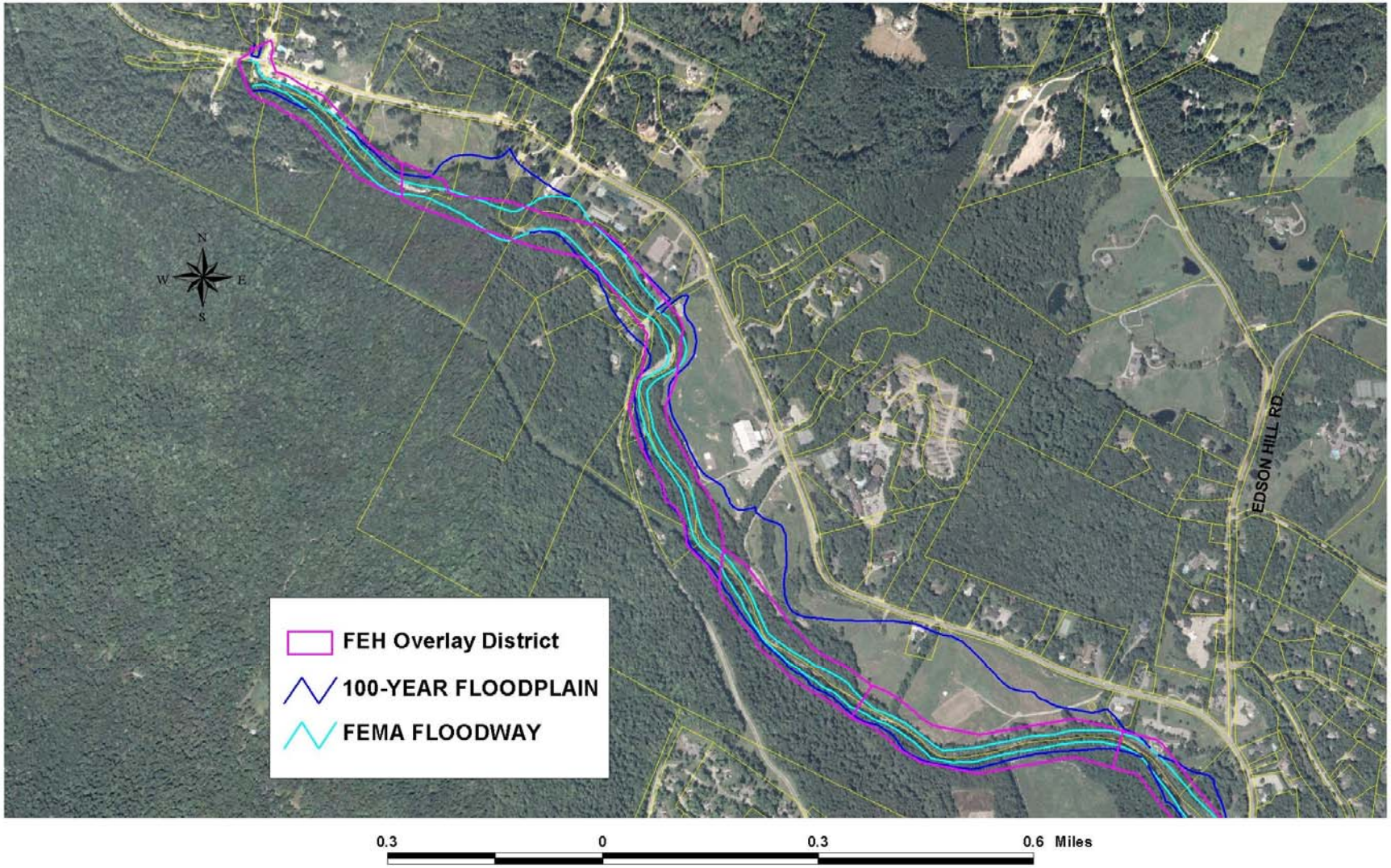
West Branch, Stowe, 2007

West Branch, Stowe
Fluvial Erosion Hazard Overlay District Adopted

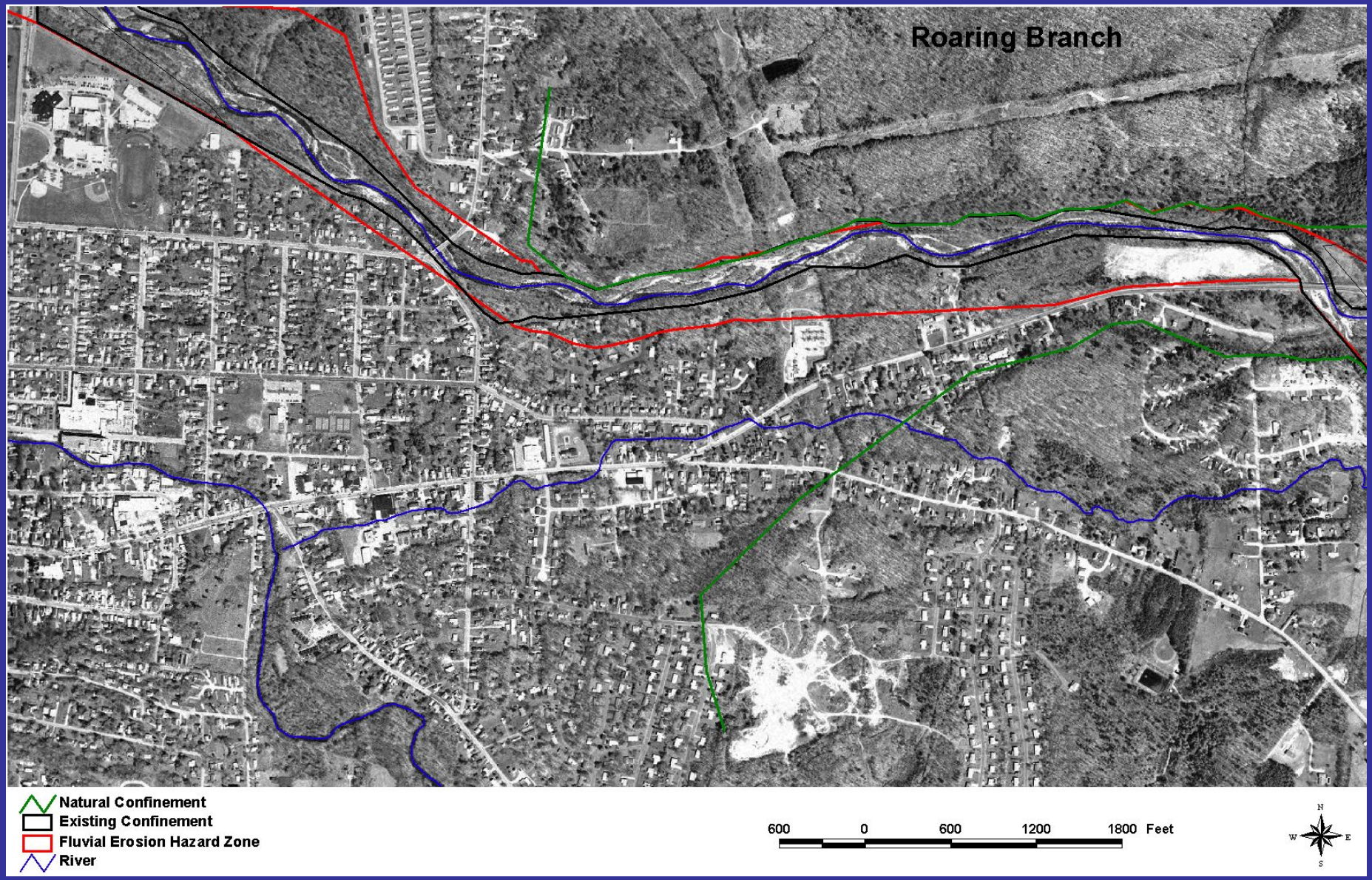



FEH Overlay District
100-YEAR FLOODPLAIN
FEMA FLOODWAY
CAPE COD RD.

0.5 0 0.5 Miles


N
W
E
S
EDSON HILL RD
FEH Overlay District
100-YEAR FLOODPLAIN
FEMA FLOODWAY
0.3
0
0.3
0.6 Miles

Roaring Branch, Bennington


Roaring Branch
Natural Confinement
Existing Confinement
Fluvial Erosion Hazard Zone
River
600
0
600
1200
1800
Feet
N
W
E
S

Roaring Branch, Bennington, 1927

Roaring Branch, Bennington, 1987

ACOE Levee, Roaring Branch, Bennington, 1987

Roaring Branch, Bennington, 1987

Roaring Branch, Bennington, 1987

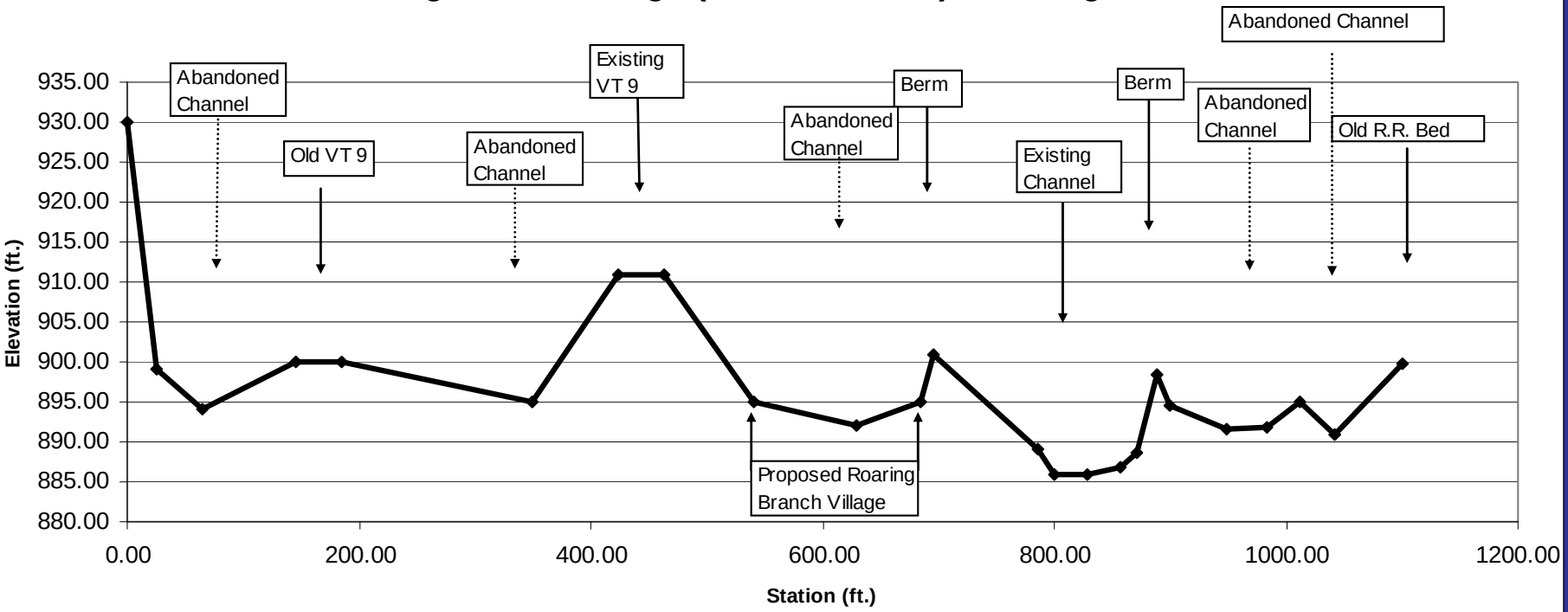
Roaring Branch, Bennington, 1987

ACOE Levee

Roaring Branch

Bennington

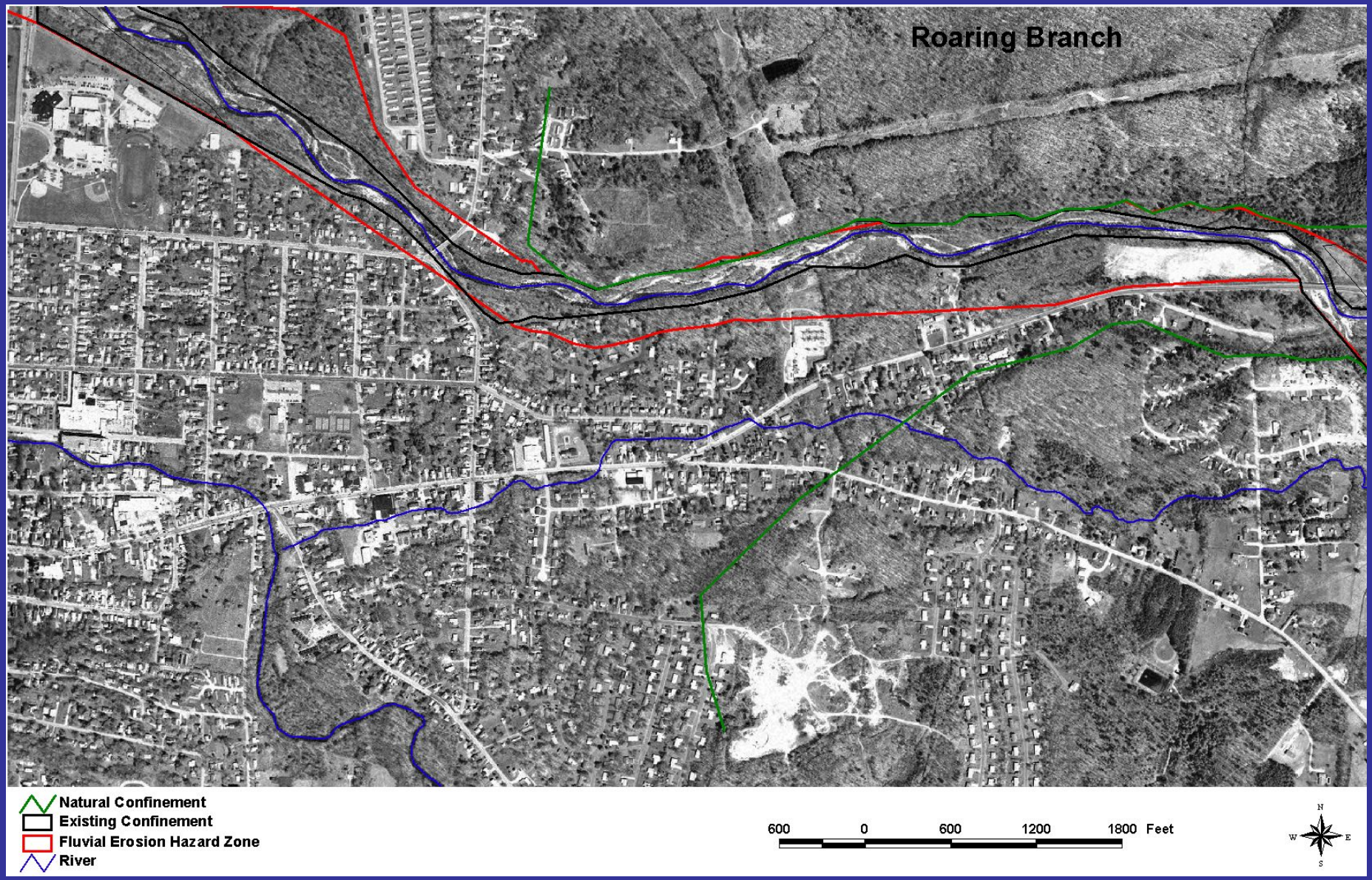
Downstream View, Existing Valley Cross Section at Roaring Branch Village (COE FPI XS-67), Bennington, VT

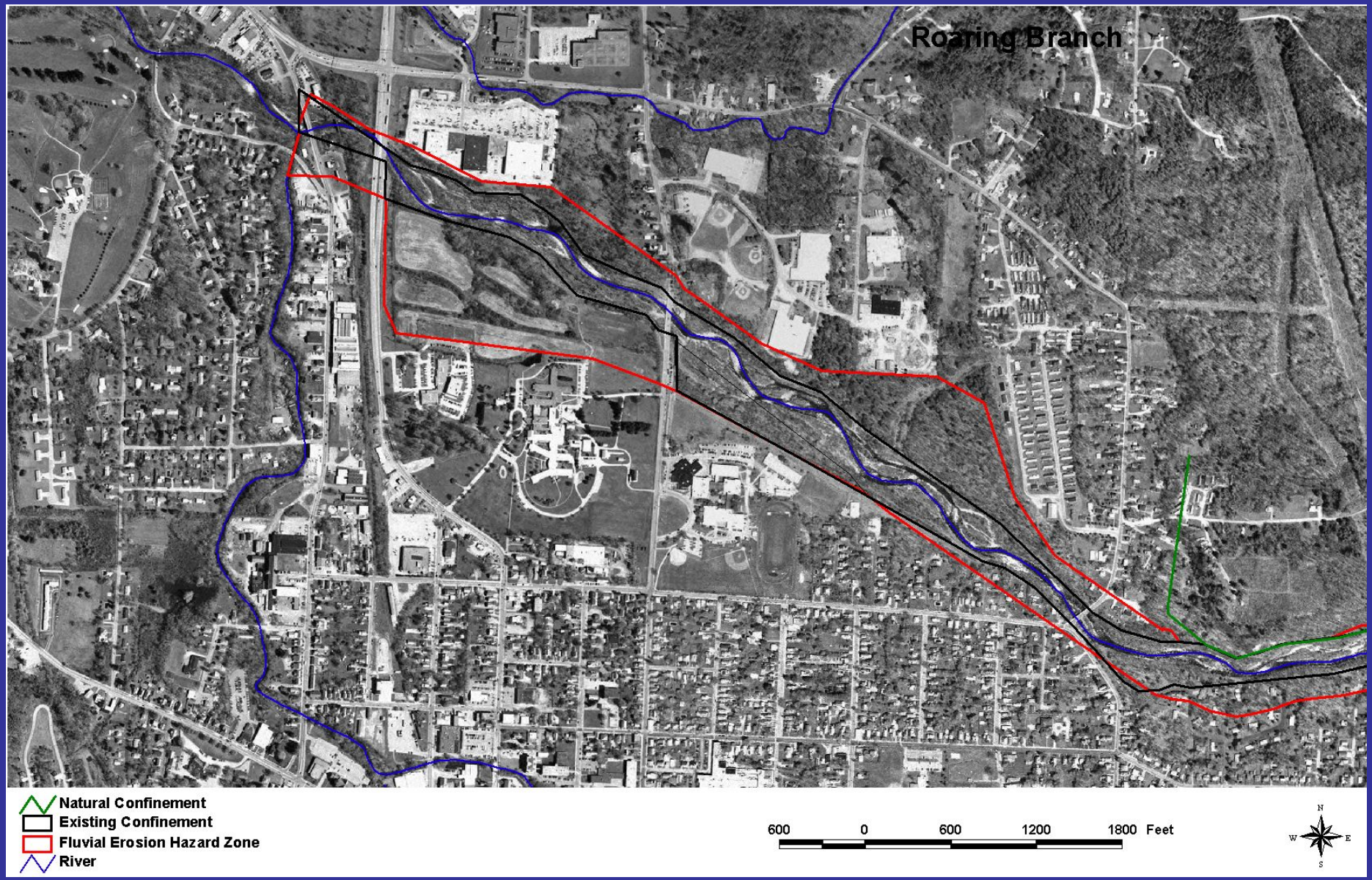


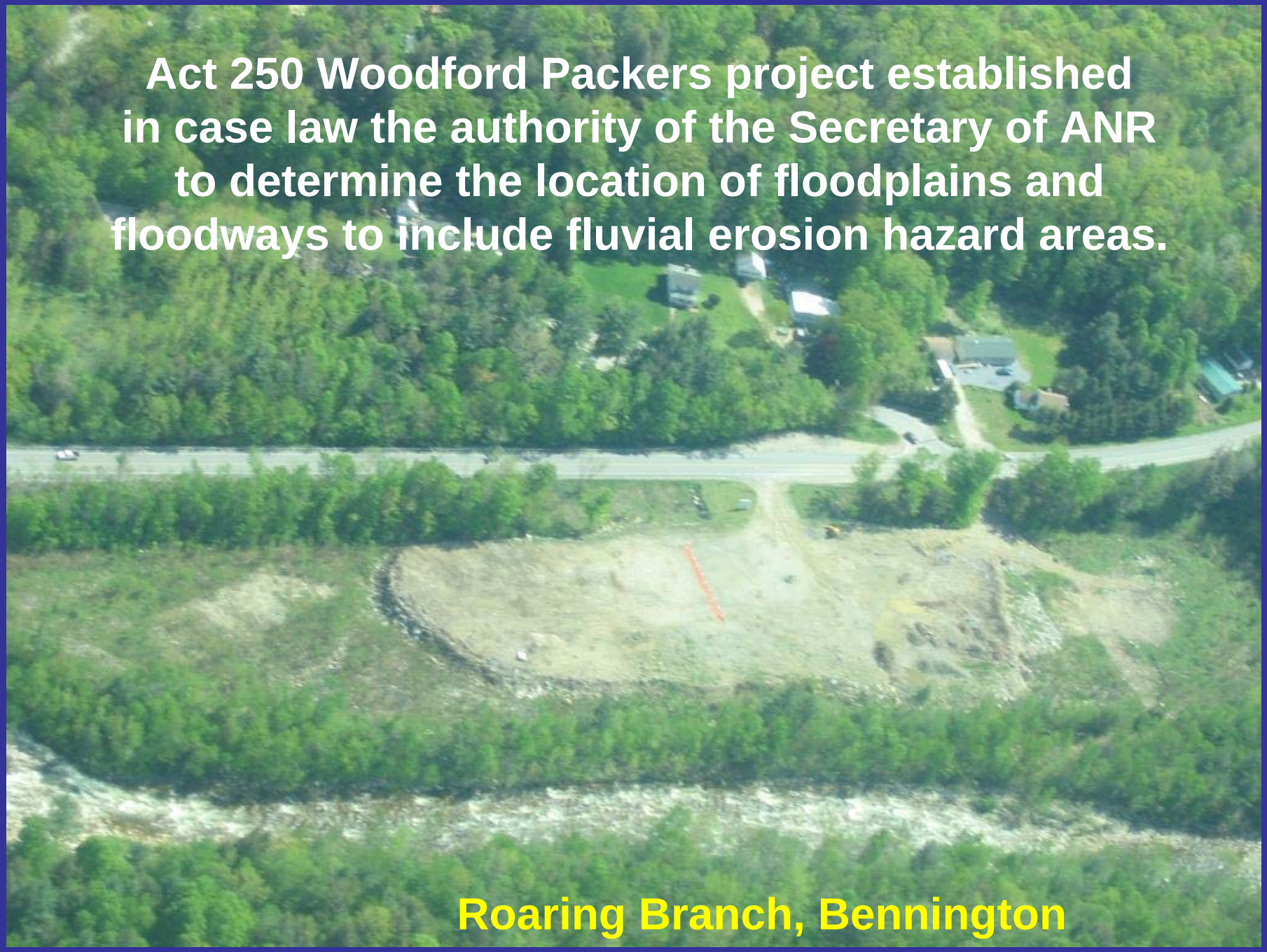
Data Sources: 1898 USGS Topo
1942, 1962, 1974, aerial photos
1998 Parks Ass. Survey
1975 USACOE FPI Report
2001 VT Survey

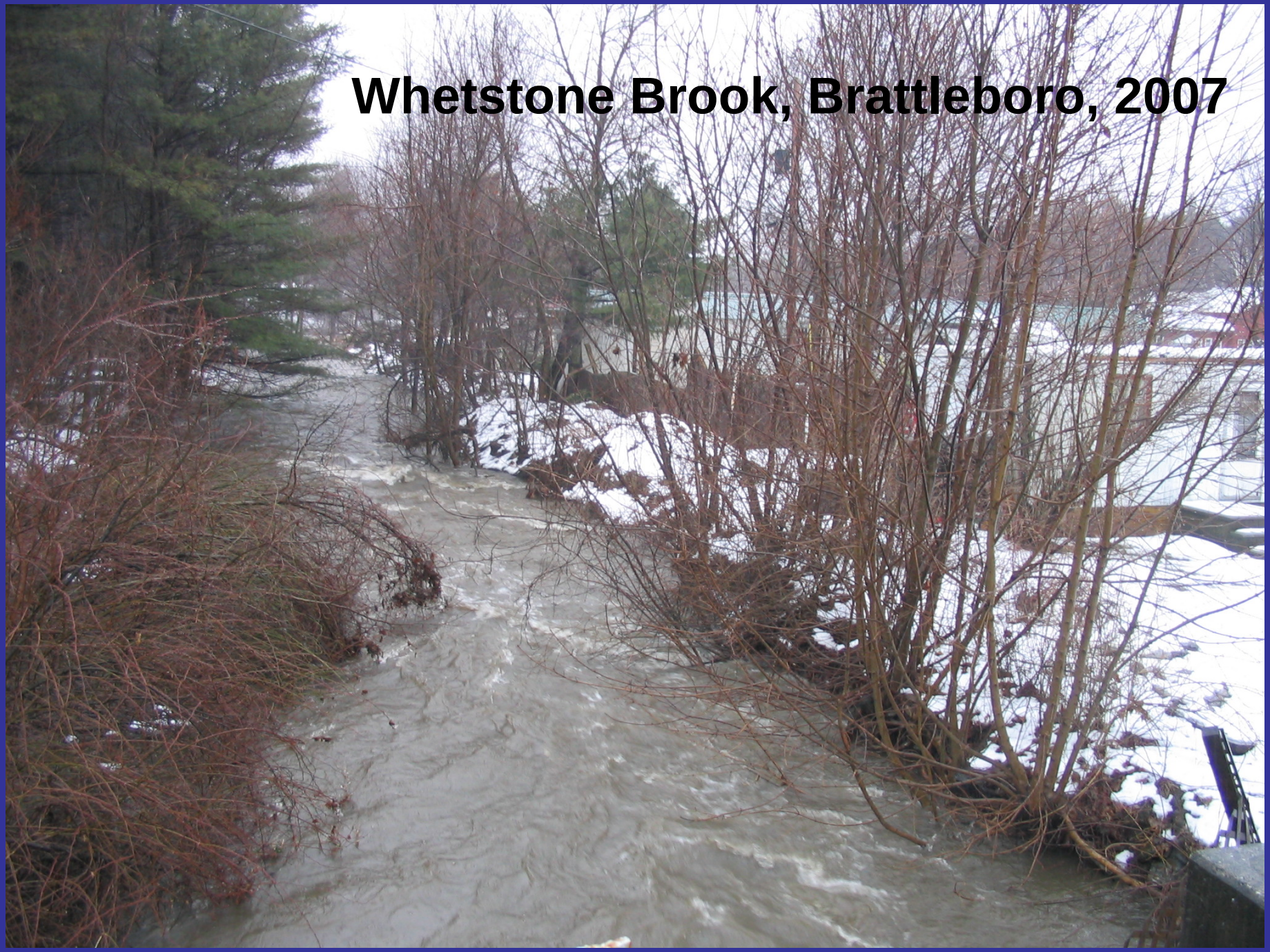
Existing Valley Cross Section

Roaring Branch,
Bennington 2007


Roaring Branch
Natural Confinement
Existing Confinement
Fluvial Erosion Hazard Zone
River
600
0
600
1200
1800
Feet
N
W
E
S


Roaring Branch
Natural Confinement
Existing Confinement
Fluvial Erosion Hazard Zone
River
600
0
600
1200
1800
Feet
N
W
E
S

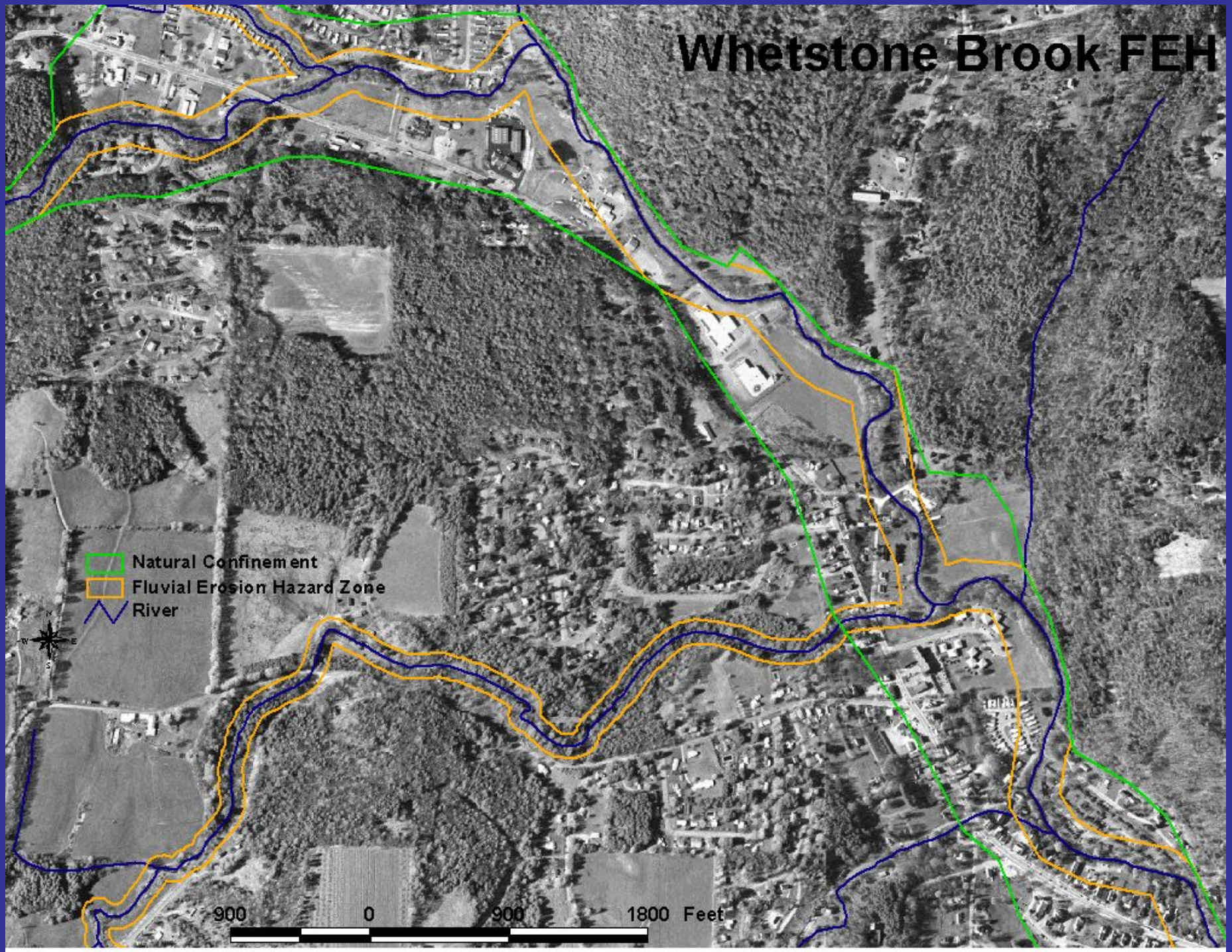

Act 250 Woodford Packers project established in case law the authority of the Secretary of ANR to determine the location of floodplains and floodways to include fluvial erosion hazard areas.
Roaring Branch, Bennington


Whetstone Brook, Brattleboro, 2007

Whetstone Brook, Brattleboro, 2007

Whetstone Brook
Brattleboro, 2007

Whetstone Brook Brattleboro, 2007


Whetstone Brook FEH
Natural Confinement
Fluvial Erosion Hazard Zone
River
900
0
900
1800 Feet

Thousands of acres of farmland consist of converted wetlands within river corridors that are dependent upon ditches, tile drains and channelized streams to maintain productivity. But in wet years the drainage systems are not good enough and always function as an efficient conduit to collect and transport phosphorus into the rivers and to the lake. New incentives & compensatory Ag Programs are Needed to Protect & Restore River Corridors.

We are working with VTrans to develop design standards for sediment transport to increase the functional life time of structures and reduce flood hazards.

River Management Educational Program

We make dozens of demonstrations with our portable flumes annually.
We have produced and distributed educational videos and DVDs.
We make 40-50 public presentations every year.
We make sure there is an educational component to every VT RMP activity.

VT RMP Active External Partners

- Lamoille, Franklin, Caledonia, Essex, Bennington, Windham, Winooski, Poultney-Mettowee, & Rutland Natural Resource Conservation Districts
- Central VT, Addison, Chittenden, Southern Windsor, Windham, Two Rivers-Ottauquechee, Bennington, Rutland, Lamoille, Northwest Regional Planning Commissions & the VT Association of Planning & Development Agencies
- VT Agency of Transportation
- VT Agency of Commerce & Community Development
- VT Agency of Agriculture, Food & Markets
- VT Department of Public Safety Division of Emergency Management
- USDA Natural Resource Conservation Service
- US Forest Service
- US Fish & Wildlife Service
- Environmental Protection Agency
- US Army Corps Of Engineers
- VT League of Cities & Towns
- White River Partnership, West River Watershed Alliance, LaPlatte River Association, Lewis Creek Association, Friends of Missisquoi Bay, Missisquoi River Basin Association, Friends of Winooski River, Lamoille River Anglers Ass., Friends of the Mad River, Hoosic River Watershed Association, Battenkill Alliance
- Vermont Land Trust, Vermont River Conservancy, Upper Valley Land Trust, & Passumpsic River Land Trust
- University of Vermont Rubenstein School of Natural Resources
- Vermont Water Resources and Lake Studies Center
- Vermont Law School, Land Use Institute
- Vermont Municipalities – Too numerous to list

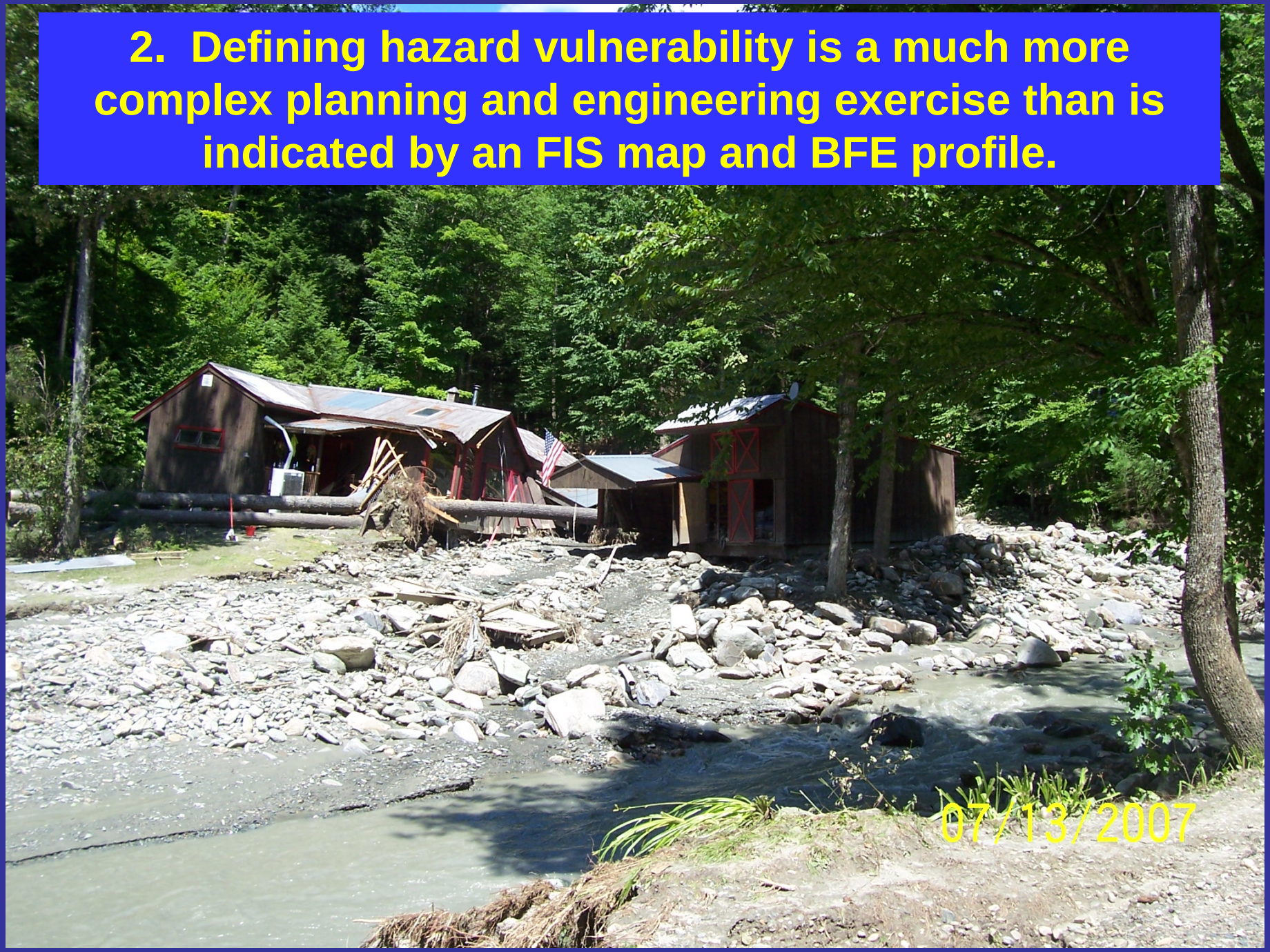
Technical Tools and Resources Currently Available in Support of River Corridor Protection:

- Stream Geomorphic Assessment Data & ANR Staff Scientists
- GIS River Corridor Delineation Tool
- National Flood Insurance Program Coordinator
- Fluvial Erosion Hazard Program Coordinator
- Clean & Clear Action Plan River Corridor Grants
- Fluvial Erosion Hazard Risk Assessment & Mapping
- FEMA Pre-Disaster Mitigation Planning & Project Funding
- FEMA Hazard Mitigation and Flood Mitigation Ass. Grants
- Clean & Clear Action Plan River Corridor Grants
- Conservation Reserve Enhancement Program (Ag)
- USDA Programs (WHIP, WRP, GRP)
- Riparian Corridor Conservation Easements

Rivers Are of Inestimable Value to Everyone
Tyler Branch, West Enosburg, 2006

1. Flood Hazard Mitigation is a shared and complementary objective to many social, economic, and ecological public goals, initiatives, programs and agency missions.

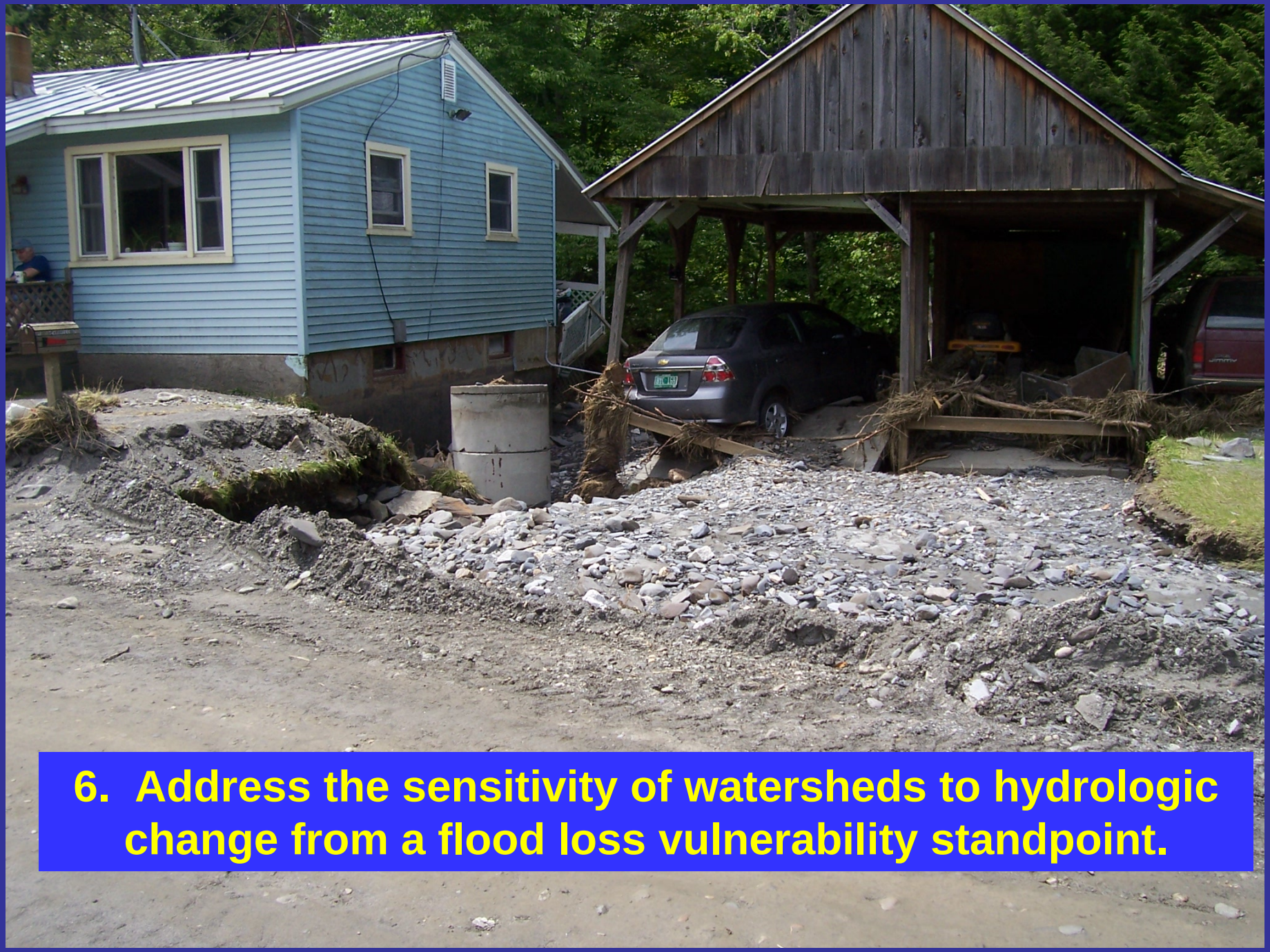
2. Defining hazard vulnerability is a much more complex planning and engineering exercise than is indicated by an FIS map and BFE profile.



3. Real, effective mitigation is true avoidance, not just retrofit. B/C determinations must recognize avoided potential future costs as a benefit; not just reduction of the magnitude of historic loss.

4. We can't keep paying to just put things back the way they were before as if everything was OK to start with; when putting it back is nothing more than a guarantee we will pay for it again. Provide meaningful incentives (far beyond 406) for enhanced state and local flood plain management, watershed development, infrastructure investment and riparian corridor protection.

5. Recognize streams as dynamic fluvial systems. Acknowledge the flaws and deficiencies of the NFIP to define hazard exposure. Redefine individual and community relationships with fluvial systems to promote sustainability of fluvial-related ecosystem services.



6. Address the sensitivity of watersheds to hydrologic change from a flood loss vulnerability standpoint.

7. There must be accountability for flood loss vulnerability caused by infrastructure expansion made necessary to serve profit-driven economic growth and development.

8. Climate change is re-shuffling the deck and changing all the rules. We need to get ahead of this terrifying inevitibility.

Information about

and publications by the

Vermont Agency of Natural Resources

River Management Program

are available at:

www.vtwaterquality.org/rivers

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Publications and References available at our website:

http://www.anr.state.vt.us/dec/waterq/rivers.htm

or: www.vtwaterquality.org/rivers