River Corridor Protection and Management

FACT SHEET ①

Vermont DEC River Management Program

Overview

Vermont towns, like many others in America, were, for the most part, established and developed along rivers and waterways. Before roads and electricity, the benefits of a river as a source of transport and power far outweighed the risks of flooding for most settlements. As towns and communities have grown, so have the costs of flood damage.

The past century has been one of great change for Vermont's waterways. Early in the century many watersheds were cleared of forests, river systems have been straightened and channelized and sediment and erosion have become an increasing problem. Works, large and small, have been carried out to allow for roads, railways and bridges, and to repair flood damage.

Tyler Branch in Enosburg, Vermont

Balance

Experience and science tell us that a stable, balanced river—that is, one that is just wide enough, deep enough and long enough to move the amount of water and gravel produced in its watershed—will erode its banks and change course only minimally, even in flood situations. However, if a river becomes "unbalanced," then it will change course, slope, depth, or width—or all four—until it becomes balanced again.

An important way to keep rivers from becoming unbalanced, or to allow them to re-establish balance, is to protect their "river corridors." River corridors consist of the river channel, the banks on either side, and the areas close to the river that carry flood water and accommodate the meander pattern of the river (see RMP Fact Sheet ②).

Flood Damage

Unbalanced rivers increase the risk of damage from flooding to our communities—and it's an expensive risk. From 1995 through 1998 alone flash flooding damage in Vermont approached $60,000,000.

Much of this damage occurred where rivers have been separated from their floodplains by some kind of development, or where rivers have been adjusting their length, depth or width because activities in the river, on the banks, or in the flood plains have caused a river to become unbalanced and destabilized.

The dollar cost of such damage may well be equaled by other economic losses including diminished recreation opportunities, impaired ecological functions, and long-term channel instability.

Partnership

Because rivers and waterways don't follow state and town boundaries the approach to fixing problems needs to cross political boundaries. The solution requires a community, local, regional, State and Federal partnership that can work in watersheds to protect river corridors, across political boundaries.

Fundamental Principles of River Systems

Until recently, river management has largely focused on water and how to contain or withstand the force of its flow. Throughout North America river scientists and managers are now bringing the principle of river “stability” into the management of river corridors.

This has meant understanding that human activity near rivers must not only withstand the forces of running water but must avoid changing the movement of sediment (sediment regime) in the river in order to remain secure.

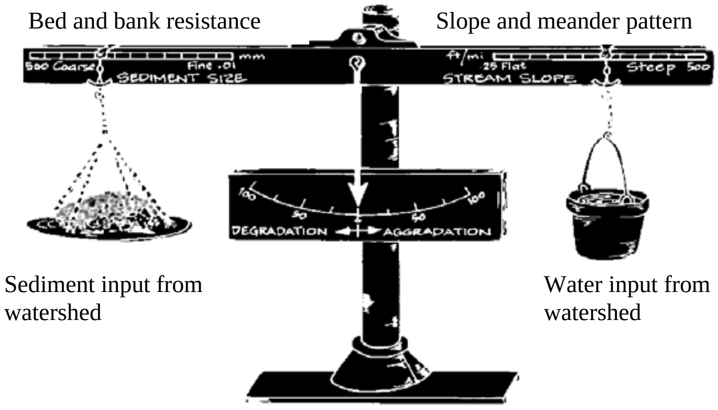


Figure 2. Stable Channel Equilibrium (Lane, 1955)

Stream or river channels are a reflection of what goes into them (water, ice, sediment and woody debris) and the valley type within which the stream is located. The shape of a river channel including its dimension (the width & depth), its pattern (or plan form), and its profile (or slope), is developed and maintained over time by the action of water, sediment and debris that drains from the surrounding area. This “channel forming flow” is approximated by the average annual high water event, which, by virtue of its frequency, does the greatest amount of “work” on the channel and floodplain and transports the greatest volume of sediment over time.

Stable rivers are recognizable by their ability to carry water, sediment and debris, even during high water, without changes occurring in the depth, width, length, or slope of the channel.

Figure 1 illustrates a stable channel balance and indicates the relationship between the watershed inputs of water and sediment, channel slope, channel boundary resistance (sediment size), and the physical response of the channel either by aggradation (building up of sediment) or degradation (scouring down). A change in any one of these parameters will cause adjustments of the other variables or a physical response of the stream channel until the system regains its balance.

Human land uses, especially within river corridors, that significantly alter the runoff patterns of water **and** sediment will trigger a channel adjustment process. When these processes change the relationship of the river with its floodplain (by aggrading or degrading) or constrain the river from maintaining or re-establishing a balanced condition, it becomes increasingly difficult to plan and very expensive to maintain those land uses.

Floodplain Access and Channel Evolution

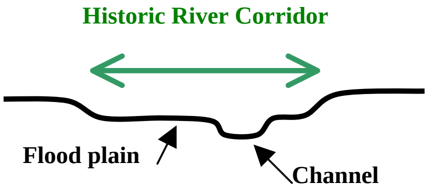
Cutting a river off from its floodplain by raising bank heights, armoring, or deepening a channel will cause a river to attempt to regain its balance through physical change.

The result of containing greater flows in the channel, or to prevent access to the floodplain, is to increase the stream’s power that must be resisted by the channel boundary materials; i.e., the rocks, soil, vegetation or man-made structures that make up the bed and banks of the river. The following set of diagrams show channel evolution as predicted by the model published by Shumm (1984). These diagrams only illustrate channel response at one cross section. There are equally profound physical adjustments that occur upstream and downstream from the site of alteration as bed degradation (head cuts) migrate up through the system and aggradation in the form of sedimentation occurs downstream.

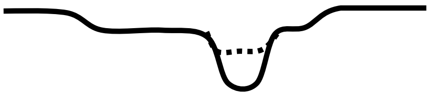
It is important to recognize the temporal aspect of channel response to change. Fluvial systems are energized by episodic events. Channel adjustment in response to management practices or encroachments may begin immediately but may also persist for decades depending on the sensitivity and morphology of the affected stream, the magnitude of alteration, and the frequency of high flow events. The first three stages might occur within a few months to a few years. The last three might not reach completion for one hundred years or more.

Review of Channel Evolution and Flood Hazard Identification

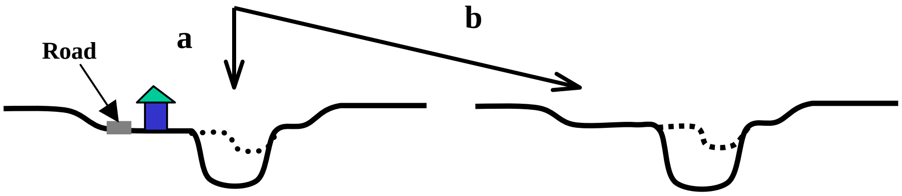
1880 Stable channel with fully accessible floodplain at discharges at and above the average annual high flow.



1930 Channel is dredged, deepened and straightened after the 1927 flood damaged agricultural land in the adjacent floodplain.

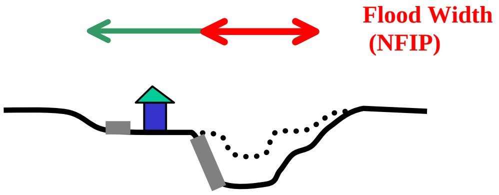


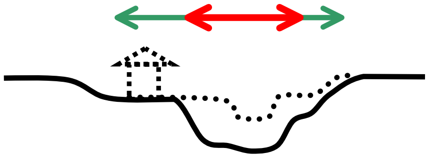
1960a The road is upgraded and relocated into the river corridor encroaching within the historic floodplain.



1960b Channel is widening and migrating laterally in response to the post-1927 flood recovery works (channelization) through bank erosion caused by the increased stream power.

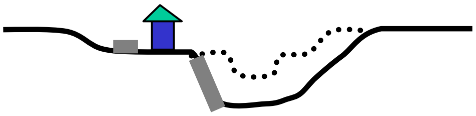
1980a As erosion and lateral migration of the channel threaten residential development and highway infrastructure, the channel bank is armored to prevent or repair damage to human investments.

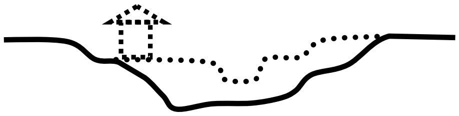




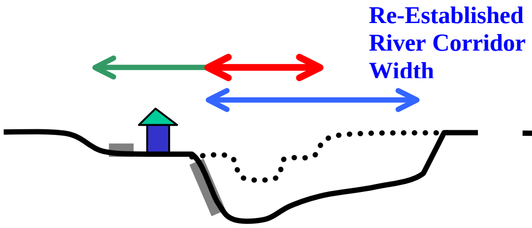
1980b Channel continues eroding and migrating laterally. NFIP floodway limits are delineated without consideration of the channel undergoing an active adjustment process.

1990a Channel dimension and plan form adjustment process continues but on adjacent property across the river and upstream and downstream of the armored bank.

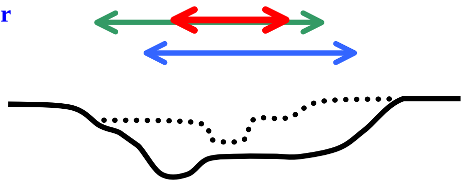




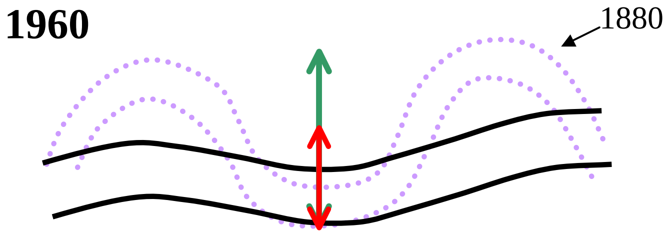
1990b Channel dimension and plan form adjustment process continues as the river builds a new floodplain at a lower elevation within the active channel.

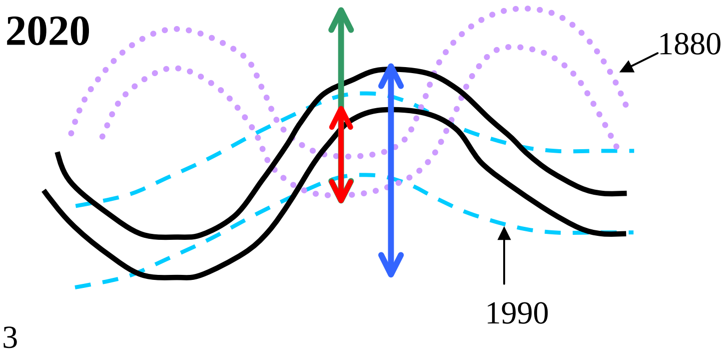


2020a Channel adjustment process is complete.



2020b Channel adjustment process is complete. Channel dimensions and relationship with floodplain are as they existed prior to channelization but at a lower elevation.





Erosion Hazards

Mad River in Waitsfield, Vermont

Much flood damage in Vermont is associated with stream channel instability as opposed to inundation related losses. This is a reflection of Vermont's natural geography and its human landscape consisting of steep, relatively narrow valleys with agricultural land uses, highway infrastructure, private residences and commercial properties located in close proximity to stream channels.

River channels that are undergoing an adjustment process as a result of historic channel management activities or floodplain encroachments oftentimes respond catastrophically during large storm events. Stable, balanced channels, on the other hand, can handle major floods and may experience insignificant changes to dimensions, pattern, and profile.

Historically, landowners and local government have relied on the standards and the flood hazard boundary maps provided by the Federal Emergency Management Agency (FEMA) though the National Flood Insurance Program (NFIP) to determine areas within river corridors susceptible to flood damage. The maps are also used to delineate the allowable (floodway) limits of river corridor encroachments and human land use investments. However, the NFIP maps address only inundation issues by applying a water surface elevation based standard.

Table 1 compares values for floodway widths as delineated under the NFIP with the river corridor widths necessary to accommodate and maintain channel stability. Data was obtained from representative valley locations unconstrained by human encroachments, FEMA Flood Insurance Studies, and hydraulic geometry relations published for Vermont rivers (DEC, 2001) and for North American rivers (Williams, 1986).

Table 1	Drainage area (sq. mi.)	Bankfull channel width (W_{bkf})	Predicted corridor width 6 x (W_{bkf})	Measured corridor width (ft.)	NFIP floodway width (ft.)
Otter Creek	87	95	570	500	840
Third Branch White River	108	106	636	550	550
Mad River	57	77	462	500	100
Middle Branch Williams R.	33	58	348	400	100

For this reason the NFIP maps are often inadequate as an indicator of flood hazards. The "no encroachment" limits defined by the NFIP floodway do not necessarily provide for the river corridor width necessary for the channel to maintain a stable balance with its watershed inputs.

The NFIP standards do not recognize unstable channels which may be undergoing a physical adjustment process. The stream bed may be eroding or it may be actively aggrading due to erosion occurring upstream. The NFIP standards often allow for significant encroachment within floodplain areas and river corridors that may prevent the stream from ever re-establishing its stability.

The NFIP floodway widths for the Otter Creek and Third Branch are consistent with their corridor width needs for maintaining a stable, balanced condition. For other rivers, such as the Mad and Middle Branch, NFIP delineations grossly underestimate the corridor width that is necessary to achieve and maintain stability.

Physical (Geomorphic) Stream Assessment

Physical assessments performed at a watershed level can provide scientifically sound indicators of river channel condition, stage of adjustment process and sensitivity to change. Geomorphic assessment can help answer the following questions:

- What are the physical processes and features that characterize river corridors?
- How have human activities influenced these processes and features over time?
- Which of these physical processes and features are more sensitive to change and how are they likely to change in the future?
- Which of these processes and features present high erosion and flood hazard risks to human investments?

The results of watershed level assessments enable knowledgeable decisions to guide the protection, management, and restoration of stable river corridors. Geomorphic assessments will be essential for fluvial erosion hazards (FEH) mapping to support flood hazard prevention, mitigation and recovery activities. The assessments will be useful in guiding land use, development and infrastructure planning and design. They can play an important role in the protection or restoration of the economic, aesthetic and ecological values of river corridors. Through understanding of the relationships between watershed processes and human investments, we are able to make wise river corridor management decisions.

Watershed assessment projects have been initiated by the VT ANR and its local and regional partners in a growing number of Vermont watersheds.

A VT ANR Stream Geomorphic Assessment Handbook (2004) is available for public distribution. The handbook provides standard protocols for stream and river corridor geomorphic condition and sensitivity assessments.

Hazard Mapping

Information produced using the ANR Protocols can be used to conduct a FEH risk assessment and develop a fluvial erosion hazard map that will more comprehensively define high-hazard streams. The maps will be used to delineate river corridors that should be protected from encroachments thereby preserving channel stability. FEH maps can be applied by local government as an affective flood hazard avoidance and mitigation planning tool.

A fluvial erosion hazard mapping methodology and corridor delineation tools are presently being developed by the VT DEC River Management Program and should be available to the public sometime in 2004.

River Corridor Protection

A stream stability assessment is an essential component of the on-going basin planning efforts by VT ANR in partnership with local governments, landowners, watershed associations and regional planning commissions. Watershed plans, hazard mapping and stream geomorphic assessments will support adoption and implementation of river corridor plans thereby accounting for fluvial erosion hazards and maintaining stability of the fluvial system. The most effective method of implementation may be through establishment of a Fluvial Erosion Hazard Area Zone or Overlay District under the municipal zoning by-laws.

A more direct, but less effective option would be to adopt standard set-backs from streams. The selection of the set-back dimension may be guided by the width of the river corridor delineation.

Rules governing administration of the State Emergency Relief and Assistance Fund (ERAF) by the VT Agency of Administration, which involve the distribution of the emergency assistance to municipalities following disaster events, provide incentives to communities for the adoption and implementation of river corridor protection ordinances. The State Pre-Disaster Mitigation Plan under development will also express prioritization of federal and state funding to local governments which have adopted and implemented comprehensive riparian protection programs.

VT ANR has adopted Floodway Procedures and Technical Guidance to determine floodways that address both inundation and fluvial erosion hazards when reviewing Act 250 applications for projects located within river corridors and floodplains.

VT ANR has begun utilizing data obtained from stream stability assessments in its technical assistance to land-owners, municipalities and governmental agencies and in its review of stream alteration proposals.

Sources of Additional Information

Available on the River Management Program WEB page: www.vtwaterquality.org/rivers.htm

Alternatives for River Corridor Management; VT DEC, 2003.

Options for State Flood Control Policies and a Flood Control Program; VT DEC, 1999.

ANR Stream Geomorphic Assessment Handbook; VT ANR, 2004.

Procedure on ANR Floodway Determinations in Act 250 Proceedings; VT ANR, 2003.

Technical Guidance for Determining Floodway Limits Pursuant to Act 250 Criterion 1(D); VT ANR, 2003.

The Streamside Sentinel; VTDEC, 2001

References

1. Lane, E.W. 1955. The Importance of Fluvial Morphology in Hydraulic Engineering. Proceedings of the American Society of Civil Engineers, Journal of the Hydraulics Division, vol. 81, paper no. 745.
2. Schumm, S.A. 1984. The Fluvial System. John Wiley and Sons, New York.
3. VT ANR. 2004. Stream Geomorphic Assessment Protocol Handbook. www.vtwaterquality.org/rivers/htm
4. VT DEC. 2001._VT Regional Hydraulic Geometry Curves. www.vtwaterquality.org/rivers/htm
5. Williams, G.P. 1986. River Meanders and Channel Size. Journal of Hydrology 88:147-164.