Municipal Guide to Fluvial Erosion Hazard Mitigation

River Management Program
Vermont Agency of Natural Resources

Overview

Individuals and local governments in Vermont face significant economic loss, risks to public safety, and degraded waterways from flooding. While inundation-related flood loss is a significant component of flood disasters, the predominant mode of damage is fluvial (river-related) erosion. Local governments have the mapping, planning, and zoning tools to minimize fluvial erosion hazards, and thus, are the most appropriate entities to implement flood hazard mitigation efforts. The intent of this guide is to provide municipalities with a better understanding of: (a) River processes and fluvial erosion hazards; (b) Options to mitigate fluvial erosion hazards; and, (c) Fluvial erosion hazard assessment and mapping.

This guide also contains five appendices:

- Appendix A: A reference containing funding and technical resources available to help reduce flood-related erosion hazards;
- Appendix B: Frequently Asked Questions and Answers about Fluvial Erosion Hazard Areas;
- Appendix C: The Model Fluvial Erosion Hazard Area Overlay District;
- Appendix D: The Model Fluvial Erosion Hazard Language for Municipal Plans; and,
- Appendix E: A Discussion of River Corridors, FEH Areas, Setbacks, and Buffers,

For a more in-depth technical discussion of FEH Area Development, please refer to the "Vermont Guide to River Corridor Protection" available on the ANR website: http://www.watershedmanagement.vt.gov/rivers.htm

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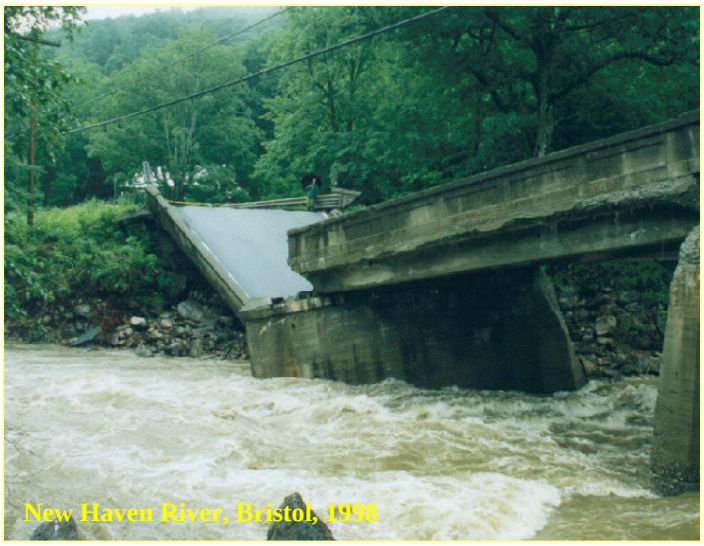
May 10, 2010

I. Understanding Fluvial Erosion Hazards

Fluvial Erosion



Of all the natural hazards experienced in Vermont, flooding is the most frequent, damaging, and costly. Over the last 50 years, flood recovery has cost Vermonters an average of $14 Million a year. During the period of 1995-1998 alone, flood losses in Vermont totaled nearly $57 Million.

While some flood losses are caused by inundation (i.e. waters rise, fill, and damage low-lying structures), most flood losses in Vermont are caused by "fluvial erosion," *Fluvial erosion* is erosion caused by rivers and streams, and can range from gradual bank erosion to catastrophic changes in river channel location and dimension during flood events.

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One reason for the high cost and frequency of damages associated with fluvial erosion is Vermont's geography. Vermont is a mountainous state of narrow valleys and powerful, flashy rivers and streams. The climate is extreme, with intense rainstorms, deep snows, and destructive ice jams.

Vermont's erosion hazard problems are also due to pervasive, human-caused alteration during the past 150 to 200 years of our waterways and landscapes they drain. By end of the 19th century, forests had been cleared from many watersheds, resulting in major changes in watershed hydrology and sediment production. Towns and villages, the centers of commerce, grew on the banks of rivers, whose role in power generation and transportation at first outweighed flood risks. In addition, many rivers were moved and channelized to accommodate development, agriculture, log drives, roads and railways. The legacy of this landscape manipulation is rivers and streams which are unstable and prone to fluvial erosion.

River Fundamentals

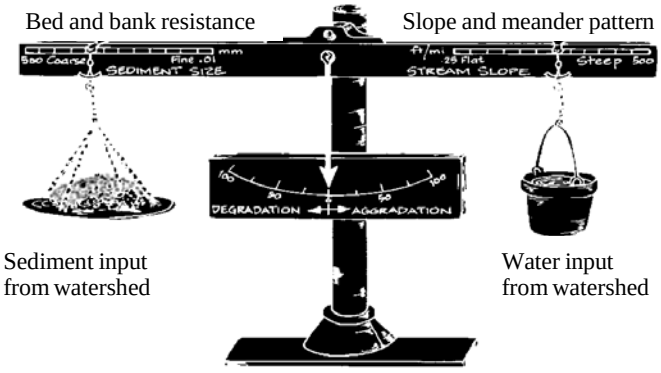

Figure 1. The channel balance (Lane, 1955)

Every river has a probable form, reflecting its complex interaction of many factors, including inputs from its watershed (water, sediment, ice, woody debris) as well as the physiographic setting (geology, soils, vegetation, valley type). Figure 1 illustrates the balance between watershed inputs (water and sediment), channel characteristics (slope and boundary conditions) and the physical response of a channel either by aggradation (sediment deposition), or degradation (scouring of sediment). When all the elements are in balance, a river is said to be in "dynamic equilibrium." A river in equilibrium can carry its load of water, sediment, and debris, even during high flows, without dramatic changes in the width, depth, or length (slope). A dramatic change in any of these elements will tilt the balance and lead to changes (or adjustment) as a river attempts to move back toward an equilibrium condition. This adjustment is often expressed as fluvial erosion, or major changes in channel dimension and location, as a river attempts to regain equilibrium.

One common mode of channel adjustment seen throughout Vermont is the response of a river to straightening. When a river is straightened, the slope of the channel is increased. As a result, the river has more power, and a

greater ability to carry sediment, and begins to incise, eroding the stream bed. The incision leads to a situation where the river becomes disconnected from its floodplain. Without floodplain access, which serves the essential purposes of slowing floodwaters and storing sediment, stream banks are subjected to the full power of flood flows, leading to extensive fluvial erosion. If left alone, the river will eventually erode its banks enough that it can lengthen its channel, regain a more stable slope, and develop a new floodplain at a lower elevation.

The response to erosion-related flood losses historically has been additional channel and floodplain manipulation more dredging, armoring, berming, and straightening in an attempt to limit flood losses through engineering works. These efforts often exacerbate the problem by further limiting floodplain access and encouraging even more encroachment. The destabilized rivers inevitably break through these man-made barriers and inflict even more extensive and costly flood damages. For decades we have been trapped in this cycle of escalating costs and risk to public safety.

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A New Approach to River Management and Hazard Mitigation

Without the expertise and tools to manage fluvial erosion hazards, towns have been helpless to break out of this cycle of repetitive and costly flood damages. In recognition of this problem, the Vermont General Assembly (1997-1998) directed the Agency of Natural Resources (ANR) to identify options for state flood control policy and a state flood control program. The resulting policy is centered on the goal of managing rivers and their corridors to maintain or reestablish the equilibrium condition. To implement this policy, the River Management Program of ANR has developed tools to understand dynamic river systems and identify appropriate management activities. A major component of this effort is the Fluvial Erosion Hazard (FEH) risk assessment and mapping process. FEH maps identify the location and intensity of fluvial erosion hazards, as well as the area needed by a river to maintain equilibrium.

With FEH maps in hand, local governments are now equipped to carry out their responsibility to protect citizens and their property by mitigating (reducing or moderating) fluvial erosion hazards. Fluvial erosion hazard mitigation can lead to enhanced public safety and reduce long-term flood damages. Some fluvial erosion hazard mitigation activities can even lead to additional benefits that are harder to put a price tag on, like healthier rivers, enhanced recreational opportunities, improved aesthetics, and better wildlife habitat.

II. Options for Mitigation

Floods are inevitable, but there are many different approaches that can help reduce flood losses. One common approach in the past has been to intensively manage river channels, by armoring and dredging and through the construction of berms, levees, and floodwalls. In addition to being very costly, these traditional engineering solutions often fail, leading to even more extensive and costly flood damages. This approach has been shown to be unsustainable, and has led to the situation we are in today, trapped in an escalating cycle of increasing flood damages and costly repairs. In addition, this engineering approach has negative impacts on the ecological health of river systems and the wildlife they support.

In recent decades, more environmentally-friendly river restoration techniques (including “natural channel design”) have gained popularity. While these techniques still try to control riverine processes, they attempt to employ a more natural channel configuration. These restoration techniques can be an effective tool for mitigating fluvial erosion hazards by slowing bank erosion or limiting lateral channel migration. The high cost of designing and installing restoration projects limit the usefulness of restoration as a general approach to flood hazard mitigation. In addition, restoration projects are prone to failure, either during high flow events, or because the design may not have been compatible with river processes.

Another approach to mitigate flood losses is to remove or relocate existing structures which are threatened by flood hazards. Removal of structures from hazardous areas can be an effective approach when it is feasible.

FEMA-funded home buyouts, for instance, were a successful mitigation activity after several of Vermont's destructive floods in the 1990's. While removal or relocation is effective, it is generally far too costly to be applied at a broad scale. In addition, many large structures, particularly transportation infrastructure or public facilities, are rarely feasible to remove or relocate. Retrofitting, another engineering approach (which includes elevating and flood proofing) is appropriate for mitigating inundation hazards but is ineffective in addressing fluvial erosion hazards.

In sum, river management alternatives include stabilization practices, retrofit or removal of existing structures, active restoration, and avoidance. The most cost-effective way to mitigate flood hazards is *avoidance*: limiting human investments in river corridors. In addition to preventing future flood losses to structures built in hazardous areas, this approach limits constraints on a river, allowing them over time to achieve a more stable, equilibrium condition.[1]

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Local Land Use Planning and Regulation

Town planning and zoning can play a central role in mitigating flood and erosion hazards through avoidance. Towns have the ability to regulate land use, encouraging development in appropriate areas and preventing investment in hazardous areas. Pre-disaster mitigation (PDM) planning, FEH overlay districts, setbacks or buffers, and effective flood hazard zoning are ways a community can mitigate flood and fluvial erosion hazards.

National Flood Insurance Program (NFIP)

Most communities rely on the standards of the flood hazard boundary maps provided by the Federal Emergency Management Agency (FEMA) through the National Flood Insurance Program (NFIP) to determine areas susceptible to flood damage. While participation in NFIP is one important approach to flood hazard mitigation, NFIP maps are based *only* on inundation hazards, and fail to consider fluvial erosion, the cause of most flood damage in Vermont. NFIP maps treat rivers as static, unchanging systems and are frequently based on surveys completed when a river is deeply incised and has lost access to its floodplain, leading to significant under-representation of flood hazards as the river adjusts.

Worse yet, floodplain management based solely on NFIP participation often results in significant development in floodplains, regardless of the physical state of the stream. In many cases, these encroachments are at risk of damage due to fluvial erosion and rob a stream of the opportunity to ever adjust toward equilibrium. Towns can use their participation in NFIP to minimize encroachment in river corridors. For instance, towns can adopt floodplain regulations more restrictive than the minimum required for participation in NFIP (such activities may also make a town eligible for additional benefits such as discounted flood insurance).[2] While participation in the NFIP is one important element of a town's efforts to mitigate flood hazards, supplemental tools to address the fluvial erosion component of flood damage are clearly needed.

Pre-Disaster Mitigation Planning

The Disaster Mitigation Act of 2000 requires states and local communities to undertake hazard mitigation planning in order to maintain eligibility for disaster recovery and mitigation funding. Vermont's State Hazard Mitigation Plan, as well as the Regional Pre-Disaster Mitigation Plans (developed by Regional Planning Commissions) identify fluvial erosion hazards as a (and in many cases *the most*) significant natural hazard and recommend actions communities can take to mitigate these hazards. For example, the Bennington Regional Hazard Mitigation Plan contains the following language:

> *"... local Hazard Mitigation Plans should support the implementation of a landslide and fluvial geomorphic hazard assessment and mapping program conducted on a watershed basis prior to any mitigation activities which may potentially affect that watershed. These assessments provide value in identifying unstable and hazardous rivers, stream banks and related infrastructure. Such assessments should, whenever possible, be*

[1] For a more extensive discussion of the alternatives mentioned above, please see "Alternatives for River Corridor Management", located at: www.anr.state.vt.us/dec/waterq/rivers/docs/rv_mngmntalternatives.pdf

[2] More information about the NFIP in Vermont is available in Appendix A: Additional Resources.

conducted according to assessment protocols and mapping methodologies published by the VT Department of Environmental Conservation, River Management Program and the VT Geological Survey."

As this passage explains, the FEH mapping and risk assessment process is essential both to identify hazardous areas, and to guide local mitigation activities. Towns with extensive local knowledge and historical perspective are ideally equipped to supplement this broad hazard mapping by identifying specific sites known to be susceptible to erosion and flood damages. State and regional pre-disaster mitigation plans identify FEH mapping as an essential first step toward mitigating flood damage in Vermont, and both the State (through the River Management Program) and many Regional Planning Commissions are committed to supporting towns in undertaking this important task.

Setbacks or Stream Buffers[3]

Setbacks or stream buffers in town zoning and land use regulations, while generally used to protect water quality by filtering surface runoff, can also help mitigate fluvial erosion hazards by preventing development in hazardous areas immediately adjacent to streams.

Fluvial Erosion Hazard Overlay[4]

Fluvial Erosion Hazard overlay districts are one of the best avoidance strategies for fluvial erosion hazard mitigation. An overlay district is an additional zoning requirement placed on a specific geographic area (in this case the FEH zone) without changing the underlying zoning. The degree of protection afforded by a FEH overlay district depends upon the exact wording, but could include limits on structures, land use activities, or even vegetative condition. Limiting development within an overlay district based on the boundaries of a FEH map has two major functions. First, it will prevent development in hazardous areas, reducing costly flood losses and increasing public safety. Second, it will prevent river corridor encroachment which would increase overall fluvial erosion hazards and impede a river's natural tendency to adjust toward a more stable, equilibrium condition.

The FEH risk assessment and mapping process provides a sound scientific and technical basis for determining the boundaries of an FEH overlay district. Because overlay district boundaries do not shift as a river channel changes position, this approach can provide a consistent, easy-to-administer tool for mitigating fluvial erosion hazards over a wide geographic area. In the long term, this option will do the best job of minimizing human/river conflicts and limiting losses caused by fluvial erosion.

Limiting development within an overlay district based on the boundaries of a FEH map has two major functions. First, it will prevent development in hazardous areas, reducing costly flood losses and increasing public safety. Second, it will prevent river corridor encroachment which would increase overall fluvial erosion hazards and impede a river's natural tendency to adjust toward a more stable, equilibrium condition.

River Corridor Protection

Another way a town can mitigate fluvial erosion hazards is by sponsoring or participating in river corridor protection projects. Protecting existing undeveloped floodplains and low-lying riverine wetlands is one of the best ways to limit flood and fluvial erosion losses in the long run. These areas serve the essential functions of spreading, slowing, and storing floodwaters as well as sediment. In addition, protecting undeveloped land along rivers leaves space for lateral adjustment over time, which is necessary to allow the river to achieve a balanced, equilibrium condition. Protection mechanisms include outright purchase, purchase of development rights, and river corridor easement acquisition. The same stream geomorphic assessments which support FEH mapping can also be used to identify these key river corridor areas. Many communities may want to take the additional step of developing a comprehensive River Corridor Management Plan which catalogues strategies and opportunities for corridor

[3] A setback establishes a distance perpendicular to a stream in which certain standards are established regarding land use. A stream buffer is a naturally vegetated area adjacent to a stream which are established or managed to protect the stream from human disturbances. See Appendix E below for a more in depth discussion.

[4] Refer to Appendix C: *Model Fluvial Erosion Hazard Overlay District language.*

protection. The Vermont River Management Program, in partnership with area land trusts, is committed to supporting river corridor protection projects, both technically and financially.

Infrastructure Management: Bridges, Culverts, and Roads[5]

The largest single source of flood losses, both in terms of cost and number of people affected, is damage to transportation infrastructure. Infrastructure damage also represents the greatest public safety hazard. All three flood-related fatalities in Vermont since 1995 were associated with washed out culverts on town highways. Public health and safety is also at risk when access to homes and businesses is unavailable, and when emergency services, power, communications, water supply, and wastewater collection and treatment are disrupted.

Town roads, drainage systems, bridges, and culverts commonly experience major destruction during flash floods. Town roads that suffer extensive damage during flood events are due to:

- Inadequate stormwater drainage,
- Poor embankment stability,
- The degree to which they encroach into stream channels and flood prone areas, making them vulnerable to extensive damage during flood events, and,
- Culverts and bridges that were undersized or improperly aligned or graded. Such stream crossings prevent the transport of sediment carried by floodwaters, become plugged and fail. Discontinuity of sediment transport can cause channel instability adjacent to the structure (both up and downstream), heightening erosion hazards.


Jones Road, Wolcott 1995

Infrastructure management informed by an understanding of the fluvial geomorphology of a river system is an important part of a town's flood and erosion hazard mitigation strategy. The River Management Program has developed a rapid bridge and culvert assessment protocol to assess the geomorphic compatibility of bridges and culverts with ongoing river processes. Bridge and culvert assessments can be completed in conjunction with the stream geomorphic assessments.

Stormwater Management

Development in a watershed increases the amount of impervious surface (pavement, rooftops, etc), which in turn affects the magnitude and timing of runoff. In general, an increase in impervious surface leads to "flashy" (more overland runoff in a shorter amount of time) runoff patterns which can have an affect on flooding, channel stability, and erosion in rivers and streams. While the effect of hydrologic changes due to stormwater is most dramatic in small, heavily developed watersheds, stormwater changes can have an impact on flooding and erosion in many rivers. Refer to Appendix A for additional resources on stormwater impacts and solutions.

[5] See Appendix A for additional information on this topic, including a link to the bridge and culvert assessment protocols.

III. Understanding the Process

The following steps outline the FEH mapping process that enable towns to identify the location and nature of fluvial erosion hazards, understand physical processes in rivers, and develop and implement mitigation measures:

FEH Mapping Process, Step 1: Getting Started

Take action to mitigate fluvial erosion BEFORE the next destructive flood occurs in your community. A good first step is to learn what your town is currently doing to deal with flooding and fluvial erosion. Is your community participating in the NFIP? Has your town adopted any setbacks or stream buffers? Which rivers and streams in your community have a history of flood and erosion problems? Are there other areas with a high potential for fluvial conflict? Gathering this initial information will help focus available resources on the areas where mitigation actions can have the greatest impact.

Many resources exist to support fluvial erosion hazard mapping. The River Management Program is committed to providing both technical and financial support to towns interested in undertaking FEH mapping projects. In addition, the RMP is partnering with many of Vermont's Regional Planning Commissions, partly funded by FEMA Pre-Disaster Mitigation Grants, to support both FEH mapping and implementation.

> Take action to mitigate fluvial erosion BEFORE the next destructive flood occurs in your community.

Step 2: Fluvial Erosion Hazard Mapping

The next step in the fluvial erosion hazard mapping process is to complete Phase 1 and 2 Stream Geomorphic Assessments for streams to be mapped. Geomorphic assessments may have already been completed or be underway in your region. Many towns and organizations in Vermont (including Natural Resource Conservation Districts, Regional Planning Commissions, and local watershed groups) are sponsoring geomorphic assessments that typically are contracted to qualified consultants. All geomorphic assessments are conducted according to VTANR's Stream Geomorphic Assessment Protocols. The assessment data undergo a thorough quality assurance analysis by River Management Program staff and are stored on a web-based Data Management System.

Phase 2 geomorphic assessment data provide the basis for fluvial erosion hazard map development, and must be collected for all portions (called reaches) of a stream to be included in a FEH map. Phase 2 assessments enable FEH mapping by identifying the sensitivity of each reach of a stream. Some streams, due to their setting or physical characteristics, are inherently sensitive, meaning that they are more likely to experience rapid adjustment in channel dimension and location during storm events. In addition, human alterations of the channel or within the watershed can heighten the inherent sensitivity of a stream.

The FEH area is then mapped based on the quality-assured fluvial geomorphic assessment data. It includes the stream and the land adjacent to the stream. At a minimum, it identifies the river meander belt where stream processes can occur to enable the river to re-establish and maintain a stable width, depth, and slope over time[6]. The FEH boundaries also attempts to capture areas most likely to experience damage caused by fluvial erosion.

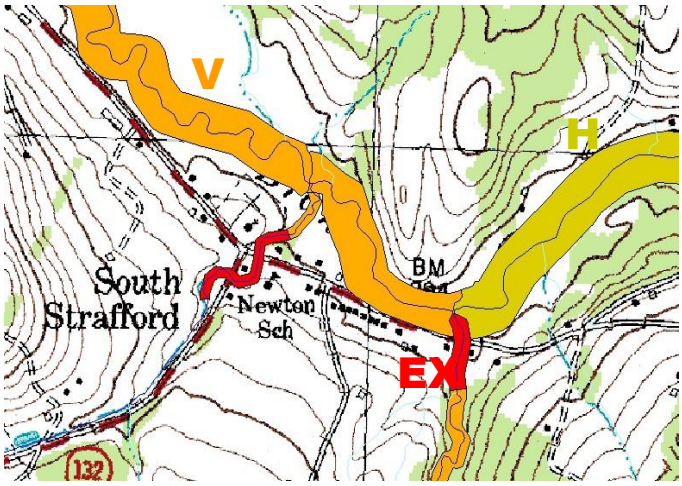

Figure 2. FEH areas based on sensitivity

[6] A detailed description of river corridor delineation and its use in FEH area determinations are found in the Vermont Agency of natural Resource 2008 Guide to River Corridor Protection.

Figure 2, an example of an FEH map, illustrates how the width of a FEH area is scaled to the size of a stream. Smaller tributaries have a narrower FEH area associated with them. The width of an FEH area also depends upon its sensitivity. For example, a steep, headwater stream with a bed made up mostly of boulders is very stable (Very Low sensitivity), limiting its FEH area to the width of the channel. In contrast, a meandering, lowland stream with fine substrate is much more prone to lateral migration and sensitive to disturbance (Very High sensitivity rating). In this case, the FEH area, based on the stream meander belt, would be six to eight channel widths wide.

The River Management Program has developed a computer program (a GIS extension), the Stream Geomorphic Assessment Tool (SGAT), to automate the drawing of FEH areas. Once an initial draft FEH map is produced by SGAT, it undergoes a field verification and quality assurance process where manual adjustments can be made (if necessary) to reflect conditions on the ground, resulting in a final, science-based FEH map.

Step 3: Implementation

A fluvial erosion hazard map provides a town valuable insight into the location and nature of fluvial erosion hazards, and can be used to support many effective mitigation options. FEH area boundaries from the final, science-based FEH map can be translated directly into boundaries of a FEH overlay district, or can be used as a guide for the development of a FEH overlay district that meets the specific needs of a town.

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In some cases, zoning regulations (like a FEH overlay district) that place limits on property use can often be perceived as an infringement on the rights of property owners. It is important to remember that these concerns must be balanced against the net benefit (enhanced public safety, reduced flood damage and reduced public expenditures to recover from flooding) to the community and society as a whole. Courts throughout the nation have been consistently supportive of the right (and in cases, the responsibility) of local governments to restrict the use of some private land (e.g. zoning) in order to benefit the community (and society) as a whole.[7]

The River Management Program is committed to providing continued technical support and financial assistance to towns, after they have completed the FEH mapping process and incorporated it into their planning and zoning. This support and services include map production and maintenance, and technical review of conditional use or map amendment requests which arise as towns administer any FEH-based zoning regulations. The River Management Program is working to develop an array of incentives to reward towns who are taking an active role in mitigating fluvial erosion hazards. For example, the selection process for river corridor grants gives preference to communities pursuing FEH overlay districts or proactive FEH mitigation activities. It is anticipated that other State-administered disaster mitigation and recovery funding will be similarly structured.

It is important to note that undertaking the fluvial erosion hazard mapping and risk assessment process is voluntary; there are no state regulatory strings attached. The decision to adopt and the responsibility to administer any zoning regulations supported by FEH mapping belongs solely to the town. When delineating floodways during Act 250 proceedings, ANR uses a technical process similar to the FEH mapping procedure described in this guide. However, ANR is *only* involved in a regulatory role when a development is subject to Act 250.

In sum, the substantial and escalating financial and social impact of flood damage in Vermont, most of which is caused by fluvial erosion, justifies a concerted mitigation effort. Municipalities are the key entity that can take proactive steps to reverse the costly trend of encroachment, loss, and rebuild. *Avoiding* further encroachment in river corridors through effective zoning and planning is the cornerstone of a new and more sustainable relationship that communities can have with their rivers and streams. Act now to help make your town more resilient for when the next flood occurs.

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[7] Links to more detailed information about this issue ("takings") can be found in the Legal Issues section of Appendix A: Resources.

Appendix A: Additional Resources

River Fundamentals:
Vermont Agency of Natural Resources. 2004. River Corridor Protection and Management Fact Sheet #1. *This document provides an overview of river dynamics, with references to even more detailed information. This document if available online at:*
http://www.watershedmanagement.vt.gov/rivers/docs/Educational%20Resources/rv_RiverCorridorProtectionManagementFactSheet.pdf

National Flood Insurance Program (NFIP):
Federal Emergency Management Agency (FEMA) official NFIP Website:
www.floodsmart.gov

Rob Evans
State National Floodplain Insurance Program Coordinator
103 South Main Street
Waterbury, VT 05671-0408, (802) 241-3759

Vermont Fluvial Erosion Hazard (FEH) Program:
Kari Dolan, Fluvial Erosion Hazard Coordinator 103
South Main Street
Waterbury, VT 05671-0408, (802) 241-3770

Pre-Disaster Mitigation Planning:
Federal Emergency Management Agency (FEMA) Mitigation Division website:
www.fema.gov/fima/

Vermont Emergency Management mitigation information is available on the web at:
www.dps.state.vt.us/vem/mitigation.htm
Or by contacting:
Ray Doherty, State Hazard Mitigation Officer
103 S. Main Street
Waterbury, VT 05671, 800-347-0488 or 802-241-5258, FAX 802-241-5556, E-mail rdoherty@dps.state.vt.us

Regional Planning Commissions (RPC) are heavily involved in pre-disaster mitigation planning in Vermont
A map showing the location of Vermont's RPC's with phone numbers and links to their websites can be found at:
www.vpic.info/rpcs/

Setbacks and Stream Buffers:
In addition to Appendix D below, refer to: *Vermont Agency of Natural Resources. 2005. Riparian Buffers and Corridors Technical Papers, 2005*. This document provides a general overview of the functions of riparian buffers and the supporting science, as well as a bibliography of additional resources. This document is available online at: http://www.watershedmanagement.vt.gov/rivers/docs/Educational%20Resources/rv_RiparianBuffers&CorridorsTechnicalPapers.pdf, or by contacting:
Agency of Natural Resources - Watershed Management Division
1 National Life Drive, Main 2
Montpelier, VT 05620-3522, 802-828-1535

The Vermont League of Cities and Towns, Municipal Assistance Center, Technical Paper #2: Creating an Effective Riparian Buffer Ordinance, April, 2007. This document is available at: www.vlct.org or by contacting:
Milly Archer, (marcer@vlct.org)
Vermont League of Cities and Towns
Municipal Assistance Center
89 Main Street, Suite 4
Montpelier, VT 05602-2948, (800) 649-7915

Infrastructure Management:
The River Management Program's bridge and culvert geomorphic assessment protocols can be found in Appendix G of the Stream Geomorphic Assessment protocols:
http://www.watershedmanagement.vt.gov/rivers/docs/rv_SGAB&CProtocols.pdf

The Vermont Better Backroads Program provides technical and financial support for municipalities to deal with infrastructure management issues. More information available at their website:
http://vtransengineering.vermont.gov/sections/environmental/betterbackroads

Stormwater Management:
Department of Environmental Conservation
Watershed Management Division – Stormwater Program
1 National Life Drive, Main 2
Montpelier, VT 05620-3522, (802) 828-1535
http://www.watershedmanagement.vt.gov/stormwater.htm

NEMO (Nonpoint Education for Municipal Officials) Vermont
Emma Melvin – Water Quality Educator
(802) 656-9110, emelvin@uvm.edu
Education for municipal officials on nonpoint source pollution, including stormwater.

Funding Sources:
Upper Connecticut River Mitigation and Enhancement Fund
Managed by the Vermont Community Fund and the New Hampshire Community Fund
Details at: www.vermontcf.org/guidelines-forms/mef.html
The Vermont Community Foundation
Three Court Street
P.O. Box 30
Middlebury, VT 05753, Phone: 802-388-3355, Fax: 802-388-3398, info@vermontcf.org

Regional Planning Commissions (RPC)
Vermont has 11 RPC's, 7 of which are currently undertaking FEH mapping and mitigation activities in cooperation with the River Management Program, funded FEMA Pre-Disaster Mitigation Planning Grants.
A map showing the location of Vermont's RPC's with phone numbers and links to their websites can be found at:
www.vpic.info/rpcs/

Legal Issues:
A good general discussion of the legal issues relating to floodplain management can be found at the Association of State Floodplain Managers website: www.floods.org
A more detailed treatment of the "takings" issue and how it relates to town zoning can be found at:
www.floods.org/PDF/EdThomas_Courts_GoodNews_FloodplainManagement.pdf

Appendix B: Frequently Asked Questions about Fluvial Erosion Hazard Areas

Q1. What are Fluvial Erosion Hazards?
A1. Fluvial (or river-related) erosion hazards (FEH) refer to major streambed and streambank erosion associated with the often catastrophic physical adjustment of stream channel dimensions (width and depth) and location that can occur during flooding. Fluvial erosion becomes a hazard when the stream channel that is undergoing adjustment due to its instability, threatens public infrastructure, houses, businesses, and other private investments.

Q2. Why Should My Community be Concerned with Fluvial Erosion?
A2. Of all the natural hazards experienced in Vermont, flooding is the most frequent, damaging, and costly, averaging $14 million a year in damages. While some flood losses are caused by inundation (i.e. waters rise, fill, and damage low-lying structures), most flood losses in Vermont are caused by fluvial erosion.

Q3. What is a Fluvial Erosion Hazard Area?
A3. An FEH area includes the stream and the land adjacent to the stream. It identifies the area where stream processes can occur to enable the river to re-establish and maintain stable conditions over time. The area boundaries also attempt to capture the lands most vulnerable to fluvial erosion in the near term and indicate the type, magnitude, and frequency of fluvial adjustments anticipated during flood events. The area can be mapped, and is based on quality-assured fluvial geomorphic assessment data (i.e., data that describe the physical form and process of a riverine system).

Q4. How is a Fluvial Erosion Hazard Map Used?
A4. Since avoidance is the most cost effective approach to mitigating fluvial erosion hazards, in comparison to a retrofit, removal of a structure, or a modification to protect the structure, an FEH overlay district is an important municipal planning tool for limiting encroachment along rivers. The ANR uses FEH maps to help identify floodways under Act 250 Criterion 1(D). An FEH map can also be used to support other flood mitigation opportunities, including the identification of stream and floodplain restoration projects, bridge and culvert replacements, and river corridor protection opportunities. An FEH map and overlay district can be a critical tool enabling the establishment of a sustainable community relationship to the fluvial systems within its community and to permanently protect and enjoy the social, economic and ecological benefits of rivers, streams and their riparian areas.

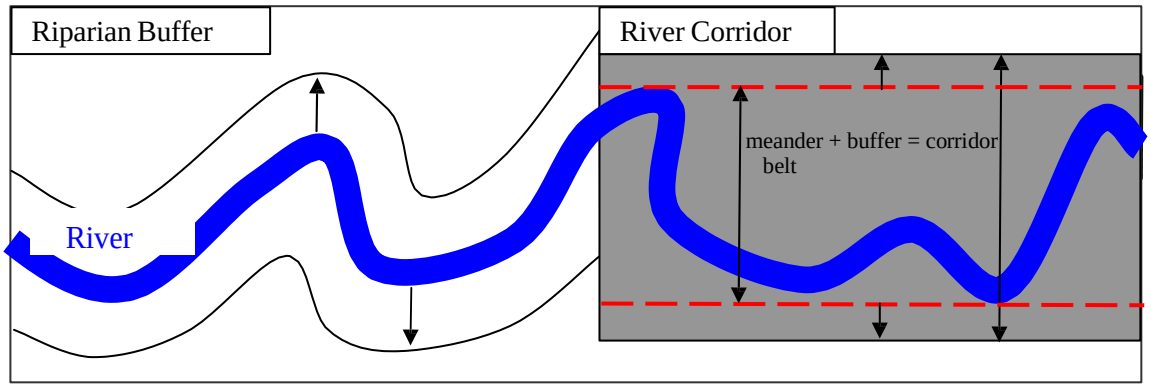
Q5. Why Should a Community Adopt a Fluvial Erosion Hazard (FEH) Zone?
A5. Communities are considering FEH mapping and zoning as a cost-effective strategy to reduce flood damages over time. Keeping development out of the fluvial erosion hazard zone will serve to protect public safety, reduce damages to private property and public infrastructure, and minimize the recovery costs and misery associated with those damages. Moreover, adopting an FEH overlay district provides important sustainable social, economic, water quality, and ecological benefits that come from allowing a river to achieve a physically stable condition over time. The FEH zone enables the stream to re-establish floodplain function that will serve to attenuate flood waters, store sediment, enhance aquatic and riparian habitat functions, reduce the frequency of in-channel management and flood recovery operations, and reduce nutrient pollution during times of flooding.

Q6. What is a Stable Stream?
A6. A stable stream refers to a stream that has evolved to its most probable, least erosive form. It is in balance with its watershed inputs – water, sediment, and woody debris – given a certain depth, slope, and boundary sediment size. The term "equilibrium condition" is often used to describe a naturally stable stream.

Q7. FEH Areas the Same as Buffers?
A7. Not quite. Refer to figure below. FEH areas and buffers both refer to land adjacent to streams. They differ in that FEH areas are specified structural setbacks necessary to accommodate the width and depth dimensions, meander pattern, and slope profile of a stream in its most stable, least erosive, "equilibrium" condition. The width of the FEH Area is minimally based on the stream meander belt, which is derived from fluvial geomorphic (or physical) assessments, and extends to a width necessary to capture the outside bends of the naturally stable river.

A buffer is a specified, vegetated setback from the top of a streambank or top of a slope. A buffer typically assumes that the river is a static, unchanging system, unless it is allowed to "float" (or move) with the river. It can contribute to stream bank stability, depending on its size and vegetation. How effective a buffer may be in enhancing stability is also dependent upon other physical parameters of the stream. For example, a deeply incised channel with high banks tends to be minimally influenced by streambank vegetation. However, the principal benefits of a buffer include providing water quality, habitat function, and shade for keeping water temperatures cool. (The term, "setback" is a specified distance from the top of a riverbank or shoreline, measured perpendicular from the waterway.)

Ideally, the FEH Area incorporates the entire river corridor, which includes both the meander belt and a buffer, providing space for both the channel in its most probable, stable, equilibrium form and sufficient woody vegetation to naturally stabilize the banks. A healthy stream requires the attributes of both: (i) a river corridor to improve stream stability, enhance public safety, reduce flood losses, sustain high quality aquatic and riparian (riverside) habitats, and provide long term water quality benefits and, (ii) a vegetated buffer to provide bank stability, temperature moderation, and additional water quality and habitat function.[8]



Comparing a buffer setback to a river corridor. Adapted from Ohio DNR, Rainwater and Land Development Manual, 2006 Ed., Ch 2. Post Construction Stormwater Management Practices, p. 21.

Q8. Isn't the National Flood Insurance Program (NFIP) Adequate for Protecting Communities from Flooding?
A8. The NFIP is an insurance program, managed by the Federal Emergency Management Agency (FEMA) that is available to property owners in a town enrolled in the program. The program provides property owners with flood insurance in order to receive financial assistance after a flood. Unfortunately, the NFIP maps are elevation-based, delineating *inundation* hazards only. The NFIP maps also represent a static impression of a dynamic system. The maps do not consider *fluvial erosion* hazards or the dynamic nature of river systems due to the physical channel adjustment processes, and thus, provide little guidance to a town or landowners assessing fluvial erosion-related flood risks. Moreover, communities need only adopt FEMA's minimum standards for flood hazard area regulation in order for their residents

[8] Refer to *Appendix E: River Corridors, FEH Areas, Setbacks, and Buffers* in this document and the Vermont Agency of Natural Resource 2008 Guide to River Corridor Protection for more information.

to be eligible to purchase flood insurance. These minimum standards allow for extensive encroachment into areas vulnerable to fluvial erosion and often result in extensive loss of flood plain and riparian lands throughout Vermont.

To assume that the FEH area is mostly captured by the FEMA regulated inundation floodplain area may be dangerous and costly. In fact, the NFIP minimum standards allow for new development into mapped flood hazard areas without regard for the fluvial erosion hazard potential, which exacerbates flood loss, degrades river conditions, and increases costs associated with flood recovery.

During 2008, one-third of all flood insurance claims nationwide were from areas outside of the 100-year floodplain. http://www.floodsmart.gov/floodsmart/pages/flood_facts.jsp. Over 75% of damages in Vermont caused by the five major floods of the 1990s were due to fluvial erosion. FEMA's regulations recognize that the NFIP standards offer minimal protection against inundation and erosion hazards, and they explicitly encourage communities to adopt more protective standards.

Q9. What Flood-Related Costs Does an FEH Zone Mitigate?
A9. There are direct and indirect costs associated with flooding. A town with a designated FEH zone or overlay district minimizes these costs. Direct costs include evacuation, rescue and relief support, emergency preparedness, cleanup, restoring public utilities and facilities, rebuilding public infrastructure, rebuilding homes and businesses that are not insured or are underinsured, restoring destroyed bridges and culverts providing access to homes and property, and providing temporary shelter for flood victims. Indirect costs include interruption of business functions, loss of wages and sales, operation and maintenance of flood control facilities, cost of loans for repairing or replacing damaged investments, and subsidies for flood insurance.

Q10. Does an FEH Zone Affect Property Taxes?
A10. An FEH zone should not have any impact on property taxes. The value and associated property tax base of a property adjacent to a river are already tempered by how susceptible it is to flood damages and whether the property owner is required to carry flood insurance.

Q11. Will the FEH Zone Affect Flood Insurance Rates?
A11. The FEH zone can overlay onto the FEMA National Flood Insurance Rate Maps (FIRM), but it does not affect the FEMA flood maps. Therefore, it will not affect flood insurance rates. It is important to understand that portions of the FEH zone may be outside the mapped high risk inundation zone on the FEMA flood maps. Flood insurance policies do cover damage from flood-related erosion, and thus purchase of flood insurance is highly recommended for structures located in the FEH zone. Moreover, flood insurance premiums for areas outside of the FEMA high risk flood zone are substantially lower.

Q12. Will the FEH Zone affect Homeowner's Insurance rates?
A12. No. The Vermont Department of Insurance verifies that Homeowners Insurance policies do not cover damages from flooding, and therefore, flood risks, such as those illustrated on an NFIP flood insurance rate map or a fluvial erosion hazard map, do not affect homeowner's insurance rates. Damages from flooding and flood-related erosion are insurable under a separate policy for residents in communities that participate in the NFIP.

Q13. How Will the FEH Zone Affect Existing Development that is Within the FEH Area?
A13. The model FEH Area Overlay District should have little if any effect on existing structures. The FEH overlay district has been written in such a way as to recognize that individuals and communities have already made encroachments into river corridors. If a person is interested in modifying an existing structure or adding an accessory structure, the proposed modification should be designed so as to not create or increase the level of the erosion hazard by encroaching further toward the stream.

Q14. How Will an FEH Zone Affect New Development Being Proposed Within the FEH Area?
A14. The model FEH Area Overlay District describes new development under three land use categories: a) permitted, b) conditional, and c) prohibited. Towns have some discretion in describing use restrictions and still remain eligible for support and incentives under the State FEH Program and FEMA pass-through funds. The fundamental goal of the FEH zone is to keep people, their investments, and taxpayer-supported pubic investments out of harm's way. Thus, the FEH zone discourages unwise development within the boundaries of the FEH map. Avoiding the placement of public and private infrastructure within the FEH area, based on the boundaries of the FEH map, will accomplish four objectives: (i) to protect public safety; (ii) to reduce flood losses; (iii) minimize public and private expenditures for flood recovery, and, (iv) to minimize fluvial erosion hazards by affording the stream the space and time it needs to adjust toward and maintain a more stable, equilibrium condition.

Q15. Where Can I Go for More Information About the Vermont Fluvial Erosion Hazard Program and How my Community can Participate?
A15. To find information about the FEH Program and a copy of the Municipal Guide to Fluvial Erosion Hazard Mitigation, including a Model FEH Area Overlay District, visit the VT River Management website: http://www.watershedmanagement.vt.gov/rivers.htm . You can also find useful factsheets, such as:

(i) NFIP & FEH: http://www.watershedmanagement.vt.gov/rivers/docs/rv_NFIPFEHFactSheet.pdf
(ii) Page 3-4 of the Two Rivers/Ottauquechee Regional Commission Fact Sheet entitled, "Using Freeboard and Setbacks to Reduce Damage: http://www.trorc.org/pdf/wq/floodsheet4_web.pdf

Appendix C: Model Fluvial Erosion Hazard Area Overlay District

(A) STATEMENT OF PURPOSE

The purposes of the Fluvial Erosion Hazard (FEH) Area Overlay District are to:

1. Implement related goals, policies, objectives, and recommendations of the current municipal plan, hazard mitigation plan, and supporting river corridor management plans.
2. Avoid and minimize the loss of life and property, the disruption of commerce, the impairment of the tax base, and the extraordinary public expenditures that result from flood-related erosion.
3. Avoid and minimize the undue adverse effect on public services and facilities, including roads, bridges, culverts, and emergency services, during and after fluvial erosion events.
4. Protect mapped fluvial erosion hazard areas that are highly subject to erosion due to naturally occurring stream channel migration and adjustment.
5. Limit new development within fluvial erosion hazard areas to protect public safety and to minimize property loss and damage due to fluvial erosion.
6. Allow rivers and streams to maintain or re-establish their natural equilibrium, thereby avoid the need for costly and environmentally degrading stream channelization and bank stabilization measures.

(B)APPLICABILITY

1. The Fluvial Erosion Hazard Overlay District is depicted on the most current Fluvial Erosion Hazard (FEH) maps on file at the municipal office. These maps, prepared for the Town of in accordance with state-accepted stream geomorphic assessment and mapping protocols, are hereby adopted by reference and declared to be part of these regulations. If uncertainty exists with respect to the location of a district boundary, the location shall be determined by the Administrative Officer [Zoning Administrator] from the map, in consultation with the Vermont River Management Program.
2. New development may be allowed within the FEH District if, based on a review by the River Management Program (RMP) of the Vermont Agency of Natural Resources, it is determined that the proposed development is not located or should not be located within the FEH area due to an error in delineating the FEH boundary. A letter of determination from the RMP shall constitute proof of that adjustment.
3. The Fluvial Erosion Hazard (FEH) District shall be superimposed over any other zoning districts. Where there is a conflict between the underlying zoning district and the FEH District, the more restrictive regulation shall apply.

(C) DISTRICT DEFINITIONS

For the purposes of this overlay district, the following definitions shall apply:

Accessory Structure: A structure which is: 1) detached from and clearly incidental and subordinate to the principal use of or structure on a lot, 2) located on the same lot as the principal structure or use, and 3) clearly and customarily related to the principal structure or use. For residential uses these include, but may not be limited to garages, garden and tool sheds, playhouses, and in-ground swimming pools which are incidental to the residential use of the premises and not operated for gain.

Channel: The area that contains continuously or periodic flowing water that is confined by banks and a streambed.

Channel (Bankfull) Width: The width of a stream channel when flowing at a bankfull discharge – the water stage that first overtops the natural banks. This flow occurs, on average, about once every one to two years.

Development: Any human-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations, or storage of equipment or materials.

Fill: Any placed material that changes the natural grade, increases elevation, or diminishes the flood storage capacity at the site.

Fluvial Erosion Hazard Area: Stream channels and the area adjacent to stream channels subject to fluvial erosion processes or other channel adjustments as delineated on the current Fluvial Erosion Hazards Area Map(s) for the municipality.

Improvement: Any repairs, reconstruction, enhancements, or additions to a structure. For the purpose of administering flood hazard area regulations, this definition excludes the improvement of a structure to comply with existing municipal or state health, sanitary, or safety code specifications which are solely necessary to assure safe living conditions.

Top of Bank: The vertical point along a stream bank where an abrupt change in slope is evident. For streams in wider valleys it is the point where the stream is generally able to overflow the banks and enter the floodplain. For steep and narrow valleys, it will generally be the same as the top of slope.

(D) PERMITTED USES

The following uses, if so allowed within the underlying zoning district, are allowed in the FEH Area Overlay District upon meeting the District Development Standards in Section (H) and District Application Requirements in Section (I) and upon receiving the issuance of a zoning permit. The zoning permit shall be issued following receipt of written comments from the State, which will be incorporated under associated conditions of approval or reasons for denial.

1. Improvements to an existing structure that cumulatively do not increase the structural footprint by more than 500 square feet, and do not decrease the structure's existing setback distance from the stream channel, as measured horizontally from the nearest point of the structure to the top of bank.
2. Accessory structures to an existing principal structure that:
   (a) In total have a combined footprint area of no more than 500 square feet.
   (b) At a minimum, do not decrease the setback distance from the stream channel established by existing structures on the lot.
   (c) Are located within 50 feet of the existing primary building.
3. Recreational vehicles.

(E) PROHIBITED USES

The following uses and activities are specifically prohibited within the FEH Area Overlay District:

1. All new development, including new structures, dwellings, septic systems, and other infrastructure and utilities, except as specified under Sections (D), (F), and (G).
2. Junk or salvage yards.
3. The storage of floatable materials, chemicals, fertilizers, pesticides, explosives, flammable liquids, and other toxic or hazardous materials.
4. Fill, except as necessary to elevate existing structures above base flood elevation.

(F) CONDITIONAL USE REVIEW

The following uses, if allowed within the underlying zoning district, are also allowed in the FEH Area Overlay District subject to conditional use review and approval by the [Board of Adjustment/Development Review Board] prior to the issuance of a zoning permit:

1. Fill, only to elevate existing structures above base flood elevation as required within Special Flood Hazard Areas or as otherwise authorized by the State.

2. Infrastructure and utility improvements necessary to serve existing structures and uses that do not decrease the structure's existing setback distance from the stream channel, as measured horizontally from the nearest point of the structure to the top of bank.
3. At-grade parking for existing structures and uses.
4. New or replacement storage tanks for existing structures.
5. Grading and excavation.
6. Stream crossings and stream channel management activities, as authorized by the State.
7. Improvements to existing driveways, roads, bridges and culverts.
8. Public facilities which are functionally dependent upon their proximity to water.
9. New driveways and access roads.
10. Improvements to existing flood and stormwater management facilities, as authorized by the State.
11. Outdoor recreation facilities, excluding structures.

(G) EXEMPT ACTIVITIES

The following activities are exempt from the requirements of this overlay district:

1. The removal of a structure of building in whole or in part.
2. Normal maintenance and repair of existing utilities and infrastructure (e.g., water and wastewater systems, driveways, roads, bridges and culverts, and stormwater drainage systems).
3. Normal maintenance and repair of existing structures that involve no additions, expansions or relocations.
4. Lawns and gardens located outside of any required riparian buffer area, excluding grading, fill, terracing and structures.
5. Forestry (silviculture) activities, excluding structures, conducted in accordance with Vermont Department of Forests, Parks and Recreation Accepted Management Practices (AMPs).
6. Agricultural activities conducted in accordance with Vermont Agency of Agriculture, Food, and Markets Accepted Agricultural Practices (AAPs); however, no new or expanded farm structures, or manure, fertilizer or pesticide storage structures shall be constructed within the FEH overlay district, in accordance with Section 4.07 the AAPs. Prior to the construction of any farm structure, written notification, including a sketch of the proposed structure and any required setbacks, must be filed with the municipality.
7. Power generation, transmission and telecommunications facilities regulated by the Vermont Public Service Board under 30 V.S.A. §248.

(H) DISTRICT DEVELOPMENT STANDARDS

1. All development within this district, unless specifically exempt from regulation under Section (G) above, shall meet the following standards, as applicable to the proposed use or activity:
   (a) Improvements to existing structures shall not decrease the distance between the structure and the stream channel as measured horizontally from the top of bank.
   (b) Fill is allowed within this district only as required to elevate existing structures above base flood elevation, or as otherwise authorized by the State in association with stream crossings, channel management activities, or other allowed activities within this District. Fill shall not decrease the existing distance between the structure and the top of bank.
   (c) New stream crossings by transportation and utility corridors shall be allowed only if it is determined by the Development Review Board that a new crossing is justified for routing, public or emergency vehicle access, and that there are no other viable routes or locations for a crossing outside the FEH Overlay District or within an existing utility or road crossing. Stream crossings shall be located and designed in accordance with state guidelines, and to minimize fluvial erosion and flooding hazards both up- and downstream from the crossing area.
   (d) Bridges and culverts shall be located, designed, sized, and regularly inspected and maintained to minimize erosion as well as flooding hazards.
   (e) In this District all utility lines, including water, sewer, power, telephone, and cable lines, shall be buried.
   (f) Recreational vehicles shall be on the site for fewer than 180 consecutive days and be fully licensed and ready for highway use.

2. In addition to other requirements for conditional uses under Section (F) of these regulations, the Board, in consultation with the RMP, must find that conditional uses within this district shall not:
   (a) Increase the susceptibility of the property or other properties to fluvial erosion damage.
   (b) Increase the potential for materials to be swept into the stream channel or onto other land and cause damage from fluvial erosion.

(I) APPLICATION REQUIREMENTS

1. In addition to other required application materials and fees, applications for development within the FEH Overlay District shall include the following:
   (a) A project description, including the type and purpose of development, a description of alternatives considered to proposed development, including alternate locations on site, especially outside of the Fluvial Erosion Hazard Area, and why it must be located within, rather than outside of, the FEH Overlay District.
   (b) A general location map showing the location of the proposed development in relation to existing development, the FEH District boundaries, and the nearest public road.
   (c) A site plan of the property, drawn to scale, that shows all water bodies, the district boundaries; pre- and post-development grades and drainage; the location of existing structures, infrastructure, utilities and rights-of-way; and the shortest horizontal distance of the proposed development to the center line (or measured to the top of the nearest bank if not possible to measure to the center line) of any of the mapped stream channels.
   (d) A state project review sheet that identifies required state permits and approvals.
   (e) Identification of the horizontal distance from the centerline of the nearest public road to the center line (or top of nearest bank if not possible to measure to the center line) of any stream.
   (f) Other information as deemed necessary to determine project conformance with district requirements. This may include an impact or other assessment of the site, prepared by a qualified professional.

2. The Administrative Officer [Zoning Administrator] shall refer complete applications for all development proposed within the FEH Overlay District to the RMP at the Vermont Agency of Natural Resources. No municipal permit or approval shall be issued until comments have been received from the State, or 30 days have elapsed from the date of referral, whichever is sooner.

(J) DECISIONS

Agency comments shall be incorporated as applicable in municipal findings and determinations. The [Board of Adjustment/Development Review Board] may recess the proceedings on any application pending submission of additional information.

(K) CERTIFICATES OF OCCUPANCY

Prior to the issuance of a certificate of occupancy by the Administrative Officer [Zoning Administrator] for development within this district, the applicant shall document that development has been completed as approved by the municipality, and that all applicable municipal and state permits have been obtained.

(L) WARNING AND DISCLAIMER OF LIABILITY

This Overlay District does not imply that land outside of the areas covered by this District will be free from fluvial erosion hazards. This regulation shall not create liability on the part of the Town of , or any municipal official or employee thereof, for any flood or erosion damages that result from reliance on this regulation, or any administrative decision lawfully made hereunder.

Appendix D: Model Fluvial Erosion Hazard (FEH) Language for Municipal Plans

Vermont cities and towns are authorized to adopt comprehensive plans and land use regulations pursuant to the Vermont Planning and Development Act (24 V.S.A. Chapter 117). Municipal plans typically refer to the need to protect surface waters to benefit water quality. For municipalities participating in the National Flood Insurance Program, their plans typically include policy statements for regulating development within Federal Emergency Management Agency (FEMA)-mapped special flood hazard areas. Thus, generally speaking, municipal plans already provide the foundation for flood hazard mitigation planning and regulation that address both inundation and fluvial erosion-related impacts.

Nonetheless, municipal plans can and should be strengthened, since most municipal plans pre-date the geomorphic assessment, FEH mapping, and river corridor planning projects recently completed or underway. Updating the municipal plan will serve to:

- Identify and describe fluvial erosion hazards in the water resources and land use sections;
- Describe by reference or as addenda pre-disaster mitigation plans, fluvial erosion hazards maps, and river corridor plans. Although pre-disaster mitigation and river corridor plans may be "supporting plans" to the municipal plan (pertaining to 24 V.S.A. §4432), they serve as the basis for local regulation and should be formally adopted under the municipal plan.

<u>Model Language Pertaining to Fluvial Erosion Hazards for Municipal Plan</u>

Resource Protection Section:

Description: Areas subject to fluvial erosion hazards, from gradual stream bank erosion to catastrophic channel enlargement, bank failure, and change in course, due to naturally occurring stream channel adjustments, have been identified and mapped in accordance with accepted state fluvial geomorphic assessment and mapping protocols for the following streams:

Policy: Avoid development and other encroachments – including fill, dredging, new structures, parking areas, infrastructure and utilities, and unnecessary public investments, within mapped fluvial erosion hazard areas. Allow only forestry, agriculture, passive recreation, functionally dependent facilities, limited improvements to existing structures and facilities, and state-recommended channel management activities within these areas, subject to municipal review and approval.

Recommendations:

- Conduct stream geomorphic assessments and prepare fluvial erosion hazard area maps and river corridor management plans for all major rivers, streams, tributaries;
- Prepare and adopt fluvial erosion hazard area regulations – as an overlay district or stream setback requirements – under updated land use regulations.

Land Use Element: The purposes of the Fluvial Erosion Hazard Overlay District are to:

- Implement related goals and objectives of the adopted municipal plan,
- Support pre-disaster mitigation and river corridor management plans;
- Protect mapped river and stream corridors that are subject to erosion due to naturally occurring stream channel migration and adjustment;
- Limit new development within fluvial erosion hazard zones to minimize erosion hazards, protect public safety and welfare, and minimize property damage and loss; and,
- Allow rivers and streams the area they need to maintain or re-establish their natural "equilibrium" (or stability) and thereby avoid the need for costly, and long-term environmentally damaging stream channelization and bank stabilization measures.

Appendix E: River Corridors, FEH Areas, Setbacks, and Buffers

Riparian (or riverside) buffers, setbacks, fluvial erosion hazard (FEH) areas, and river corridors are important land use planning tools for communities to work with in maintaining a wide variety of river and floodplain functions. Towns that take steps to integrate these tools into local zoning ordinances, over the long-term term, will realize the economic, societal, and ecological benefits that healthy, stable river systems can provide.

Although river corridors, FEH areas, setbacks, and buffers are used to achieve different objectives, those objectives are complementary. In fact, river corridors integrate the river meander belt (the basis for FEH areas) and vegetated buffers, and represent an ideal avoidance tool for towns zoning and site-specific river conservation and management planning. River corridor protection[9] will help to achieve the multiple objectives and minimize the limitations cited below.

FEH Areas:

Definition: Specified structural setbacks necessary to accommodate the width and depth dimensions, meander pattern, and slope profile of a stream in its most stable, least erosive condition. Allowing for naturally stable stream geometry is essential for protecting water quality, providing habitat, and mitigating flooded-related hazards. The width of the FEH Area is minimally based on the stream meander belt, which is derived from fluvial geomorphic (or physical) assessments, and extends to a width necessary to capture the outside bends of the naturally stable river. Ideally, the FEH Area incorporates the entire river corridor, which includes both the meander belt and a buffer, providing space for both the channel in its most probable, stable form and sufficient woody vegetation to naturally stabilize the banks.

Benefits: As stated above in Appendix B, FEH areas discourages unwise development within the boundaries of the zone which will: (1) protect public safety; (2) reduce flood losses; (3) minimize public and private expenditures for flood recovery, and, (4) minimize fluvial erosion hazards by affording the stream the space and time it needs to adjust toward and maintain a more stable, equilibrium condition.

Limitations: FEH areas, based solely on the meander belt requirements of the stream, may not be wide enough to provide a sufficient vegetated buffer, particularly where the stream is running near the boundary of the FEH area.

Setbacks:

Definition: Specified distances from a waterway, measured perpendicular from the waterway. Rules, standards, or zoning requirements determine conditions or acceptable land uses allowed within the setback.

Benefits: Objectives are to provide water quality, habitat, and aesthetic benefits. The extent of protection is a function of the width of the setback. Setbacks can range from restricting development in the floodplain to a fixed setback width, such as 100 feet from the stream. Easy to administer. Ideally suited for steeper, stable tributaries that have a low probability of lateral adjustment over time.

Limitations: The distance of the setback may or may not be based on geomorphic assessment. Additionally, standard setbacks assume that the river is static. Rivers are not and will never be static in the landscape. Rivers adjust both laterally and vertically, in part due to natural processes, but largely due to generations of watershed, floodplain, and channel alterations. Assuming that rivers are static will invariably lead to more human conflict with river systems and subsequently greater public and private costs to address those conflicts.

Buffers:

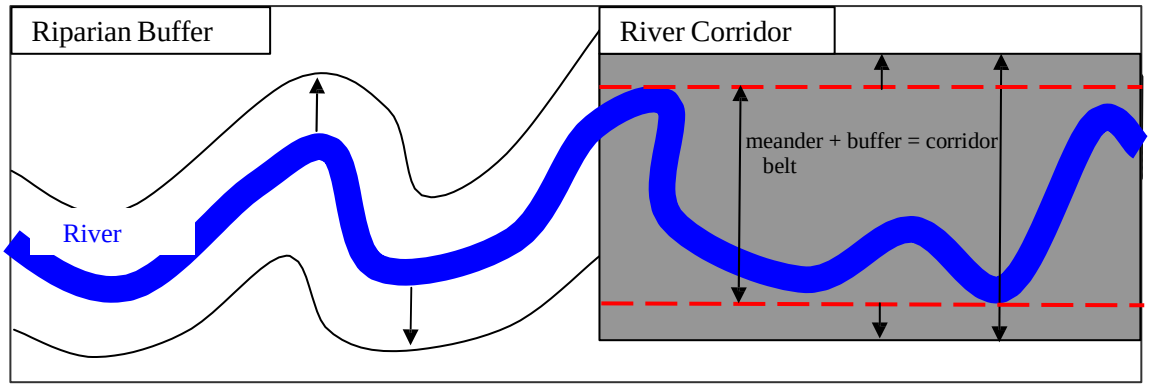
Definition: Specified permanently vegetated, undisturbed setbacks as measured from the top off bank/top of slope which contribute to stream bank stability, while providing other water quality, habitat, and aesthetic functions. Buffers are also established at a fixed distance and measured perpendicular to that waterway.

[9] A detailed description of river corridor delineation and small stream setbacks and their use in FEH area determinations are found in the Vermont Agency of natural Resource 2008 Guide to River Corridor Protection.

Benefits: As described in the League of Cities and Towns' *Technical Paper #2: Creating an Effective Riparian Buffer Ordinance*, vegetated buffers protect water quality from filtering surface runoff and provide shade. Buffers also provide habitat, and their vegetative root depth and density contribute to streambank stability. For smaller, steeper streams, a standard vegetated buffer zone of a specified size would be adequate for stream corridor protection (including FEH mitigation).

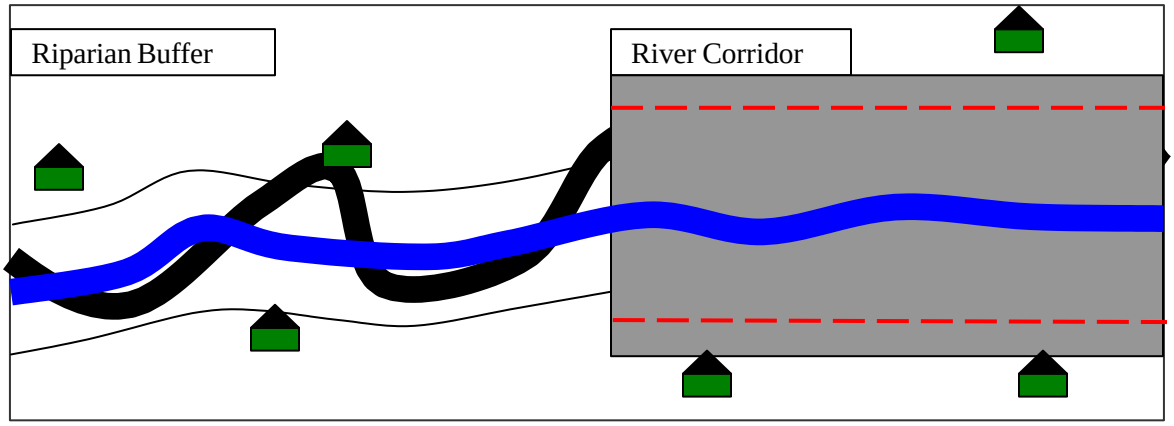
Limitations: As with standard setbacks, the buffer width may or may not be based on geomorphic assessment. (The Act 250 buffer guidance, for example, recommends larger buffers on unstable streams and smaller buffers on stable.) Moreover, establishing buffers on low gradient sensitive streams, in the absence of protected river corridors, may make it virtually impossible to re-establish or maintain healthy, stable riverine conditions. As soon as development encroaches within the corridor, albeit outside the buffer, the stream no longer has access to its meander belt, the lateral extent of room and floodplain access it needs to maintain stable conditions and attenuate floods. Similar to standard setbacks, buffers typically assume that rivers are static. (Buffers that "float" with the stream are an exception.) Buffers could then become another investment to protect using channelization practices such as berms and rock riprap.

The illustrations below explain the difference between a riparian buffers, meander belts, and river corridor. In the first figure, the left portion of the diagram shows only a buffer setback adjacent to a meandering stream, while the right portion shows a river corridor on the same stream. The "Buffer Only" section assumes that the river will remain static. The "River Corridor" section allows for channel adjustment within the corridor.



Comparing a buffer setback to a river corridor. Adapted from Ohio DNR, Rainwater and Land Development Manual, 2006 Ed., Ch 2. Post Construction Stormwater Management Practices, p. 21.

The next figure shows a stream that has been straightened with development legally built up to the buffer on the left and the river corridor on the right. The straightened stream is unstable, characterized with a steepened slope and loss of flood plain access. The houses along the "Buffer Only" section are vulnerable to catastrophic channel adjustment that can occur during flooding. The "River Corridor Section accommodates channel adjustment and minimizes property damage from flooding.



A straightened river shadowed by the equilibrium meander geometry to which the stream will likely evolve. This figure illustrates the expected degree of conflict with encroachments (green houses) and future loss of vegetated buffer as the channel evolves with only a buffer setback (left) and with a protected corridor (right).