

River Corridor Management in a Flood Resilient Vermont:

An approach to reducing vulnerability in a flood-prone state.

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This white paper has been prepared to frame the public discourse on river corridor management that has occurred in the months following Tropical Storm Irene and make a set of recommendations for resolving current policy issues. On the two ends of the post-Irene debate are those who want to manage all streams, primarily by dredging, and those who want all the stream channelization to stop. Most people take a position in the middle, but have been active in the debate with no less passion.

Where and why do we channelize rivers? What are the true costs and impacts of the dredging completed after floods? Do we have planning, regulatory and funding options to better balance our public and private riparian land uses? What are the public interests in natural river and floodplain functions and values?

This paper will attempt to answer these questions; but first, what is channelization and how does it change the way a river works? *Channelization involves confining or straightening the course of a river and stopping its movement to protect private investments and public infrastructure.* Straightening increases the river slope and velocity and hence the river's power to dislodge and move sediment and debris. Channelization typically involves bank armoring and the excavation of bed sediments and debris, resulting in a smoother river bed and banks. These actions reduce roughness and increase depth within the channel, and therefore cause the river to have even more power and capacity to transport sediment during floods. Channelized rivers are more erosive. Rivers with greater power to erode are more hazardous; provide less habitat and fewer water quality benefits.

A more complete analysis of channelization benefits and costs is followed by a short history of the practice in Vermont, including an account of post-Irene channel dredging, berming, and armoring. These accounts are made to support a common understanding of the issues surrounding current river corridor and floodplain policy and attempt to set the stage for a set of proposals to enhance river corridor management and flood resiliency.

Benefits and Costs of Channelization

River channelization is done to protect private investments and public infrastructure that have been placed in river corridors and floodplains. Wise investments are weighed against their costs, and therefore, riparian land uses must be weighed in consideration of the costs of channelization:

1. *There is an ongoing but necessary cost to maintaining channelized conditions.* Rivers made more powerful through channelization are at work eroding the river bed in places, depositing in others, regaining sinuosity, and basically undoing the straightening, berming and armoring that was done to the stream channel. These forces may be slowed down, but not stopped; and there is a cost to regularly maintain grade control structures and bank armoring. For instance, bank armoring in streams and rivers ranges from \$40-100 per linear foot. If this maintenance is deferred, investments nearby become increasingly vulnerable to loss or damage; i.e., the heightened power of a channelized river is often unleashed catastrophically during floods. As was seen following the Irene flood, state and federal agencies and municipalities paid millions of dollars to rechannelize previously straightened river beds to try and protect nearby investments.

2. *River channelization practices often increase the vulnerability of downstream people and property.* River segments, maintained as straightened channels, send flows, sediment, and debris to river segments downstream. In the reach where the channelization ends, channel slope and depth decrease, and river power and sediment transport capacity also decrease. These downstream reaches are where the sediment will deposit, resulting in channel migration and sometimes avulsions (i.e., new channels are cut). Any private or public property located in the valley bottom below a channelized reach is more vulnerable to flood damage than before the channelization took place. If these property owners respond by straightening, berming, and armoring their river reach, the damage and vulnerability perpetuate to an even greater degree downstream—as will the cost of flood recovery.
3. *Channelized reaches are typically disconnected from their floodplains and the beneficial functions they serve.* When floods occur, flows confined to a deepened river channel do not spill onto adjacent floodplains. The loss of floodplain function has a several costs. In addition to serving as pressure relief valves, shunting off the flows and debris heading downstream, floodplains are the place where fine sediment and nutrients settle out of the floodwater. When suspended sediment and nutrients are not captured and stored on floodplains they travel great distances downstream to quieter waters. Millions of dollars are spent annually working to reduce nutrient loads to receiving waters, like Lake Champlain, where algae blooms create social, economic, and environmental damage.
4. *Channelized rivers are kept from meandering, which is an essential habitat-forming process.* The loss of meandering means a loss of river features like deep pools on outside bends and the rocky steps and riffles in between. It is these undulations of the river bed in combination with woody debris, bank undercuts, and overhanging vegetation that are the habitat for fish and other aquatic life in rivers. Straightened rivers are like fire hoses that scour beds and debris and offer little cover, feeding, and reproductive habitats. Straight, deepened channels do not have the same hydrology (i.e., high flows are higher and low flows are lower) and they have lost important hydrologic connections to adjacent wetland and floodplain habitats. These riparian habitats harbor some of the highest biodiversity in Vermont and may be significantly altered or lost (at immeasurable cost) when a river is channelized.

The benefits of channelization are more commonly understood. Villages, which were settled long ago around rivers for mill power, could not still exist without ongoing channel relocation and maintenance. Some steep narrow valleys could not be traversed with roads, bridges, and culverts without channelization practices and their maintenance. Tropical Storm Irene demonstrated, however, that during great floods even well-armored embankments will be lost. For some damaged roads and crossings, a benefit/cost analysis may be prudent to understand whether the infrastructure should be moved or remain where it is currently located. In many cases, it is likely that moving a road will be financially and environmentally cost prohibitive, and a commitment to stream channelization is the most reasonable alternative.

A central question surrounds the piecemeal encroachment on rivers and floodplains that will increase the need for channelization, raise damages and maintenance costs, and make people that much more vulnerable when large floods occur. Open river corridors and functioning floodplains are assets that society cannot afford to squander. They function to absorb the power of floodwater and thereby protect existing structural assets, that would otherwise be more vulnerable to flood and fluvial erosion.

Recent History and Social Context of Dredging and Channelization in Vermont

Stream geomorphic data collected in Vermont indicate that a third to half of all stream and river miles have been channelized and re-channelized since European settlement. In recent decades, large scale channel dredging has occurred in the aftermath of every large flood event. Prior to Tropical Storm Irene, the most recent statewide and regional floods occurred in 1973 and 1976, respectively. After these floods, some Vermont rivers were channelized along much of their length. This period was also the height of the commercial gravel mining in Vermont where hundreds of thousands of cubic yards were extracted from certain rivers. In 1987, Vermont passed legislation prohibiting the commercial mining of river gravel. Since then, people talk about the need for gravel removal and re-dredging channelized rivers to avoid flood inundation and erosion hazards. This may benefit a localized area during a minor flood, but almost always fails to mitigate damage during a major flood.

During the last decade, watershed groups, conservation districts, and municipalities have participated in stream geomorphic assessments and river corridor planning exercises. These plans promoted an understanding of river dynamics and the role of different human stressors, including channelization, in causing instability, erosion hazards, and environmental impacts. Over 120 assessments have been completed involving 165 communities, and resulting in statewide data that tells a compelling story in which three-fourths of Vermont rivers are more erosive, in part, due to channelization and the loss of floodplain function. These insights have led to new river plans and policies which, in effect, have shifted public funding and assistance from channelization practices to the protection of river corridors that accommodate stream meandering. Just like the re-dredging of rivers, policies that curtailed channelization during minor flood years; have been largely ignored following a major flood.

Post Irene Channelization

Irene resulted in flows that exceeded the 100 year flood stage in many streams and rivers. Many steep, confined headwater streams were severely downcut by the flood water. This channel incision undermined valley side slopes, and landslides brought hundreds of thousands of cubic yards of sediment and debris into the channels. These materials were transported downstream to low gradient, unconfined reaches, which subsequently filled in, often to the brim, sending flows overland to cut new channels elsewhere on the valley floor. During Irene, channel down-cutting, rerouting of stream flows, erosion, and inundation damaged or destroyed thousands upon thousands of roadsides, bridges, culverts, backyards, houses, trailers, utilities, and commercial structures.

The phases of post-Irene emergency and recovery work are as follows:

- Phase 1 – Emergency dredging was conducted by VTrans, municipalities and private individuals to open up clogged channels and extract gravel to rebuild roads and fill scour holes in fields. ANR river work guidance and verbal authorizations were largely ignored, in part, due to statutory provisions allowing municipalities to clear river channels during emergencies, and the urgency to rebuild at any cost. ANR River Management Engineers had some success moderating channelization during this period by technically advising Vtrans and municipalities against counterproductive activities that were increasing vulnerability to infrastructure repairs. This phase lasted for 4-5 weeks after the flood.



Dredging to open up Roaring Branch in Bennington

- Phase 2 – ANR exerted more authority by issuing river work guidance which included a notice that written authorization was required. Compliance checks were made by Environmental Enforcement Officers and Game Wardens. These actions were largely successful in slowing things down and getting “bad actors” out of the rivers. The lack of control and oversight of channelization conducted by municipalities and private individuals led to work that went beyond the scope of that which was authorized, and in some locations led to environmental damage and river conditions where vulnerability to future hazards is of concern. The lack of time and money was a severe limiting factor in getting full municipal cooperation, but as time passed, more and more towns began seeking technical assistance and adhered to their guidance of the State river engineers.

As in other great Vermont floods, the conflict between human investments and river dynamics was severely felt by valley bottom communities during Irene. Since most damage occurred to roads and homes dependent on historically straightened reaches, it is reasonable to suggest that most of the post-Irene river work has been done to reclaim lands by dredging and redirecting streams that had been impacted by channelization before.

The rivers affected by Tropical Storm Irene will continue to adjust (i.e., erode, fill in, and move around) for several years to come. The impact of floods over the next several years may be compounded and felt as “after-shocks” in the riverside communities of southern Vermont. Roads, bridges, homes, and businesses within river corridors and floodplains will remain vulnerable from Irene, because when landscape-scale events, such as Irene, put great quantities of earthen material into motion, they will stay in motion for some time to come.

Rivers that are channelized always evolve back over time. When large floods break up the bank and bed armaments that have been placed to maintain a channelized reach, the evolution process takes off at a more rapid pace and may last for years. These river adjustments, in more developed places, will require work to keep people safe and protect homes, businesses, and transportation networks as the after-effects of Irene and future floods play out. Equally important will be the task of removing encroachments where possible and protecting corridors to make room for the newly forming meanders and floodplains that will naturally attenuate the flows, sediment and debris of future floods.

***Flood Resiliency**, as a goal, may be supported with policies to: manage streams, rivers, and floodplains toward dynamic equilibrium conditions; curtail new encroachments within river corridors; remove existing investments where possible, and with compensation if necessary; and conduct river management to protect existing investments in a manner that causes the least harm to others and the environment.*

Current River Management Issues

Channelization practices are perpetuated after floods because there is no broad agreement that river corridor and floodplain functions are essential for mitigating the hazards to existing private investments and public infrastructure. Towns or the State may rebuild or permit new riparian developments, which then create an obligation to allow channelization practices which are contrary to the public interests (10 V.S.A Secs.1023 and 1421). Stream alteration permits “shall be” issued to landowners when requested to protect existing investments; if, at the same time, those alterations do not add to the significant damages (i.e., social, economic and environmental costs) that accrue after major floods. Our understanding of rivers as systems makes these requirements and standards increasingly difficult to reconcile, yet to deny such permits and channelization practices to protect structures, would be to condemn those structures.

Even before Irene, there was a growing awareness that river corridor and floodplain management laws and regulations were not keeping pace with river science. Act 110 was a significant step for the State to recognize the importance of river corridors and require the provision of maps and incentives to municipalities for the protection of river corridors. These statutory changes, however, do not bridge the gap between state authority over stream alterations and the municipal authority over land uses and emergency stream work which can make or break efforts to mitigate flood and fluvial erosion hazards.

The key river corridor management issues may be summarized as follows:

- Without more explicit ANR statutory authority and resources to maintain river channels in developed river corridors using environmentally sound practices, Vermont roads and villages will become increasingly vulnerable; because towns have very limited resources or expertise to conservatively manage river systems on their own, especially during emergencies and in the aftermath of major floods.
- Without better incentives to landowners and towns and state administrative orders to limit development in river corridors and floodplains; and more explicit State authority and resources to reduce channelization practices in less developed corridors and floodplains, Vermont rivers will become more unstable, natural resource assets will diminish, and the costs of structurally protecting our road and villages will increase.

Enhancements to Vermont's River Corridor Management programs could resolve these issues. Flood resiliency initiatives will depend, in part, on the State's ability to manage risk and reduce the vulnerabilities to human and natural communities that have been created by historic land use and channelization.

River Corridor Management as part of a Flood Resiliency Initiative

Proposals for enhancing river corridor management to address issues brought to the forefront by flood recovery in the wake of Tropical Storm Irene and advance the State's flood resiliency initiatives include:

1. *State planning program enhancements to identify and protect the wetlands, meander areas, and floodplains within river corridors that serve as critical natural resource and flood attenuation assets.* Given the increasing cost of flood recovery, the state has an interest in protecting river corridors upstream and downstream of development areas. River corridors upstream are important as storage for flood flows, sediment, and debris which may otherwise create hazards to downstream developed areas. Downstream river corridors are also important attenuation assets because they receive the higher velocity flows and debris shunted through upstream developed areas where the river has been confined and constrained.

This river corridor planning would involve stakeholders in a process of deciding how and where different river channel, river corridor, and floodplain management approaches will be used. State sponsored planning involving local constituencies would help manage expectations and identify alternatives for resolving conflicts between human investments and river dynamics, especially in the aftermath of major floods. Without such planning, river management engineers and their local partners will find it increasingly difficult to reconcile the interests of those wishing to protect existing private property, with those who are interested in natural resource values and/or hazard mitigation for the community as a whole.

The State could form strong partnerships with municipalities by creating a "resilient community scoring system" for river corridor protection and flood hazard mitigation. This system would allow municipalities to become eligible for state river corridor funding. A community that develops and makes progress

with implementing enhanced hazard mitigation plans, particularly with the adoption of river corridor and floodplain protections, would receive scores that could make them increasingly eligible for state capital and river management funds, emergency relief funds, and increase their competitive edge for other state and federal grants.

2. *State regulatory program enhancements; managing stream alterations in consideration of river corridors, floodplains, and flood emergency situations*, to include more explicit:
 - a. allowance for channel management in certain high risk, densely developed river corridors where the public interest (i.e., as defined in the statutory criteria of 10 V.S.A. §1023) is achieved in recognition of the risks to people, property, and the environment;
 - b. limitations on stream alterations and berming in river corridors that have been protected for the purpose of attenuating flows, sediment, and debris in highly sensitive river reaches; and
 - c. state authority and capacity to manage stream alterations during both emergency and post-flood recovery periods.

3. *State funding program enhancements for river corridor management*. The State and municipalities will decrease their flood recovery costs if they find ways to make greater investment in hazard mitigation projects that reduce the vulnerability of private investments and public infrastructure. The State could better leverage environmentally sound channel management using easements to protect river corridors and floodplains in critical areas upstream and downstream of high risk reaches. State river corridor management funds would not replace, but would serve to augment, existing State and Federal programs already in place to manage or restore rivers (e.g., this fund would not replace the VTrans existing operations and maintenance money used to work in rivers, or FHA or FEMA public assistance funds used to replace flood-damaged infrastructure.)

Some of these proposals to enhance river corridor management may require or benefit from statutory changes and new sources of State funding. Each proposal, however, could be achieved at some level with administrative changes only.

Conclusion

Tropical Storm Irene damaged many of our rivers; some will take years to recover. Vermont must recognize several realities that have come out of this disaster. First, there are villages, roads, and other critical infrastructure right next to rivers. Perhaps many of these investments were made in places that have turned out to be not so wise. But while they are there, the State must recognize that particular river reaches have to be managed to protect our homes and public infrastructure. Also going forward, the State must acknowledge that rivers move, meander, and create a tremendous amount of power, sediment, and debris during floods—floods that will become more frequent because of climate change. Therefore, it is essential that the State works with landowners and communities to do easements and create other incentives that make room for the river. The State must find ways to help communities pull back from and protect critical river corridors and floodplains upstream and downstream of our villages, so that the rivers can spill out and release their flood energy and materials in these less-developed areas. Only if the State takes the lead in creating a new river management paradigm for the 21st century will we be resilient from flooding, with safe and sustainable communities, cleaner water, and better river and riparian habitats.