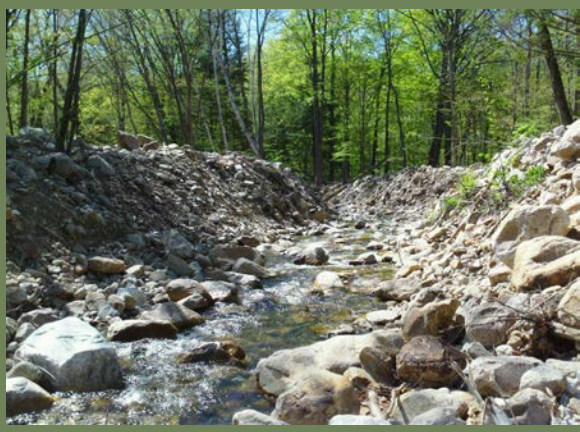
Lake Champlain Committee





Lessons from the FLOODS

A publication of the Lake Champlain Committee, a membership-supported, bi-state non-profit organization working for Lake Champlain's health and accessibility since 1963.

Produced and Published by

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LCC thanks its partners for assistance and collaboration on "Lessons from the Floods." Photo by Lori Fisher.

Front Cover photos: *Cold River road washout (upper left), Home in floodplain (lower left), Former Vermont Tubbs furniture factory (center), Homer Stone Brook berm (upper right) and Vegetated Lake Champlain lakeshore (lower right).*

Back Cover photos: *Flooded Otter Creek Wetlands (far left), Middletown Springs bridge (second from left), Consider Bardwell Farm (second from right) and Lakeshore staircase in Burlington (far right).*

Executive Summary

Lake Champlain Committee

Lessons from the Floods

In the spring of 2011, Lake Champlain rose to 103.27 feet – the highest the lake has been since records have been kept. High waters and waves battered the lake shoreline. Then, on August 28, 2011 Tropical Storm Irene slammed into the Champlain Valley. Up to 11 inches of rain fell; rivers swelled and flooded; homes, roads and bridges were wiped away. These, and more recent flood events, are forcing Vermont communities to reexamine their relationships with water. In preparing this publication, the Lake Champlain Committee (LCC) sought examples from communities that are particularly vulnerable to flooding, and those that are trying to better prepare for it. As we toured the region and listened to stories of flood damage several themes resurfaced. We have identified eight "lessons" to be considered by communities seeking to increase their resilience to and recovery from future flood events. Seven are focused on river systems and one addresses how to protect lakeshore properties.

#1 Berms create a false sense of security

Throughout the region residents have relied on artificial berms to protect them from floodwaters, resulting in a false sense of security. Irene dispelled that notion. In some instances berms exacerbated flood damage. Once breached, they trapped rivers on the populated side of the berm rather than keeping the river channel away from property. We examine examples from Forestdale, Cuttingsville and Wallingford where berms were breached leading to loss of property. Some communities learned from these failures, abandoning berms to increase the river's access to its floodplains. In other locations berms remain, increasing the risk of future floods to homes and property.

#2 Wide floodplains store water and help minimize flood damage

The story of the Otter Creek in Rutland and Middlebury offers a stark reminder of the importance of river access to floodplains to ameliorate flooding. During Irene, the Otter Creek in Rutland swelled, reaching a peak discharge of 15,700 cubic feet of water per second (cfs). Thirty miles downstream at Middlebury the maximum peak discharge was only 6,180 cfs. Between Middlebury and Rutland a vast complex of wetlands held the flood waters, slowly releasing them over time. While the Otter Creek Wetlands are massive, there are many smaller projects that increased the capacity of floodplains to store water, limiting downstream damage. We look at examples from West Pawlet, Castleton, Forestdale and Mt. Holly.

#3 Floodplain development puts entire communities at risk

Homes and other structures built in floodplains represent not just a risk for property owners, but for the community at large. A house that tears away during a flood becomes a dangerous projectile hurtling down the river. In Danby, Bridgewater, and Woodford, houses swept into rivers obstructed downstream bridges, in some cases also wiping the bridges out. FEMA flood risk maps, upon which the National Flood Insurance Program (NFIP) is based, have limitations. The maps do not accommodate the increased frequency and severity of storms that has been measured in the Northeast; they do not account for watershed development that may increase the amount of water reaching a stream during a storm; and they do not include site specific hazards like channel migration potential or erosion hazard. Communities need to take steps to limit development in flood hazard areas.

#4 Advanced preparation pays off

Irene's damage was widespread and devastating, but flood related damage occurs regularly in Vermont. Some communities have been adept at avoiding damage by securing federal grants to increase resiliency. Federal funds can cover up to 75 percent of total project costs for culvert or bridge replacements that have failed in the past. Preparing the grants can be time consuming and difficult, but pays off in the end. We profile projects and individuals in Pawlet, Warren and Middletown Springs where advance preparation helped communities and individuals minimize flood damage during Irene.

#5 When emergency measures create future dangers, go back and fix them

During emergencies road crews and rescue personnel act quickly to protect individuals and communities. Some necessary actions taken in haste can lead to long-term problems. Within the recovery period from emergencies it is important to take stock and go back to repair problems created in the initial chaos of disaster response. We look at how emergency actions to protect the Rutland City water supply led to problems which were corrected later.

#6 Consider whether you really need to rebuild everything

In the rush to rebuild after a flood, communities can miss opportunities to increase resilience by moving roads and buildings out of floodplains. In many places, alternate routes could get vehicles and people to the same location with only a marginal increase in travel time. We present examples from Lincoln and Shrewsbury.

#7 Constructed ponds can pose a hazard

Many rural properties are dotted with constructed ponds built as watering holes for livestock or the aesthetic enjoyment of the homeowner. Ponds are a great amenity, but when built too close to a river they present a hazard.

#8 What makes a lakeshore protection project successful

There are a myriad of ways – both good and bad – to control erosion along lakeshores. Not all are successful. A tour along Appletree Bay in Burlington provides some examples of projects that work and those that did not. Pre-planning and professional design help are key.

A berm along the right bank of Gully Brook (far left of photo) was removed prior to the storm providing the river additional flood storage capacity. Photo by Lori Fisher.

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Irene left widespread destruction in its path, destroying roads and bridges like these along Route 100. Photo by Mansfield Heliflight.

Introduction

The floods of 2011 brought widespread devastation to the Champlain Basin. A large snow pack and extensive spring rains swelled Lake Champlain to a record height of 103.27 feet above sea level. The lake reached flood stage (100 feet) on April 13 and stayed above that level for 67 days. Lakeside homes, roads and buildings were inundated and battered by wind-driven waves. Then on August 28 Tropical Storm Irene slammed into Vermont. Many areas received over seven inches of rain. Floodwater and debris poured through our rivers affecting 225 municipalities. Roads, bridges and homes were swept away. Six people lost their lives.

During Irene, intense flooding occurred in at least 10 of Vermont's 17 major river basins. Some river locations appeared unscathed, while others underwent catastrophic channel enlargement, debris deposition and relocation. Wild trout in two surveyed streams were reduced by 33 to 58 percent compared to pre-flood levels. Stream channel adjustments wrought by Irene were exacerbated by decades of human attempts to confine streams within artificially stabilized and maintained stream courses.

"We are doomed to experience these events again."
– Barry Cahoon, former river engineer

The chaotic nature of disaster response in the days and months following Irene led to extensive stream alteration, often without appropriate oversight. Activities included large scale removal of streambed material and downed wood, berming to raise streambank elevations, and the straightening of stream channels. At least 77 miles of streams experienced major degradation of aquatic habitat resulting from post-flood channel alteration activities. In many cases the alterations increased future flood vulnerability, former lead state river engineer Barry Cahoon to observe, "We are doomed to experience these events again."

Examples of stream alterations that increase vulnerability are common; examples of projects that minimize future flooding are not. Looking at instances of both 'good' and 'bad' examples of river corridor management can provide useful guidance. We spoke with regional planners and river engineers to identify projects. We then distilled these conversations into seven themes that provide lessons for municipal planners, road commissioners and others tasked with preparing for or responding to flooding disasters. With each lesson we present concrete examples of how it has played out in Vermont.

Flooded Otter Creek Wetlands in 2011. Photo by Mansfield Heliflight.

These lessons are not meant to provide a comprehensive understanding of river geomorphology. There are many useful guides on that topic in the state. For further information on this topic we recommend contacting the Rivers' Program within the Vermont Agency of Natural Resources, or your local regional planning commission.

To address lake flooding, we found a typical area of developed lakeshore and sought examples of management practices that protect properties from flooding without exacerbating damage to neighbors. Such examples are rare, but they do exist.

Climate change models predict that our part of the country will become wetter still. Precipitation records for Burlington International Airport extend back to 1884. During that time, the amount of rainfall, measured on a rolling ten-year average, has steadily increased – we now get about five more inches of precipitation each year than we did at the end of the 19th century. It shouldn't be a surprise if we continue to see more floods in the years to come. We hope this document offers guidance and inspiration for community projects that increase our region's resilience to future floods.

Landslide damage from Tropical Storm Irene along the Cold River. Photo by Lori Fisher.

Lesson #1 Berms create a false sense of security

Irene's rains swelled the Neshobe River on August 28, 2011. The river raced down from the western face of the Green Mountains before reaching the relatively level ground around the hamlet of Forestdale. There a six-foot high berm of stone had been built to constrain the river and protect homes and businesses in the hamlet. It was not enough.

Where the river channel narrowed, Irene's waters crashed through the berm. Portions of the Vermont Tubbs furniture factory were destroyed. The river carved two-foot ditches on either side of Newton Road, and gouged channels through corn fields, tearing away topsoil and leaving only gravel deposits. Basements filled with river water.

The Neshobe River flows from the west face of the Green Mountains before passing through Forestdale.

Berms like the one in Forestdale give communities a false sense of security. Prior to Irene, residents believed berms protected them from floodwaters. Yet berms often exacerbated Irene's flood damage. Once breached they trapped rivers on the populated side of the berm rather than keeping floodwaters away from property. In a few cases, communities learned from these failures and abandoned the berms, increasing a river's access to its floodplain. Unfortunately in other locations berms remain, increasing the risk of future floods to homes and property.

The former Vermont Tubbs furniture factory in Forestdale. The factory was destroyed when the Neshobe River escaped a berm on the left bank. Photo by Lori Fisher.

Evening Song Farm sits in the picturesque valley of the Mill River along Route 103 in Cuttingsville. The Mill River has been bermed at least three times to protect Route 103 and the railroad tracks that traverse the valley. During Irene, the river breached the berm upstream of Evening Song Farm. The main current of the Mill River roared across the farm's vegetable field, destroying the year's crop and leaving a boulder-strewn expanse. Farm owner Kara Fitzgerald told Vermont Public Radio, "the river just eminent-domained my farm."

For river scientists, the destruction at Evening Song Farm was not a complete surprise. A river corridor management plan prepared prior to Irene noted how the river had been straightened and forced against the valley wall. The plan recommended removing the berm.

In some places, Irene's flooding inspired local residents to allow a river to access its floodplain rather than rebuilding destroyed berms. That's what happened in Forestdale. A farmer offered conservation easements on two parcels, totaling 14 acres. The river can now spread across his farm fields instead of being confined to the stream channel by a berm. This also happened along Freeman Brook in Mt. Holly. The river escaped its berms during Irene, threatening Freeman Brook Road, one of the main routes between Mt. Holly and Shrewsbury. Instead of rebuilding the berm, the town decided to let the river reclaim its floodplain. Now the floodplain can store more water during future floods.

The Mill River (right) broke through its berm wiping out prime agricultural land at Evening Song Farm. Photos by Mike Winslow.

Other communities insist on rebuilding berms. Homer Stone Brook in Wallingford drops over 1,200 feet along its approximate two-mile length from its origins at Little Rock Pond on Green Mountain to its confluence with the Otter Creek. In the last one-sixth of that route, the brook's course flattens. Here berms were constructed to prevent the brook from fanning out to homes and railroad tracks that cross it downstream.

Like the Mill River, Homer Stone Brook escaped from its berms during Irene, carving a new route to the Otter Creek. Once outside the berm, the river could no longer access its old channel. The new channel paralleled the railroad tracks for a few hundred feet before cutting underneath them to a new outlet. The railroad incurred hundreds of thousands of dollars in damage as a result. Despite this failure, the berms were reconstructed and heightened after the storm, and the river channel was narrowed even more.

In East Middlebury the river also left its course, streaming down Route 125. Fortunately, damage was minor, even though there are nine houses located in known erosion hazard zone and eight in the 100-year floodplain. The state has been working with FEMA seeking federal funding approval for a hazard mitigation project to restore floodplain in this area.

Homer Stone Brook drops over 1,200 feet between Little Rock Pond and the Otter Creek.

Berms along Homer Stone Brook gave local residents a sense they were safe from the water, but the brook escaped the berms during Irene. Photo by Mike Winslow.

Rivers naturally meander across valley bottoms, particularly as streams reach more level ground at the toe of mountain slopes, as in Forestdale, Wallingford and East Middlebury. When we place roads, railroad and homes in these locations, conflicts with rivers ensue. Berms to protect structures and roads offer false security. Berms can only temporarily constrain the river to a narrow channel in such locations. They are always at risk of failing in the next inevitable flood.

Lesson #2 Wide floodplains store water and help minimize flood damage

During Irene, the Otter Creek in Rutland swelled reaching a peak discharge of 15,700 cubic feet of water per second (cfs) and flood waters caused tremendous damage. Thirty miles downstream Middlebury is situated on the Otter Creek, but conditions there were quite different. The maximum peak discharge was only 6,180 cfs. Within four days the storm flow in Rutland had returned to normal, but in Middlebury flows did not even peak until then. Middlebury flows remained high for another two weeks and there was no flood damage! The dramatic differences in the Otter Creek at these two points can be explained by the presence of a vast, 9,000-acre complex of wetlands, in the floodplain of the Otter Creek between Middlebury and Rutland. The wetlands stored flood waters, slowly releasing them over time so that Middlebury and points downstream never experienced the full force of the flood. Businesses remained open and life went on as usual.

A vast complex of wetlands sits along the Otter Creek between Rutland and Middlebury. The wetlands protected downstream communities by soaking up immense amounts of water during Irene. Photo by VTDEC.

The story of the Otter Creek in Rutland and Middlebury provides a stark reminder about the importance of wetlands and floodplain access to ameliorate flooding. Throughout our region wetlands have been lost to dredging, filling and development. Their loss exacerbates flood damage during Irene-like events. While the Otter Creek Wetlands are massive, there are many smaller places where floodplains could store more water. Restoring wetlands and increasing river access to floodplains will limit downstream flood damages.

Berm removal allowed access to extensive floodplains (top of photo) along the Indian River in West Pawlet at the Consider Bardwell Farm. Photo by Mike Winslow.

The Consider Bardwell Farm in West Pawlet, Vermont provides an example. The farm produces cheeses from goat milk collected on premises and Jersey cow milk from their neighbors. The current owners, Angela Miller and Russell Glover, began the operation in 2000, though the eponymous Consider Bardwell started Vermont's first cheese-making co-op on the site in 1864. To promote healthy grasslands, grazing goats rotate between pastures spread over 300 acres. The Boston Globe called the farm's Mettowee cheese "the creamiest chevre ever", and its Manchester was included in Wine Spectator's list of 100 great cheeses.

Berm removal increases river access to floodplains

In 2007, farm owners used conservation grants to remove 2,000 feet of a berm that constrained the Indian River to a narrow channel between the Delaware and Hudson Rail Trail and an old corn field, now pasture. Berm removal allowed the river access to extensive flood storage to the west. Areas downstream saw little damage during Irene – clearly the added flood storage helped.

Berm removal also helped avoid flood damage along Gully Brook in Castleton. Gully Brook parallels Birdseye Road near its confluence with the Castleton River just south of Route 4A. At the point where the land around the brook levels off, the stream was bermed in 1959 to protect adjacent cropland and pasture. Berming increased the velocity of the water and its ability to carry sediment which the stream then deposited as it reached the Castleton River. Sediment accumulation led to regular flooding of the Traverse Farm barnyard and cattle pasture. The farmer found himself regularly removing sediment from the stream. Scientists from the Agency of Natural Resources suggested taking out the upstream berm to allow the river to deposit sediment where the berm was, thus reducing the risk of downstream barnyard flooding and the need to dredge the channel. The berm came out in 2004 and indeed land and property damage during Irene was minimal, as predicted. Property owner Bob Traverse told the Poultney-Mettowee Conservation District, “Gully Brook did as well as any stream in Vermont” during Irene.

Examples like these inspired other communities not to rebuild berms destroyed following Irene. In Forestdale a berm washed out. The Neshobe River flooded basements, carved two-foot deep ditches along the road, and scoured farm fields. Rather than trying to recreate the berm, 14 acres of farmland were placed in river corridor easement, increasing the opportunities for the Neshobe to store water during subsequent floods. Freeman Brook in Mt. Holly wiped out portions of a berm along Freeman Brook Road. The town has opted not to rebuild so this stream will also have access to additional floodplain storage during future storms.

A berm along the right bank of Gully Brook (far left of photo) was removed prior to the storm providing the river additional flood storage capacity. The white rocks in this photo were deposited in the restored floodplain during Irene. Photo by Lori Fisher.

The massive scale of the Otter Creek Wetlands makes the lesson about the importance of floodplain storage more dramatic. Yet, there are numerous small-scale examples of berm removal and other stream channel and wetland restoration efforts intended to restore access to floodplains that also demonstrate the importance of maintaining and enhancing floodplain storage.

Lesson #3 Floodplain development puts entire communities at risk

Homes and other structures built in floodplains represent not just a risk for property owners, but also for the community at large. A house that tears away during a flood becomes a dangerous projectile hurtling down the river. In at least three instances, in Danby, Bridgewater and Woodford, houses that swept into rivers obstructed downstream bridges, in some cases wiping them out.

In Bridgewater Corners a house washed up against the bridge, blocking water and threatening to wipe out the bridge. Photo by Mansfield Heliflight.

At one point during Irene, the Mill Brook House in Danby, once owned by the author Pearl S. Buck, collapsed into the adjacent river. The house was built somewhere between the early 1700 and 1800s according to unnamed town officials cited by the Manchester Journal. When it slipped into the water the Danby-Mt. Tabor Historical Society, which had purchased the house just 10 months earlier, lost its collection along with the building. Once in the river the Mill Brook House got caught against the Main Street Bridge, creating a dam. The river threatened to jump its channel, flow down Main Street and inundate homes in nearby low-lying areas. The bridge and an attached water main would have been lost. Fortunately, Thomas Fuller Jr., operating an excavator in the area, was alert to the potential danger. He acted quickly to smash the house, using the bucket of his machine to push through the roof and walls. The river then carried the debris underneath the bridge.

In Woodford, George Davis told the Bennington Banner what happened to the house he had built on the Roaring Branch.

> *"That house just picked up off the foundation, just like it was when it sat there, and started floating down the river. It went down around and rested against the bridge. It was fully intact. We could have gotten a crane, picked it up, and brought it back home, literally. But, then a big, huge tree came down the river with a whole root system on it. Huge thing. It hit that house and just smashed it to pieces. Literally, pieces."*

A 10-foot section of the bridge collapsed, isolating Woodford for 11 days and severing a water main that served Bennington. In Bridgewater, four houses were completely destroyed and many more were damaged. One destroyed building slammed into a bridge on Hale Hollow Road just off Route 100A. Water flowing around the destroyed home overran and seriously damaged the bridge.

National Flood Insurance Maps don't offer sufficient protection

Many communities get in trouble because they rely solely upon the National Flood Insurance Program (NFIP) to assess flood risk. NFIP offers flood insurance to homeowners, renters and business owners if their community participates in the program. Participating communities agree to adopt and enforce ordinances that meet or exceed FEMA requirements to reduce risk of flooding. However NFIP is an insurance program, and should not be substituted for community-specific planning around flood risk.

Structures built in floodplains like this one along the Danby-Pawlet Road are a risk for homeowners and the community at large. Floods can threaten to wash them downstream into bridges or other structures. Photo by Lori Fisher.

FEMA flood risk maps, upon which the NFIP program is based, have limitations. The maps are not flexible, especially in the face of the increased frequency and severity of storms that have been measured in the Northeast. The maps also do not account for watershed development that can increase surface runoff and the amount of water reaching a stream during a storm. FEMA floodplain maps do not include site-specific hazards like erosion and streambank failure from channel migration. Small feeder streams are typically omitted in such maps, but can be a significant source of local flooding. Channel debris can increase water levels above risk areas identified in flood maps. Rather than solely relying on standard FEMA maps, communities should consult with the Vermont Rivers Program and their local regional planning commission to address specific local conditions. The following steps will help any community prepare for floods (adapted from materials prepared by the Two Rivers Ottauquechee Regional Commission):

- Develop a Pre-Disaster Mitigation Plan that includes steps to reduce losses in the event of flooding and explicitly considers limitations of FEMA flood maps;
- Create mutual aid agreements for flood warnings and response; and
- Improve local regulations to limit impervious cover, elevate buildings and require flood-proofing well above base flood elevations (freeboard requirements), and increase setbacks from stream channels with a high risk of erosion.

Vermont municipalities aren't required to prepare comprehensive plans, but most do. Following Irene, state requirements for local and regional plans changed – all plans adopted after July 1, 2014, must include a new "flood resilience plan" that:

- Identifies flood hazard and fluvial erosion hazard areas, based on river corridor maps provided by the state;
- Designates those areas to be protected, including floodplains, river corridors, land adjacent to streams, wetlands, and upland forests, to reduce the risk of flood damage to infrastructure and improved property; and
- Recommends policies and strategies to protect those areas identified and designated for protection, and to mitigate risks to public safety, critical infrastructure, historic structures and municipal investments.

A FEMA-approved local hazard mitigation plan should be incorporated in a community's flood resilience plan. Hazard mitigation planning and proposed mitigation measures must be coordinated with the community's other long-term planning programs and flood preparation efforts. The Vermont Agency of Natural Resources has developed a community web portal "Flood Ready" that allows communities to check their flood vulnerability.

Living by a gurgling brook may have great appeal, but homes built too close to water represent a danger to the owners and to the community. Municipalities must take steps to limit new development, and outdoor storage of materials in known flood hazard areas. Any new structures in hazard areas need to be securely anchored and designed to withstand periodic flooding. Existing structures should be retrofitted to the extent feasible so that they do not become a hazard. Towns need to enact strong regulations that limit new floodplain development to minimize such risks.

Lesson #4 Advance preparation pays off

Pawlet sits in the southeastern corner of Rutland County surrounded by the Taconic Mountains. The Mettowee River rolls through town as do many smaller feeder streams. Given the topography, the rivers and the six inches of rain Irene brought to the area, it is surprising how little damage the town suffered. Much of the credit for the town's resilience in the face of Irene belongs to Clarence Decker.

Clarence Decker wrote many grants that increased flood resiliency in the Town of Pawlet. As a result, the town was better prepared than many others when Irene hit. Photo by Lori Fisher.

Decker, who died in 2016, was an officer in the town for over 35 years. He served as road commissioner and on the select board. Decker was also a prodigious grant writer. Over the years he had a hand in securing funding for at least half a dozen projects that increased the region's flood resilience. Here are a few examples:

- A $7,000 grant from Vermont Better Back Roads in 2008 led to appropriately-sized culverts and better ditching practices along Kelly Brook. Shortly after completion and well prior to Irene, the project paid for itself when heavy rains hit the area washing out similar nearby roads.
- In 2010 Pawlet got a Federal Emergency Management Agency (FEMA) grant to increase the size of a culvert on Route 153.
- Decker's work also helped nearby Castleton where he served as road commissioner. He got the town a FEMA Hazard Mitigation Grant for upgrades along Birdseye Road to divert runoff away from the road and reduce erosion. As a result, flooding in 2003 left the road unscathed, requiring only some ditch repair.

Grant writing is not easy. Decker estimated FEMA grants required 200 to 300 hours to prepare. He received assistance from the regional planning commission. He was known and trusted by local engineers who assisted with design, or signed off on design work he had done. He relied upon the fire and rescue squads to help him document risks associated with losing certain road crossings during emergencies. And he kept good records about culvert failings to build the case for their future replacement. "I just want to be able to say I bettered this town," he noted. He certainly did.

FEMA money can help with planning

FEMA Hazard Mitigation Grant applications are actually made to the state which reviews proposals and passes the top ones on to FEMA. Federal funds can cover up to 75 percent of total project costs. Only communities that have FEMA-approved mitigation plans and that participate in the National Flood Insurance Program are eligible for Hazard Mitigation Grants.

While Decker's commitment may have been unique, money is available for those seeking to deal with repeat flooding problems. A successful application must show repetitive damage at a site to document a positive benefit to cost ratio. Repeat damage helps meet this need, as does the input of the fire and rescue squads.

The Town of Warren also took steps prior to Irene to mitigate future floods. Warren was devastated by flooding in 1998 when heavy rains fell on already saturated soils in late June, swelling the Mad River. Following the flooding the town, with FEMA assistance, purchased three homes along the Mad River. Two of them later became the town-owned Riverside Park. Over the years gifts and additional purchases have helped the park expand. A 2008 plan for the park identified a primary goal of allowing the river channel to return to a balanced state. Over time, the river would top its banks and erode and deposit sediments along its channel and the park, which it did in 2011. According to Caitrin Maloney, formerly of Friends of the Mad River, Riverside Park area offers one of the first opportunities downstream from Warren Village, for "the river to blow off some steam" during high flow.

Despite two rivers and lots of mountains, Pawlet was well-prepared for Irene's wrath.

Advanced preparation can help individuals as well as towns. Along North Road in Middletown Springs the Irene-swollen North Brook wiped out multiple stream crossings. Of the four stream crossings along the road, only one bridge survived; the one where homeowners sought input from a river scientist prior to construction. Heeding their input assured the bridge would be wide enough to outlast high water events. Stream crossings that failed were substantially smaller.

Road project designers would be well served to follow the examples of Clarence Decker, the town of Warren and the homeowners along North Road and consider future flooding during the planning stage. Many communities are already doing so. As one example, Bristol plans to replace two small undersized bridges on the New Haven River with a single 360-foot structure that will span the full flood-prone area. The new bridge will increase the capacity of the river to pass water and lessen the likelihood of future flood-related damage both to the bridge itself and downstream. Climatologists predict more intense storms and more flooding for our region. Adjusting our infrastructure to face this new reality will require foresight and preparation, but it is imperative that we do so.

Of four stream crossings along North Road in Middletown Springs, this is the only one to have survived Irene. It was the only crossing built in consultation with a river scientist. Photo by Lori Fisher.

Lesson #5 When emergency measures create future dangers, go back and fix them

Raging floodwaters in Mendon Brook threatened the water supply system for Rutland during Irene. Water treatment plant supervisor Michael J. Garafano and his son Michael G. Garafano lost their lives when they went to check on the intake during the storm. The flood destroyed the water intake, plugging it with debris and rock, and forcing the utility to rely on a back-up on East Creek. At one point the city was down to a 13-day supply of water; its reservoir typically holds a 30-day supply. The backup system helped to refill the reservoir for a few days, but eventually the East Creek water levels dropped too low to be used. The city faced an emergency situation, and needed to reopen the Mendon Brook intake as quickly as possible.

Emergency measures to protect the Rutland water supply led to later sediment build-up in Glen Dam, a hydropower source. Affected parties worked together to go back and correct the problems.

Emergency work ensued to stabilize a berm, protect the pump and inlet area, confine the brook to its channel, and ensure a stable water supply. Bulldozers windrowed the river channel creating nine-foot high levees on either side of the stream. It took almost a month to get the water intake functioning again, but eventually the reservoir began to refill.

The work that occurred on Mendon Brook in the immediate aftermath of Irene was clearly necessary, but it also created problems. The brook lost access to floodplains between it and East Creek, making future flooding potentially more dangerous. The channelization of the stream increased its velocity and transport capability. Excess sediment settled out in the Glen Dam impoundment.

Glen Dam sits just downstream of the confluence of Mendon Brook and East Creek. It was owned and managed by Central Vermont Public Service (CVPS – now Green Mountain Power). From Glen Dam water passes via a penstock to the 2,000-kilowatt Glen Station on the western side of Route 7 in Rutland Town, generating power. Excess accumulation of sediment in the impoundment threatened future power generating ability.

The Mendon Brook near the Rutland water intake jumped the left bank near this spot threatening the intake. Photo by Lori Fisher.

CVPS/GMP worked with Rutland and the Department of Environmental Conservation to reconfigure some of the stream alterations that had taken place under emergency conditions. They lowered berms, brought large debris into the stream channel to help slow the water flow, and opened floodplain access along the river bank opposite the drinking water intake. While the stream still shows clear signs of channelization, the future flood risk has been reduced.

By necessity, work done under emergency conditions prioritizes speed over perfection. Mistakes will be made. Mike Kline of the Vermont DEC Rivers Program estimated that "Twenty percent of the (river) work after Irene reduced flood vulnerability; 40 percent of the work put the river back where it had been, but that was already a vulnerable condition; and 40 percent of the work made our risk and vulnerability greater." Rutland and CVPS/GMP went back and mitigated their mistakes. Their follow-up efforts deserve the same degree of commendation that the initial emergency work received.

Lesson #6 Consider whether you really need to rebuild everything

In the rush to rebuild after a flood we can miss opportunities to increase community resilience by moving roads, buildings and structures out of floodplains. In some places, alternate roads outside the floodplain can get vehicles and people to the same location with only a marginal increase in travel time. Some examples follow.

Upper Cold River Road in Shrewsbury washed away during Irene. Continued water seepage from the nearby hillside poses a significant construction challenge for this dirt road. Photo by Lori Fisher.

West River Road parallels the New Haven River and connects Lincoln and Bristol. It is the main route out of Lincoln. Flooding in 1998 washed out portions of the road and isolated Lincoln, and flood damage along the road still occurs on a regular basis. Lincoln has adopted a River Overlay Area in its zoning regulations to prevent floodplain development, but the overlay specifically avoids public roads under an assumption that they would always be protected. Yet alternate travel corridors exist – at least three other routes travel uphill from West River Road and avoid the floodplain. Increasing the capacity of these roads rather than continually rebuilding West River Road could save the town money in the long run.

Upper Cold River Road in Shrewsbury is a dirt track that angles off of Cold River Road four miles east of its intersection with Route 7. The road hugs a steep hill before crossing the Cold River at a picturesque covered bridge. Brown's Bridge has spanned the Cold River since 1880 and is listed on the National Register of Historic Places. Irene spared it, barely. The bridge was knocked off its foundations and required substantial repair. With assistance from FEMA the bridge was rebuilt. Landslides along the road between Brown's Bridge and Cold River Road had made the route impassible. A few years after Irene, the town of Shrewsbury submitted a Pre-Disaster Mitigation (PDM) grant application which was selected by FEMA for federal funding to relocate a portion of the road onto more stable slopes. The project is underway.

Deciding not to rebuild has become a more accepted means of increasing resilience to future floods. A host of communities, with FEMA assistance, have bought and removed homes destroyed by flooding. As of July 2019 Vermont communities have purchased and removed more than 120 flood-vulnerable homes, using a combination of hazard mitigation grant funding and community development block grant funds associated with Tropical Storm Irene. Under this program, the properties purchased must be maintained as open land.

People – and communities – understandably develop emotional attachment to what they have built, nurtured and maintained over the years. Homes, buildings and infrastructure represent significant, hard to replace, financial investments. Yet, it's important to look ahead and take advantage of available opportunities to reduce flood vulnerability. In doing so, we minimize risks to life, property and community facilities. We need to change and evolve as a society and adapt to new circumstances.

Lesson #7 Constructed ponds can pose a hazard

Many rural properties are dotted with constructed ponds, built as watering holes for livestock or for the aesthetic enjoyment of the homeowner. Ponds have also been developed for stormwater management and to provide water for snow-making. Ponds can be a great amenity, but when built too close to a river they are also a hazard.

This Mt. Holly pond (top of photo) was constructed in the floodplain. During Irene the stream captured the pond releasing a surge of water and sediment downstream. Photo by Mike Winslow.

Shrewsbury resident Lee Wilson described what happened to his pond during Irene,

> *"With a startling suddenness, the stream overlapped the Old Plymouth Road Bridge opposite the house and a flood of water began crossing the road, pouring into and out of our small pond on the other side of the road. Debris had jammed under the bridge turning it into a dam. The force of water through the pond knocked a hole in the embankment between pond and stream, and the pond was no more. Shortly after, the Old Plymouth Road Bridge collapsed from the rushing water destroying its abutments."*

In 1995, Sugarbush Ski Resort built a new snow-making pond. Since then it has been captured by floods in 1995, 1998, 2001 and 2011. The 10-acre pond is adjacent to the Mad River mainstem, just downstream from Clay Brook. When it is breached, large sediment loads enter the river and move downstream so that deep pools downstream are almost entirely filled by loose unconsolidated sediment. During Irene, the pond collected tons of dirt and gravel.

Sugarbush Ski Resort's snow-making pond along Route 100 in Warren has been captured multiple times by the Mad River.

Streamside ponds represent an extreme form of gravel dredging in the way that they promote instability in streams. In all streams the force of flowing water transports sediment. When gravel is removed from a stream the water's force takes sediment from either the stream bed or banks. This creates a head-cut which over time migrates upstream as it erodes further.

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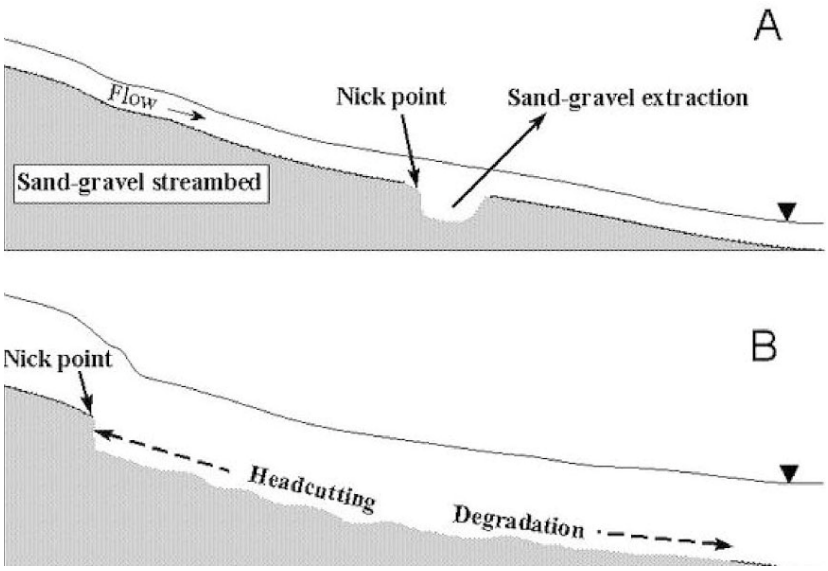

A pond's impact on a stream is similar to sand or gravel extraction. The pond creates a nick point in stream channels. If the pond fails, the river erodes at the head of the pond while the downstream area degrades. Diagram by San Diego State University.

Ponds can be "captured" by flooding streams. Digging a hole next to a river leaves a depression lower than the river bed, and water will always seek the lowest point. During high water a river may flow into or capture an adjoining pond, and change its course. Over time, fine sediments accumulate in ponds. When ponds get captured by a flooding stream, those sediments wash out, accentuating any downstream debris jams. Gravel pits and golf course sand traps and water features are also susceptible. Care must be taken when planning, approving or constructing any depressions like ponds within a river corridor.

This sand trap on a central Vermont golf course was captured by the nearby river during Irene. Note the sand that has been delivered downstream at the top of the photo. Photo by Mansfield Heliflight.

Lesson #8 What makes a lakeshore protection project successful

Poorly planned do-it-yourself projects like this one often lack structural integrity and soon fall apart. Photo by Mike Winslow.

Flooding impacts lakeshores in a different manner than it does riverbanks. Inundation is a more pressing problem than fluvial processes, though wind, waves, currents and ice also cause shoreline erosion. Property owners use a variety of methods to stabilize eroding shoreland. Poorly designed projects can be very expensive and unattractive, and harm the lake ecosystem, without even adequately protecting the shoreline.

We studied Lake Champlain's shore along Appletree Bay in Burlington's New North End to identify some successful and unsuccessful projects. Appletree Bay offers stunning vistas to the west across the broad lake. The views are a prime attraction and large homes have sprouted along the shore. But the broad lake generates large waves here and the area's sandy soils are especially susceptible to erosion. A cruise along the shore can expose the boater to a myriad of shoreline stabilization projects.

The Little Eagle Bay development consists of townhouses and one-bedroom flats, some of which sit right on the shore of Lake Champlain. The property managers built a massive sea-wall to protect their investment. Within a few years of construction however, the wall was tilting out over the lake and its structural integrity was weakened.

What went wrong? The wall was designed to dampen the force of lakeside waves, but the developers failed to account for the pressure of down-slope movement of land toward the lake. Erosion can be caused by water coming from the landside as well as lakeside waves. In this instance, the impervious surface created by buildings, parking areas and roads increased the amount of stormwater runoff flowing toward the lake.

The push and pull of ground water from the landside plus waves from the lakeside, rock sea walls back and forth leading to cracks like this one. Cracks can be seen in scores of sea walls around the lake. Photo by Mike Winslow.

Controlling shoreline erosion is complicated. All the forces acting on a particular site need to be considered. A project that fails leads to loss of money, loss of land and ecological damage. Shoreline erosion control projects should not be undertaken lightly and land owners would be wise to consult with professional engineers before proceeding. The do-it-yourself project is the one most likely to require rebuilding in just a few years.

Three preliminary steps are necessary for any erosion control project:

1) Identify the forces leading to erosion,

2) Identify potential impacts both from and to neighboring properties, and

3) Identify the vulnerabilities that cause the erosion.

Forces to consider when assessing an erosion control project include not just waves and lake level, but wind, ice and stormwater runoff from the landside. The interplay between waves and landside stormwater push a wall back and forth, loosening its foundation and weakening it over time.

The resulting cracks and tilting can be seen in scores of walls around the lake. To identify landside sources of erosion, it is helpful for landowners to go out during a rain storm and look at the property from the lakeside. Where is the water running off? This step should be undertaken even for landowners that do not currently have an erosion problem.

Failure to provide controlled access to the waterfront can lead to development of herd paths like this one. Once a herd path forms, erosion accelerates along it and it is extremely difficult to reestablish vegetation. Photo by Mike Winslow.

Lakeshore projects can have repercussions beyond just a single property. When waves come into shore at something other than a 90-degree angle, they bounce off walls, rocks and other hardened shoreline surfaces and impact the neighboring properties downwind, increasing erosion. Structures built too close to the lake can thus be destabilized by waves from the side. Walls can also cut off the supply of sand that feeds neighboring beaches. Waves that hit the shore on an oblique angle also create longshore currents which pick up sediment and carry it down shore. Over time the beaches that had developed down shore disappear once the source of the sediment is walled off. Whenever possible, erosion control projects should be coordinated with neighbors to avoid such impacts.

A designated staircase limits trampling of vegetation and preserves soil on slopes. Note too, gabions to left and right of staircase provide protection from erosion, but allow vegetation to grow through the wires. Photo by Mike Winslow.

Vulnerabilities are often inherent with the site. Pre-existing conditions such as erodible soils, or exposure to a wide stretch of lake over which winds can blow and waves can grow increase the likelihood a given site will have erosion problems. However, the management of the shoreline also matters. According to the Lake Champlain Basin Program's summary of the effects of the 2011 spring floods, "Shorelines with poor management, such as steep banks with little vegetation and lawns extending to the water's edge or shoreline immediately adjacent to seawalls were especially vulnerable to erosion."

Good vegetation management can enhance most any erosion control project, and even eliminate the need for some. Shoreline vegetation breaks the force of waves before they reach land. Clearing vegetation to create a view, building site, or boat launch will often accelerate erosion.

The trees in the foreground of this photo provide protection from wave action and lessen erosion along the lakeshore. Photo by Mike Winslow.

Natural shoreline vegetation also offers clear benefits to lake ecosystems. Bass preferentially build nests along undeveloped shorelines. Bass reach the legal size for fishing faster in undeveloped lakes. Trout get most of their food from terrestrial insects in undeveloped lakes, but at most two percent in lakes with extensive shoreline development. As a result, trout in undeveloped lakes ingest 50 percent more energy daily than those in developed lakes. Development decreases macroinvertebrate diversity in lakes leading to less and fewer types of food for fish. Cleared shorelines contribute 18 times more sediment, five times more runoff and seven times more phosphorus to the lake than those where the shoreline is wooded.

From a distance, the beach along Leddy Park in Burlington shows a stone base with extensive vegetation along the hillside. Upon closer inspection you see the vegetation pokes through wire mesh baskets holding the stones together, known as gabions. These can be filled with small rocks to create a large mass. They are a fairly cheap and aesthetic form of erosion control. The added vegetation improves the look of the shoreline while offering additional shoreline stability.

Limiting and minimizing access points to a beach also reduces erosion. At Leddy Beach a staircase funnels visitors to the water. However, herd paths and bike trails at other points along the beach create rills and gullies that concentrate erosion and diminish the effectiveness of the gabions. Thorny plantings at the top of the slope like roses or blackberries would discourage such haphazard beach access.

Like vegetation, beaches help dampen the force of waves. The gradual slope towards shore that beaches provide allows wave energy to be expended before hitting higher ground. Sand dunes, where they exist, act as natural sea walls in blunting the force of wind and waves. Retaining walls set back from the water allow natural beach development and increase the life of the wall by enhancing protection at the toe of the structure. Walls set at the lakeshore have a shorter lifespan and a greater negative impact on the ecology of the lake.

A strong awareness of your surroundings will improve lakeshore protection measures. Before undertaking a project, make sure you know the true causes of erosion you are trying to eliminate. Seek means to utilize your natural surroundings, vegetation and beaches, to increase a project's likelihood of success and reduce its cost. There are many resources available to help landowners with more detailed selection and planning of a project. In particular the Northwest Regional Planning Commission’s publication The Shoreline Stabilization Handbook provides an excellent overview of shoreline management techniques and guidance for choosing the right project for a given site. In the long run landowners will be well served by hiring a professional engineer to design their project.

Additional Resources

The following are additional resources about topics discussed in this document:

- **Disaster Recovery and Long Term Resilience Planning in Vermont -** 2013, 27 page publication designed to help municipalities incorporate smart growth and sustainable community approaches into development plans, regulations, and hazard mitigation plans to increase flood resilience. Prepared by the U.S. Environmental Protection Agency.

- **Living in Harmony with Streams: A Citizen's Handbook to How Streams Work -** 2012, 44-page publication explaining how streams work and highlighting incentive programs available to landowners. Prepared by Friends of Winooski River, White River Natural Resources Conservation District, and the Winooski Natural Resources Conservation District.

- **Reading Vermont's Rivers -** 2013, 15-page publication providing an introduction to how rivers behave and what makes them healthy. Prepared by the Vermont Natural Resources Council.
  Available in PDF: www.vnrc.org/wp-content/uploads/2013/07/Reading-Rivers-reduced.pdf

- **The Shoreline Stabilization Handbook for Lake Champlain and Other Inland Lakes -** 49-page publication introducing causes of lakeshore erosion and shoreline stabilization options. Prepared by Northwest Regional Planning Commission. Available in hardcopy and PDF: https://docs.wixstatic.com/ugd/cf375c_3e5165613c4c4c7f9588ad6d4636f06f.pdf

- **Vermont Agency of Natural Resource River Corridor Planning Guide** (2nd ed.) - 2010, 93-page technical guide directed toward river scientists, planners, and engineers. Prepared by the Vermont River Management Program.
  https://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/rv_rivercorridorguide.pdf

- **Vermont Association of Planning and Development Agencies** fosters a community environment that provides for the needs of both residents and our natural surroundings. It is a central contact point for all of the **Regional Planning Commissions** in Vermont. www.vapda.org

- **Vermont Agency of Commerce and Community Development** is the state agency responsible for providing technical resources, municipal planning grants, training and other assistance for Vermont communities. Its resource page includes links to an array of tools to help communities plan for tomorrow's flood. www.accd.vermont.gov/community-development/flood

- **Vermont Emergency Management** serves as the grantee agency for FEMA hazard mitigation grants to Vermont communities. https://vem.vermont.gov/funding/mitigation

- **Vermont League of Cities and Towns Municipal Assistance Center** provides local officials with education, training and professional assistance. It offers an on-staff water quality planner to provide technical assistance to communities. www.vlct.org/mac

- **Vermont Planning Information Center** is an online clearing house for information for planning commissions, zoning boards, development review boards, and their staff and all others involved in land planning and regulation in Vermont. www.vpic.info

- **Vermont Rivers Program** has a wealth of technical resources to help communities become more flood resilient and qualify for more state funding through the Emergency Relief and Assistance Fund (ERAF). https://dec.vermont.gov/watershed/rivers

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Our Work

The Lake Champlain Committee is a membership-supported, bi-state non-profit organization working since 1963 to protect Lake Champlain's environmental integrity and recreational resources for this and future generations through science-based advocacy, education and collaborative action.

Lake Champlain Committee

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